स्वाध्याय स्वमन्थन स्वावलम्बन

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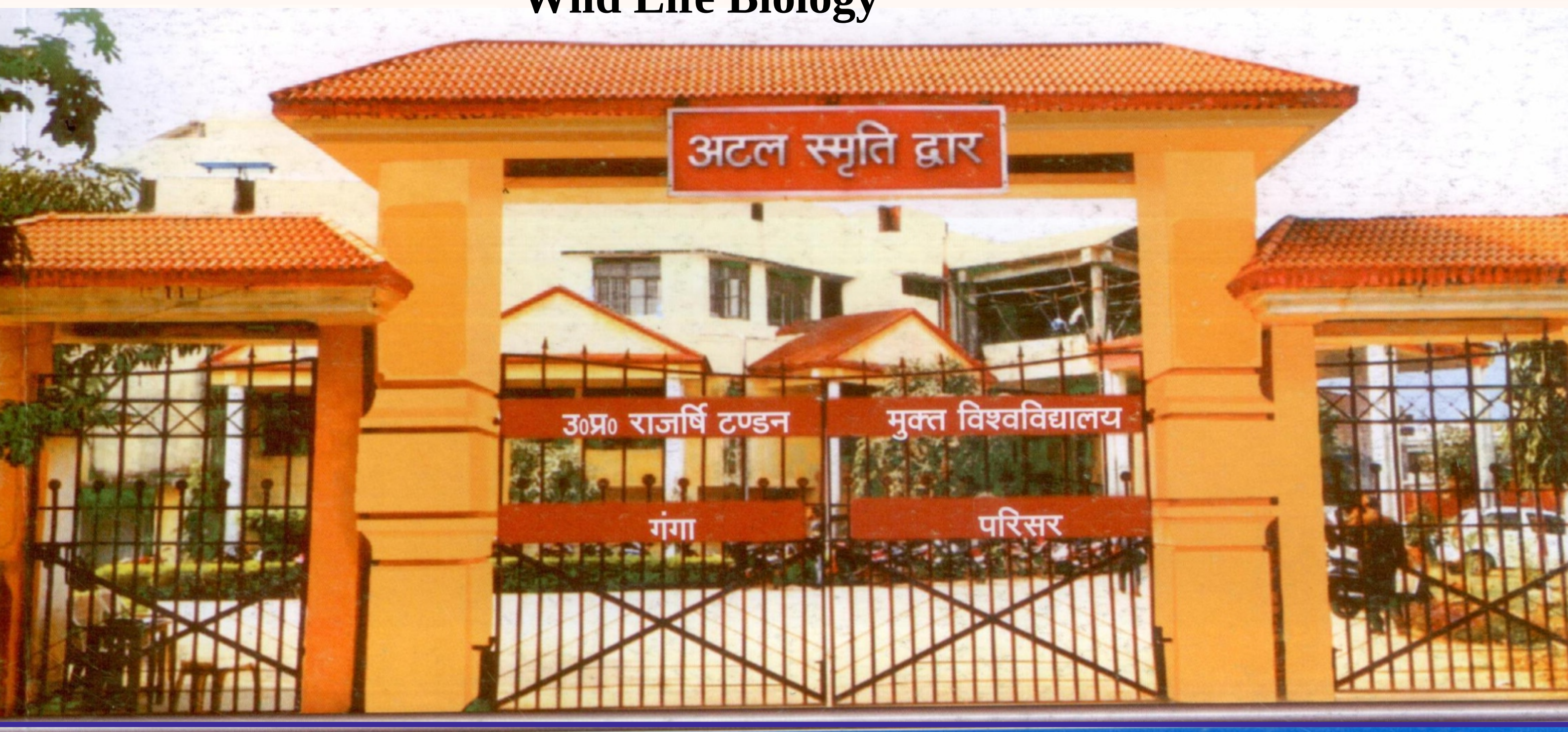
Master of Science

PGZY-103(N)

Animal behaviour and Wild Life Biology



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संदेश

प्रयागराज की पवित्र भूमि पर भारत रत्न राजर्षि पुरुषोत्तम दास टण्डन के नाम पर वर्ष 1999 में स्थापित उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, प्रयागराज उ0प्र0 का एकमात्र मुक्त विश्वविद्यालय है। यह विश्वविद्यालय उ0प्र0 जैसे विशाल जनसंख्या वाले राज्य में उच्च शिक्षा के प्रत्येक आकांक्षी तक गुणात्मक तथा रोजगारपरक उच्च शिक्षा के अवसर उपलब्ध कराने में निरन्तर अग्रसर एवं प्रयत्नशील है। तत्कालीन देश की सामाजिक एवं आर्थिक परिस्थितियों में एक वैकल्पिक व नवाचारी शिक्षा व्यवस्था के रूप में भारत में मुक्त एवं दूरस्थ शिक्षा प्रणाली का पदार्पण हुआ था, परन्तु वर्तमान परिस्थितियों तथा तकनीकी का सार्थक प्रयोग करते हुये मुक्त एवं दूरस्थ शिक्षा आज की सर्वोत्तम पूरक शिक्षा व्यवस्था के रूप में स्थापित हो चुकी है।

वर्तमान शिक्षा प्रणाली के सामने व्याप्त पाँच मुख्य चुनौतियों - (i) पहुँच (Access), (ii) समानता (Equity), (iii) गुणवत्ता (Quality), (iv) वहनीयता (Affordability) तथा (v) जवाबदेही (Accountability) को केन्द्र में रखकर घोषित देश की राष्ट्रीय शिक्षा नीति (NEP-2020) के प्रस्तावों को क्रियान्वित करने में उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय कृत संकल्पित है। उ0प्र0 की माननीय राज्यपाल एवं कुलाधिपति की सद्इच्छाओं के अनुरूप उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, शैक्षिक दायित्वों के साथ-साथ सामाजिक दायित्वों के निर्वहन में भी लगातार नवप्रयास कर रहा है। चाहे वह गाँवों को गोद लेकर उनके समग्र विकास का प्रयास हो या ग्रामीण महिलाओं, ट्रान्सजेन्डर व सजायाफ्ता कैदियों को शुल्क में छूट प्रदान कर उनमें आत्मविश्वास जागृति व उच्च शिक्षा के प्रति अलख जगाने का प्रयास हो ।

राष्ट्रीय विकास को बढ़ावा देने के लिए शिक्षा एक मूलभूत जरूरत है। ज्ञान-विज्ञान एवं तकनीकी के क्षेत्रों में हो रहे तीव्र परिवर्तनों व वैश्विक स्तर पर रोजगार की परिस्थितियों में आ रहे परिवर्तनों के कारण भारतीय युवाओं को विभिन्न क्षेत्रों में गुणवत्तापूर्ण शैक्षिक अवसर उपलब्ध कराने पर ही भारत का भविष्य निर्भर करेगा। इसीलिए विभिन्न क्षेत्रों में सफलता हेतु शिक्षा को सर्वसुलभ, समावेशी तथा गुणवत्तापरक बनाना समसामयिक अपरिहार्य आवश्यकता है। वर्तमान परिस्थितियों ने परम्परागत शिक्षा को और भी सीमित कर दिया है जिसके कारण मुक्त एवं दूरस्थ शिक्षा व्यवस्था ही एकमात्र पूरक एवं प्रभावी शिक्षा व्यवस्था के रूप में सार्थक सिद्ध हो चुकी है। ऐसी स्थिति में विश्वविद्यालय का दायित्व और भी बढ़ जाता है। इस दायित्व को एक चुनौती स्वीकार करते हुए विश्वविद्यालय ने प्राचीन तथा सनातन भारतीय ज्ञान, परम्परा तथा सांस्कृतिक दर्शन व मूल्यों की समृद्ध विरासत के आलोक में सभी के लिए समावेशी व समान गुणवत्तायुक्त शिक्षा सुनिश्चित करने तथा जीवन पर्यन्त शिक्षा के अवसरों को बढ़ावा देने के लिए अपने शैक्षिक कार्यक्रमों में जागरूकता में प्रमाणपत्र, डिप्लोमा, परास्नातक डिप्लोमा, स्नातक, परास्नातक तथा शोध उपाधि के समसामयिक शैक्षिक कार्यक्रमों की संख्या तथा गुणात्मकता में वृद्धि की है।

शैक्षिक कार्यक्रमों में संख्यात्मक वृद्धि, गुणात्मक वृद्धि तथा रोजगारपरक बनाने के साथ-साथ प्रत्येक उच्च शिक्षा आकांक्षी तक पहुँच सुनिश्चित करने के लिए अध्ययन केन्द्रों व क्षेत्रीय केन्द्रों के विस्तार के साथ-साथ प्रवेश परीक्षा, प्रशासन तथा परामर्श (शिक्षण) में आनलाइन व्यवस्थाओं को सुनिश्चित किया गया है। विश्वविद्यालय कार्यप्रणाली में पारदर्शिता तथा जवाबदेही सुनिश्चियन की दृष्टि से तकनीकी के प्रयोग को बढ़ाया गया है। 'चुनौती मूल्यांकन' की व्यवस्था सुनिश्चित करने का कार्य किया गया है, तो शिक्षार्थी सहायता सेवाओं में भी वृद्धि की जा रही है। शिक्षार्थियों की समस्याओं के त्वरित निस्तारण हेतु शिकायत निवारण प्रकोष्ठ को सुदृढ़ करने के साथ-साथ पुरातन छात्र परिषद को गतिशील किया गया है।

"गुरुकुल से छात्रकुल" के सूक्त वाक्य को आत्मसात करते हुए विश्वविद्यालय ने शिक्षार्थियों को विश्वविद्यालय द्वारा तैयार किये गये गुणवत्तापूर्ण स्वअध्ययन सामग्री उपलब्ध कराने के साथ-साथ विश्वविद्यालय की वेबसाइट पर भी उपलब्ध कराया गया है। छात्रहित को ध्यान में रखते हुए शिक्षकों द्वारा तैयार व्याख्यान को भी ऑनलाईन उपलब्ध कराया गया है।

शोध और नवाचार के क्षेत्र में अग्रसर होते हुए विश्वविद्यालय अनुदान आयोग (UGC) नई दिल्ली तथा माननीय राज्यपाल एवं कुलाधिपति, उ0प्र0 की अनुमति से विश्वविद्यालय में शोध कार्यक्रम पुनः प्रारम्भ किया गया है तथा वर्ष पर्यन्त समसामयिक विषयों पर व्याख्यान, सेमिनार, वेबिनार तथा आनलाइन संगोष्ठियों आदि की शृंखला भी प्रारम्भ की गयी है। विभिन्न क्षेत्रों में रिसर्च प्रोजेक्ट सम्पादन पर भी ध्यान केन्द्रित किया गया है। पुस्तकालय को अत्याधुनिक तथा सुदृढ़ बनाने हेतु कदम उठाये गये हैं। शिक्षकों व कर्मचारियों के स्वास्थ्य तथा कल्याण की योजनायें क्रियान्वित की गयी हैं।

प्रो0 सत्यकाम
कुलपति

Uttar Pradesh Rajarshi Tandon Open University

Master of Science

PGZY-103 (N)

Animal behaviour and Wild Life Biology

Course Introduction

This course covers details of Animal Behaviour and Wild Life Biology. Scientific study of animal behaviur is known as ethology. This field of biology is most interesting and has made most notable advances during last two decades. All behaviour shown by organisms (irritability, movement, change in shape, posture, reflexes, instincts, learning etc.) may be grouped under two major heads (I) Innate behaviour (inborn or inherited behaviour), (II) Learned behaviour (Acquired behaviour)

The study of animal behaviour encompasses a wide range of topics and approaches from understanding and underlying mechanisms to exploring the ecological and evolutionary significance of behaviour.

Innate behaviour are instinctive and genetically programmed, while learned behaviours are acquired through experience and can be modified by the environment.

Animals use various forms of communication, including visual signals (body language, coloration), auditory signals (vocalizations) chemical signals (pheromones) and tactile signals (touch) to convey information to other individuals.

Many animals exhibit complex social structure and engage in behaviours such as cooperation, competition, aggrission, mating systems.

This course on Animal Behaviour and wild life biology has been divided into three blocks.

Block I- Animal Behaviour-I

Block II- Animal Behaviour-II

Block III- Wild Life Biology

Uttar Pradesh Rajarshi Tandon

Open University

Master of Science

PGZY-103(N)

Animal behaviour and Wild Life Biology

Block

1 Animal Behavior - I

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PGZY – 103 (N) : Animal behaviour and Wild Life Biology
ISBN-

Block I- Animal Behaviour-I

This block has been divided into 03 units.

Unit-1 this unit deals with the factors affecting survival behavior, choice of breeding

sites, habitat selection, determinants of habitat preference.

Unit- 2 It deals with Evolutionary and neurological basis of behavior, innate behavior, Stereotype and acquired behavior, Neural and hormonal control of behavior. It also deals with patterns of communication (chemical, visual, light, audio, Species specificity of songs, evolution of language with respect to primates).

Unit-3 This unit deals with flocking in birds, herding in mammals, group selection, kin selection, altruism, reciprocal altruism, inclusive fitness, social organization in insects and primates. It also deals with social structure and behavior, Parental care with reference to fish, amphibians and birds, territorial behavior

Objectives:

After studying this block you will be able to know:

- selection of habitat
- evolutionary and neurological basis of behavior
- social behavior

Unit-1 Selection of Habit

Structure

1.1 Introduction

Behaviour is of immense practical value to the taxonomist, because behaviour may give significant evidence about evolutionary relationships in groups in which the morphological evidence is not convincing. To the game biologists, knowledge of animal behaviour is a basic necessity for intelligent management. The psychologist may learn from the behaviour of animals something about the learning process which will be helpful in human education. The physiologists may study the neural patterns associated with different kinds of behaviour.

Behaviour is the result of interactions of the nervous system and the endocrine system with the muscles and other organs of the body, and of the characteristics of the environment in which the animal lives. Some aspects of behaviour are governed by the laws of genetics. Some aspects are flexible and may change as a result of learning.

Objectives:-

After studying this unit you will be able to know:

- Factors affecting survival behviour
- choice and breeding sites.
- Determinants of habitat preference

1.2 Factors Affecting Survival Behaviour

Behaviour Patterns

A behaviour pattern may be defined as a segment of behaviour which has a specific adaptive function. The principal behavioural patterns observed in animals are-

A. Ingestive Behaviour

When some birds are seen feeding on grains it can simply be called eating behaviour. Some animals get most of their food in liquid form. Since the same organs are involved in eating and drinking and the behaviour is very similar it may be called as infective behaviour.

B. Agonistic Behaviour

This behaviour pattern includes aggression, threat, appeasement and avoidance behaviour that takes place during encounters between individuals of the same species-

(i) Aggression — When an animal attacks another animal.

(ii) Threat — A form of communication, intentional move-ment of attack.

(iii) Appeasement- Act of reducing aggression in situations where escape is impossible or disadvantageous.

(iv) Avoidance- The reaction which allows animals to escape from actual or potential danger in the environment.

C. Sexual Behaviour

This type of behaviour pattern includes courtship, mating and any other related behaviour.

D. Shelter Seeking Behaviour This behaviour pattern is a tendency to seek out optimum environmental conditions and to avoid dangerous and injurious conditions. For example, *Paramecium* just moves around until it finds the spot which has most favourable conditions. As the water dries, the paramecia come close to each other resulting in aggregation. This is infact a primitive type of social behaviour which may be called as contractual behaviour. Higher types of social behaviour have evolved from this type of adaptation.

E. Epimeletic Behaviour

- This pattern applies to rearing the young. As a consequence of sexual behaviour youngs are born. Since the young ones are not able to take care of themselves, the care taking tendency is seen in the parents long before the youngs are born. For example, after mating, a nest is built by the birds, the eggs are laid and the female sits upon them until they hatch.
- Then the young are fed by the parents. This care-giving has been variously called as attentive behaviour, maternal behaviour or parental behaviour. But there are instances, where care and attention are frequently given by others and not by the parents. For example, in bees

the care of young is done by the workers which are sterile females and not able to become parents.

F. Et-epimeletic Behaviour

This behaviour pattern involves calling or signalling for care and attention. After the youngs are hatched born, they show a behaviour pattern which is not characteristic of adults, as for example, chirping noise and holding head up in the air with gaping beak in young birds.

G. Eliminating Behaviour

- The general effect of this behaviour is to clean the living place. For example, "The young birds release the faeces and urine in pellets surrounded by a membrane and the parent birds throw them out of the nest.
- In many animals there is no special behaviour pattern associated with their own elimination. Certain young hawks have the habit of flipping the tail at the time the faeces are released so that the material is thrown out of the nest. In case of cats holes are dug and the excreta is buried there in.

H. Allelomimetic Behaviour In this pattern two or more animals do the same activity with some degree of mutual stimulation and coordination.

- For example, young birds fly together in flocks which are sometimes shaped like a great bird.
- Movement of fishes in "schools" is the same sort of behaviour. It is often called 'contagious behaviour'.

- It is the tendency of animals to form social groups such as schooling of fish, flocking of birds, herding of mammals.

- Mimetic behaviour is the another term used. It is used to describe situations in which there is a model whose appearance is more or less independent of the mimic For example, the "hawk moth" in its behaviour and appearance mimics humming bird. From flocks, schools and heirds, it is clear that the animals are responding to each other rather than to a single model.

I. Investigative Behaviour

- This behaviour pattern involves the sensory investigation of the environment. The birds or those animals which have better developed sense of vision can observe the surroundings at a glance. But a rat, dog or cat will use its nose and whispers to know about strange objects, food etc.
- These animals that manipulate things with hands (like raccoons, monkeys and man) may pick up a strange object, turn it over and over as they look at it and feel and may also smell or taste it.

J. Dominance

- It is a feature of social organization where certain animals acquire a higher status as a result of aggression and the others retain a low status. Dominance relationships were first seen in flocks of domestic fowl.
- Here the dominant individuals tend to peck subordinate individuals when they come in close vicinity. Dominant individuals use their status to gain priority in getting food, resting site etc.
- Dominance is usually established after aggressive encounters. For example, if an animal wins a fight, the encounter may not be repeated on subsequent occasions and instead the defeated one shows submission.

- When a dominant animal comes, a subordinate moves away typically showing appeasement behaviour.
- Dominance relationship is generally established by learning and dominant individuals may differ from subordinates both in appearance and behaviour, e.g large size, prominent comb and wattle in male fowl.
- Male sex hormones contribute very much to the dominant behaviour of most of the males. The dominant status is advantageous in many ways, e.g. unchallenged access to limited resources of food, space, females etc. For example, in elephant seal, most dominant 6% bulls inseminate 88% of the females.

K. Territoriality

- This behaviour pattern is seen at the time of defence of home range from intruders. For example, pairs of tawny owls inhabit a fixed, exclusive area in a jungle for the whole of their life and defend it against all other tawny owls by loud calling and chases. In this way they identify and defend their territory
- Following benefits are derived from territoriality-

a Feeding territory-Food requirements influence the territory size, as in many groups of animals like lizards, birds and primates. Territory size increases with increase in body weight.

b Mating territory-In some animals defence of territory is seen only during breeding reason. It is usually the male who defends areas where the females come for mating. Such territory has plenty of food, nests and good egg laying sites.

c Predator avoidance-Territorial behaviour also helps in decreasing the predation by having the knowledge of the location of shelter.

L. Social Relations

In social relations there is always involvement of two or more members of the same species. In other words it may be said that in one way or the other they maintain social relations and exhibit the so called social behaviour.

basic concepts:

Because ethology is considered a topic of biology, ethologists have been concerned particularly with the evolution of behavior and its understanding in terms of natural selection. In one sense, the first modern ethologist was Charles Darwin, whose book "The Expression of the Emotions in Man and Animals" in 1872 influenced many ethologists. He pursued his interest in behavior by encouraging his protégé George Romanes, who investigated animal learning and intelligence using an anthropomorphic method, anecdotal cognitivism, that did not gain scientific support.

Darwin's influence

The origins of the scientific study of animal behavior lie in the works of various European thinkers of the 17th to 19th centuries, such as British naturalists John Ray and Charles Darwin and French naturalist Charles LeRoy. These individuals appreciated the complexity and apparent purposefulness of the actions of animals and they knew that understanding behavior demands long-term observations of animals in their natural settings.

At first, the principal attraction of natural history studies was to confirm the ingenuity of god. The publication of Darwin's On the Origin of Species in 1859 changed this attitude. In his chapter on instinct, Darwin was concerned with whether behavioral traits, like anatomical ones can evolve as a result of natural selection. Since then, biologists have recognized that the behaviors of animals, like their anatomical structures, are adaptations that exist because they have, over evolutionary time (that is, throughout the formation of new species and the evolution of their special characteristics), helped their bearers to survive and reproduce.

Furthermore, humans have long appreciated how beautifully and intricately the behaviors of animals are adapted to their surroundings. For example, young birds that possess camouflaged color patterns for protection against predators will freeze when the parent spots a predator and calls the alarm. Darwin's achievement was to explain how such wonderfully adapted creatures could arise from a process other than special creation. He showed that adaptation is an inexorable result of four basic characteristics of living organisms:

1. There is variation among individuals of the same species. Even closely related individuals, such as parent and offspring or sibling and sibling, differ considerably. Familiar human examples include differences in facial features, hair and eye color, height and weight.

2. Many of these variations are inheritable—that is, offspring resemble their parents in many traits as a result of the genes they share.

3. There are differences in numbers of surviving offspring among parents in every species. For example, one female snapping turtle (family Chelydridae) may lay 24 eggs; however, only 5 may survive to adulthood. In contrast, another female may lay only 18 eggs, with 1 of her offspring surviving to adulthood.

4. The individuals that are best equipped to survive and reproduce perpetuate the highest frequency of genes to descendant populations. This is the principle known colloquially as "survival of the fittest," where fitness

denotes an individual's overall ability to pass copies of his genes on to successive generations. For example, a woman who rears six healthy offspring has greater fitness than one who rears just two.

An inevitable consequence of variation, inheritance and differential reproduction is that, over time, the frequency of traits that render individuals better able to survive and reproduce in their present environment increases. As a result, descendant generations in a population resemble most closely the members of ancestral populations that were able to reproduce most effectively. This is the process of natural selection.

Following kinds of Factors Affecting Survival Behaviour-

❖ **Psychological Behaviour**

- The psychologists have learned a great deal about the behaviour of a limited number of animals, largely under laboratory conditions and emphasizing only learned behaviour. Their aim has been to learn something about man by studying other animals.
- Harry F. Harlour has studied for some years the affectional development in primates other than man.
- His studies are of significance to those who have the responsibility of rearing children and to those interested in primate behaviour.
- Hardly any psychologist has contributed to our knowledge of animal behaviour under natural conditions.
- Behavioural psychologists have utilized very few species in their studies. The rat, pigeon, dog, chimpanzee, chicken and men have been studied along with a few others. The extension of laboratory, zoo or field studies have been one of the major thrusts of behavioural study.

❖ **Neurophysiological Behaviour**

- Behaviour occurs when stimuli cause a reaction. The secret of this process lies in the nervous system.
- Physiologists can probe the secrets of the nervous system with the help of electronic equipments, chemical analysis and advanced physical techniques. Modern workers prefer to go to the field for interpretation of laboratory data.
- A technique for recording nerve impulses from free-flying butterflies in a large cage has been developed.
- By coupling the results of electrophysiological work on tropical butterflies with field observations, the relationships between neural activity and certain behavioural patterns can be shown.
- Development of miniaturized electronic equipment has helped to monitoring the kinds of neural activity associated with specific behaviour patterns in a variety of larger animals.

❖ **Ethological Behaviour**

The study of behaviour is termed ethology. Since its inception, it has aroused widespread interest and has following approaches-

- To categorize behaviour as learned or instinctive.
- To study it under natural conditions as well as under controlled laboratory conditions.
- To attempt to explain it in neurological, genetic, and evolutionary terms.
- Ethology does not concern itself with learned behaviour and has few ties with the psychological approach. It emphasizes to a much greater extent, the branches of behaviour which are a part of the genetic equipment of the species.

- Therefore, ethologists are most likely to work with organisms which have a variety y of fixed instinctive patterns, birds, fishes and insects, rather than with rats and primates which are a part of the genetic equipment of the species.
- Therefore, ethologists are most likely to work with organisms which have a variety of fixed Study of Behaviour:
- Ethology and its Methods instinctive patterns, birds, fishes, and insects, rather than with rats and primates which are the subject of most psychological behaviour studies

1.3 Choice of breeding sites-Reproductive Behaviour

In many land animals, fertilization involves mating or copulation. This requires more than mere synchronization. During actual mating, the females are in a defenceless position. In such animals the mating involves the suppression of the escape behaviour. In many species the female takes a larger share than the male in feeding and protecting the young, she is more important than the male. Also, one male can fertilize more than one female, another reason why the individual males are biologically less valuable than females. It is the reason why the female needs pursuation more than the male and courtship is so often the concern of the male.

Further, apart from synchronization, there must be close coordination between the males and females i.e they must find each other, during actual copulation they must bring their genital organs in contact with each other, and the sperm must find the egg cell. This orientation is also a task of mating behaviour. Thus reproductive behaviour can be discussed under the following heads

A- Choosing the Member of the Right Species

- Since the genes are different in each species, mating between animals of different species bring widely different genes together. This easily disturbs the delicately balanced growth patterns. Mating between different species, therefore, often results in fertilized eggs which are unable to live or die at the beginning of their growth.
- In certain cases, hybrids may live but are less vital or infertile. This has led to the development of differences between the mating patterns of different species so that each individual can easily recognize its own species

B- Sexual Selection

- Within a breeding population, there is often intense competition between members of one sex for opportunities to mate. Typically, it is males that compete with each other for access to females because, whereas females need mate only once, males can enhance their reproductive success by mating with many females.
- Sexual selection is the evolutionary force that arises when some males are more successful than others in obtaining matings. Male competition may take one of the two forms-
- Males may fight with each other over females. In such cases sexual selection favours those that are largest, strongest or which have the most effective weapons. This form of sexual relation is responsible for the antlers of deer stags and for the larger size of males than the females.
- Alternatively, males may compete in a less direct way. In such cases mating success depends on how effective a male is in attracting and stimulating females. Thus, variation in male mating success depends on preferences among females for certain males rather than others.

- This form of sexual selection favours elaborate male displays and the physical characteristics that are associated with them, such as bright colours and elaborate plumage. The courtship display and huge tail of the peacock are thought to have evolved through sexual selection based on female preference.

The theory of sexual selection has been controversial since it was first formulated by Charles Darwin. While there has been no disagreement over the idea that male strength and weapons have evolved because of the advantages they confer in direct competition for females. A recent study has provided the evidence that female choice has been responsible for elaborate male displays and plumage. Further, the females do prefer those males that have the most exaggerated courtship characters.

C- Seasonality

- Many species, particularly those living in temperate zones, breed during a part of the year only. The birds have a spring peak in their reproductive activity. In other species, the breeding behaviour takes place at other times of the year. Many species of deer and elk breed in the fall; wolves and coyotes breed in midwinter and many species of seals and sea-lions breed in the late spring and early summer.
- Although different species have different gestation periods, most give birth in late spring and early summer.
- The major advantage to seasonality lies in timings of the birth of offsprings so that they appear when there is good weather and plenty of food available.
- Mating season and gestation period appear to interact in such a way that youngs take birth in late spring or early summer.

- The nature of the stimuli responsible for the initiation of breeding activity varies from species to species. Temperature, rainfall, growth of plant life and length of day, all vary with season and influence reproductive activity in different species.
- The length of day seems to control the onset of breeding in many species. For example, in both male and female Japanese quail, short days (8 hours light and 16 hours darkness) result in the reduction in size of various reproductive organs and a loss of sexual behaviour.

SAQ 1

- Gain advantage or resources over others. ForEx. Competition for food, mates, territory, power, or social status are called ………………………
- Acquire knowledge, skills and adapt to new environments. e.g. Exploring, observing, experimenting, problem-solving, studying are called ………………………
- Benefit others or the community, often at the expense of oneself. e.g. Helping, sharing, donating, volunteering, acts of kindness are called ………………………

1.4 Determinants of habit preferences (Habit Selection)

Animals that move freely across habitats and exercise selectivity in their location can influence community patterns through habitat selection.

SAQ-2

- Ensure individual or species survival and well-being. e.g. Seeking food, water, shelter, and avoiding threats or danger are called ………………………

- Establish, maintain social connections and relationships. e.g. Communication, cooperation, bonding, forming alliances, resolving conflicts are called ………………………
- Ensure the continuation of the species through reproduction. e.g. Courtship rituals, mate selection, mating behaviors, parenting are called ………………………

A- Learned aspects of Habitat selection are [a] imprinting [b] social facilitation and [c] trial and error

[a]Imprinting: Form of learning in the early period of life is called imprinting. Sometimes particular early experience is retained throughout life. It is concerned with behaviour elicited by particular visual, auditory, olfactory or tactile stimuli.

Imprinting like phenomenon is clearly involved in the social develop- ment of mammals. It is of common knowledge that the younger we adopt and rear a litter of mammals the easier is to tame them.

[b]The term 'Social organization' refers to populations and not to individuals. It defines the nature of interactions between members of a species. In social insects it is fairly rigid and specics specific whereas in vertebrates it is much more dynamic and varies with changing conditions.

Thus social organization may be defined as on aggregation of individuals into a well integrated and self consistent group in which the unity is based upon the interdependence of the separate organisms.

In view of this, social behaviour may be defined as the reciprocal interactions of two or more animals and the resulting modifications of individual action systems or any behaviour affecting another animal, usually of the some species. It may also be defined as an interaction between two individuals of a species.

Animal learns many things by trial and error. Learning begins when animal associates certain movements with favourable or unfavourable results. Thus, experimentally, trial and error learning involves either 'reward' or 'punishment' or both.

[c] Trial and error by Maze-Trial and error learning can be studied with any animal that is capable of learning by maze. Basically, a maze is a route with one or more choices of turns learning to a goal that is favourable or unfavourable to the animal. The simplest maze is called T maze. A rat was kept in the T maze. With a T maze we expect that by chance 50% of the turns. will be to the right and 50% to the left. If, after several trials, the rat turns to the right (where food is placed) 90% of the time and to the left (no reward) only 10% of the time, it is easy to counclude that learning has occurred in rat by trial error method. In this case the animal is required to make a discrimination of right turn.

Trial and error is the most appropriate category under which young animals perfect the co-ordination of their movements by practice, often during sessions of play with their sibling or parents.

Repetitive reinforcement eventually produces a maximum response beyond which we cannot show that learning has improved in terms of performance on any one trial. However, the longer we go on reinforcing a response beyond this maximum ('over training'), the more resistant it becomes to 'extinction' i.e. the animal will go on responding longer if reinforcement is removed.

[b]Habitat is the natural environment where an animal usually lives. Habitat provides shelter; food, protection, mates and space for breeding, feeding, resting, roosting, courtship, grooming, sleeping, etc. Rich habitats give higher fitness" to the organisms living there. Poor habitats give lower fitness. The quality of the habitat consists of the following variables:

- Food availability, Predator occurrence, Ease of defense, Likelihood of offspring survival, Microclimate changes, Distance to human settlements.
- Habitats are heterogeneous. There are many factors that are involved in the organism's choice of habitat. Animals must be able to tolerate two kinds of factors in the habitat, namely:
- Abiotic factors and Biotic factors
- Abiotic factors include temperature, humidity, salinity and pH.
- Biotic factors include competition, predation and disease. If both abiotic and biotic factors can be tolerated, the animal able to find the resources that it needs to survive. Habitat selection is a hierarchical process. Habitat selection is generated by foraging decisions. Foraging is the only process of driving habitat selection.

SAQ-3

- Express or regulate emotions and maintain psychological well-being. e.g. Crying, laughing, expressing joy, anger, fear or sadness are called ………………………
- Adjust to changing circumstances and optimize chances of survival. e.g. Flexibility, adjusting to new environments, behavioral modifications are called ………………………

1.5 Summary

- The study of animal behavior begins with understanding how an animal’s physiology and anatomy are integrated with its behavior. Both external and internal stimuli prompt behaviors external information (e.g., threats from other animals, sounds, smells) or weather and internal information (e.g., hunger, fear).
- Behavior can be defined as observable activities an animal performs in response to the various stimuli in order to survive and reproduce.

- Another phrase is “ behavior is the response of an organism to stimulus.” A stimulus is a change in the environment that produces a behavioral response.
- It may be an object or an event perceived through an animal's senses (visual, auditory etc.). Stimuli may include the sight of food, the sound of a potential predator or the smell of a mate.
- Animals respond to stimuli. Each of these stimuli elicits specific behaviors from animals. A stimulus may be in the form of signs/symbols or releases. Signs can be visual, auditory, chemical or other types of sensory models. A releaser stimulus releases certain programmed stereotyped activities or fixed action patterns.
- Understanding how genes and the environment come together to shape animal behavior is also an important underpinning of the field. Genes capture the evolutionary responses of prior populations to selection on behavior. Environmental flexibility gives animals the opportunity to adjust to changes during their own lifetime.
- The modern discipline of ethology is generally considered to have begun during the 1930s with the work of Dutch biologist Nikolaas Tinbergen and Austrian biologists Konrad Lorenz and Karl von Frisch, the three recipients of the 1973 Nobel Prize in Physiology or Medicine.
- Ethology combines laboratory and field science with a strong relation to some other disciplines such as neuroanatomy, ecology and evolutionary biology.
- Ethologists typically show interest in a behavioral process rather than in a particular animal group and often study one type of behavior, such as aggression, in a number of unrelated species.

- Ethology is a rapidly growing field. Since the dawn of the 21st century researchers have re-examined and reached new conclusions in many aspects of animal communication, emotions, culture, learning and sexuality that the scientific community long thought it understood. New fields, such as neuroethology, have developed.
- Understanding ethology or animal behavior can be important in animal training. Considering the natural behaviors of different species or breeds enables trainers to select the individuals best suited to perform the required task. It also enables trainers to encourage the performance of naturally occurring behaviors and the discontinuance of undesirable behaviors

1.6 Terminal Questions

Question-1 Describe in detail factors affecting survival behaviour.

Question-2 Describe in details reproductive behaviour.

Question-3 Describe in details habitat selection.

Question-4 Write short notes on imprinting.

Question -5 Write short notes on sexual selection.

1.6 Answers

SAQ-1

- Competitive Behavior
- Learning Behavior
- Altruistic Behavior

SAQ-2

- Survival Behavior
- Social Behavior
- Reproductive Behavior

SAQ-3

- Emotional Behavior
- Adaptive Behavior

References :

1- Dr. Sat Guru Prasad.

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Unit-2 Evolutionary and neurological basis of behaviour

Structure

2.1 Introduction

In Previous unit you have studied about the selection of habit. This unit covers the evolutionary and neurological basis of behaviour. Scientific study of animal behaviour is known as ethology. This field of biology is most interesting and has made most notable advances during last two decades. It serves to draw together diverse disciplines such as Physiology, Genetics, Endocrinology, Bio-chemistry etc. All behaviour shown by organisms (irritability, movement, change in shape, posture, reflexes, instincts, learning etc.) may be grouped under two major heads (I) Innate behaviour (inborn or inherited behaviour), (II) Learned behaviour (Acquired behaviour). Genetics plays an important role in behavior, as many behavioral traits have a heritable component. This means that the genes an individual inherits from their parents can influence their behavior and personality.Ethologists have observed that communication behaviour occurs in regular patterns, nearly unchanged from event to event. These sequences are called fixed action patterns. The most striking patterns are the stereotyped sequences that occur in the animals interacting with conspecifics for courtship, territory defence or dominance encounters. The primary function of behaviour is to signal. The signals are coded to convey information

Objectives

After studying this unit you will be able to know:

- Evolutionary and neurological basis of behavior
- Innate behavior Stereotyped and acquired behavior,
- Neural and hormonal control of behavior.
- Patterns of communication

2.2 Innate behaviour and Acquired behaviour

Behavior can be categorized into two main types,

a. **Innate or inherent behavior**

b. **Learned or acquired behavior**

Innate behaviors are genetically hardwired and are inherited by an organism from its parents.

Learned behaviors are not inherited but develop during an organism's lifetime as the result of experience and environmental influence

(I) Innate behaviour - A male moth (adult male silkworm) emerges from its cocoon and at once flies towards the females of its own species for copulation. Young spider without any previous experience weave webs as well as constructed by those of older spiders. These are examples of un- learned or innate behaviour.

These are "build in" the species. Thus "the behaviour which is inbom or inherited and which can not be acquired by practice "is called innate behaviour." The simplest form of innate behaviour shown by organisms is called irritability. Besides irritability, plants and all protistans 'show simple kind of innate behaviour called tropism. Tropism is the orientation of body towards or against the axis of stimulation. The orientation of plants towards sun light is called *phototropism.* The orientation of roots of plants towards centre of earth is called geotropism. If the orientation is not in a definite direction then it is called *nastictropism*. Tropism is advanced over irritability and most probably controlled by hormones.

CLASSIFICATION OF INNATE BEHAVIOUR

There are various kinds of innate behaviour. They are as follows :-

1. Kineses
2. Taxes,
3. Reflexes,
4. Instincts,
5. Motivation.

Various orientation and locomotory behaviour exhibited by animals (Protista to higher vertebrates) in response to environmental stimulus is called kineses and taxes.

1. Kineses: It is undirected orientational movement in response to a specific stimulus, coupled with occasional avoidance or approach move- ments. Following experiment exhibits the phenomenon of kinesis.

In kinesis a relationship may exist between the speed of locomotion and the intensity of stimulation. To demonstrate this phenomenon in Paramecium, following simple experiment is performed:-

Experiment: Take a large drop of Paramecium culture on a glass slide with the help of dropper. Make sure that a few paramecia are present in the drop by examining under microscope. Note that the paramecia are distributed evenly on the slide. Now add a drop of acid on the slide. Paramecia move away from acid. Their rate of orientation away from acid depends on concentration of acid. High concentration of acid orieni them- selves quickly away from acid.

- **2. Taxes:** It is directed orientational movement towards or against the stimulus. (Singular - taxis). In a taxis the whole organism moves towards or away the source of a stimulus. There are various kinds of taxes. They are as follows:
- **Positive taxis-**When the organism moves towards the source of stimulation, it is called positive taxis.
- **Negative taxis-**When the organism moves against the source of stimulation it is called negative taxis.
- **Geotaxis-**Orientation of organism towards or against the earth is called positive and negative geotaxis respectively. **Hirsch and Kimling** (1962) discovered that the tendency of **Drosophila melanogaster** to move towards or away from the direction of gravity (positive and negative geo- taxis) depends on the basis of chromosomal marker genes. He found that in an unselected population, chromosome x and chromosome II contributed to positive geotaxis and chromosome III I contributed to negative geotaxis.
- **Chemotaxis** Orientation due to chemical stimulation is called chemotaxis
- **Phototaxis**-Orientation due to light stimulation is called photo- taxis. When the larva of house fly (Musca domestica) has finished feeding, it seeks out a dark place to pupate. At this stage it will crawl away from a light source and

it is said to show **'Negative phototaxis'**. Euglena is positively phototactic. Near its anterior end is a spot of pigment (stigma) sensitive to light. Stigma receives stimulation of light. This information is transmitted to the flagellum, which then directs the organism to move towards the light.

- **Phototaxis**-Orientation by successive comparison of stimulus intensity requires truning movements. Usually it is called Klinotaxis.
- **Telotaxis**-Telotaxis is a form of directional orientation that does not depend upon simultaneous comparison of the stimulation from two receptors. When there are two sources of stimulation, the animal moves towards one direction and never in a median direction, showing that the influence of one stimuli is inhibited.
- **Menotaxis**-It is light compass response that involves orientation at an angle to the direction of stimulation. In this phenomenon the orientation is not simply towards or away from the source of stimulus, but rather the organism orient and moves at some angle to the source of light.

  Menotaxis is exhibited by ants while returning to their homes. Homing ants change their direction in relation to the change in position of the sun even when they are captured and kept in dark boxes. Such a wonderful time compensated compass reaction have been shown to occur also in the beetle (Geotrupes sylvaticus) and honey bee (Apis mellifora).
- **Mnemotaxis-**Orientation of animals stimulated without configurational stimuli is known as Mnemotaxis. This phenomenon was also observed by Fraenkel and Gunn (1940). Hunting bee (Philanthus triengulum) uses many territorial signs while returning to nest. Removal of any of the sign disturbs the path of hunting while returning to nest.
- **Tropotaxis-**It is a complex example of taxis. In tropotaxis besides external stimulation, condition of internal organs also influences the orientation of animal.

3. Reflexes

- It is simple innate dehaviour and is found only among animals having a nervous system. This is an automatic response of part of the body to a specific stimulus. Its nature is determined by the inheritance of the organism.
- Common examples of reflex action are the withdrawal of hand in response to sudden prick of a pin, the constriction of pupil of eye to sudden intense light etc. In general, the reflexes are relatively invariable and stereotyped.
- Reflexes are of two types, tonic and phasic reflexes. The tonic reflexes are slow, long lasting adjustment that maintains muscular tone, posture and equilibrium. The phasic reflexes are rapid, short lived adjustment such as that seen in sudden withdrawal of hand from a prick of pin.
- Complex reflexes depend on the higher segments of the nervous system. Simple flexion and extension reflexes may be organised within a few segments of the spinal cord. But locomotion which is a process of coordinated alteration of flexion and extension is organised over many seg- ments of the spinal cord and also requires influence of the midbrain for its normal appearance. Many patterns of behaviour, when closely examined, appear to be complex arrays of simple reflexes.
- Reflex response is one of the major mode of adaptation in the animal kingdom. The sudden withdrawal of hand from a pin prick and other examples of this kind are definitely self protective. The knee jerk reflex is important in maintaining balance and posture. If a standing person begin to lose his balance, proprioreceptors in the tendons and muscles of the leg initiate nerve impulses which travel through the reflex arc and produce as response corrective muscular contraction in the leg.

4. Instinct-

- Instincts are complex behaviour pattern and of values in adapting the animal to its environment. Social behaviour of insects, nest building behaviour in birds, weaving of net in spider, migratory behaviour antt parental care in various animals are examples of instinct behaviour.
- A male moth (adult silkworm) emerges from its cocoon and at once flies towards the source of odour (pheromones) produced by a female of its own species to copulate is the case of instinctive behaviour.)
- The idea of instinct as a prime mover was taken up by psychologists such as Freud (1915) and Medougali (1908). Lorenz (1950) maintain that much of animal behaviour was made up of a number of fixed action pattern or instinct.
- Tinbergen (1951) proposed that instinct centres were arranged in hierarchy so that energy responsible for one type of activity like reproduction would drive a number of subordinate activities, such as nest building. courtship and parental care behaviour in bird. Lorenz and Tinbergen stated that instincts differ from reflexes in their degree of complexity.
- There are three criteria of instinctive behaviour.

  (i) it is unlearned,

  (ii) it is adaptive and

  (iii) it is characteristic of the species.
- It is, however, difficult to apply all these criteria, specially in the case of higher animals, since we can't be always sure that learning has not contributed to a behaviour pattern. For example the chaffinch (a

sparrow like bird) when reared in isolation, sings a much simpler song in comparison to those reared with adult birds of their own species.

- Sometimes a complex instinctive behaviour appears when members of two different species of animals of same genus were mated and offspring were obtained. The African peach faced love bird carries nesting materials to the nesting site by tucking them by its feathers.

The closely related fischer's love birds uses its beak to transport nesting materials. When these two species are mated, their offspring, first of all try to tuck the nest building materials in their feathers but fail, and then they successfully transport the nest building materials in the beak only.

- The carrying out of instincts often depend on the conditions of the internal environment of the organism. In higher animals courtship and mating behaviour will not occur unless sex-hormones are present in the blood stream of concerned animal. If hormone quantity is high a minimal stimulation can elicit a complete pattern of sexual behaviour.
- It is a notable thing that stimuli serve only to trigger instinctive behaviour. It do not guide the animal throughout the behaviour pattern.
- The greylag goose tries to retrieve an egg that has rolled outside its nest by pushing it through its beak. She may continue the pushing act even when the egg has reached below the abdomen.
- The reproductive behaviour of *'three-spined stickleback`* fish com- poses of migratory, territorial fighting, nesting, mating, parental care etc. Above mentioned, all components of reproductive behaviour come under instinctive acts.
- Migration is set off by increased gonadal hormones during the breeding season and directed by temperature. The fishes move to warm, shallow, fresh water during breeding season.

- Birds also migrate from one place to another due to gonadal hormones. Selection of a territory by a male stickle- back is made in response to the sight of green vegetation.
- A nest is built by male stickle-back with the help of mouth, picking small stones. The terri- tory is defended by the same male. The females are attracted by the increased redness of the males belly and by its peculiar zig-zag dance.
- Mating takes place when the female enters the nest and eggs are fertilized by males. Besides selection of territory and nest building, males also perform the duty of parental care by fanning the eggs, placed in the nest, with the help of their fins.
- Thus instinct is a complex interaction of both internal (endogenous) and external (exogenous) factors. The external factors may be physical aspects of external environment such as colour, light, temperature, vegetation, nesting materials etc. These signals which trigger instinctive ácts are called as sign stimuli or releaser (Russel 1943). Few interesting cases of sign stimuli or releaser influencing instincts are as follows:

(A) During the breeding season the female three-spined stickle-back fish (Gasterosteus aculeatus) normally follows the red bellied male to the nest and lay her eggs there. She will, however, follow almost any small red object presented to her. Once within the nest, the presence of neither male nor red object is necessary any long. By touching the female fish near the base of the tail will even cause her to liberate eggs. It is due to the fact that stickle-back were tuned internally for each item of behaviour and needed only one specific signal to exhibit the sexual behaviour pattern.

(B) Tinbergen (1951) has shown a classic work on the sign stimuli or relcaser to which a male stickleback responds during its reproductive cycle. Models were used in tests of aggression in male stickieback. Four crude models of different shapes and sizes of stickle-back with red belly were placed before a real male stickle-back. All models causes attack by real male stickleback. An accurate model of stickle-back lacking red belly did not evoke aggressiveness. Even a simple object having red colour causes aggressiveness in real male stickle-back.

(C) There are examples of auditory and chernical sign stimuli also. Turkey hens breeding for the first time will accept any object, as chick, which makes the typical cheeping call. They ignore visual stimuli. If the ear of mother turkey hen is destroyed, the deaf turkey hen kill most of her chickes as she never receive the auditory sign stimulus neccessary for her to exhibit parental care.

- Tinbergen (1951) has also studied the case of super normal stimulation (releaser) in herring gull by supra normal model. The nestings of herring gull beg for food even when presented with models of gull heads. The lower beak of real herring gull consists of a clear yellow spot with a red circular patch. The artificial model having a red circle and three white bars on lower mandibule attracts the herring gull chicks maximum for begging the food, more than does a realistic model or even a real perent.
- Another example of super normal stimulation has been studied in a fish Rhodeus. The eggs of Rhodeus (bitterling) are deposited in the Mantle of fresh water mussel by the female. The oviduct of female Rhodeus is drawn out in the form of long tube acting as an ovipositor. The male Rhodeus become sexually excited not by the presence of female of his own species but by the sight of the shells of mussel in which the eggs have been

deposited. According to Prof. Canningham it is most interesting case of model which had a red spot on beak.

SAQ-1

- Behavior can be categorized into two types ……………… and …………………..
- Reflexes are of two types,………………… and …………………….
- ………………………are slow, long lasting adjustment that maintain muscular tone, posture and equilibrium.
- The ……………………are rapid, short lived adjustment such as that seen in sudden withdrawal of hand from a prick of pin.

5. Motivation:

- Motives are internal stimuli such as hunger, thirst, urge of sex etc. It is of common observation that the same stimulus given to the same animal at different time does not always evoke same response.
- Some- thing inside the animal must have changed in different times. Thus we can say that motives are internal stimuli and may be either psychological or physiological or both. According to this approach many patterns of instinct behaviour can be interpreted in terms of drive towards a goal.
- A specific motivation is called a drive. A dog deprived of food (goal) will show high feeding drive. The dog move about restlessly and is highly responsive to the smell and sight of the food. A thirsty animal will search for water and a sexually aroused animal will search for a mate. So motivation is drive that leads to goal directed satiation. The attainment of goal result in reduction of the drive and this phase is known as satiation.

- The neurophysiological aspect of motivated behaviour has been investigated by many workers on mammals. In mammals it has been found that excitatory mechanism are present in the hypothalamus contributing to the arousal of motivated behaviour. Similarly there are inhibitory mechanism which contribute to the satiation of motivated behaviour.
- The action of both these mechanism is believed to be controlled by relevant sensory stimulation, changes in internal environment and influences from cerebral cortex.
- Motivated behaviour is also regulated to a great extent by learning specially in higher primate and man.
- The interesting case of motivation was reported due to same abnormal growth (tumor) in kidney. A three year old english child had extreme drive for salt. He used to eat salt from his early age of six months. He used to lick salt put on pork or biscuits. When he became 18 months old he learnt to speak word 'salt' first of all. He started using spoon to take salt from the salt pot. Later on it was revealed that the boy was alive due to his extraordinary feeding drive for salt. When he was kept on limited quantity of salt, he died within seven days. Post-mortem report revealed that there was a tumor in the adrenal gland of the boy. Due to tumor there was lack of hormones. Lack of hormones caused the kidney non-functional for salt absorption. The salt content was maintained due to extreme drive for salt. The loss of salt through kidney was maintained by excess intake of salt. This also indicate the role of physiology in motivation.
- Ethologists are often interested in measuring the strength of different kinds of motivation. The method used to measure the motivation depends both on the type of motivation and animal. We may try to measure the persistence of appetitive behaviour, or the frequency with

which a consumatory act is performed. It is usually not possible to measure directly the internal state of an animal and we have to remain contented with measuring a response of some kind.

- The result of the interaction between stimulus and some mechanism which controls the performance of the response and whose properties will vary with the internal state.

- Feeding is best to use for measures of motivation. All animals require food at regular intervals and it is easy to control their motivation by depriving them of food for varying length of time. The following list gives a few of the possible measures of the feeding tendency. All of them could equally well be used to measure thirst drive-

  (1) amount of food taken,

  (2) how bitter food can be made before it is refused

  (3) strength of pull towards food,

  (4) level of electric shock accepted,

  (5) rate of bar-pressing for a food reward.

- Ethologists have also measured the strength of sexual urge, parental care aggressive motivation etc. Three Netherlanders Von Jersel, Sevenster and Sevenster-Bol have made an extensive study of reproductive behaviour of three spined stickle-back fish. They have developed a series of measures which have proved useful for analysing the interactions between sexual, aggressive and parental-care tendencies in male fish.

II. Learned behaviour –

- Learned behaviour is acquired behaviour of In the animal which it attains during its life time. According to Thorpe learned behaviour can be defined as "That process which manifests itself by adaptive changes in individual behaviour as a result of experience." This behaviour is the process through which individual attains experiences and leave their mark which permits that individual to develop new adaptations in the light of past experiences. There is a wide variation in the ability of different animals to learn.

- A lion cub born quite helpless is sheltered and fed by its mother until it can move about. It gains agility in playing with its mates. It has constant opportunity to watch and copy its parents and other members of the group. It may hunt its first small live prey when six months old. But within two years it can hunt large animals such as deer, buffalow etc. Its behaviour, and particularly the method and art of hunting may change according to circumstances throughout its life. A tamed lion may not be able to hunt large animals.

Classification of learned behaviour: There are various kinds of learnning which may be described as follows:

(1) Habituation,

(2) Imprinting.

(3) Conditional reflex,

(4) Trial and error,

(5) Latent learning,

(6) Insight learning.

(7) Reasoning.

(1) Habituation: Habituation may be considered as the simplest form of learning. Habituation represents the reduction of responsiveness which are of no use or harm to the life of the animal. It is an important process for adjusting animal's behaviour to its environment. Habituation involves not the acquisition of new responses but the loss of old ones also. In this case when an animal is repeatedly given a stimulus, its natural response gradually decreases and it may disappear entirely. This can be understood with the help of following examples

A snail moving across a sheet of glass retracts into its shell when the glass is tapped. After a short pause it emerges and continues crawling. A second tap also causes retraction but very soon it emerges more quickly. Tapping is continued for many times and it is observed that the snail's response deceases gradually and finally ceases

Clark studied the reduction of responsiveness i.c. habituation in nereis. He got the nereis - (a marine annelid living in burrow in sea-shore), to live in a glass tube in shallow basins of water. He found that jarring the basin (mechanical shock) causes rapid retraction of the head and anterior seg- ments of the worm into the tube. They emerge again within a minute. The stimuli (jarring of basin) were repeated frequently. It was observed that the proportion of worms response fell down and finally - vanished.)

(2) Imprinting: Form of learning in the early period of life is called imprinting. Sometimes particular early experience is retained throughout life. It is concerned with behaviour elicited by particular visual, auditory, olfactory or tactile stimuli. It was Lorenz who introduced this topic by experiments with geese. He found that broods of geese follow the object it looks or hears just after hatching. It will do so, completely ignoring anything else. Lorenz kept the mother geese away from hatching broods of gosling (young geese) and kept himself standing there. He got broods of gosling to follow him even if it sees its mother along the way. Heinworth has also found the same result with chick. A good work on imprinting has been carried out using those birds which have precocial young.

Imprinting like phenomenon is clearly involved in the social development of mammals. It is of common knowledge that the younger we adopt and rear a litter of mammals the easier is to tame them. Orphan lambs reared by humans follow them about and often show little attraction towards other sheep, though sheep's general tendency is to live in group. Imprinting may have long term consequences, particularly upon the sexual behaviour of animals. Zoo authorities have noticed the fact that hand reared animals are often useless for breeding when they mature. The breeding behaviour of mammals is very much dominated by their sonse of smell, and it is perhaps not surprising to find that their early olfactory experiences about pheromones often affect their choice of a mate. The development of social responses in man also depend on early experiences. Bowlby (1969 and 72) has developed a theory of the attachment of a baby to its mother which draws extensively from the animal experiment. He suggested that the period from 18 months to 3 years was specially sensitive and that separation from or lack of an adequate mother at this time led to a greatly increased risk of psychological disturbance in adolescence and later life.

(3) Conditioned reflex: Reflex action shown under some condition is called conditioned reflex. Ivan Pavlov (1849-1936) a Russian physiologist, was really one of the founder of experimental psychology. Our under- standing of the mechanism of conditioned reflex is based on the Pavlov's classical experiment on dog, demonstrating conditioned reflex.

- Pavlov placed a hungry dog on a stand, restrained by a harness and every precaution was taken to exclude disturbances. In this condition a controlled stimuli meat powder was puffed into dog's mouth through a tube.

- This caused the secretion of a certain amount of saliva. He arranged a long narrow pipe from the salivary duct through the check of the dog so that the drops of saliva could be measured. He blew meat power into the dogs mouth and recorded the amount of saliva. This process was repeated several times. Now Pavlov rang a bell every time he puffed meat powder into the dog's mouth. This process was also repeated many times. After many pairing of the sound of bell with meat powder, the dogs salivate upon hearing the sound of bell alone. Eventually the amount of saliva produced to the sound of bell alone was the same as that which was given to the meat power.
- The dog had learnt to respond to a new stimulus which was previously neutral. Pavlov called the salivation response to the bell a conditioned reflex (CR), the bell a conditioned stimulus (CS). Prior to learning, the meat powder was unconditioned stimulus (UCS) and salivation unconditioned reflex (UCR).Thus classical conditioning is said to be "learning that takes place when a conditional stimulus (CS) is paired with an unconditioned stimulus (UCS)".
- Pavlov found that when CS and UCS were repeatedly paired, the strength of the CR increased steadily. But when CS alone is repeated, the strength of CR decreases, steadily. This was called extinction by Pavlov. The conditioned is formed by the association of a new stimulus with a reward (Meat powder) and this is called 'Positive reinforcement'. A "CR" for withdrawal can also formed by associating the C.S. with a punishment or 'negative reinforcement'. An electric shock to the foot causes a dog to lift its paw; if a sound of bell is paired with the electric shock, the dog soon raises its paw to the sound of bell alone.

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Thus classical conditioning is said to be **"learning that takes place when a conditional stimulus (CS) is paired with an unconditioned stimulus (UCS)".**

- Conditioned reflexes have been observed in many different animals from **arthropods** to **chimpanzees**. Birds learn to avoid the black and orange caterpillars of the cinnibar moth after one or two trials which reveal their evil taste. In nature we rarely observe a conditioned reflex in a 'pure' form as in the laboratory. Bees do not just learn to associate a colour with the nectar reward, they also learn the position of the group of flowers with respect to their hive. They learn even at what time of day the nectar secretion in highest.

SAQ-2

- ……………..are internal stimuli such as hunger, thirst, urge of sex etc.
- ………………………… is acquired behaviour.
- Various kinds of learning …………….., ………………… and ………………..

(4) Trial and error learning: Animal learns many things by trial and error. Learning begins when animal associates certain movements with favourable or unfavourable results. Thus, experimentally, trial and error learning involves either 'reward' or 'punishment' or both.

Trial and error by Maze-Trial and error learning can be studied with any animal that is capable of learning by maze. Basically, a maze is a route with one or more choices of turns learning to a goal that is favourable or unfavourable to the animal. The simplest maze is shown in called T maze. A rat was kept in the T maze. With a T maze we expect that by chance 50% of the turns. will be to the right and 50% to the left. If, after several trials, the rat turns to the right (where food is placed) 90% of the time and to the left (no reward) only 10% of the time, it is easy to counclude that learning has occurred in rat by trial error method. In this case the animal is required to make a discrimination of right turn.

Trial and error is the most appropriate category under which young animals perfect the co-ordination of their movements by practice, often during sessions of play with their sibling or parents.

Repetitive reinforcement eventually produces a maximum response beyond which we cannot show that learning has improved in terms of performance on any one trial. However, the longer we go on reinforcing a response beyond this maximum ('over training'), the more resistant it becomes to 'extinction' i.e. the animal will go on responding longer if reinforcement is removed.

(5) Latent learning: According to Thorpe latent learning is "the association of indifferent stimuli or situations without patent reward". By this he means that the actual process may involve associative learning, but there is lack of any obvious reward of drive reduction and the fact that what is learnt may not be obvious at the time, that is, it remains 'latent' or hidden. The learning experience is exhibited when needed by the animal.

(6) Insight learning: The theory of insight learning was given by Kohler and Koffka in the year 1912. It states that the ability to solve complex problems demands something more than trial and error, conditioned reflex, latent learning etc. It required some degree of previous learning to be used in new situation in a flash, insight appears to as one of the highest form of learning. Everyone can recall occasions when the solution to a problem has 'come in a flash'. Insight may be climax to several minutes of concentrated thinking

This ability can be recognised in apes and man as the ability to develop concepts, to act in a quite new situation quite independently. It is obviously difficult to demonstrate conclusively that these are similar processes going on in the animal. Most workers have used the term 'insight' when, for instance, they observe animals solving problems very rapidly. In the year 1917 Kohler performed many experiments on apes specially on a ape named Sultan. His two experiments are very famous (1) stick problem experiment (2) Box problem experiment. In an hungry ape used three boxes one on the other to get the hanging banana without any previous experience of this kind.

(7) Reasoning: The early ethologists do not separate the reasoning with that of insight learning. But modern ethologists separate it and consider it to be highest evolved form of animal behaviour found only in apes and man.

According to Maier and Schneirla (1935) the reasoning may be defined "...... the ability to combine spontaneously two or more separate expe- as "... riences to form a new experience, which is effective for obtaining a desired end." In simple words by reasoning, we mean "the mental process of drawing an inference from two or more than two statements or happenings." Reasoning in often motivated by the need to reach solutions to problems involving an individual's survival. Much is yet to learn about reasoning and symbolic capacity and their neural mechanism in apes and nan. But what we have learned so far shows that there is continuity from less evolved animal to a man, even though man's specialization is great in this field. Mere rudiments of reasoning and symbolic processes are ob- served in animals. But in primates reasoning contribute to behaviour in a way that clearly marks them off the subprimate animals. Both laboratory experiments and the technique of factor analysis give evidence that three different processes may be involved in reasoning.

- Deductive reasoning,
- Inductive reasoning, and
- Evaluating reasoning.

- **Deductive reasoning:** It implies proceeding from general to a particular deduction. According to Mrs. L. S. Stebbing-"when the conclusion is implied by the premises the argument is deductive. For example, all men are mortal, but Ram is a man, therefore he is mortal.

- **Inductive reasoning:** It means general inference from particular instant. According to Mrs. L. S. Stebbing "when the premises do not suffice to imply the conclusion but nevertheless have some weight as evidence in favour of it the argument is said to be inductive. For example- 'a baby monkey was reared with a group of human children. At first the monkey's intelligence developed as fast as the human children. As soon as human children began to talk, they showed more intelligence than baby Monkey.

Baby monkey also failed to gain power of speech. Talk, therefore, is what makes us human. Here the thinker builds from the known to the unknown. From the known, he makes an intuitive leap, formulates a new hypothesis about what future observation may reveal, or suggests several new lines of exploration. This is the essence of creative thinking.

- **Evaluating reasoning:** It is the judging of appropriateness of an idea or work. It involves judging the suitability or goodness of effectiveness of an idea or representation, as distinguished from trying to create or add to it. With the great development of the cortex in the sub-human primates and man, particularly of its association areas and related thalamic nuclei, new capacities for behaviour emerge in evolution that fall under general category of reasoning, abstract ability and symbolic process. When these are developed, the animal can make its adaptation to the environment with insight, reasoning, use of symbols and language besides depending on sensory stimuli, reflexes, instinct and other behaviours.

2.3 Role of nervous System

- The nervous system is the body's communication network, allowing animals to sense and respond to changes in their environment, coordinate movements and regulate physiological processes.
- The nervous system consists of two main components: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is composed of the brain and spinal cord, while the PNS includes all the nerves that connect the CNS to the rest of the body.
- The CNS is responsible for processing and integrating sensory information from the environment and generating appropriate responses. This process begins with the sensory organs,

which detect environmental stimuli such as light, sound, and odors. These signals are transmitted to the CNS, where they are processed and integrated with other sensory information to generate a behavioral response.

- The brain is the central processing unit of the nervous system and is responsible for many complex behaviors, including learning, memory, decision-making, and social interactions. Different regions of the brain are specialized for different functions, and the activity of these regions can be modulated by various neurotransmitters and hormones.
- White-crowned sparrows sing because they have a song control system, a set of interconnected neural modules embedded in their brains . In fact, every aspect of the behavior of a white-crowned sparrow, or any other animal with a nervous system, depends upon the operation of its neurons.
- Some neurons acquire information from the animal's environment, others process messages from these sensory cells, and still others send out commands telling the body to do something in response to these inputs.. As multicellular animals develop, they acquire a nervous system, the properties of which are crucially important to the proximate control of behavior.
- In vertebrates, the nervous system consists of the central nervous system (the brain and spinal cord) and the peripheral nervous system (nerves). Because nervous systems represent one way in which information from the environment is translated into behavior, biologists have been eager to learn how these systems work.
- Although our current understanding of nervous systems has been greatly helped by the application of sophisticated

technologies, even simple observations of animals in action can sometimes provide considerable information about the proximate properties of their neural mechanisms.

2.4 Hormones and Behavior

- Hormones play a critical role in the mechanism of behavior in animals.
- Hormones are chemical messengers that are produced by various glands and travel through the bloodstream to different parts of the body, where they can have a wide range of effects on physiology and behavior.
- Hormones can influence behavior in a variety of ways. For example, they can affect an animal's motivation to engage in certain behaviors, regulate the timing of seasonal behaviors such as reproduction or migration, and modulate social behavior.
- One well-known example of hormones affecting behavior is in the reproductive behavior of many animals. In males, the hormone testosterone is involved in regulating sexual behavior and aggression. In females, hormones such as estrogen and progesterone are involved in regulating the menstrual cycle and preparing the body for pregnancy.
- Hormones can also play a role in the development of behavior. For example, exposure to certain hormones during early development can shape the neural circuits underlying social behavior in birds and mammals.
- Another way that hormones can affect behavior is through their interaction with the nervous system. Hormones can modulate the activity of neurons in various regions of the brain,

affecting an animal's perception of the environment and its ability to respond to stimuli.

- The ability to measure hormone levels in blood or other tissues has greatly increased the power of behavioral biologists to study the mechanistic bases of a variety of behaviors in the field or lab.

Glucocorticoids and Response to Environmental Change

- Discussion of hormones has primarily focused on the social environment and how steroid hormones such as **testosterone, estradiol, and progesterone** (often referred to as "**reproductive hormones**") influence reproduction and aggression.
- Hormones such as these are among the primary ways in which information from the environment leads to rapid behavioral change.
- In other words, hormones are modulators that both cause changes in behavior and themselves change in response to different behaviors. We saw an example of this bidirectional nature of the hormone–behavior relationship in the context of reproductive behavior, in which as predicted by the challenge hypothesis, testosterone increases during the time of year when male–male aggressive interactions can be anticipated but also when interactions between males can lead to a rapid rise in testosterone in the blood.
- In other words, testosterone can cause behavior appropriate for a social environment, and in turn, the social environment can generate increased hormone production, providing strong evidence for the bidirectional relationship between steroid hormones and the social environment.

- Hormones are not only influenced by social factors—they can also be affected by ecological factors such as food availability, severe weather, and even the presence of predators. Glucocorticoids are another class of steroid hormone that can be influenced by both social and ecological factors. Although glucocorticoids are often referred to as **"stress hormones,"** because they can be released in response to a variety of stressors, they also **play an essential role in metabolism, immune function, and various other physiological processes**.
- If anything, they should really be referred to as "anti-stress" hormones because they enable animals to respond rapidly to stressors by adjusting their behavior and physiology.
- Although there are several chemicals involved in this flight response (hormones such as adrenaline and neurotransmitters such as norepinephrine), glucocorticoids play a central and rapid role, acting on the scale of seconds to minutes.
- T glucocorticoids can be adaptive in the short-term by allowing animals to respond to environmental stressors, but maladaptive in the long-term if individuals are continually exposed to chronic stress. Although ecological factors can greatly influence circulating levels of glucocorticoids, it is also true that social factors can affect them. For example, high population density or frequent territorial intrusions are associated with elevated glucocorticoids in several vertebrate species, ranging from mammals to birds to fish and reptiles (Creel et al. 2012).
- Chronically elevated glucocorticoid levels in high-density populations may negatively affect immune function and survival, particularly in the very young or very old individuals, or those in poor body condition.

- For species that are highly social and live not just in dense populations but in groups, there is often a relationship between dominance rank and glucocorticoid levels. However, the direction of this relationship depends on the stability of the social hierarchy and the way in which high rank is obtained and maintained. That is, in species where dominant individuals can easily maintain their status without having to fight with subordinates, then dominants typically have lower levels of glucocorticoids than subordinates. However, when dominants must continually fight with subordinates to maintain their status, then the dominants often have higher levels of stress hormones (Goymann and Wingfield 2004).

SAQ-3

- The nervous system consists of two main components: …………………………… and …………………………..
- The CNS is composed of the………………..and ……………
- ……………includes all the nerves that connect the CNS to the rest of the body.

- …………….are chemical messengers that are produced by various glands and travel through the bloodstream to different parts of the body
- ……………..are chemical signals that animals release into their environment to communicate with other members of their species.

2.5 Pheromones

Pheromones are chemical signals that animals release into their environment to communicate with other members of their species. These chemicals can convey information about a variety of things, including sex, social status, territory, and alarm signals. Pheromones can be detected by other animals through specialized sensory structures, such as the vomeronasal organ in many mammals.

The mechanism of animal behavior involving pheromones can be divided into four stages:

Production: Pheromones are produced by specialized glands in the animal's body.

Perception: Other animals detect the pheromones through specialized sensory structures, such as the vomeronasal organ in many mammals.

Processing: The animal's brain processes the pheromone signal and generates a behavioral response.

Behavioral response: The animal exhibits a specific behavior in response to the pheromone signal.

Examples of animal behavior involving pheromones include:

Mate attraction: Many animals use pheromones to attract mates. For example, female moths release a pheromone that attracts male moths from a distance, allowing them to find a mate.

Territory marking: Many animals use pheromones to mark their territory and communicate with other members of their species. For example, dogs and cats mark their territory with urine, which contains pheromones that signal ownership and deter other animals from entering.

Alarm signaling: Some animals use pheromones to signal danger or alarm to other members of their species. For example, ants release pheromones when they detect a threat, which signals other ants to defend the colony.

Aggression: Some animals use pheromones to signal aggression or dominance. For example, male mice release pheromones that signal dominance to other males, allowing them to establish a hierarchy within a group.

Pheromones Functions

Pheromones are chemical signals released into the environment to elicit various different behavioral responses in members of the same species. Pheromones are secreted outside body and capable to act-like hormones to affect the behaviour of the individual which receives it. The functions of pheromones include:

- Triggering sexual arousal
- Creating food trails
- Alerting other individuals about a danger (predators, intruders, disease, etc)
- Marking territory (keep out invaders)
- Warding off other members of the same species
- Recognition between mother and offspring

2.6 Genetics in Behavior

Genetics plays an important role in behavior, as many behavioral traits have a heritable component. This means that the genes an individual inherits from their parents can influence their behavior and personality.

There are a variety of ways in which genetics can impact behavior, including:

Personality traits: Many personality traits, such as extroversion, conscientiousness, and agreeableness, have a heritable component. This means that an individual's genes can influence their tendencies towards these traits.

Mental health disorders: Many mental health disorders, such as depression, anxiety, and schizophrenia, have a genetic component. This means that an individual may be more likely to develop these disorders if they have certain genes.

Cognitive abilities: Genes can also influence an individual's cognitive abilities, such as their intelligence, memory, and attention span.

Risk-taking behavior: Certain genes may influence an individual's tendency towards risk-taking behavior, such as substance abuse or dangerous activities.

Aggression and impulsivity: Genes may influence an individual's tendencies towards aggression and impulsivity.

It is important to note that genetics is not just one factor that can influence behavior but it interacts with a range of environmental and social factors to shape an individual's behavior and personality. Additionally, the relationship between genetics and behavior is complex and still working to fully understand the mechanisms underlying this relationship**.**

Communication and Stimulus Conduction

Ethologists have observed that communication behaviour occurs in regular patterns, nearly unchanged from event to event. These sequences are called fixed action patterns. The most striking patterns are the stereotyped sequences that occur in the animals interacting with conspecifics for courtship, territory defence or dominance encounters. The primary function of behaviour is to signal. The signals are coded to convey information in the following ways-

1. Coded and Graded Signals

Some signals are discrete and others are graded. The alarm calls of many species are relatively constant and are a means of communication among different species. The signals are of such frequency and duration that the predators fail to pin-point them.

Graded signals may vary in intensity. The waggle dance of the honey bee illusrates both the complexity and graded properties of the signals. The number of turns per minute is inversely proportional to the distance from the food source. The duration and liveliness of the dance increase with the quality of food) Signals that might at first seem discrete, often turn out to be graded. The bursts of light emitted by fireflies seem to be discrete and species-specific, but under conditions they vary in intensity and duration.

2. Distance and Duration

The distance travelled by various signals varies. In some cases, the detection threshold of a receiver is no more than several molecules of a substance, as with sex attractants of several insects. Thus a small amount of material emitted out by a female can be detected by a male several kilometres downwind. Visual displays usually operate over much shorter distances.

The signals also vary in their duration. Alarm signals such as chemicals produced by many invertebrates may have a localized, short term effect with a rapid fade-out time, but the signals such as male secondary sexual characters in polygamous species can last for a long period of time. Information about reproductive status like the antlers of male deer or the bright red perineal region of female rhesus monkeys in estrus is communicated during the breading season.

In contrast, the brightly coloured epaulets or the red-winged blackbird, although present during the entire breading season, are conspicuous only when the male exposes and erects these feathers. /

3. Composite Signals

When two or more signals are combined, these form a composite signal with a new meaning, **example -** Zebras communicate hostile behaviour be flattening their ears and friendliness by raising their ears. The mouth-opening pattern is the same for both hostile and friendly behaviour. Animals are able to convey additional information by changing the sequence of displays. **IInd example** is the two composite signals A and B would have different meanings depending on whether A or B came first. The same signals may have different meanings depending on the context, Le., what other stimuli are impinging on the receiver.

Next example is the lion's roar can function as a spacing device for neighbouring brides, as an aggressive display in fights between males, or as a means of maintaining contact among bride members. The ruff out display of the male cowbird serves in courtship as well as in conflict with other males.

4. Metacommunication

It is communication about communication. One display changes the meaning of the display that follows.

Examples-Play behaviour among animals provides good examples of metacommunication. Animals use aggressive, sexual and other displays in play. Such behaviour is preceded by an act that communicates the message that what follows is play, join in.

Dogs and wolves precede play with a play bow. Monkeys communicate play behaviour through a relaxed, open-mouthed face.

5. Information and Manipulation

When potential mates meet, it is advantageous to both of them that they communicate with each other about the species to which they belong, because if they are not members of the same species, both of them will waste their breeding effort. As a matter of fact, animals will produce signals when these are to their advantage, regardless of whether others benefit from receiving them. Prey animals send signals to predators when they gain by doing so and the gain they make is usually at the preuator's expense.

Likewise, within a species, the signal transmitted by one animal may not necessarily be useful to the other who receives it. There are examples where the animals manipulate pach other rather sharing the information.

Example-Most males of bluegill sunfish do not mature until they are seven or eight years old. On attaining maturity, they set up territories to attract females for mating. The females are smaller and look quite different. Sometimes two ofthem may spawn simultaneously with the male. The sperm and eggs are shed into the water as they swim around together together in the male's territory. But, about 20 percent males mature when only 2-3 years old and much smaller then the normal ones. These look like females and join in the mating. The territorial male is deceived as he fails to distinguish such smaller males from the spawning females

Deception is possible in this case as there is no cue that the signal receiver can use to discriminate between the male and female fish.

There are cases where deceit is not possible as there are ways in which other animals can see through it. Some animals appear to be larger than they really are. This is aggressive display for the larger an animal appear to be the more a rival is likely to be intimidated into retreat.

Examples-Siamese fighting fish extend all their fins as far as possible when swimming alongside an opponent and raise their gill covers when facing one. This makes them as large and striking as they can be.

The male toads cling onto mature females in amplexus posture to ensure the fertilization of eggs as they emerge. Males often fight to take up this position and the male in amplexus kicks and croaks to repel others. Larger males usually win in such encounters. Being larger, they are also able to produce deeper sounds. The toads use the calls to assess the size of others and may not like to fight with those whose calls are deeper.

Thus communication involves the transmission of information in the form of signal from one individual to another. The production of signal is in the benefit of the animal that produces it. Sometimes the deception is possible and the animal may gain from it. But this is not always possible if the animal receiving the signal detects that the signal is misleading.

Messages and their Meaning

The act of communication can be viewed from two vantage points-that of the sender and that of a recipient. Smith (1977) has made the distinction between message and meaning. The message is what the signal encodes about the sender and describes the state of that individual. It may indicate that-

(a) It is an adult male in breeding condition or

(b) It has just seen a predator.

The meaning is what the recipient makes of the message. This can be inferred from the response that the recipient shows. It can differ greatly from one recipient to another and is quite distinct from the message. The meaning can also vary according to context so that the same signal may elicit different responses in different circumstances. Thus a small range of signals may come to elicit many different responses, the one shown depending on the nature of the individual perceiving the signal and on its experience.

Examples-The distinction between message and meaning can best be explained by the following examples-

1. Consider a male bird singing at the top of a tree: In many bird species, only males sing. They only do so during the breeding season. This is so because they require testosterone to be circulating in their blood andthey sing much more when they are unmated. The message in a particular species song will vary according to the listener-

- To a predator it may mean 'Approach stealthily and attempt to catch.
- To a songbird of another species it may simply mean ignore.
- To a male of the same species it may mean 'keep out. This territory is already occupied.
- To an unmated female it may mean 'Approach and attempt pair formation.

When an animal communicates, the message is encoded in a signal. Signals are often stereotyped, though they may form graded series so that slight nuances can be transmitted. Whatever be the case, the message in some way defines the probability of what the signaller is doing or may do. It is not easy to define the state as the signal may appear in different contexts and animal signals are often more closely linked to states of motivation or emotion than to situations which are easily put into words.

A well known exception is the alarm calling of vervet monkeys. These monkeys produce different alarm calls when predators are spotted. The messages are quite simple: 'I have seen a snake', I have seen a leopard', I have seen an eagle. Their meanings are also appropriate. Other monkeys respond to the snake call by looking downwards or approaching and examining the snake. To the eagle call they respond by looking up and seeking cover in the undergrowth and the leopard call leads them to climb hurriedly into the trees.

To understand a message, it is essential to study the situation in which an animal produces a signal and how does the recipient responds to the signal. The response varies from one animal to other. In the case of a contact call, other members of the flock may approach so that the group keeps together, animals of other flocks may keep a distance, predators may be attracted and animals of other species are likely to ignore it. The critical factor for a signal to be produced is that the advantages must outweigh the disadvantages.

Forms of Signals

Definition

The message is what an animal encodes in a signal it sends; the meaning is what another makes of it. The signal is the physical form in which transmission from one animal to other takes place. Just as the word 'dog' has neither four legs nor a bark, so the signal is not related in a very clear way to the message that it conveys. But, certain types of signals are better adapted to certain functions.

Most animal communication uses sights, sounds and smells. In close contact the senses of touch and taste may also come into play. Certain fishes use electric signals.

1. Vision

Among vertebrates and many invertebrates, vision or the response to light is the most important sense in determining behaviour. Vision helps moving organisms to avoid obstacles and to orient themselves-

A. In Invertebrates

1. Phototaxis is used in selecting a favourable environment. Newly hatched fly larvae are positively phototaxic, which aids in their dispersal from the hatching area, but as they mature they become negatively phototaxic. This helps in protecting them from predators.

2. Light is important for the orientation of the body among many animals. Fish have otoliths in their inner cars for gravity perception and crusta- ceans have statocysts serving the same function. Shrimps and many species of fishes characteristically orient with their dorsal sides toward the light. This is known as dorsal light reaction. If the light is moved so as to shine from the side of the aquarium, the fish tips over to an angle of approximately 45º because its body position is a function of both light and gravity responses.

B. Among Vertebrates

Vision represents a direct response to a stimulus. Many predatory fish automatically strike at any moving object of appropriate size. If an insect is motionless, a frog will not strike. In fact, the frog cannot even see it because it has been found that certain nerve fibres leaving the frog's eye do not carry impulses unless they are stimulated by a moving object.

The nature of responsiveness to light differs among various animals. For example, insects are able to respond to the ultraviolet spectrum, but cannot see red. The structure of the eye varics among different organisms. The insect eye is a compound eye consisting consisting of small units each of which is a small eye in itself. The image formed is quite complex, with one of the units receiving a complete image of the object on which the eye is focussed. The human eye is probably the most superior of the vertebrate eyes in reproducing the image. Some lower organisms have light sensitive structures, but no image-forming structures are present. These organisms can only detect light and dark.

Visual activity enables an animal to see prey or predator at a distance. It helps in establishing social behaviour by enabling recognition within the group.

Vision is important in the behaviour of those animals whose activities are confined to the daylight hours. Many nocturnal animals such as owls and cats, hunt at night and use vision. Their eyes are adapted for night vision in a number of ways. For example, there are reflecting layers which serve to amplify the of light by by sending it back across the retina. There are also more light low level of sensitive rods per ganglion which serve to multiply the low light levels.

In man, the highly developed ability to focus his eyes represents an adaptation correlated with the development of hand. The movements of the hand in manipulating objects can only be accomplished through the use of eyes.

The use of vision and the various types of visual sense organs represent an adaptation towards more complex behaviour patterns. These behaviour patterns enable the organism to occupy its particular ecological niche with greater SUCCESA

2. Sound and Behaviour or Audition

Physical changes in air, water and soil generate vibrations called sound which, if great enough, can be detected at some distance from the point of origin. Organisms have developed various means of perceiving these vibrations and use them to determine the nature of the environment to avoid danger, to locate food, and to communicate with other members of the population and community. There are two basic machanisms of perceiving sound vibrations. It registers the actual movement of the air molecules causing the sound, while the other registers changes in pressure

The structure of hearing receptors is either membranous or made up of hair-like cells. The location of the sound receptors in the various organisms differs. In insects, they may be located on hairs of the antennae or in a membrane on the leg, In fish, the labyrinth of the internal ear, the lateral line receptors, and the swim bladder act as sound receptors. In other vertebrates, the sound receptors are located on the head

Many animals can hear as well as emit sounds not audible to humans. Bats emsit sounds of extremely high frequency. These sounds bounce off obstacles which are then perceived by the bat. Predatory insects locate prey in the bark of trees through sound and owis locate mice at night mostly through sound. A large number of animals emit sound. The most widespread function of sound is social communication.

Sound Producing Organs

1. Insects usually produce sound by rubbing two parts of the body together

2. Crickets and grasshoppers rub their legs or wings against a specialized structure. Some fish generate sound by using the air bladder as a drum or by passing gas from one part of the bladder to the other.

3. Vertebrates produce sounds by a specialized structure in the throat (syrinx).

The production of sounds by certain species may occur only when evoked by some external stimulūs such as a predator or competitor. Among some species sound may be confined to the reproductive seasons, while in birds sound changes during the reproductive season.

Sound responses represent an adaptation that enables organisms to survive better. It informs them of an unseen danger, the location of food, or the presence of a mate.

3. Olfaction

At first sight the production of olfactory signals or pheromones seem to have very few advantages. Smells diffuse only slowly through the environment, their speed and direction being highly wind dependent. Further, they can carry very little information, for after one smell is released time must elapse for it to disperse before another signal can be employed.

Pheromones are ideal under certain situations. These can transmit information in the dark, can travel around solid objects, can last for hours or days and have a long fade out time. Much work has been done on insect pheromones. For example, the sex attractant bombykol, produced by the female silk-moth has been isolated. A single molecule of this pheromone triggers a nerve impulse in a receptor cell in the malc's antenna. About 200 receptor cell firings in one second lead to a behavioural response. The male responds by flying upwind, equalizing the pheromone concentration on both the antennac, until the reaches he female With the commercial synthesis of insect sex attractants, traps baited with pheromone to lure males are used to control such pests as the gypsy moth in United States,

Since pheromones have a long fade-out time, they can continue to signal even when the animal is not there. Many mammals have different scent glands which are used for various purposes. Territorial animals mark the boundaries of their range as a signal to others that the arca is occupied. They may do this with special glands, or with scents in their urine or facces and a number of information may be contained in such signals. The intruder may glean not only where the territorial boundary is, but which individual is occupying it, in what reproductive state he is, but even by sensing how fresh the mark is and how long ago it was that the owner of the territory went by.

Pheromones in the urine of male mouse speed up maturation in young females. Other urinary products inhibit aggression, increase aggression, stimulate the adrenal cortex or block implantation of embryos.

4. Touch

Short-range communication in the form of physical contact is used by many invertebrates, where the antennae are the first to contact other objects and organisms. Cockroaches and bees use their antennae for this purpose.

Perhaps the most widespread use of tactile displays occurs during copulation. In many rodents, stimulation of the posterior end of an estrous female produces concave arching of the back and immobility. In some mammals vaginal stimulation induces ovulation. In most primates grooming is an important social activity and seems to have a function not only in the removal of ectoparasites but also as a social cement in the reaffirmation of social bonds.

5. Electroceptors

Some sharks and electric fish have electroceptors that they use passively and actively in detecting objects and in social communication, Mormyrids have well-developed system of social communication using electric signals. They a produce electric displays in the context of aggression, during courtship, and for promoting aggregation and dispersal. Electric communication is important in sex and species recognition. Mormyrids have three types of electroceptors-

(i) ampullary organs by which fish senses a steady D.C. field given off by a predator or prey organism.

(ii) electrolocation where the fish produces an electric field in the electric organ in its tail, senses the distortions in the field surrounding is body, and thereby feels the presence of distant objects with conductivities different from that of the water.

(ii) Communication, where one fish senses the electric signals of a second, using the electroceptors.

2.8 Summary

- **Innate behaviors** are genetically hardwired and are inherited by an organism from its parents.
- **Learned behaviors** are not inherited but develop during an organism's lifetime as the result of experience and environmental influence
- Reflexes are of two types, tonic and phasic reflexes. The tonic reflexes are slow, long lasting adjustment that maintain muscular tone, posture and equilibrium. The phasic reflexes are rapid, short lived adjustment such as that seen in sudden withdrawal of hand from a prick of pin.
- Nest building behaviour in birds, weaving of net in spider, migratory behaviour antt parental care in various animals are examples of instinct behaviour.
- Motives are internal stimuli such as hunger, thirst, urge of sex etc.
- Learned behaviour is acquired behaviour.
- The nervous system consists of two main components: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is composed of the brain and spinal cord, while the PNS includes all the nerves that connect the CNS to the rest of the body.

- Hormones play a critical role in the mechanism of behavior in animals. Hormones are chemical messengers that are produced by various glands and travel through the bloodstream to different parts of the body

2.9 Terminal Questions

Question-1 Describe in details Innate behaviour.

Question-2 Describe in details Acquire behaviour.

Question-3 Describe in details neurological basis of behaviour.

Question-4 Describe in details evolutionary behaviour.

Question-5 Explain patterns of communication.

Question-6 Write short notes on insight learning .

Question-7 Write short notes on imprinting.

2.10 Answers

SAQ-1

- Innate behavior and learned or acquired behavior
- tonic and phasic reflexes
- The tonic reflexes
- phasic reflexes

SAQ-2

- Motives
- Learned behaviour
- Habituation, Imprinting and Conditional reflex

SAQ-3

- central nervous system (CNS) and the peripheral nervous system (PNS).
- brain and spinal cord
- The PNS
- Hormones
- Pheromones

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Unit-3: SOCIAL BEHAVIOUR

Structure

3.1 Introduction

Objectives

3.2 Flocking in Birds, herding in Animals

3.3 Group Behaviour and Group Selection

- Kin, Reciporcal & Inclusive Fitness

3.4 Socio Organization in insects

3.5 Parental care with reference to fish, amphibians and birds.

3.6 Territorial Behaviour

3.7 Summary

3.8 Terminal Questions

3.9 Answers

3.1 Introduction

Tinbergen (1953) and Dimond (1970) stated that "positive interactions between one individual of a species with the other is called social behaviour".

The oldest and highest grade of society is found among insects in animal kingdom. Societies were formed in insects since last three crores years ago approximately. Evolution of social behaviour has taken place separately in each group of insects. First of all progeny were dependent on parents and later on parents became dependent on progeny. In this way evolution of social behaviour came into existence among insects.

Many insects live in association with each other, but they are not dependent on each other, therefore, they can't be said as social. Many insects spend solitary life but for reproduction they come in contact with other members of the species. In some cases females die after laying eggs and do not get chance to care own offspring. In some (Silk moth; honey bee) males die after copulation.

Some insects are gregarious. They form a dense but temporary population. A different type of insects assembling near source of light during night is good example of gregareous phenomenon. To be gregareous is a temporary phenomenon. It can't be said as social-behaviour.

Social insects: Species of insects which form colonies for the benefit of every member of the colony is called social insects. Members of colony live together and contribute their services for the welfare of the other. This behaviour of insects is known as social behaviour

The phenomenon of parental care is very common in insects, fishes, amphibians, birds and mammals. The protection and care taken by the parents to their eggs and developing offspring at nursing stages is known as parental- care. It is an inborn instinctive behaviour, shown by different groups of animals, which are directly related to their existence. Most fishes leave the eggs in the breeding ground uncared. But there are many fishes which show parental care to their eggs and developing young ones (Fingerlings), involving many interesting behaviour Parental-care to eggs and young is often performed by one or both parents by various methods. Parental-care is an instinctive behaviour in which parents take care of their offspring. Parental-care has solved the survival problem because it helps is preservation of species. Well developed parental-care is found in amphibians.

Amphibia presented by three important groups: Gymnophiona, Urodela and Anura

Objectives

After studying this unit you should be able to know-

- Flocking in Birds, herding in Animals
- Group Behaviour and Group Selection
- Territorial Behaviour , Socio Organization in insects
- Parental care with reference to fish, amphibians and birds.

3.2 Flocking in Birds, herding in Animals

- **FLOCKING IN BIRDS:** Birds have a reputation of flying over a large distance in search of food, better climates etc. Siberian Crane fly from Siberia to India covering thousands of Kilometer to get away from adverse cold weather and to give birth of their young ones.
- This behavior of birds is done by Flocking. Flocking is a behavior where group of animals combined together and started to work as a group. This behavior is quite similar to schooling in fishes where birds forms a group and fly for a large distance displaying remarkable pattern in the sky.

- They flock to evade their predators, food searching and navigation. Birds flying in flocks are able to better manage the wind direction during their flight.
- A social structure is formed and a constant flow of communication happens within the group deciding on various set of resources, wind direction, Levels of Threats etc.
- Some Birds prefers a large size flocks while others prefer a smaller size flocks. Some Birds don't stick with a strict pattern. They just wanted all birds move easily. Robins, Bluebirds etc. are an example of unrestricted patterns.

Rules of flocking behaviour

- Each individual has the ability to sense its mates in a flocking. Each individual can sense the current environment.
- Each individual calculates the current state and come up with the next decision to be taken. Based on the above assumption Reynolds put forward threerules which has been recognized and accepted.
- **Alignment:** Individuals try to match their velocity with their nearest one. The alignment angle is also checked from the velocity of its nearest one.
- **Separation**: Individuals always keep a fixed distance from its nearest one. Whenever the distance becomes less than the threshold value, suddenly they increase their distance.
- **Cohesion:** Cohesion refers to the block structure. Individuals always try to move towards the center of mass of their neighbors.

Each Flocking has the following measure to manage flock namely:

- **Leaders:** Each Flock has a leader. It is the leader or the line leader which guides its line or an entire group. These leaders take the decision about a line or throughout a group. These leaders inform all the individuals under them about alignment, separation etc.
- **Sick Birds:** Each individual has a position in a flock. Some animals got injured during flocking. Then the sick birds will drop from the flock. A new individual take its positions until it recovers or dies.
- **Replacement**: Flock has to undergo a direction change due to any reason then the entire flock is led by a new leader.
- **Fatigue:** When the leaders become tired, then they revert to the flock, new individual birds become leader and take the lead role.
- **Resistance:** Birds feel more resistance when they are out of the Flock. As soon as they feel more resistance, suddenly they realign and put up efforts to come up with the pattern of Flock.

Shapes and benefits of Birds Flocks:

- **Grounloar Shape:** These birds form a flock's pattern which is like moving in circle in their flight.Example: Cheel
- **V Shaped:** Diagram: These birds form a flock pattern which is in the form of V shape in their flight. Example: Flamingo, Crane etc.
- **Disperse:** These are those set of birds which don't form any pattern. They just want to stay close to one another. Example: Pigeon

Benefits of Flocking: Flocking helps the group in searching food, it reduce the chance of falling to a prey. Flocking helps in evolution of new species and helps in mass migration,it also helps to save energy during their flight.

- Herding in Mammals:

A-Herding means a process where individual of the same species is combined into herds (Group). These herds can be of domestic animals like cow, buffalo, sheep, Goat etc. or wild animals like wolf, dogs.

B- Herding has also been thought as the human interference in forming groups for its some benefits. Some animals like wolf, dogs have inherited the herds system of social behavior due to primitive hunting. Others like Deer, Wild beast, Wild Buffalo, Elephants have followed the herds system for their Safety, food and migration.

C- The Herding group have a leader which take all decision for their group like availability of food, water, threats level, threats countering, navigation (migration) etc.

Some common types ana benefits of herding : . Herds increase the chances to deceive their predators, it provide them shelter, food and protection. Herds allow them to grow in a secure environment and allows them to move over distances (migration). It also provide a better security for themselves and their young ones ,male don't have to go for a large distance to find mates.

Types of Herding: Territorial Herding: In Territorial Herding, area is divided into several territories. All male and female of the same species living in area becomes a part of the Herds. Male fights among themselves to get their females. Example: Sheep's

- **Guarding Herding:** In Guarding Herding, a Female controls the entire group. Male generally live a solace or in a group of male. Male can only enter with the permission of female. Group has all Females. Female Leader are responsible for its other members and young ones. Example: Elephants
- **Social Herding:** In social Herding all Female and Male lives under the dominating male and Female Mate called as Alpha Male and

Female. Only Alpha male and female have the right to reproduce and mates. Others Members are responsible for their Herds. Example: Wild Dogs (Lycaon pictus), Meerkat(Suricata suricatta).

Benefits Of herding system

1. Safety of Individual in groups,chances of getting more mates ,help in locating food resources.

Conclusion: Animal exhibits a social behavior where they come together for need of some common resources like food, water, protection, mating etc. This coming together led to the formation of a social group which is known as Aggregation behavior. This is known by different names like Herding in mammals, Flocking in Birds Schooling in Fish. Their objectives are same, but a slight variation has been observed in their aggregation behavior. This Aggregation Behavior is quite species based in Fish where as it has be uniform across bird and mammals. (Sources: Uttarakhand Open University)

3.3 Group Behaviour and Group Selection

- As the young of a species mature, they become less attractive to the parent and new behaviour patterns are established. The parents become more aggressive and provide less and less care.
- The young become members of a group such as packs, herds, or flocks in which different types of interactions take place. The main advantage of forming these groups is their effectiveness in providing a defence against predators. In some species they simply provide social relationships. Among vertebrates, the organisms living in a group are capable of living longer and establish better cating habits then when living solitary.
- It has been found that goldfish secrete substances from their body which condition the water for other goldfish by neutralizing

poisons. The combined effect of a large group of fish is more effective than that of small groups.

- Most relationships in a group depend to a great degree upon the movements of others within the group. When one bird in the flock becomes alarmed, the others also become alarmed.
- Feeding, flying and sleeping are closely coordinated with each individual watching the type of a social cooperation. When a small bird comes upon a predator such as a roosting owl or large hawk, it raises an alarm that attracts other birds in the neighbourhood who then join in driving off the predator.

Role of Stimuli in Family and Group Behaviour

- There are several sign stimuli, These involve such actions as preventing parents from eating their young, protecting the young until they are able to fend for themselves, indicating to the group a source of food and warning the group of danger. The sign stimuli are mostly reciprocal, i.e, while one member evokes a positive deneficial response, the other surpasses a negative harmful response, For example, when the chicks of gulls hatch, a whole new species of parental behaviour patterns emerges, involving such activities as feeding, protecting and guiding the chicks. The shape of the body of the parents evokes a response in the chicks. The chicks in turn peck at a red spot on the bill of the adult herring gull before it gives up food for the young. The feeding behaviour follows a pattern of sign stimuli between the young and adults.
- Certain stimuli are important in maintaining the parent-offspring relationship. When the sequence of stimuli does not follow the established behavioural patterns, the parent-offspring relationship ceases to exist. Among many mammals such as cats, rats and dogs, licking behaviour plays an important role in the care of the young. In the feeding

of birds, the gaping mouth, a persistence of the young begging for food, evokes the feeding response in the parents. Usually, the hungriest bird begs the most and, therefore, is fed first.

- Early imprinting also plays an important role in the establishment of groups. Once the organism has been imprinted with other members of the group, the imprint remains. To establish a group, organisms have effective sign stimuli. Among birds these stimuli are usually visual, such as colour plumage, and spot on the body among fish which aids in indentifying and keeping the schools together. Specific sounds and call notes also help to establish and maintain the group. Social insects recognize members of their colony through characteristic odour.

Kin, Reciprocal and Inclusive Fitness a type of natural selection that considers the role relatives play when evaluating the genetic fitness of a given individual.

- **Direct Fitness and Indirect Fitness :** survival and reproduction (direct fitness) and any impact that an individual has on the survival and reproduction of relatives (indirect fitness).
- Theory of kin selection is one of the foundations of the modern study of social behaviour. British evolutionary biologist W.D. Hamilton first proposed the theory in 1963 and noted that it plays a role in the evolution of altruism, cooperation, and sociality; however, the term *kin selection* was coined in 1964 by British evolutionary biologist Maynard Smith.
- Altruistic behaviour of many animals is, like some manifestations of sexual selection, a trait that at first seems incompatible with the theory of natural selection. According to the theory of sexual selection, even though some individuals possess certain conspicuous physical traits (such as prominent coloration) that

places them at greater risk of predation, the trait is thought to remain in the population because the possessors of such traits have greater success in obtaining mates.

- Altruism is a form of behaviour that benefits other individuals at the expense of the one that performs the action; the fitness of the altruist is diminished by its behaviour, whereas individuals that act selfishly benefit from it at no cost to themselves. Accordingly, it might be expected that natural selection would foster the development of selfish behaviour and eliminate altruism.
- This conclusion is not so compelling when it is noticed that the beneficiaries of altruistic behaviour are usually relatives. They all carry the same genes, including the genes that promote altruistic behaviour.
- Genes are passed from direct parentage, but they are also passed by assisting the reproduction of close relatives. Natural selection favours genes that increase the reproductive success of their carriers, but it is not necessary that all individuals that share a given genotype have higher reproductive success. It suffices that carriers of the genotype reproduce more successfully on the average than those possessing alternative genotypes. A parent shares half of its genes with each progeny, so a gene that promotes parental altruism is favoured by natural selection if the behaviour's cost to the parent is less than half of its average benefits to the progeny. Such a gene will be more likely to increase in frequency through the generations than an alternative gene that does not promote altruistic behaviour.
- Parental care is, therefore, a form of altruism readily explained by kin selection. (In other words, the parent spends energy caring for the progeny because it increases the reproductive success of the parent's genes.)

- Kin selection also extends beyond the relationship between parents and their offspring.

For example-

- Female lions (*Panthera leo*) appear to nurse cubs that are not their own, although some authorities note that such cubs suckle the lioness when she is asleep.

- Belding's ground squirrels (*Spermophilus beldingi*) give alarm calls that warn other group members of a predator's approach but also attract the predator's attention to the caller.

- Worker honeybees (Apis mellifera) perform suicidal attacks on intruders to defend their colony.

- **Inclusive fitness**, theory in evolutionary biology in which an organism's genetic success is believed to be derived from cooperation and altruistic behaviour.

- Inclusive fitness theory suggests that altruism among organisms who share a given percentage of genes enables those genes to be passed on to subsequent generations. In this way, an altruistic act that supports the survival of a relative or other individual theoretically enhances the genetic fitness of both the recipient of the act and the altruistic organism.

- The propagation of shared genes was believed to be an underlying mechanism for the evolution of eusociality (cooperative behaviour characterized by division of labour and group integration that is found in certain species of animals, mainly social insects).

- Inclusive fitness theory is most commonly applied to eusocial organisms, such as bees and ants, although it has also been invoked to explain cooperative breeding in animals such as birds and the adoption of orphaned young by asocial red squirrels (*Tamiasciurus hudsonicus*).

- In certain bird species, such as the Florida scrub jay (*Aphelocoma coerulescens*) and the groove-billed ani (*Crotophaga sulcirostris*), some individuals will stay near nesting sites and participate in the rearing of related offspring. Individuals that do not disperse to their own territories have been thought to perceive the inclusive fitness gains of cooperative breeding as being greater than fitness gains offered by dispersal to potentially less-favourable territory.

- In such instances, inclusive fitness through cooperative breeding is the result of constraints on territory quality and is influenced by factors such as food, mate attraction, and predation. Indeed, in the absence of constraints, staying near relatives is less advantageous, potentially limiting breeding opportunities and thereby making kin selection and inclusive fitness less beneficial to reproductive success. (References: www.britannica.com/science/inclusive-fitness)

3.4 Socio Organization in insects

The term 'Social organization' refers to populations and not to individuals. It defines the nature of interactions between members of a species. In social insects it is fairly rigid and specics specific whereas in vertebrates it is much more dynamic and varies with changing conditions.

Thus social organization may be defined as on aggregation of individuals into a well integrated and self consistent group in which the unity is based upon the interdependence of the separate organisms.

In view of this, social behaviour may be defined as *the reciprocal interactions of two or more animals and the resulting modifications of individual action systems or any behaviour affecting another animal, usually of* *the some species. It may also be defined as an interaction between two individuals of a species.*

Characteristics of Social Life

Social insects exhibit following common features-

1. The insect societies are characterized by a large population.

2. Members of the colony show mutual cooperation.

3. Division of labour and caste system are the marked features of insect societies. It is well developed among the ants, viz. the queen, the males and sterile workers. In termites a soldier caste is also seen. The main duty of soldiers is to protect the colony against the enemies and intruders.

4. Parental care is a common feature. It takes the form of-

(i) Cleansing the young ones by the workers.

(ii) Removal of debris and dead bodies by workers from the nests.

(iii) Cleaning and feeding of the queen by workers.

(iv) Depositing the eggs safely in proper chambers.

(iv) Among honey bees, the workers by fanning their wings serve to keep the chambers cool during summer and during winter protect the queen against cold by clingering and clustering around.

5. Exchange of food between one insect and the other. It is known as trophallaxis. Ants feed one another from mouth to mouth.

6. In societies characterised by large population swarming occurs periodically. This serves to relieve the congestion in the colony when it is over-populated and at the same time serves as a means of distribution over a wider range.

7. Elaborate nests are constructed in all the insects. The nests of termites measure 8-10 feet.

8. The young ones are fed till they reach their adulthood, as in ants, bees and termites. In polter wasps and stingless bees, sufficient food is provided at the time of laying eggs for the development of larvae

Characteristics of social insects: Few characters are common among all social insects. They are as follows:

(i) Large population: Numerous individuals of a species live together by forming a colony. 35,000 to 50,000 members of honey bee may remainpresent in a comb. Number of ants in a colony may be 6 lacs and termites may exceed even the number of crores. All members of such type of insects arise from one female. Therefore the genotype of all members is almost same. Normally members of one colony do't accept the members of the other colony.

(ii) Elaborate nests: Social insects make elaborate nests for the storage of food, maintenance of broods and for their safety.

(iii) Extra population of nests: Few crustaceans, mites, beetles and other arthropods spend symbiotic life with ants. They get food debrises, protection and heat from ants colony. Ants may steal their eggs and make them slave when they become adult.

In the same way beetles lay their eggs in brood chambers of ants. Larvae of beetle feed on larvae of ants.

Some hunting insects, for example *(Stylopids)* feed upon wasps and bees. Bee moths eat wax of honey-bee's comb.

Division of labour: Normally 'Division of labour' is found in social insects. Division of labour requires a good co-ordination among all members of colony. Members of an insect family live together with great affinity and integration. They do useful work with the help of each other. Members of a species of social insects remain divided into different castes. There is highest grade of diversity of castes among social insects. Different castes present in the colony of honey-bee are as follows:

(i) Queen: Queen is fertile female. Only one queen is found in a colony. The size of the queen-bee is largest among the other castes of bees. She can be easily indentified by its long abdomen, strong legs and short wings. The queen has a ovipositor on the tip of the abdomen which is the egg laying organ. Queen's work is only to lay eggs. Her life is very long.

(ii) Males or Drones: These are haploid fertile males. These are intermediate in size (smaller than queen but larger than sterile females i.c. workers). They do not work.. Their sole function is to copulate with the queen and fertilize the eggs. They are driven out from the colony after discharging the male genitilia into the queen's body.

(iii) Workers: Workers are diploid sterile females. These are smallest in size, but their number in colony in highest. They do all the works of the colony except laying eggs. Numerous adaptations have taken place in the body of workers bee to perform various functions. Its body is hairy. When it visits a flower, pollen grains adhere to these hairs and other parts of the body. The worker cleans off pollen grains with the help of a special structure the cleaners present on each forelegs. Pollen brushes are present on all legs and pollen combs on hind legs. All pollen are stored in the pollen-basket present on the outer surface of tibia on hind legs. Water and nector are gathered by means of sucking by mouth parts. The tip of abdomen bears a sting which is modified ovipositor. A large poison-storage- sac remains connected with the base of the sting. Sting is used as a defensive organ.

Bee-dance: There are certain worker bees called **'foragers or scout bees',** who search the feeding place and pass on this information to other workers by peculiar movements called bee-dance. This dance provides a blue about the exact location and distance of feeding place from the hive.

Dr. Adrian Wenner (1964) discovered that the foragers communicate about food resources to the other inmates of their hive not only by their dance but also by producing diagnostic sound which results due to the vibration of wings. The intensity of sound is proportional to the distance of food source from the hive and also indicates the quality of the food.

Structure of the comb: Social insect makes special comb for their members. Comb of honey-bee is made up of bee-wax. It consists of several hexagonal small rooms called chambers of cells. There are three different kinds of cells in a comb:

1. Attachment cells for attaching the comb.

2. Storage cells 3 Fo. Storage of honey and pollen grains.

Brood cells For rearing the young.

Brood cells are also of three types: (i) for workers, (ii) for drones and (iii) for Queen.

Honey is kept in the top-most portion of the comb. Next to it pollen is stored, below which eggs and broods develop. There is no chamber for adults. They move on the surface of the comb.

In social wasps, **honey bee** and **ants**, workers are only females, but in bigger ants and termites worker belong to both sexes.

Parental care- In the Relationship family, first of all, children re- quire home, food, shelter and protection. For the parental-care of children adult life is very long. These make an association between young and old, while young get care of the old. Parental-care includes feeding, cleaning (removal of debrises and dead bodies), placement of eggs in definite cham- bers, to keep the chambers cool during, summer, to keep the Queen warm during winter. These works are performed by workers.

Progressive provision of food: Social insects provide food continuously to their offspring till they metamorphose in adult. This phenomenon is called progressive provision of food.

Trophallaxis: Introduction of food from one insect to the other by mouth is called trophallaxis. Ants and termites provide food by this method to each other. Trophallaxis plays main role in determination of castes.

Swarming: Over population of colony is controlled by the phenomenon of swarming. Insects leave one place and settle in other place by this phenomenon. Swarming is for food, mating and migration.

Protective device: There are many protective devices in insects. Ants, honey-bee, wasps have sting. Soldiers of honey-bee and ants have well developed jaws. They protect themselves with the help of jaws. Guards of the colony have the duty to protect the nest from enemy.

Communication: Chemicals, tactile, visual and auditory symbols are used for communication among insects. Pheromone is one of the volatile liquid used as chemical stimulation. Male silkmoth searches female with the help of pheromones as soon as it emerges out from the cocoon.

Different insect societies:

(1) Bees- Bees are of three types from the point of view of social behaviour -Solitary, Gregarious and Social.

(1) Solitary: Anthophora, Andrena, Helictus etc. are solitary bees. Anthophora dig many vertical burrows in close proximity without any connection between them. A single female bee occupies each burrow rearing up her own larvae. Andrena and Helictus dig a single burrow with blind branches in which eggs are stored. They also store some food in these branches.

Pristhyrus make temporary colonies for one season only.. the colony is formed by females.

(ii) Gregarious: Some bees are gregarious, they form a temporary population. It is a temporary behaviour. Locust, grass-hopper etc. are gregarious.

(iii) Social: Honey-bee exhibit highest degree of social behaviour. They make permanent colonies. The division of labour is very well marked. There are different castes for different works (described above in detail).

(2) Wasp- There are two social aspects in case of social behaviour of wasp (i) the relationship between workers and grubs and (ii) the division of labour amongst their members.

The grubs can attract the workers by many methods for their proper care. The most prominent social wasp is of the genus vespula. These wasps have mainly two types of members in the colony, i.e. the egg-laying females and workers. The males occur for a short period only when they fertilize the young Queen of the next generation. The workers are not totally sterile like honey bee. Some of them may lay eggs, especially when Queen dies, producing only males.

Comb: Wasps construct hexagonal cells of collected wood fibres. There is no advanced type of division of labour like honey-bee.

(3) Ants- Ants also show highest grade of social behaviour. New colony is founded by a single queen. After mating the queen (largest in size) falls on the ground and forms a new colony. Ant colony consists of a single queen, developing eggs, young and adult workers. The workers are smaller than queen and they are sterile females.

Army ants *(Eciton)* have three types of workers. Small workers per- form the task of feeding the developing broods. Intermediate size of workers act as foragers or scout ants (search the food), largest workers are soldiers defending the colony. Sometimes soldiers attack the colony of other insects and capture the young larvae and pupae using them as food. Some ants bring home the larvae and pupae of other ant colony. After hatching they are used as slaves.

(4) Termites: Termites also show highest grade of social behaviour. A termite colony consists of three types of castes -

(1) Males and female having deep colour, well developed eyes and wings, (ii) the workers are small, blind, unpigmented and wingless individuals having jaws, (iii) the soldiers are wingless, blind and unpigmented with swollen heads and well developed jaws.

In termites there is no grub stage. Each individual after some moultings becomes a potential worker and its form and function depend on the number of moulting. Highest grade of division of labour is found in termites like honey-bee. The female lay their eggs. The soldiers defend the colony. The workers care for the eggs, young and queen. The workers of some species cultivate fungus in special chamber to use as food.

Genetic basis of social behaviour: Hamilton (1964) worked on the problem of evolution of social behaviour in insects from the genetics point of view. He draws attention to the significance of Hymenoptera's unique form of sex-determination. They show haplodiploidy, that is, males are haploid developing parthenogenetically (developing from unfertilized eggs) whereas females are diploid developing from fertilized eggs, receiving half its chromosomes from mother and half from its father.

In a diploid organism, offspring get haploid set of chromosomes from cach parent. Thus the genetic affinity of offspring to either mother or father is half. Thus the average genetic affinity of one sibling to another is 1/2. Therefore, as far as genes are concerned, one is as closely related to a sibling as one is to a parent.

In case of hymenopterans the total relationship is the same on the maternal side, but on the paternal side, since the father is haploid. Then sister will get the full share of the father's gene. As a consequence, the relationship between sisters is not half but (1/4 + 1/2) = 3/4. Thus the sister hymenopterans are more closely related to one another than they are to their own daughters or than they are to their mother. Workers relationship with their brothers is quite different. The brother (drones) get no genes from their father, he gets only half his mother's chromosomes. His chances of getting the same half as any given sister is 1/2 x 1/2 or 1 in 4. That is why males are selfish, performing no work of the hive.

Thus Hamilton was correct is suggesting that haplo-diploidy have played an important role in the evolution of social behaviour in insects specially among hymenoptera.

Conclusion The study of social behaviour of insects reveals of thefact that the oldest and highest grade of social behaviour is found among insects, in animal kingdom. Societies were formed among insects before three crores years ago. Greatest socialism and highest grade of division of labour is found among insects. Social behaviour of insects have solved the survival problem besides many other problems. Hamilton has suggested that haplo-diploidy type of life cycle have played an important role in the evolution of social behaviour among insects (specially members of order hymenoptera).

Evolution of Social Life

In mode of life the great majority of insects are solitary. Each individual lives to itself and d members of a species have no marked attraction for each other except at times of mating but some are sometimes found together in large gregarious swarms and few others have worked out complex societies embracing almost all phases of the individual activities with distinct division of labour. Other insects exhibit interesting tendencies towards the beginning of social life through such phenomena as material care, social larvae and community development.

1. Maternal Care

The female earwigs of certain species deposit their masses of eggs in a sheltered chamber and guard them till the young nymphs are active enough to leave the brood chamber. Similar observations of maternal care are seen in mole crickets-*Gryllotalpa.*

Social Larvae

The larvae of certain species of moths, hatching from the same egg mass, construct a silken web-like nest somewhere around a fork or branch of a tree They leave the nest during the day to food on the foliage of the tree and return to it for rest. Larvae of the tentcatterpillars (*Malacosoma*) construct such a nest and leave it finally at the time of pupation. Similarly larvae of wetrworms (Hyphanria) spin a nest for them which they leave in their last larval instar

3. Community Development

Certain species of order *Embioptera* (=webspinners) are gregarious, living in colonies that consist of interlocking silken tunnels in the soil or on the base of plants. Some of these colonies contain hundreds and possibly thousands of individuals and spread out their nest to over many square yards. Their females exercise maternal care, watching over the eggs and young nymphs. However the individuals of a colony exhibit no intimate relationship. Therefore they are said to represent gregarious nature like aphids and scale insects.

A step ahead in the colony formation is exhibited by certain cockroaches Wood cockroaches of the genus Cryptocercus form colonies in rotten logs. The wood cockroaches feed upon wood, which is digested by symbiotic protozoa, living in their alimentary canal. When young cockroaches moult, they completely empty their alimentary canal, so that after moulting they have no symbiotic bacteria. To restore it, they feed upon the fresh excreta of another member of the colony. Hence the colonial life has evolved in them.

The termites, ants, certain wasps and few species of bees have developed social life to a high degree. They live in family colonies that have division of labour under three headings.

1. Defence of the community
2. Reproduction
3. Feeding

In termites, ants, certain wasps and bees, social life has arisen independently. The actual details of metamorphosis, feeding habits, and colony formation are totally different yet the final organization is remarkably similar.

SAQ-1

- The Mormyrids (*Gymnarchus*) construct a **………………** of large size using the aquatic vegetation. The wall of the nest remains projected several centimetres above the surface of water.
- The formation of foamy nests by the male fighting fish (*Betta*) and many other **………………** fishes belonging to family anabtidac is very unusual but interesting type.
- Parental-care is an **………………** behaviour which is found among many species of fishes..
- Parental care in amphibian is done by all possible methods i.e. laying eggs in proper places; **………………**; carrying of eggs and **………………** by nutrition of embryo by pseudoplaceta.

SOCIAL ORGANIZATION IN PRIMATES: Primates are known to live in large groups. Primates are marked by large body size, large brain size and diurnal behavior. Primates social organization has been made to increase survival, cooperative predator avoidance, ready access to mates, kin selection, and thermoregulatory benefits. Their social organization structure is quite complex with female making up the center of organization. They are mother, sisters, and their child living in the same group. Primates have a polygamous structure with one dominating male controlling the all females. Male young ones have a high probability of leaving the group as they can begum a threat to alpha male. Generally Females stay in the same group. Their social structure is at disadvantage like competition for food, mates and space, predators.

Semi terrestrial species: These species lives in large groups. They live to protect themselves from their predators like Lions, Leopards, Hyena etc. and also protect their food which is generally scare. Example Baboons. Some Species like Langurs lives in a small group as they have little competition for food. Generally, they live a solitary life.

Most Primates have a closely knitted group with little or very little contact with other communities. They lives their entire lives in a certain area and rarely they moves to a new area. They are quite aggressive towards their other group. The aggression is due to the fact that increase of individuals will put the burden on the resources, which will eventually harm their own group.

Chimpanzee are quite friendly with another group. They have been seen to interact with other group with some interaction lasting for few hours. Even some female chimpanzee switches the group for matting purpose. Howler Monkey and Gibbons shows a territorial protection behavior by intimidating the members of other group by making exceptionally loud sounds. These group meet each other at a place where both group territorial meet.

There are different types of Social Organization found in Primates. They are as follows:

1. Solitary Primate System: This pattern is rare in Primates where Single Female and their offspring live together. The male generally comes only for matting purpose. In this structure male have a large area with many female living. Young Ones leaves their mother once they attain puberty. Their mode of communication is vocal and olfactory. Example: Loris, Lemurs, Tarsiers, Orangutan

2. Monogamous Family Group: This pattern has a one male and one female with their offspring. Once the young ones grow, they leaves the group to start their own family. This is quite analogue to Nuclear family of Human beings. Both the parents work and share their responsibility of taking care of young ones. This system is rare in primates, but is found in small Asian apes and in New world Monkey. Example: Gibbons.

3. Polyandrous Family Group: This pattern starts with a monogamous group with one male and female. Later a new male primate will join the group and assist in rearing of child. Both Males will mates with female. Generally, the second male is not capable of breeding, his role is just concerned with young ones care. This is also rarer in Primates. Example: Termarin& Marmoset

4. Polygamy Family Group: This pattern has one male with multiple female. Primates form a social group where the whole group is divided into multiple group. Male only mate with Female of alpha (Dominating) group. They form a distinct mating and child bearing group. Example: baboons, langurs, howler monkeys, and gorillas. In this Social group it is female which decides the hierarchy. Males are bigger, stronger and aggressive than the female. Female comprising of Mothers, aunt and sister club together and can rid of unwanted males. Female decides about their mates from their groups or from outside their group. Their relationship with the Male is of temporary. Alpha Male can only be dominate till it shows a cordial and carrying attitude towards the female and is readiness to defend their territories.

5. Multi Male Multi Female Group: This pattern has no stable heterosexual bonds – both males and female have multiple partners. This is mostly found patterns in semi-terrestrial primates. This group has a hierarchical order for each member in both sexes. Each member knows to whom they have to submit. Primatologists have named the dominant male and female as Alpha Male and Alpha Female. Female Rank always stays in group throughout their life. Male also have a rank, but they have to leave their group after attaining puberty and join another group, Male start from lower rank and then gradually raise its rank in the newly joined group. Alpha Male will mate with multiple female partners. It has been seen that Female especially of Lower order in the group generally sneaked away and mate with lower order females. Thus in this Group It feels that it is Male dominant but it is the Female which manages the gene flow. Example: Rhesus Macaque, Baboons, Few Monkey species.

6. Fission-Fusion Society: This Class of animal have no Fixed size and no proper composition. It keeps on changing. Fission refers to individual been reduced where Fusion means the addition of new members.

Adult Male and Female occasionally wanders and align with others groups. Male can join other males coming from different group, can laugh, hunting exercise etc. together.Female can leave the group especially when they are in heat (Reproductive Active) for their mates. Their group interrelationship continuously change, group are regrouped etc. Example: Chimpanzee.

3.5 Parental care with reference to fish, amphibians and birds.

Parental care with reference to fish:

I- Laying of Eggs and their protection .

II- Fish species which build nests.

III- Fish species which do not build nests.

IV- Viviparity

V- Care for young

(I) Laying of Eggs and their protection .

- In some fishes like pikes, *Cyprinus carpio, carrassiusauratus* etc. eggs are scattered over aquatic plants to which they are attached.
- Cypienids (Carps etc.) eggs are usually laid with some special sticky covering by means of which they are attached to each other and to the bottom of stones, weeds etc.
- Suitable spawning grounds are selected by *Salmo solar, Acipenser, Onchohyrrchus* etc. These fishes show anadromous migration for depositing eggs at suitable places.

(II) Fish species which build nest: Parental-care in few fishes is being performed by the formation of different types of nests for the safe deposition and protection of eggs. The nest provide suitable and safe place for the development of their young. In the formation of nests only male or both sexes participate. For the formation of nests they use various kinds of materials such as stones, aquatic vegetation, secretion of their body etc. various kinds of nests build by different species of fishes are as follows:

- During spawning season the male *Darter (Etheostoma congregate)* selects a suitable place called '**Domain'** repelling with vigour any attempt by rival male to dispute their claim. The female Darter makes a basin like depression for releasing the eggs. She skins in basin like nest where eggs are deposited. The eggs are promptly fertilized by the males and are being covered by the sticky secretion, secreted by the kidneys of the male fish. These sticky eggs remain attached to the stone till hatching. Fresh water *sun fishes* (contrarchidae) scoop out a shallow **basin like nest** at the bottom of water. Pebbles are carefully removed leaving behind the large stones. A layer of the fine sand or gravel remains attached with the eggs. Male sun fish guard the eggs till the hatching of the young. Many **chichids** build basis like nest, where both parents take up the task of guarding the eggs. **American cyprinids** (Chubs and Shioners) make a nest composed of large heaps of stones but the eggs are left uncared.

African osteoglossids usually make the nest by cleaning the space among vegetation and lays their eggs.

- **Male bow fish (*Amia calva*) construct a crude circular nest** at the end of the lake using aquatic vegetation. One or more females attend the nest to lay her eggs. The male fertilizes and guard the eggs till hatching. The young leave the nest under the protection of the male.

  Both the parents of Cat fishes of America (*Arius*) build a crude 50 cm circular excavation at the bed of the river. Fertilized eggs are covered with large stones and are left uncared.

- **Lung fishes (*Protopterus*)** and *Lepidosiren* usually make nest in the mud of a swamp (water reservoir). *Protopterus* scoops out a hole in mud. Its nest is surrounded by long aquatic weeds and grasses. The male fish usually provide constant aeration to the eggs of nest, by the movement of their fins.

  The nest of ***Lepidosiren*** is in the form of burrow, in the bed of swamp varying in length from 1 to 2 metres. The nest consist of short vertical and much larger horizontal partition in which eggs are deposited. Males take care of eggs. During care of eggs male develops a long red filament from the pelvic fins, performing the function of aeration without coming on to the surface to gulp the air.

- Male of **'Three-spined stickleback fish'** (*Gasterosteus aculeatus*) construct a much more elaborate nest before courtship. First of all male selects a suitable place (territory) such as one among the stem of aquatic weeds where there is continuous flow of water. Now male collects the nest building materials such as algae, roots and stems of plants, aquatic weeds, etc. collected building materials are joined together in a desired fashion in the shape of barrel. A sticky secretion produced by the kidney of male help in sticking the nest building materials together. Now the male drags a mature female into the nest for laying eggs. Sometimes male muzzles female at the base of the tail to stimulate her to lay eggs. The female swims away immediately after laying eggs. Male fertilizes the eggs and takes care of the fertilized eggs. The male fans the developing embryo sending a constant stream of water through the nest. Male keeps close watch over the brood, not allowing any young ones to go for from nest.

- Male of **fifteen-spined stickleback** builds as **pear shaped** nest from a suitable branch of weeds. The frond (leaf like stem) is bounded by the sticky secretion of the kidney. The sticky secretion forms the thread like structure which passes round and round the fronds till they are bound together into a pear shaped nest. The female is invited there for egg laying. Male fertilizes the eggs and takes care of them till hatching.
- The Mormyrids (*Gymnarchus*) construct a **floating nest** of large size using the aquatic vegetation. The wall of the nest remain projected several centimetres above the surface of water.
- The formation of foamy nests by the male fighting fish (*Betta*) and many other **Labyrinth** fishes belonging to family anabtidac is very unusual but interesting type.
- **Paradise fish** also prepare identical foamy nest, where the eggs being lighter rise upto the level of water. Nest float freely without being carried by the male.

(III) Fish species which don't build nest. There are many species of fishes which don't build nests. They deposit their eggs in

(a) Suitable places

(b) Keep in the body.

(a) Deposition of eggs in suitable palces.

The fishes which do not form their nests have developed very intelligent design of depositing their eggs in suitable forms in order to ensure proper protection. There may be various way of depositing eggs. Few ways are as follows:-

- The eggs are deposited in single mass, *Example*- Hollow ropes of the yellow perch (*perca flavescens*). The eggs are held together by membrane and form long floating bands, so that eggs are not scattered away. Similarly the eggs of the Angler fish (*Laphius*) are invested by a gelatinous outer coat and joined together to form a transparent mass of enormous size.
- The eggs of skippers, garfishes and flying fishes have sticky threads. The another end of thread help them to adhere with any aquatic substratum or become entangled with other eggs of the same species.
- The lumpsucker (*cyclopterus*) deposits their eggs in the form of spawn in the cervices of the rocks above the level of the water at spring tides. The spawn may contain 80,000 to 1,36,000 eggs. Time to time fish presses his head into the mass of spawn to allow the water to penetrate into the spawn ensuring proper aeration of the eggs.
- Some fishes such as Rhodeus (bitterling) Gobies, Blennis, Bull heads etc. deposit their eggs in the dead shells of mussels and oysters.

(b) Deposition of eggs in the body of fish: Fish species which do not form their nest, have developed many structures in their body to safeguard the eggs. Few examples are as follows:

- Female chichlids (*Tilapia*) and many other fishes protect their eggs by carrying them in their mouths. Males of most of marine cat-fishes (*Arius*) and also cardinal fishes have similar habits of carrying the eggs in oral cavity until hatching. The male of a Brazilian cat-fish (*Loricaria typus*) develops an enlarged lower lip forming a sort of pouch in which labial incubation takes place. This phenomenon ensures safety and perfect aeration. These fishes swim upward to give the eggs mucous which stick them to the mouth. Even after hatching the young ones remain near the mother and if there is any disturbance they enter into the bucal cavity of mother for shelter.
- In butter fish (Pholis) the eggs are rolled into a round ball and one of the parent, often the male, guard the egg ball till hatching of young.
- The male of Australian Kurtus bears the mass of eggs on forehead.
- In the cat-fish (*Playstacus*) the skin of the lower surface of the female becomes soft and spongy during breeding season. No sooner the eggs are fertilized the female presses her body against the eggs in such a manner that each egg becomes position till hatching of young.
- In the pipe fish (*syngnathus*) and the sea horse (*Hippocampus*) the male is only responsible to care the eggs till the hatching.
- Eggs and fry are always undertaken by the males in the brood pouches. Brood pouches are found on the lower surface of the abdomen of the male. Females transfer the eggs into the brood pouch

after courtship. During incubation brood pouch remain closed by the flaps of the skin.

- In the family Solenostomidae, pelvic fins of females form the brood pouch. Inside the brood pouch numerous long filaments remain present which keep the eggs in position.

- Some of the sharks and rays produce a special type of leathery case called mermaids purse. It is a shell secreted by the shell glands of oviduct. The shape of the purse varies in different groups but the function is the same, that is, protective. The corners of the shell are drawn out into four long twisted elastic filaments which serve to attach the eggs to sea weeds. The development is completed within this purse.

(IV) **Viviparity**: In order to provide high degree of parental care and provides maximum protection of youngs one, some fishes such as sharks, *surfperch*, Cymatogaster, *scupines* andcarps, have evolved internal incubation. They do not lay eggs, rather they directly give birth to their young in order to provide absolute protection of eggs. Among the sharks, live bearing has been noticed in more than dozen families, where the development of eggs take place in uterus. Some species of shark have well developed special structures for nutritive and respiratory exchange.

Among bony fishes, viviparous forms rare. In the culpins and the carps viviparity is only confined to a single genus each, comephors are Barbus, where the development of eggs takes place in ovaries.

(V) Parental-care for the young. Paraental care in fishes does not stop at caring for the eggs only. Members of many families such as *Gasterosteidae,Centrachidae, Ictaluridae* defined their young ones activity. The said fishes have been actively found to defend their young by placing them to safe places and away from the enemies. The hatching of *Tilapia* and pipe fish are protected by their parents. They are protected in mother's oral cavity and father's brood pouch respectively.

Parental care in Amphibians

(I) Deposition of eggs in suitable places and preparation of nests.

(II) By Carrying the eggs by parents.

(III) By keeping the eggs in special pouch.

(IV) Viviparity

(I) **Deposition of eggs in suitable places and preparation of nests.** This is the primitive methods of parental care. It is done by following various ways:

- *Female Hyla faber*(*Tree frog*) construct 7-10 cm. deep hole in the mud in shallow water. She lays eggs in it after about two days of nest building. Male discharges sperms there fertilizing the eggs. Eggs and early stages of larva are saved from predator (Insects and others fishes)
- Female **tree frog** (*Rhacophorous ocellatus*) makes a spherical hole of 6-9 cm wide in mud banks, both male and female sinks in the hole embraced with each other. They make the surface of the tunnel smooth while sinking. Finally they close the mouth of tunnel. Female emits a spongy ball from her cloaca, laying eggs on it. Eggs become entangled with froathy bubbles. Now male discharges their sperms on the froathy bubble fertilizing the eggs.
- Tree frog of south America (*Phyllomedusa*), India (*Rhacophorous malabariens*) and Africa (Chiromantis) etc. Keep their eggs in the nests made on the leaves of trees. The nest is covered by many other leaves. Eggs develop into larva. After

hatching larvae jump into the water. Metamorphosis of larvae take place in water.

- Female *Phrynixallus biroil* secrete a transparent gelatinous bag and keep their fertilized eggs in it. The transparent membranous bag is left in water current of hills stream. Entire metamorphosis occurs in it. small frogs come out of this bag.
- *Hylodes* of American frogs keep their eggs below the rocks, moss and leaves of trees. The eggs are bigger in size. Development of eggs occurs fastly as yolk is in sufficien quantity. Young frog comes out and performs pulmonary respiration.

II Caring of eggs by parents.

- The male toad, *Alytes obstericans* glues the eggs in strings. These strings of eggs are winded around the body, mainly the legs, up to the time of their hatching. During this period it remains in concealment.
- Male *Mantophryne robustia* species covers the eggs by elastic gelatinous covering in row. Their number in one row is about 17 and they form a bunch. Male sit on the bunch of eggs and holds them with the help of fore limbs. Limbless amphibians (*Icthyophis*) surround eggs with the help of their body.
- Male *Alytes obsteiricans* perform the copulation and oviposition on land. Female lays eggs twice or thrice at some intervals. Male raps the rows of eggs around their legs and carries them till hatching. *Desmognathus fucus* carry their eggs around neck.
- Female *Brazilian tree frog (Hyla goeldil)* carries eggs on her back. Male helps to place the eggs on her back.
- South American *Phyllobates* and *Dendrobates* carry their tadpoles on their back. Tadpoles remain attached, with the back of

paraents, with the help of sucker like lips and flat abdomen. Tadpoles are being carried by their parents if the pond becomes dry.

III. By keeping the eggs in special pouch- Parents care and carry their eggs and tadpoles in their special self made brood pouches. These are of various types-

- Small cutaneous pouches are formed on back of female of *Pipa crypiobranches. Desmognathus, gastrotheca* species of frog. Eggs are surrounded by these cutancous pouches. Each pouch is covered by a lid. These pouches are formed by the secretion of cutaneous glands. Each pouch consists of more than 100 eggs. Development of eggs and metamorphosis of larva occurs in these pouches. Full developed young frogs come out from these pouches.
- In *Nototrima* all eggs are placed in a common pouch. This common dorsal pouch is formed only in breeding season. The pouch bears a small hole. The transfer of eggs in these pouches is still not known.
- Female *Rhacophorus reticulate* of Ceylon carry their eggs on their belly. Eggs remain attached with the skin of belly. On removal of eggs the belly bears small grooves.
- *Rhinoderma darwinni* of chill are very small frog. Male of this species keep 10 to 15 young frogs in the gullar pouch where they metamorphose. The gull pouch is modified vocal sac.
- West African female of *Hylambates breviceps* keep eggs in her mouth where the eggs develop. The number of eggs are less but size is bigger.

IV. Viviparity. Two species of small toads of western Africa *Pseudophryne vivipara* and *Nectophryne tortnieri* are viviparous. They give birth to their young. Their embryo are found in their uterus. Embryo of *pipa dorsigera* get nutrition by pseudoplacenta.

Parental care with reference to Bird

All birds are oviparous (egg laying). They take care of their eggs and young ones. Birds have to face maximum struggle with the changing environment and with their enemy. They are warm blooded, oviparous and bear minimum defensive organ. They maintain their existence by protecting their offspring in many ways. One of the method to protect their offspring is the nest building for their eggs and young. Nest provides protection and heat to the eggs. Heat is essential for the incubation of eggs. Nest building behaviour of birds is an instinctive behavior. Different species of birds make different kinds of nests. Brooding means protection of eggs and young ones against chilling wetting or undue heat of the sun. young ones are attended, defended and trained for catching prey, to remain beware of enemy, migrating from one place to another place.

Types of Nests

The choice of a nest site and its construction are important because this will be where the egg-laying incubation, and caring for the young activities occur. The nest is a structure built or conditioned by the parents, although sometimes they can use a natural depression of the land or existing nest. Depending on the nest’s location, parents may camouflage the nest or cover the eggs with twigs and dead leaves to conceal them from possible predators.

- **Nest in a Depression on the Ground:** This is one of the simplest constructions of nests and consists of a small depression in the ground or vegetation. This depression has to be deep enough to prevent the eggs from rolling out of the nest. The depression on the ground is sometimes reinforced or lined with branches or even small rocks.

Depression in the ground as nests are used by quails, most shorebirds, seabirds, rails and night.

- **Nest in a Mound:** This particular form of nesting includes the construction of a pile of plant material and dirt. The eggs are placed in the middle of this pile and buried with more branches, dirt and leaves. The parents abandon the mounds and eggs. The decomposition process of organic matter radiates heat, which incubates the eggs until they hatch. The chicks never know their parents, and find food and take care of themselves from the moment they hatch. The size of these nests can reach sizes of more than 100 m^2 of material. Mound nests are exclusive to the megapods of Australasia.

- **Nest in a Cavity:** Cavity nests consist of a chamber located in the wood of living or dead trees or trunks of arborescent ferns or cactus. Nests in cavities also include chambers dug in termite nests. The nests in cavities in the wood are found in any region where there is wood as a substrate. The nests in termite nests are mostly restricted to tropical regions where termite nests are prevalent. The birds using cavity nests include woodpeckers, toucans, trogons, barbets, and a few species of the Tyrannidae family (flycatchers), which use existing cavities.

- **Nest in Cup or Bowl:** The nests in the shape of a bowl or cup are mostly circular or semi-circular in shape. It can also be said that this type of nest has the shape of a cup or half a cup. The materials used for constructing this type of nest vary between purely plant material and threads of spider webs or caterpillars, mud, lichens, saliva that the bird produces, or a mixture of mud or saliva with plant materials.

- **Nest on a Platform:** As its name says, platform-type nests are in themselves an accumulation of plant material with a flat surface with a depression in the center to house the eggs and prevent them from rolling out of the nest. The platform nests are generally placed on bifurcations of large branches between which the material is first placed as a base. Then, additional material is added.

- **Hanging Nest:** The hanging nests are the most sophisticated among the nests of birds. There are many types of hanging nests, and they usually have an upper part of varying lengths woven to the support branch, a chamber, and an entry at variable locations on the nest. The entrance can be close to the part where the nest is woven to the branch, on one side of the chamber, or at the bottom of the nest. In some hanging nests, the entrance is covered with nest material, making it difficult to detect where it is located.

- **Spherical Nest:** Spherical nests generally have a spherical shape or a shape that conforms to the structure in which they are built. A spherical nest often looks like an accumulation of twigs and leaves with a concealed, often difficult to detect, entrance. Inside, this type of nest has a very well woven cup where the eggs are placed, and the chicks grow. The spherical nests are usually placed in hidden places, and the non-striking appearance responds to the purpose of going unnoticed by predators.

Breeding, Territory and Courtship

Breeding season-All birds lay eggs i.e. all are oviparous. Mostly they lay eggs in self-made nest. Some birds lay their eggs in summer while some lay eggs in winter. Few Australian birds lay eggs in rainy season. Flamingo of our country lay her eggs after rainy season in Runn of Kuch. Almost all birds lay their eggs once in a year. But some birds, for example. To whee (*Papilo alberti)*, lay her eggs twice in a year, once in March/April and twice in July in the same year.

Territory. Male selects any area called territory or domain and don't allow another male to enter into that area. Some birds establish territory after courtship jointly. Chinese jacana is the only bird where female establishes territory.

Birds estabilishing and protecting their territory are very ferocious. They fight, vigorously with another male trying to enter into his territory. One or both male may die during fight with each other.

Courtship. All those behaviour which may help to bring two individuals of opposite sex of same species to copulate, is called courtship. Dancing of male peacock to attract female peacock for copulation is best known example of courtship. Nest building in **Bayas** (*Ploceus philippinus*) is example of courtship because female baya enters into the best nest. Mostly birds do courtship only during breeding season but few birds, for example Geese and Eagle make pair for whole life.

Brooding Behaviour in Birds

Eggs and ovulation. Eggs of different species of birds are of different shape, size and colours. Humming birds lay smallest eggs. Largest eggs are of Elephant bird (*Erprornis*) which is on the verge of extinction and is found in Madagascar. Diameter of eggs of *Ostrich* is about 15cm (about 6".)

Eggs laid by birds in dark places are generally white. Example wood peckers, eggs laid in open places such as bushes are generally spotted. Number of eggs laid in one clutch or setting may be 1 to 20.

Incubation period. It varies species to species. Incubation period is 12-14 days in passering birds, 21 days in chickens. This period is of 45 days is ostrich and 80 days in Albatross which is perhaps longest.

In few birds female incubate the eggs. In some birds male and female incubate eggs in shifts. In few birds only male incubate the eggs.

Young of birds. Young of birds may be divided into two groups:

- **Precocial or Nidifugee.** Young remain covered with feathers, eyes remain developed and bright. They start feeding themselves just after hatching and run after their parents. Example- **Herring gull, Terns, Killdeer etc.**

- **Altricial.** Young are featherless, blind and weak. Parents feed them through beak. Example- Hawk, Cuckoo, King fisher, Passerine, Wood pewee.

- Brooding (Parental care of young ones). Young birds totally depend upon their parents for protecting, food and many other essential directions. Parents take care of their young ones till they becomes self independent. this very process is known as brooding. Brooding is instinctive behaviour which help in preservation of species.

- Fully developed embryo of birds, break the egg shell and come out of the egg. As soon as nesting (Young birds) come out of the egg, parents take care of them and protect them from adversities of environment and enemy. Parents leave caring young ones when they became self independent.

- Precocial or nidifugee young start taking food just after hatching, but their mother show them site of food. Cuckoo neither make nest nor incubate their eggs so there is no question of carrying their young ones. Passerine and shore birds are precocial and both male and female take part in parental-care. Generally male brings food. Female take the food from male and put the food in the mouth of young ones. Female Baya and English Robin (Erithacus rubecula) leave their young and become engaged in works for next generation while male bears all the work of young concerning parental-care. In Pigeon and crow both male and female bring food in shifts. They protect them till they became independent.

- Young of precocial bird select their food by their beak as per direction of parents, but parents of Altricial birds feed the food in the mouth of young by their beak. Directive marks in the mouth of young help to take food. Kestrel bird show an interesting case of brooding behaviour. Male kestrel bring the food while the female kestrel break them in small pieces and feed the smaller food particles to their young.

- Opening of mouth of young depends of various kinds of stimuli, when parents bring food for them. Mouth bears many herbst corpuscles touches the angles of mouth. On getting stimulation of touch the beak of young opens just like spring. Young of many altricial bird open their mouth on special call given by parents regarding food. Young of herring-gull tap at a red spot on the bill of the parent. The parent then feeds them, they beg for food even when a model of elder herring- gull is placed before the young.

- **Golden Eagle.**(*Aqila chrysactos*) provide food to their young twice in a day. Owl (*tyto alba*) provide food ten times to their young in one night. One insectivorous bird *Paras major* provides food to their young 900 times in 24 hours.

- Parent save their children even on the cost of own life. This instinct is found more in precocial birds. They play many distraction game to save their young from the enemy. Some times parents flutter on soil and make piteous cries, when enemy comes to catch them they fly away. Predator also follows them. Thus the parents becomes successful to keep away the predator or enemy from the young and nest. Parents even caring their young with the help of beak (Grebes, Scoter etc.); ant leg (Red tail hawk) or both with beak and leg (American wood cock) from unprotected to protected or unsuitable places.

- Period of stay of young in different species of bird is different. Generally young of bigger birds live for longer duration. Contrary to this young of smaller birds live for shorter duration.
- Young of few species even after becoming independent, depend on parents for special functions such as guidance of flight, search of special food, training of singing, etec.

Figure- brooding behaviour

Importance of Brooding

- Brooding is very important also because it activates the endocrine system in animals.
- The process of brooding also ensures that the animals have a well activated digestive system.
- The most important effect of brooding is that it develops a better immune system in the animals that helps them lead a long and healthy life which is the main purpose.

SAQ-2

- A bird nest can be a simple depression on the ground or an elaborate hanging dome, all of which protect the eggs and young from the elements and ……………………...

- Nest building could help birds to survive in ……………………...during evolution.
- Brooding behaviour is an ……………………...which is inborn.

3.6 Territorial Behaviour

There is a competition for food, space and energy as well as mating partners among organisms within the ecosystem. This competition helps in the castablishment of territories, but once the territory is established, it leads to reduced competition. An organism may castablish a definite area within the habitat and defends it from all other members of the population. The organisms which castablish and defend a territory are more vigourous and better fitted members of the population. They are more assured of producing offsprings and thus perpetuating their more favourable attributes within the species.

Examples-Territorial behaviour occurs widely among insects, fish, amphibians, birds and mammals. The size and shape of the territory depends upon the habitat and the species. Where there are no differences or only slight differences in the various sections of the habitat, the territorial areas are roughly circular because of individual defence of adjacent areas. Where there are differences in an area in terrain, food supply, and size, the shape of the territory varies.

Territoriality has following aspects-

1. Size and Boundary of Territory

The size of the territory depends on the size and diet of the animal and ranges from few millimetres to several kilometres. Territorial defence involve costs and benefits. An animal usually defends the territory when it is economical. When an animal defends its territory against members of its own species, it is termed interspecific territoriality. On the other hand defence against the members of the same species is termed intraspecific territoriality.

As stated above diet and food requirements influence the territory size. In lizards, birds and mammals, territory size increases with increase in body weight. Many animals change their defence strategies depending on the food supply. The animals which defend feeding territories appear to be very efficient in changing their behaviour.

Territorial animals spend much time in patrolling the boundaries of their space, singing, visiting scent posts, and making other displays. These displays require relatively little energy and, once the territory has been established, the neighbours have been conditioned and need only occasional reminders to keep out.

2. Territory and Breeding

Many animals cannot breed unless they hold a territory. It is usually the male who defends areas where females come for mating. The territories where the females usually arrive contains vital resources like food, proper space or nest. Thus, male sticklebacks cannot attract a mate unless they have a territory and have constructed an adequate nest. Female sticklebacks lay eggs in the nests of males with large territories. s usually

In some situations males aggregate at traditional, communal display grounds or leks where they defend patches of ground and compete for dominance status.

A lek is a type of territory held by males of certain species and is used as a communal mating ground. This type of behaviour has been observed in some frogs, birds, antelopes and bats.

When the females visit the leks, the act of copulation is performed, but only a few dominant individuals lake part in it. The most successful males are those that occupy the central territories in the lek.

Examples In the American bird, sage grouse, 80% of the copulations are achieved by three central males and in another bird, white bearded manakin, one male alone performs 70% of the copulations.

3. Avoidance of Predators

Territorial behaviour helps in avoiding predation. This may be both in spaced neighbourhood and colonial living.

Advantages of Territoriality

(A) Associated with Reproduction

1. It helps in securing a nesting site.

2. Aids in the formation of pairs.

3. Reduces the possibility of disturbances from the rivals.

4. Permits females to select the most vigourous males.

(B) Associated with Habitat and Food

1. Permits increased inbreeding within a population as a means of better adopted to the local habitat.

2. Makes the animals familiar with the location of food and water.

3. Secures adequate food for the pair and young ones.

4. Divides resources among the dominant and subordinate individuals with consequent reduction in fighting and stress.

(C) Associated with Predation and Parasitism

1. Provides knowledge of location of shelter.

2. Dispersion, thus resulting in less possibility of being detected by the predators.

3. Provides sufficient space to the members of a species, thereby decreasing the chances of transmission of diseases and parasites.

(D) To avoid Overcrowding

1. Prevents overcrowding and over exposition of resources through natural selection

3.7 Summary

- The Mormyrids (*Gymnarchus*) construct a floating nest of large size using the aquatic vegetation. The wall of the nest remain projected several centimetres above the surface of water.
- The formation of foamy nests by the male fighting fish (*Betta*) and many other Labyrinth fishes belonging to family anabtidac is very unusual but interesting type
- Parental-care is an instinctive behaviour which is found among many species of fishes. Most fishes provide parental care to their eggs and young in order to provide proper protection for their survival against struggle for existence.
- Great diversity of parental-care is found in fishes. Formation of basin shaped simple nest to viviparity and even few take care of hatching.
- For parental-care many extreme modification in structure and behaviours of amphibians have been observed. Various methods of parental-care are found among amphibians.
- Parental care in amphibian is done by all possible methods i.e. laying eggs in proper places; preparation of nests; carrying of eggs and tadpoles by nutrition of embryo by pseudoplaceta.

- The mode of parental care in amphibian is well advanced over fishes. This helps in preservation of amphibian species.
- Bird nest is a place and structure where birds lay their eggs, incubate them, and rear the nestlings.
- Nest can be built and attended by a pair or multiple individuals working together in a cooperative breeding system.
- A bird nest can be a simple depression on the ground or an elaborate hanging dome, all of which protect the eggs and young from the elements and detection by predators.
- Nests designs are specific to taxonomic groups. Member of a bird family build nests of similar design.
- Nest building could help birds to survive in struggle for existence during evolution.
- Various birds make various kinds of nest using numerous materials. In this art they show high grade of technical abilities.
- Nest building behaviours is instinctive behaviours and is controlled by genes and hormones both.
- Brooding behaviour is an instinctive behaviour which is inborn.
- Birds show highest grade of brooding behaviour. They do not only provide food and protection to eggs and young ones from enemy, rather they even teach them singing, dancing etc.
- Thus, their way of parental-care is not less than parental-cares taken by human being to their children.

3.8 Terminal Questions

Q.1. Explain the Flocking in Birds, herding in Animals

Q.2. Explain the Group Behaviour and Group Selection of Kin, Reciporcal & Inclusive Fitness.

Q.3. Explain the Socio Organization in insects.

Q.4. Explain the Territorial Behaviour.

Q.5. Write short notes on:

(a) Parental care with reference to fish.

(b) Parental care with reference to amphibians.

(c) Parental care with reference to birds.

3.9 Answers

SAQ-1

- floating nest
- Labyrinth
- instinctive
- preparation of nests; tadpoles

SAQ-2

- detection by predators.
- struggle for existence
- instinctive behaviour

Uttar Pradesh Rajarshi Tandon Open University

Master of Science
PGZY-103(N)
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Block

2 Animal Behavior - II

Unit 4	**Sexual behavior**
Unit 5	**Biological rhythms**
Unit 6	**Pheromones and behavior**
Unit 7	**Anatomy and physiology of the time photoperiodic time measurement**

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Block-II- Animal Behaviour-II

In previous block you have studied about the Animal behaiour-I (selection of habitat, evolutionary and neurological basis of behavior and social behavior). This block deals with the Animal behaviour-II. This block comprises of 4 units (unit 4, 5, 6 and 7). Including flowing topics.

Unit-4 It deals with the sexual behaviour: (courtship, sexual selection, mating patterns). Monogamy, polygamy, polyandry. It also deals with the sexual conflict, parental investment, Infanticide. Female choice, male quality and courtship. Sexual behavior in animals is a complex and fascinating topic that has intrigued researchers for centuries. The study of animal mating behavior has provided important insights into the mechanisms that drive sexual selection, reproductive success, and species diversity.

Unit-5 This unit deals with circadian and circannual rhythms, orientation and navigation. Masking and entrainment, phase shift, Phase response curves (PRC) and phase transition curves (PTC). It also deals with Biological rhythms and human health, sleep, neural mechanisms of sleep.

Unit-6 This unit deals with pheromones and hormones, hormones and behavior and role of pheromones.

Unit-7 It deals with types and properties of biological rhythms, geophysical environment Seasons; proximate and ultimate factors and regulation of seasonal migration.

Objectives:

After studying this block student will be able to know:

- sexual behavior
- biological rhythms
- pheromones and behavior
- anatomy and physiology of the time photoperiodic time measurement

Unit-4: Sexual behavior

Structure

4.1 Introduction-

Sexual behaiour in animals is a complex and fascinating topic that has intrigued researchers for centuries. The study of animal mating behaiour has provided important insights into the mechanisms that drive sexual selection, reproductive success, and species diversity. However, these observations also have implications for our understanding of human sexual behaiour in modern society. With the emergence of monogamous pair-bonding as the dominant mating system in many human societies, we must ask ourselves whether these behaiours are uniquely human, or whether they have evolved from a broader repertoire of mating strategies observed in the animal kingdom. The study of sexual behaiour in animals, using both evolutionary and social perspectives, can provide a rich framework for understanding the diversity of sexual behaiour observed in modern society. By exploring the evolutionary and ecological forces that shape animal mating behaiour, one can gain new insights into the complexities of human sexuality and relationships.

The evolution of sexual behaiour in animals is a multifaceted process, shaped by a range of ecological, genetic, and social factors. Sexual selection, which occurs when individuals compete for access to mates or when mate choice influences the reproductive success of individuals, is a major driver of sexual behaiour evolution. This process can result in the development of elaborate and often exaggerated traits used to attract mates, such as bright colors, complex vocalizations, or intricate courtship displays. Additionally, the balance between the costs and benefits of mating, as well as ecological factors such as resource availability and predation risk, can influence the evolution of mating systems and behaiours. The study of sexual behaiour in animals, using both observational and experimental methods, has provided valuable insights into the complex interplay between genetics, behaiour, and the environment in shaping the diversity of mating strategies observed in the animal kingdom.

Objectives

After studying this unit you should be able to know-

- Courtship, Sexual selection
- Mating pattern: Monogamy, Polygamy, Polyandry
- Sexual conflict, Parental investment
- Infanticide, Female choice, Male quality

4.2- Courtship

Courtship involves the various movements and behaiours that are exhibited during the process of pair formation and copulation. One crucial function of courtship is to coordinate the behaiour of males and females to enable successful mating. Courtship can be observed in animals that reproduce either internally or externally. It is particularly prominent in arthropods, mollusks, fish, birds, and mammals. The initiation of courtship behaiour is tightly regulated by an internal biological clock, which can be influenced by factors such as photoperiod and temperature, through the endocrine system.

Characteristics of courtship

- Typically, only one gender engages in displays to attract potential mates.
- These displays may involve colorful patterns, ornamental appendages, or vocalizations.
- This type of advertisement is a vital component of courtship and may be visual, auditory, or olfactory, depending on the sensory abilities of the particular species.
- However, these displays also put the individuals at risk of predation, as they become more conspicuous to predators.

A courting animal can draw attention to itself with the following signals

• **Visual**: Color patterns, waving feathers or appendages, such as the peacock's dance and display of feathers. Male butterflies locate their females by observing their zigzag flight pattern.

• **Sound**: High-pitched sounds are produced by invertebrates through the flapping of wings or rubbing of appendages, while vertebrates use moans, grunts, and barks. Examples include the croaking sounds of frogs and toads, and the songs of birds with stanzas, paras, and melodies.

• **Light:** The opposite sex is attracted by light pulses, such as those emitted by members of the syllidae family or the flashes of light produced by fireflies. Glow worms also flash lighted segments of their abdomen to attract males.

• **Pheromones**: This form of olfactory communication involves the use of chemical messengers called pheromones. Female silk moths, for example, produce the pheromone bombykol from glands in their abdomen, which male moths detect using their antennae. Queen termites and honeybees also release pheromones to attract drones for nuptial flights.

• **Tactile:** Tactile stimuli can include rubbing, pushing, nudging, coiling, twining, licking, clasping, and necking. Male elephants, for instance, caress a female elephant's head, trunk, and tusk after chasing her, before caressing her back until she indicates her willingness to mate. Grooming in non-human primates and preening in birds are other examples of tactile signals

• **Mate guarding**: Mate guarding refers to the behaiour in which one mate member of a species prevents another mate member of the same species from mating. Generally, the male remains near the female to prevent other males from copulating with her, ensuring his paternity. This phenomenon can be observed in animals such as soapberry bugs and Seychelles warblers. In some cases, animals block the vaginal passage of the female by a mating plug, vaginal plug, or sperm plug, formed of a gelatinous secretion produced by the male. This behaiour can be observed in animals such as bears, rats, reptiles, squirrels, scorpions, and parasitic worms.

• **Brood care:** Brood care is a crucial aspect of reproduction in many courting animals, where one or both parents provide parental care to their offspring after mating. Nest building by courting animals is a common phenomenon. For instance, in some bird species such as penguins, the male and female take turns to incubate the eggs and care for the chicks until they are ready to fledge. Another example is the male seahorse, which carries the fertilized eggs in a special pouch until they hatch and release the fry. This parental investment ensures the survival of the offspring and increases their chances of reaching adulthood. Brood care can also strengthen the bond between the parents and help them to form a successful breeding pair in the future.

• **Sexual suicide:** Also known as terminal investment, is a phenomenon in which animals invest heavily in reproduction at the expense of their own survival. This often occurs when the animal has a limited opportunity to mate or reproduce, and must expend all of its resources to ensure its genes are passed on to the next generation. One well-known example of sexual suicide is the male antechinus, a small marsupial found in Australia. During the mating season, the male antechinus will mate with as many females as possible, resulting in a surge of testosterone that leads to a rapid decline in its health. The male will eventually die from stress, infection, or other health complications, but not before passing on his genes to as many offspring as possible. This strategy is risky, but it can be successful in environments where mating opportunities are scarce or unpredictable.

• **Feeding or nuptial gift**: feeding or nuptial gift is a behaiour in which males of many animal species gift-wrap food to present it to their female. Many birds feed each other while courting. In most species, males present solid or regurgitated food to soliciting females. For example, a male common tern carries a fish around the breeding colony and shows it to the female. After the pair bond is formed, the male feeds the female with fish, and when the female is busy eating, the male copulates. By doing this, he is providing extra food to the female to lay healthy eggs and, in turn, spares his own life.

Examples of courtship behaviour:

- **Courtship in three spined stickleback fish**: Courtship behaiour in three-spined stickleback fish is a complex and fascinating process that involves both physical displays and strategic behaiour to ensure successful reproduction.The three-spined stickleback fish (*Gasterosteus aculeatus*) is a common species of fish found in freshwater and saltwater habitats around the world. Courtship behaiour in three-spined stickleback fish involves a complex sequence of behaiours exhibited by both males and females.Males of the species build nests by selecting and clearing out suitable areas, then constructing a nest from plant material, pebbles, and other debris. Once the nest is constructed, the male will begin to court females by swimming around them and performing a zig-zag display, showing off his brightly colored fins and attempting to lure the female into his nest.If the female is interested, she will approach the male and inspect his nest. If she approves, she will then lay eggs inside the nest. The male then fertilizes the eggs and guards them until they hatch.During the courtship process, the male may also exhibit aggressive behaiour towards other males to prevent them from entering his territory or disrupting his courtship display.courtship behaiour in three-spined stickleback fish is a complex and fascinating process that involves both physical displays and strategic behaiour to ensure successful reproduction.

- **Courtship in jewel fish:**Jewel fish, also known as African cichlids, are a group of freshwater fish native to Africa. Courtship behaiour in jewel fish is a complex process that involves a series of behaiours and signals exchanged between males and females.During courtship, the male jewel fish will establish a territory and try to attract a female to his area. He will then display a series of aggressive and submissive behaiours, such as flaring his fins and gill covers, and swimming in a zigzag pattern, to signal his interest and readiness to mate.If the female is receptive, she will display a series of behaiours, such as approaching the male, and allowing him to swim around her, indicating her interest in mating. The male may then chase the female around the tank and try to nudge her with his head or body.Once the female is ready to mate, she will lay eggs on a flat surface such as a rock or the substrate. The male will then fertilize the eggs by releasing sperm over them. After mating, the female will typically guard the eggs and the male will defend the territory.Overall, courtship behaiour in jewel fish is an important aspect of their reproductive cycle, helping to ensure successful mating and the survival of their offspring.

- **Courtship in *Tilapia***: *Tilapia* is a genus of freshwater fish that exhibit a variety of courtship behaiours. In general, courtship in Tilapia involves the male establishing a territory and then attracting a female to enter that territory for mating.One common courtship behaiour in Tilapia is nest building. Male Tilapia will clear out a circular area on the bottom of the water body, usually in a shallow location, and build a nest using plant material, sand or other debris. The male Tilapia will then begin to swim around the nest, fanning his fins and flaring his gills to attract females.Once a female is attracted to the nest, the male will begin a series of movements, swimming in circles around her, and darting towards her and then away. The male may also display his fins and coloration to the female. If the female is receptive, she will move towards the male, and the pair will engage in a side-by-side swim, followed by a vertical swim in which the female releases her eggs and the male releases his sperm.In some species of Tilapia, the male will build multiple nests, and the female will visit each nest in turn to spawn. After spawning, the male Tilapia may continue to guard the nest and eggs from predators and other fish until they hatch.Overall, courtship behaiour in Tilapia involves the male establishing a territory, building a nest, attracting a female to enter the territory, and engaging in a series of behaiours and movements to encourage the female to mate.

- **Courtship in guppy fish**: Guppy fish, also known as *Poecilia reticulata*, are popular aquarium fish known for their colorful appearance and active behaiour. Courtship behaiour in guppies involves a combination of visual displays, fin displays, and physical interactions between males and females.Male guppies typically initiate courtship by swimming rapidly around a female, displaying their bright colors and extended fins. They also perform a "sigmoid display," where they arch their bodies and point their heads downward towards the female. This display is thought to stimulate the female and indicate the male's fitness and readiness to mate.During courtship, males may also flare their gill covers and quiver their fins in front of the female. In some cases, they may perform a "shivering display," where they rapidly vibrate their body while swimming towards the female.Female guppies may respond to the male's displays by swimming closer to the male and positioning their bodies parallel to his. They may also display their own fins and coloration in response to the male's courtship displays. If the female is receptive to the male's advances, they may engage in physical contact and mating.Overall, courtship behaiour in guppies is a complex and dynamic process, with males and females engaging in a variety of visual displays and physical interactions in order to attract mates and reproduce.

4.3 Sexual selection

Sexual selection is a mechanism by which one gender showcases attractive physical or behaioural characteristics to attract a mate for mating. These traits may include features like plumage, fur, antlers, or horns. Sexual selection is an evolutionary process that is typically more pronounced in males than females. Charles Darwin categorized sexual selection into two types: intrasexual selection and intersexual selection**.**

Intrasexual selection: Intrasexual selection involves competition between members of one sex for access to the other sex. This type of selection tends to favor the evolution of traits such as male aggression, larger body size, sharper teeth, and increased fighting ability.

Intersexual selection:Intersexual selection refers to the process whereby the more selective gender determines which members of the opposite sex are granted the opportunity to mate. Sexual selection is a potent evolutionary force, as evidenced by the brutal and sometimes fatal battles that take place among males to secure a mate. In certain species of ants, for example, female Cardiocolldyla ants use their mandibles to pierce, crush, decapitate, or sever the legs and antennae of young males, to eliminate newly adult rivals for the few dozen virgin females that may emerge in their nest. In species where large males can monopolize access to numerous receptive females, sexual dimorphism in body size is likely to occur. Male size is smaller in monogamous species such as the harbour seal, where males and females are almost equal in size and weight, whereas in polygamous species, males are typically larger in size and weight than females due to their ability to mate with a disproportionate number of females per breeding season.

4.4 Mating pattern

Mating patterns refer to the various ways in which members of a particular species engage in reproduction. There are several types of mating patterns that exist in the animal kingdom, including monogamy, polygamy, and promiscuity.

4**Monogamy:**Monogamy is a type of mating pattern where a single male and a single female mate exclusively with each other. This pattern is observed in some bird species and certain mammalian species such as wolves and beavers.**Polygamy:**Polygamy, on the other hand, involves an individual mating with multiple partners. This pattern can be further divided into two types: polygyny and polyandry. Polygyny occurs when a single male mates with multiple females, which is observed in some ungulate species such as deer and elk. In contrast, polyandry occurs when a single female mates with multiple males, which is observed in certain bird species like the phalaropes.

Promiscuity or extra-pair copulation (EPC) is a mating pattern where multiple males and females mate with each other. This type of mating pattern is observed in some fish and insect species. Mating patterns have a significant impact on the social structure and behaiour of animal populations. Understanding these patterns is crucial for conservation and management efforts. For females to engage in EPC, they must have a good reason, such as improving the genetics of their offspring between clutches to ensure that they have multiple offspring with a wide range of genetic variation. This, in turn, increases the chances of adaptation and survival of their offspring in the environment.

There are several hypotheses for the plausible explanations for EPCs:

Courtship feeding before copulation: In some species, females trade copulation for food. Females also engage in EPCs for additional benefits such as the opportunity to forage in the territory of a new male or additional protection.

Male parental care: According to this hypothesis, females obtain extra help to feed their young ones by copulating with other males.

Insurance against male infertility: Females copulate with more males as an assurance against the possible infertility of their own mate. Females also engage in EPCs to reduce the risk of mate loss.

Genetic diversity and quality: Females engage in extra-pair copulation to gain good genes that would benefit the genetic fitness of their offspring. In an unpredictable environment, females might benefit from genetically diverse offspring (Williams, 1975; Gladstone, 1979).

4.5- Sexual conflict

The term "sexual conflict" refers to the competition and conflict between males and females to maximize their reproductive success, which can result in a struggle between the sexes. The conflict can arise due to differences in reproductive interests between the sexes, such as the amount of parental investment required to produce offspring. For instance, in many species, males compete with each other for access to females, while females may choose mates based on traits that indicate good genetic quality or parental investment. This can create a tug-of-war between the sexes, with males evolving traits that enhance their ability to mate with multiple females, and females evolving traits that enhance their ability to select high-quality mates. Understanding the dynamics of sexual conflict is crucial for comprehending the behaiour and ecology of animal populations, as it can significantly impact the evolution of mating systems and reproductive strategies.

4.6- Parental investment

Parental investment refers to the allocation of time, energy, and resources by a parent to their offspring to enhance their survival and reproductive success. This behaiour is widespread across the animal kingdom and can take various forms such as provisioning of food, protection against predators, and teaching of life skills. Generally, the level of parental investment is positively linked to the degree of offspring dependency and vulnerability. For instance, mammals like humans generally invest more in their offspring than birds since mammalian young are born relatively helpless and require extended care. However, there are exceptions to this pattern; some birds and fish exhibit significant parental investment, such as penguin parents that incubate their eggs on their feet in Antarctica's harsh conditions.

Parental investment theory was developed by American evolutionary biologist and sociobiologist Trivers in 1972. According to him, parental investment is any resource, time, energy, and risk that a parent uses to benefit their offspring. Females typically invest more in producing offspring than males, and this investment can be classified into different categories

Parental investment can be divided into several categories, including care before and after birth.

Care before birth involves

- investing in gamete production,
- preparing the housing for the offspring, and
- Providing care for the fertilized egg.

Care after birth may include

- protecting the young ones and
- meeting their nutritional requirements.

4.7 Infanticide:

Infanticide refers to the killing of progenies after birth.This phenomenon is observed in many animal species, where individuals kill the offspring of others. This behaiour can be motivated by various factors, such as

- eliminating potential competition,
- increasing the reproductive opportunities of the perpetrator, or
- simply seeking food.

Infanticide can occur within a species, where individuals kill the young of their own kinde.g. blue footed booby and black eagle sibling kill a weaker sibling. The parents are generally indifferent to this behaiour not just as the result of offspring’s selfish genetic tendencies but also as part of parental strategies to identify the best offspring and to concentrate resource where they will do most benefit. Sometimes parent also kill the weaker baby in the nest.

Infanticide can also occur across the species, where predators kill the young of their prey. Infanticidal behaiour can also vary in frequency and severity depending on ecological and social factors, such as population density, access to resources, and the level of parental investment. For example, infanticide is more commonly observed in species where females mate with multiple males and where males have little to no parental investment. Some species, such as chimpanzees, have been observed engaging in infanticide as a means of group control, where males eliminate offspring from other groups to increase their own reproductive opportunities. While infanticide may seem counterintuitive from an evolutionary perspective, it is a common and complex behaiour that has shaped the reproductive strategies and survival of various animal species.

4.8- Female choice:

Female choice, also known as mate choice, is a phenomenon observed in many animal species where females actively select their mates based on certain traits or behaiours. In many cases, female choice is the result of sexual selection, where males compete with each other for access to females and traits that are attractive to females become more common over time. Traits that are often favored by females include physical characteristics such as size, coloration, and ornamentation, as well as behaiours such as courtship displays, songs, and dances. Female choice is thought to be driven by the desire to increase the quality of offspring and improve their chances of survival and reproductive success. Genetically these beautiful physical traits are associated with “good genes” that has better chances of survival. For example, female birds may choose mates based on their ability to provide resources such as food or nesting materials, while female primates may choose mates based on their social status or ability to defend them from predators. Overall, female choice plays a critical role in shaping the evolution of various animal species and can have significant impacts on the traits and behaiours of both males and females.

4.9 Male quality and courtship:

Male quality and courtship behaiour are important components of animal behaiour that influence mating success. In many species, males compete with each other for access to females, and those that exhibit certain desirable traits or behaiours are more successful in attracting mates. These traits may include physical characteristics such as size, strength, or coloration, as well as behaioural traits such as courtship displays, vocalizations, or offering of gifts. Courtship behaiours can range from simple displays of physical prowess, such as the mating dances of birds, to complex behaiours that involve the exchange of gifts or food, as seen in some species of insects and spiders. The quality of males can also be determined by their ability to provide resources or defend the female and their offspring from predators or other males. Overall, male quality and courtship behaiour play a critical role in shaping mating dynamics within animal populations, and can influence the evolution of physical and behaioural traits over time.

4.10 Summary

Sexual reproduction generates a setting characterized by conflict and competition among individuals as they strive to maximize their genetic contribution to future generations. Typically, males produce smaller gametes and endeavor to fertilize as many eggs as possible, while providing little or no care for the offspring. Conversely, females produce larger, fewer gametes and often engage in parental care, resulting in a lower potential rate of reproduction compared to males. Consequently, receptive females are scarce, leading to competition among males for access to them, while females have the luxury of selecting from numerous potential partners. However, certain species exhibit reversed sex roles, offering an opportunity to test the theory that sex differences arise from variances in relative parental investment or potential reproductive rates.

Evolution through sexual selection occurs when genetically distinct individuals experience varying levels of reproductive success due to (1) competition within a single sex for mates or (2) differential attractiveness to members of the opposite sex. The competition for mates component of sexual selection underlies the evolution of various aspects of male reproductive behaiour, including competition for social dominance, alternative mating tactics, and male guarding following copulation. Although males typically exert selection pressure on each other in the pursuit of mates, females ultimately hold the power over reproduction as they control the production and fertilization of eggs. Interactions between the sexes can be seen as a combination of cooperation and conflict, as males aim to secure fertilizations within a game defined by the female's reproductive mechanism.

In many species, females often select among potential mates, giving rise to the mate choice component of sexual selection. Male individuals of numerous species attempt to win favor with females by offering offspring with maternal benefits, such as nuptial gifts, resource monopolization in territories, or parental care. Even in species where males do not provide tangible benefits, females still exhibit mate choice. Such selection may occur because females choose males whose genes enhance the viability of their offspring (good genes theory) or due to female preferences for elaborate ornaments, indicating healthy and parasite-free males (healthy mate theory). Alternatively, arbitrary elements of male appearance or behaiour may serve as the basis for female preferences, leading to the spread of exaggerated variants of these traits through runaway selection. A fourth possibility is that extreme male ornaments evolve through an escalating cycle of conflict between the sexes, where males become increasingly adept at exploiting female reproductive systems, and females become more resistant to ornament-based courtship (chase away selection theory). The relative significance of these various mechanisms of sexual selection remains to be determined.

Males often attempt to bypass female mate choice by attempting to inseminate unwilling females. Conflict between the sexes can also manifest in other forms, such as infanticide and sexual harassment, illustrating that what may be advantageous for one sex can be detrimental to the other.

4.11 Terminal Question

Q1. Explain the evolutionary aspect of sexual selection.

Q2. How does female choice and male quality affect the sexual selection.

Q3. Explain the mating pattern in animal kingdom with suitable example.

Q4. Write short notes on a) sexual selection b) extrapair copulation c) infanticide.

Q5. Explain the correlation between brood care feeding and aggression.

Q5. Define courtship behaviour. Explain the basic features of courtship behaviour.

Q6. List the different signal by which the courting animals draw attention to it.

SAQ-1 Match the following:

1.Ventro dorsal position	a)Ring dove
2.Mantis	b)jewel fish
3.Viviparity	c)dating male
4.Peacock	d)sexual selection
5.Bowing and cooing	e)mating

SAQ-2: Fill in the blanks:

1. ________ discovered courtship in stickle back.
2. Scientific name of guppy fish is _____________.
3. Males in many animals gift wrap food to present it to their female called_____________.
4. ____________selection favors the evolution of male aggression or aggressive characters large body size, large horns sharper teeth and more fighting abilities.
5. Male parental care, feeding before copulation, insurance against male infertility may be the advantage in ____________.

SAQ -3 state true or false

1. Stickle backs are mouth breeders.
2. Grasshopper produces sound by stridulating.
3. Nipping at the nest site is done by jewel fish.
4. Bees do not go for nuptial flight.
5. Extra pair copulation provide advantage to female.

SAQ-4 Multiple choice question:

1. Courtship in stickle back was reported by
   a)Lorenzb)Tinbergen c)Frisch
2. Spermatophore is deposited by

a)Newt b)peacock c) guppy

3. presentation of food filled cocoon is found in

a) crickets b)mantis c)cupid fly

4. large horns, sharp teeth are the consequences of

a)intersexual selection b)intrasexual selection c)both

5. *Hemichromisbimaculatus* is the scientific name of

a) stickle back b) guppy c)jewel fish

UNIT-5: Biological rhythms

Structure:

5.1. Introduction

Within the intricate fabric of life, a concealed rhythm dictates our very existence—a subtle yet powerful force that impacts our well-being, behaviour, and overall health. This force is none other than the extraordinary mechanism referred to as the biological clock. Imprinted deep within our essence, the biological clock orchestrates a harmonious interplay of physiological and psychological processes, aligning them with the rhythm of passing time.

From the moment we awaken to the world, the biological clock sets the stage for our daily routines, regulating our sleep-wake cycles, body temperature, hormone production, and myriad other vital functions. But its influence extends far beyond mere physicality, reaching into the depths of our cognition, mood, and behaviour. Unveiling the intricate interplay between the biological clock and human health and behaviour offers a glimpse into the delicate balance that shapes our lives.

Within this chapter, we embark on a captivating exploration into the realm of the biological clock and its profound impact on human existence. Through a detailed examination of the intricate mechanisms that govern our circadian rhythms-those essential 24-hour cycles that regulate our internal clocks-we uncover the enigmatic secrets behind our sleep patterns, energy levels, and even our susceptibility to specific diseases. Moreover, we delve into the far-reaching consequences that disruptions to the biological clock can have on our well-being, delving into the effects of factors such as shift work, jet lag, and contemporary lifestyle choices. These disruptions can result in profound repercussions, encompassing everything from mood disorders to disturbances in metabolic equilibrium.

Furthermore, we explore the fascinating interconnections between the biological clock and human behaviour. From our ability to learn and remember to our propensity for risk-taking and social interactions, the biological clock weaves its intricate threads through the tapestry of our actions and decisions. Understanding this complex relationship opens up new avenues for optimizing our daily routines, enhancing productivity, and fostering mental and emotional resilience.

As we set forth on this expedition into the realm of the biological clock, we unearth the profound influences it exerts on every facet of our existence. In doing so, we seek to cultivate a deeper comprehension of our own nature and the intricacies that define our humanness.

Objectives

After studying this unit you should be able to know-

- Biological rhythm: Circadian and circannual rhythm
- Orientation and navigation
- Masking and entrainment
- Phase shift, phase response curves (PRC)
- Biological rhythms and human health
- Sleep, neural mechanisms of sleep

5.2. Biological rhythm: Circadian and circannual rhythm

5.2.1. Biological rhythm: A biological rhythm refers to any recurring alteration in the level of a bodily substance or function. These rhythms exhibit cyclic patterns that span from hours to years and are influenced by the rotation of the Earth, affecting living organisms and plants. The presence of cues or stimuli determines whether a biological rhythm is internal **(endogenous**) or external (**exogenous**). Internal rhythms are regulated by the organism's biological clock, such as the cycle of body temperature, whereas external rhythms synchronize the internal cycles with outside stimuli, like sleep-wake patterns and day-night cycles. These stimuli, known as **zeitgebers** (from the German term meaning "time givers"), play a role in influencing an organism's internal clock. Light, for instance, is a well-known zeitgeber that prompts some organisms to awaken while inducing sleep in others. Disruptions in these cues can potentially lead to health issues and functional challenges for an organism. The concept of zeitgebers was introduced by Jurgen Aschoff, a German biologist who extensively studied circadian rhythms, in 1954. One can think of a zeitgeber as a natural alarm clock, triggering changes in an organism's internal clock as a signal to wake up, eat, or engage in various activities. These stimuli include environmental factors like sunlight, food, noise, and social interactions. Zeitgebers assist in resetting the biological clock to a 24-hour day. Based on their duration, biological rhythms can be categorized into three types:

- **Circadian biological rhythms**, which have a roughly 24-hour cycle;
- **Infradian biological rhythms**, which occur over a period longer than 24 hours, such as menstrual cycles; and
- **Ultradian biological rhythms**, which have cycles shorter than 24 hours, such as heartbeats or sleep cycles.

5.2.1.1.Circadian rhythms: Circadian rhythms refer to rhythmic patterns in physiological functions that occur approximately every 24 hours, extending beyond the typical 24-hour period. For example, the sleep-wake cycle demonstrates a series of changes in temperature, heart rate, respiration, and metabolism throughout this timeframe. Circadian rhythms combine elements of both daytime and nighttime activities. The biological clock, which is reset by zeitgebers and the Suprachiasmatic Nucleus (SCN), responds to factors like bright light, exercise, and temperature, resulting in phase shifts and entrainment by altering light/dark cycles.

Commonly measured properties of these rhythms include period, phase, and amplitude.

- **The period** refers to the time required to complete one cycle, typically measured from peak to peak but can be measured from any specific position on the curve.
- **The phase** represents the relative position on the curve (e.g., the peak) in relation to a specific time, such as when placed in constant darkness.
- **The Amplitude** measures the recorded output from the midline of the curve to either thepeak or trough. (fig.5.1.)

Free running rhythm and entrained rhythm: Circadian rhythms, which are internally generated, can sustain themselves without relying on cyclic variations in the physical environment. When these rhythms continue to occur even in the absence of external cues, they are considered to be in a **free-running state**. The process by which a self-sustaining circadian rhythm adjusts and aligns itself with a time-giving cue, such as light, is known as **entrainment.**

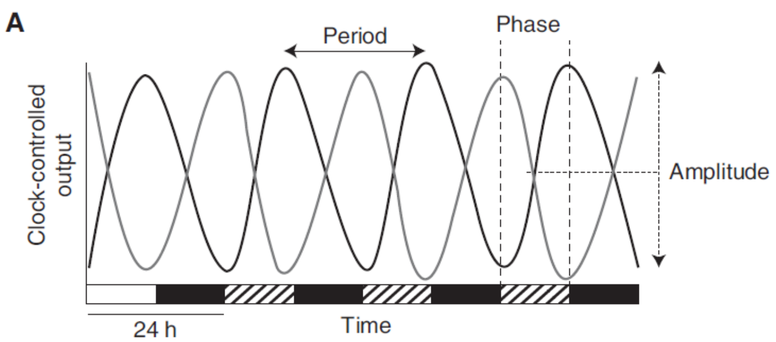


Fig 5.1.Properties of a circadian rhythm

5.2.1.2. Infradian biological rhythms: Infradian biological rhythmsencompass rhythms that extend beyond one day in duration. For instance:

- **Menstrual cycles**, which typically last for 28 days, can be influenced and disrupted by hormones and other factors. Research has indicated that when multiple women live together without taking oral contraceptives, they tend to synchronize their menstrual cycles. This phenomenon could possibly be attributed to the release of chemical pheromones, creating a scent-based influence.

- **Seasonal Affective Disorder** is characterized by a severe disruption in mood, primarily caused by increased darkness leading to higher melatonin levels. Phototherapy is a treatment method employed to address this disorder.

5.2.1.3.Ultradian rhythmsrefer to cycles with a duration shorter than one day. Examples include sleep and its various stages. Light and deep sleep stages, lasting approximately 90 minutes, constitute distinct phases within the ultradian rhythm of sleep.

In the context of sleep, there are different stages, namely NREM (non-rapid eye movement) and REM (rapid eye movement). N1 and N2 represent shallow sleep stages, while N3 corresponds to deep sleep or slow wave sleep (SWS). These cycles continue throughout the night, with SWS gradually decreasing in duration and REM sleep lengthening as the night progresses. In early infancy, these cycles last approximately 60 minutes, whereas in adolescence, they extend to around 90 minutes. Electroencephalography (EEG) is a useful tool for observing the electrical activity of the brain during sleep, revealing distinct patterns at different stages.Lastly, a circannual cycle occurs on a yearly or annual basis. This can be observed in phenomena such as animal hibernation and patterns of waking**.**

5.2.1.2.Circannual rhythms: Circannual rhythms refer to internally generated oscillations in biological processes that occur over a period of approximately one year or 12 months. These rhythms lead to changes in physiology and behaviour in long-lived animals on a yearly basis. Many different examples of circannual rhythms can be observed in the animal kingdom. Noteworthy examples include insect pupation rhythms, animal migration patterns, pelage growth, hibernation, reproduction, and molt cycles. The presence of circannual rhythms is advantageous as they have evolved to ensure the long-term success of biological functions. Misalignment of these rhythms with the seasonal changes in the environment can have significant negative impacts on an organism's fitness. For instance, organisms strategically reproduce when food availability is optimal, which directly influences the survival of their offspring.

5.2.2. **biological clock**: Biological clocks refer to an organism's inherent timing mechanism, consisting of specific molecular proteins that interact within cells throughout the body. These biological clocks are present in nearly every tissue and organ. Scientists have discovered similar genes in various organisms, including humans, fruit flies, mice, and fungi, which are responsible for constructing the components of these clocks. Biological clocks generate circadian rhythms and govern their timing. Within a living organism, a "master clock" in the brain plays the role of coordinating all the biological clocks, ensuring their synchronization. In vertebrate animals, including humans, this master clock is a cluster of approximately 20,000 neurons known as the suprachiasmatic nucleus (SCN). The SCN is situated in a region of the brain called the hypothalamus and receives direct input from the eyes. It serves as the primary control center for sleep and temperature circadian rhythms. The internal clock is housed within the SCN and regulates the production of melatonin by the pineal gland. The circadian rhythms are aligned with the external day-night cycle by the SCN. This external information reaches the SCN through an optic nerve projection from the retina. The internal clock, residing in the SCN, plays a role in regulating the production of melatonin by the pineal gland.

5.3. Orientation and navigation

5.3.1. Orientation:

Orientation refers to an animal's position relative to gravity or a resource. It is the position maintained by the animal to access the desired resource. Vertebrates possess a membranous labyrinth, while invertebrates have a statocyst to maintain an upright posture against gravity, which is known as positional orientation.Object orientation occurs when an animal approaches an object, such as food or water. Aquatic animals exhibit **strato-orientation** as they move vertically in ponds or lakes. When animals move between different habitats like grasslands, forests, deserts, or mountains, it is referred to as **zonal orientation**. Animals that migrate long distances often possess **topographical or geographical orientation**. Orientation can further be categorized into kinesis and taxis.

5.3.1.1.Kinesis

Kinesis is the movement of an animal in response to stimuli. It can be either oriented or undirected, depending on the source of the stimulus. The response may be proportional to the intensity of the stimulus.

Klinokinesis refers to a change in direction during movement, which may increase or decrease based on the intensity of the stimulus. Typically, the animal alternates its movement right and left to compare the stimulus direction and achieve correct orientation. Animals with a single receptor exhibit these alternating movements, as seen in caterpillars and maggots searching for pupation sites.

Orthokinesis reflects the speed of locomotion, which is related to the intensity of the stimulus and the accumulation of action-specific energy in the animal. The entire body of the animal is involved in this response. For instance, burrowing animals like Ammocoete larvae of lampreys burrow in sand to move away from light, while cockroaches move from brighter areas to darker ones.

Different types of kineses are classified based on the stimulus they respond to. For example,

- **Hygrokinesis** pertains to humidity and is observed in isopods**,**
- **Photokinesis** involves responding to a gradient of light, and
- **Chemokinesis** is the response to chemical stimuli.

5.3.1.2. Taxis

Taxis refers to the animal's orientation in relation to the direction of a stimulus in space. It involves movement either towards or away from the stimulus, and different terms are used depending on the nature of the stimulus:

- **Hygrotaxis** relates to humidity.
- **Geotaxis** pertains to gravity.
- **Chemotaxis** involves taste or odor.
- **Thermotaxis** relates to temperature.
- **Anemotaxis** involves air currents.
- **Rheotaxis** is in response to water currents.
- **Phototaxis** relates to light intensity.
- **Phonotaxis** responds to sound waves.
- **Astrotaxis** is in response to celestial bodies such as the sun, moon, and stars.
- **Menotaxis** involves maintaining a specific angle to the stimulus.
- **Mnemotaxis** is based on memory.

Klinotaxis occurs in animals that possess a single receptor, such as *Euglena*. They compare the intensity of the stimulus through alternating lateral movements. Similarly, maggots of Diptera have a light-sensitive organ located above and behind the mouth, and their response to light is compared through flexing movements of the body.

Tropotaxis is observed in animals with paired receptors, like eyes in Planaria. The animal receives equal inputs from both receptors, allowing it to move in a straight line towards or away from the light. If one eye of an insect is painted black, it exhibits circling movements towards the side with the painted eye.

Telotaxis occurs when an animal has a choice between positive and negative stimuli or when the input from the two receptors is unbalanced. The orientation is influenced by fixing the image on one side by moving the head and making a choice. For example, a honey bee encountering two light sources will select one by making a choice.

Menotaxis involves maintaining a constant angle in relation to the stimulus source. Nocturnal moths, for instance, keep the light source (typically stars and moon) at a right angle to their body to fly parallel to the ground. However, when exposed to artificial light that is too close, they are compelled to fly in circles. Honey bees navigate from their hives to flowers by maintaining a constant angle to the sun, as indicated by the wagging dance of scout bees. Foraging bees then follow the same angle to the sun while observing the dance on the vertical surface of the comb, guiding them towards the food source.

Mnemotaxis, first described by Kuhn (1919), involves orientation based on memory. It was studied by Niko Tinbergen (1951) in his experiment with digger wasps. The wasp circles around the nest and carries a memory map of the nest and its surroundings, enabling accurate orientation and return to the nest. This form of orientation is also known as zonal or geographical orientation, as it involves distance, direction, and landmarks that define the topography of the area and assist the animal in homing to its nest.

5.3.2. Navigation

Migratory creatures that cover vast distances, either for breeding purposes or to escape harsh climates, must accurately navigate across various terrains such as oceans, deserts, forests, and mountains. Fish, birds, and many invertebrates possess remarkable abilities to traverse oceans, deserts, and mountains in order to reach their intended destinations.

Invertebrates like crustaceans, amphipods, ants, bees, and wasps exhibit strong homing instincts and navigational skills. They rely on celestial cues such as the sun, moon, stars, and the topography of their surroundings to follow precise routes. Monarch butterflies, for instance, undertake journeys spanning thousands of kilometers from Canada to Mexico to avoid severe winters, successfully returning to the same location.

5.3.2.1.Navigation in fishes

Navigating through vast expanses of the sea and reaching destinations that lie thousands of kilometers away has long puzzled scientists studying fish behaviour. It is believed that fishes orient themselves by observing the positions of stars and the moon at night, as well as the sun during the day, to determine the direction of their swimming.

Furthermore, fish utilize temperature gradients and ocean currents both for swimming and navigation. A.S. Hasler's experiments have demonstrated that salmon, during their return journey, are guided by the scent of their parent stream. As larvae, they imprint the odour map of their home tributaries in their brains, enabling them to navigate back as adults from the sea. Eels, similarly, can migrate to the Sargasso Sea using odour maps, but the mystery lies in how their larvae, known as leptocephali, find their way back to the river mouths across vast stretches of the Atlantic Ocean. It is possible that their parents leave some form of odour trails during their own journey.

5.3.2.2.Navigation in birds

Birds employ various methods to navigate during migration. Celestial navigation is commonly used, where birds orient themselves based on the position of the sun, moon, or stars in a specific season, known as menotaxis. Remarkably, hummingbirds and pigeons can detect ultraviolet radiation emitted by the sun, allowing them to determine its position even on cloudy days.

Experiments conducted in planetariums with nocturnal migratory birds like white-throated warblers and indigo buntings have revealed their ability to navigate based on the positions of stars in the night sky. Some birds are sensitive to the Coriolis force, which arises from wind deflection caused by the Earth's rotation in the northern hemisphere.

Certain diurnal birds utilize topographical features such as mountains, river valleys, and forests as landmarks for orientation along their migration routes. Additionally, some birds can detect infrasound, which consists of low-frequency sounds produced by ocean waves. Many birds, especially seabirds, can identify their destinations by recognizing characteristic odours.

Numerous birds possess innate instincts, internal compasses, or biological clocks that guide them along their migration routes. Young birds are capable of accurately following migration routes without prior training or experience due to their inherent navigation abilities.

Specific bird species, such as oilbirds in South America and Himalayan cave swifts, possess echolocation and rely on it for guidance. A classic experiment conducted by German researcher Gustav Kramer in the 1950s supported the theory of an internal clock in birds. He placed starlings in a cage where they could see the sun, and the birds faced the direction they intended to fly. However, if the sun was not visible, they did not exhibit a specific orientation.

Similar experiments conducted by German researchers Franz and Eleonore Sauer in the 1950s, involving birds that could and could not see the night stars, yielded comparable results. Certain bird species can orient themselves based on major stars in the sky. For example, Mallard Ducks demonstrated reduced orientation ability when the brightness of the moon obscured important stars.

Some birds, like pigeons, are sensitive to changes in the Earth's magnetic field due to the presence of magnetite in their head and neck muscles. A study in the early 1970s by W.T. Keeton involved attaching small bar magnets to pigeons' backs. When released in unfamiliar locations, pigeons without magnetic bars found their way home, while those with magnets became disoriented.

In 2007, German scientists discovered tiny iron oxide crystals in the skin lining of pigeons' upper beaks, which may aid in sensing the Earth's magnetic field and identifying their geographical position. These researchers also detected cryptochromes, molecules in the retinas of migratory birds' eyes that undergo chemical changes in the presence of a magnetic field. These molecules might then influence light-sensing cells in the retina to create magnetic field-based images and assist birds in navigation during flight.

Infrasound, which travels farther than ordinary sound, originates from various natural sources such as ocean waves, winds, storms, earthquakes, and other geologic events. Birds are believed to be able to hear infrasounds that are inaudible to humans, providing them with an additional navigational capability.

5.4. Masking and entrainment

Organisms adapt to their temporary niches through two complementary mechanisms.

- The first mechanism, known as entrainment of the endogenous biological clock, restricts the activity of the organism to either the day or night.
- The second mechanism, referred to as masking, involves an alternative pathway that bypasses the pacemaker's activity. It entails a strong response from the animal during light-time, which either inhibits or enhances locomotor activities in nocturnal or diurnal species, respectively.

Masking represents the direct and immediate effects on the expression of biological rhythms induced by season-dependent environmental signals. Additionally, this masking mechanism seems to complement the entrainment of the biological clock, which allows organisms to adapt to their specific diurnal or nocturnal habitats. Mechanistically, masking occurs because sensory pathways can influence a specific behaviour independently of the biological clock.

There are several challenges associated with studying the entrainment of the biological clock and the light-associated oscillators system. These challenges arise from the fact that zeitgebers (external cues) influence the biological clock and impact the output response of the circadian system. As described earlier, masking effects occur naturally and result from the inevitable consequences of seasonal changes in the lives of organisms. Circadian rhythms not only reflect the physiological responses of biological clocks but also arise from a combination of responses resulting from masking effects and/or the entrainment mechanisms that regulate the timing of the biological clock within the animal.

Although there are noticeable differences between masking and entrained rhythms, both types of rhythms follow a similar time course. However, the transition between light and darkness (environmental changes) under masking rhythms leads to abrupt changes in animal behaviour activity, such as transitioning from rest to activity or vice versa. On the other hand, when the environment acts as a zeitgeber for entrainment of the biological clock, the behavioural transitions of the animal appear to be less abrupt. Consequently, the environmental factors affecting biological rhythms never align perfectly

Various authors have explored different masking mechanisms employed by the brain based on chronobiological studies in animals. These mechanisms are categorized according to the light-induced changes in locomotor activity responses:

a) Positive Masking: Refers to an increase in locomotor activity response in diurnal animals or a decrease in nocturnal animals due to increased lighting.

b) Negative Masking: Refers to a decrease in locomotor activity response in diurnal animals caused by decreased lighting or an increase in nocturnal animals due to increased lighting.

c) Paradoxical Positive Masking: Describes an increase in locomotor activity response in nocturnal animals exposed to increased lighting or an increase in diurnal animals after lighting decreases.

d) Paradoxical Negative Masking: Indicates a decrease in locomotor activity response in nocturnal animals when lighting is decreased or in diurnal animals when lighting is increased.

Besides the aforementioned classification of masking mechanisms based on behavioural locomotor activity responses in diurnal and nocturnal animals, other authors have categorized masking forms based on the neural mechanisms that generate these effects. These classifications are as follows:

a) Type I masking: Occurs when environmental factors such as light or darkness directly affect the output of the circadian rhythm.

b) Type II masking: Occurs when behavioural changes in an animal impact other physiological brain rhythms. For example, changes in locomotor activity can influence the temperature rhythm of an organism, thereby altering the biological clock.

c) Type III masking: Arises when physiological or biochemical changes modify the neural output of the biological clock, which conveys time-related information. Certain physiological or pathological conditions have been shown to affect specific neural pathways and their membrane receptors involved in regulating body temperature, leading to a modification in the phase of the body temperature rhythm aligned with the biological clock under normal conditions.

Studies suggest that the inhibition of melatonin synthesis and release in rats and hamsters, which is involved in masking, primarily relies on the rods, the predominant photoreceptors in the rodent retina. However, investigations on mutant mice lacking rods (rd) and experiencing a significant loss of cones demonstrate inhibition of melatonin synthesis and release as well as light-induced locomotor activity. This implies that cones and rods are not necessary for mediating the effects of light on locomotor activity, suggesting the involvement of other photoreceptor types in the retina.

Studies report the disruption of rhythmicity in drinking, locomotion, or sleep-wakefulness not only in animals exposed to constant light but also in those subjected to light-darkness cycles (L:D).

In studies involving mutant mice with two cryptochrome genes, which lack rhythmicity in constant conditions, a diminished function of the suprachiasmatic nucleus (SCN) and a loss of masking responses induced by light are observed when light pulses are applied during the subjective night. This suggests a reduction or absence of masking due to SCN lesions. However, other research indicates the persistence of masking in drinking and locomotor activity under L:D conditions after SCN lesions.

Lesions in other structures of the rodent visual system alter light masking, with a significant increase in masking observed in subjects with intergeniculate leaflet (IGL) lesions. It has been reported that masking induced by light is more pronounced in mice with lesions in the nucleus geniculatus lateralis, dorsalis (NGLd), suggesting that the increased masking observed after IGL lesions may be due to incidental damage to the NGLd. Additionally, light masking has been found to increase after lesions in the visual cortex of hamsters and mice.

The clock mutant mice exhibit distinct responses to light pulses. Bright light pulses ranging from 100 to 1600 lux completely suppress locomotor activity, displaying negative masking. Conversely, dim light pulses result in an increase in basal levels of locomotor activity, indicating positive masking, similar to normal subjects. The specific involvement of other clock genes in regulating light masking has not been identified.

Masking is not confined to laboratory conditions alone. There are instances where light has direct effects on the temporary organization of behaviour in wildlife. One remarkable example is the owl primate (*Aotus lemurinus griseimembra*), which exhibits a locomotor activity pattern influenced by the lunar cycle. Although this primate is nocturnal, its activity levels increase (**positive masking**) when exposed to luminescence between 0.1 and 0.5 lux, precisely the brightness produced by the moon. On the other hand, lower light intensities reduce the primate's locomotor activity (**negative masking**).

The masking mechanism plays a vital role in the adaptation of organisms to their environment by enabling them to respond swiftly to sudden changes in environmental conditions. Functionally, masking contributes to an enhancement in the amplitude of an entrainment rhythm and facilitates direct responses to geophysical variables selected by the organism, optimizing its evolution and adaptation to its specific temporary niche. Ultimately, these factors increase the probability of theorganism's survival in its environment

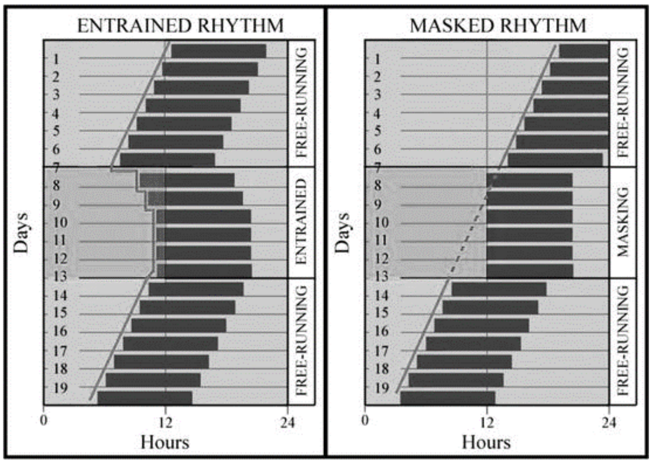


Fig. 5.2. An actogram showing free-running, entrainment, and masking effect (In this actogram, the presence of light cues from days 8 to 13 leads to the synchronization of the rhythm with the light zeitgeber. When the light cues are absent, the rhythm enters a free-running state, where it continues with its internal clock period. In the given example, the free-running period is slightly shorter than 24 hours. On the right side, masking signals influence circadian rhythms controlled by the central brain pacemaker. Masking signals cause an immediate phase change upon their presence, rather than the gradual resetting observed in phase resetting of an oscillator. During masking, the free-running rhythm of the central brain pacemaker remains unchanged, even though the behaiour appears to be aligned with the masking signal. This is evident when the masking signal is removed, and the free-running rhythm continues from the phase it would have reached had the clock continued ticking. If the response had truly been entrained, the onset of the free-running rhythm would have started from the entrained phase of the oscillator, as seen in the left actogram when the free-running rhythm resumes on day 14.)

5.5. Phase-shifting and the phase-response curve (PRC)

Transient exposure to specific environmental cues can induce a shift or reset in the phase of a rhythm (as depicted in Figure 5.3). Since free-running periods (FRPs) are nearly but not precisely 24 hours, the rhythm needs to be reset daily to prevent it from deviating from the external environmental cycle. As mentioned earlier, many organisms utilize the alternating cycles of light and darkness throughout the day as the environmental cue to entrain their rhythms to the 24-hour day. In an early study conducted on the dinoflagellate *Gonyaulax polyhedra*, a common characteristic of circadian systems was observed: the sensitivity of the biological clock to light varies across different times of the day. Subsequent research on various light-based entrainment systems in organisms has confirmed that light exposure during the early subjective night leads to a "phase-delay" shift (i.e., the rhythm is delayed to a later hour), while light exposure during the late subjective night results in a "phase-advance" shift (i.e., the rhythm is advanced to an earlier hour). On the other hand, exposure to light during the subjective day has minimal to no effect on phase shifts.

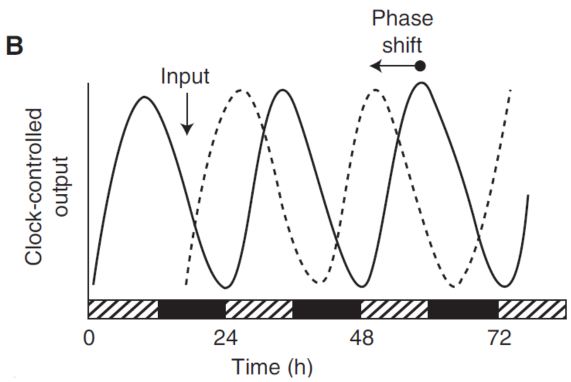


Fig. 5.3. Phase and phase shift of circadian rhythm

Hence, the organism's response to light is influenced by its internal perception of time. The magnitude and direction of these responses can be graphically represented in relation to the organism's own circadian phase when the light stimulus is presented. This graphical representation is known as a Phase-Response Curve (PRC). The PRC illustrates the extent and direction of phase-dependent responses to brief exposures of an external stimulus. On the x-axis, the circadian time is indicated when a light pulse is administered to the organism, while the y-axis depicts the change in the phase of the circadian-regulated output in response to the light pulse. Positive shifts are denoted as advances, whereas negative phase shifts indicate delays. When a brief light pulse is delivered to an organism during its subjective day (corresponding to its internal daytime), it elicits minimal to no phase response. In contrast, light exposure during the early subjective night (the organism's internal early nighttime) produces phase-delay shifts, while light exposure during the late subjective night leads to phase-advance shifts.

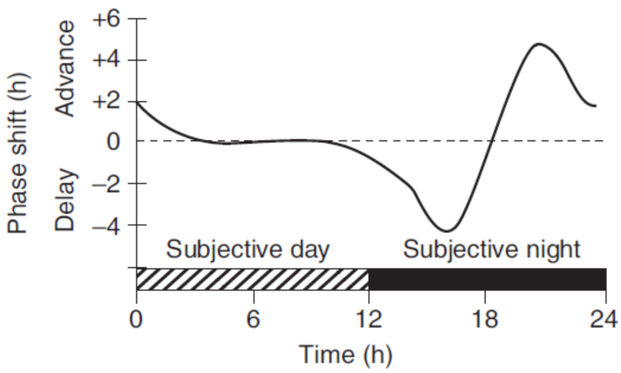


Fig. 4. Phase response curve

5.5.1. Temperature compensation

In order for a biological clock to maintain its reliability in natural surroundings, its period should remain relatively stable despite fluctuations in ambient temperature. Morning events should consistently occur at the same time, regardless of the weather conditions from the previous night. This characteristic, known as temperature compensation, arises from the observation that the Free-Running Period (FRP) of the biological clock undergoes minimal changes when exposed to different temperatures within the organism's physiological range. The impact of temperature changes on the rate of most biochemical reactions is typically quantified by a Q10 value, which represents the ratio of the rate of a specific process at one temperature to the rate at a temperature 10°C lower. Unlike many other biochemical reactions that exhibit Q10 values of 2 or 3, the Q10 value of the circadian rhythm's period remains close to 1. It's important to note that temperature compensation should not be confused with temperature insensitivity. Temperature itself can act as a potent zeitgeber in certain organisms. While individual reactions within the clock may indeed be influenced by temperature fluctuations, the system as a whole is buffered to prevent significant variations in the FRP of its rhythmic behaviours.

5.6. Biological rhythm and human health:

Biological rhythm has an impact on many aspects of our physiology. For example, circadian clocks help to regulate sleep patterns, feeding behaviour, hormone release, blood pressure and body temperature. Molecular clocks also play critical roles locally in many tissues. Ablation of clock genes in animal models results in arrhythmic production of hormones, such as corticosterone and insulin. Clock genes also exert a profound influence on metabolism through the control of gluconeogenesis, insulin sensitivity and systemic oscillation of blood glucose. Sleep is vital for normal brain function and circadian dysfunction has been linked to sleep disorders, as well as depression, bipolar disorder, cognitive function, memory formation and some neurological diseases. In rare cases, sleep phase disorders are due to mutations in circadian clock genes resulting in advanced or delayed sleepwake cycles. Studies have indicated that chronic misalignment between our lifestyleand the rhythm dictated by our endogenous circadian clock may be associated withincreased risk for various diseases including cancer, neurodegenerative diseases,metabolic disorder and inflammation. Efforts are underway to develop approachesin chronobiology and pharmacology to modify the period, phase or amplitude ofcircadian clocks to improve human health.

5.7. Sleep and neural mechanism of sleep

Sleep is a highly complex physiological process that is regulated through various mechanisms at global, regional, and local levels, involving cellular and molecular processes. While sleep is present to some degree in all animals, its expression in lower animals may overlap with periods of rest. Sleep regulation is integral to numerous behavioural and physiological functions. It is widely recognized that sleep is crucial for various vital processes, including development, energy conservation, clearance of brain waste, modulation of immune responses, cognition, performance, vigilance, disease prevention, and psychological well-being.

Sleep is a fundamental aspect of organismal existence, underscoring its physiological significance. It serves multiple essential roles in various physiological functions, encompassing development, energy preservation, clearance of waste products from the brain, modulation of immune responses, cognitive processes, performance optimization, disease prevention, maintenance of vigilance, and psychological state. Sleep has been studied and characterized across diverse species, ranging from humans, birds, fish, and flies (e.g., *Drosophila Melanogaster*) to simpler organisms like worms (e.g., *C. Elegans*). While sleep may have drawbacks, such as reduced vigilance against potential predators and the interruption of food intake and reproductive activities, animals are not constantly exposed to such pressures. Sleep likely evolved, in part, to enhance the efficiency of these physiological processes, thereby enhancing the organism's survival and reproductive success.

Traditionally, the definition of sleep in mammals is based on physiological characteristics observed in mammals, including decreased body movement and electromyographic activity, reduced responsiveness to external stimuli, closed eyes, decreased breathing rates, and alterations in body position and brain wave patterns as assessed by polysomnography (Table 1). However, when studying sleep in non-mammalian species, wakefulness and sleep are often evaluated using simpler parameters, such as decreased relative movement activity and periods of rest. In mammals, the definition of sleep primarily relies on activity and metabolism in relation to the electrical brain signals recorded in the electroencephalogram (EEG). Sleep stages are typically determined in animals by assessing both muscle activity levels in the electromyogram (EMG) and specific EEG characteristics.

5.7.1. Several structures within the brain are involved with sleep

The hypothalamus, a small structure located deep within the brain, contains clusters of nerve cells that serve as control centres influencing sleep and wakefulness. Among these is the suprachiasmatic nucleus (SCN) which consists of thousands of cells that receive direct light information from the eyes and regulate our behavioural rhythm. Individuals with damage to the SCN experience erratic sleep patterns as they are unable to synchronize their circadian rhythms with the light-dark cycle. Most blind individuals retain some ability to perceive light and can adjust their sleep-wake cycle accordingly.

- **The brain stem**, situated at the base of the brain, communicates with the hypothalamus to regulate the transitions between wakefulness and sleep. This includes structures such as the pons, medulla, and midbrain. Sleep-promoting cells in both the hypothalamus and brain stem release a neurotransmitter called GABA, which reduces the activity of arousal centres in these regions. Additionally, the brain stem, particularly the pons and medulla, plays a specific role in REM sleep by sending signals that relax the muscles responsible for body posture and limb movements, preventing us from acting out our dreams.

- **The thalamus** acts as a relay station for sensory information traveling to the cerebral cortex, which is responsible for processing and interpreting information from short-term to long-term memory. During most sleep stages, the thalamus becomes less active, allowing us to tune out the external world. However, during REM sleep, the thalamus becomes active and sends sensory signals to the cortex, giving rise to the images, sounds, and sensations experienced in dreams.
- **The pineal gland**, located between the brain's two hemispheres, receives signals from the SCN and increases the production of melatonin, a hormone that promotes sleep onset when darkness falls. Individuals who have lost their sight and are unable to regulate their sleep-wake cycle using natural light can stabilize their sleep patterns by taking small doses of melatonin at consistent times each day. The rhythmic fluctuations of melatonin levels are believed to play a role in aligning the body's circadian rhythm with the external light-dark cycle.
- **The basal forebrain**, located near the front and bottom of the brain, also contributes to the regulation of sleep and wakefulness, while a portion of the midbrain acts as an arousal system. The release of adenosine, a by-product of cellular energy consumption, from cells in the basal forebrain and other regions, promotes the drive for sleep. Caffeine counteracts sleepiness by blocking the effects of adenosine.
- Finally**, the amygdala**, an almond-shaped structure involved in processing emotions, becomes more active during REM sleep.

5.7.2. Role of neurotransmitters:

As we prepare for sleep, groups of neurons that promote sleep in various areas of the brain become increasingly active. Neurotransmitters, which are chemical messengers, play a role in "switching off" or reducing the activity of cells involved in arousal or relaxation. GABA is closely associated with sleep, muscle relaxation, and sedation. Norepinephrine and orexin (also known as hypocretin) help keep certain regions of the brain active during wakefulness. Additionally, other neurotransmitters such as acetylcholine, histamine, adrenaline, cortisol, and serotonin contribute to the regulation of sleep and wakefulness.

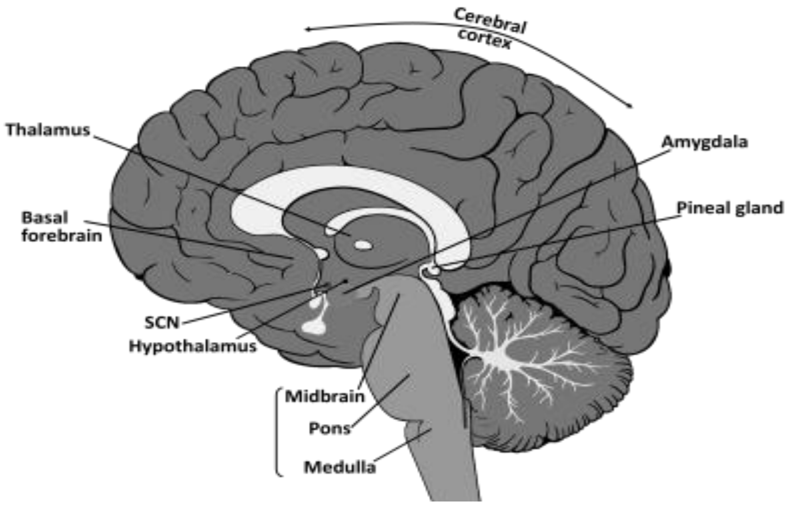


Fig. 5. Different regions of brain involved in sleep

5.7.3. Sleep Stages

Sleep can be categorized into two main types: **rapid eye movement (REM) sleep and non-REM sleep,** which consists of three distinct stages. Each type of sleep is associated with specific brain waves and neuronal activity. Throughout a typical night, you go through multiple cycles of non-REM and REM sleep, with REM periods becoming longer and deeper as morning approaches.

- **Stage 1 of non-REM sleep** marks the transition from wakefulness to sleep. This relatively short period, lasting a few minutes, is characterized by a light level of sleep. During this stage, your heartbeat, breathing, and eye movements slow down, and your muscles gradually relax, occasionally experiencing twitches. At the same time, your brain waves begin to shift from their patterns of wakefulness during the day.

- **Stage 2 of non-REM** sleep occurs after stage 1 and serves as a lighter phase before entering deeper sleep. In this stage, your heartbeat and breathing continue to slow down, and your muscles relax further. Your body temperature decreases, and eye movements cease. Brain wave activity slows down, but you may experience brief bursts of electrical activity. Stage 2 sleep occupies a significant portion of your sleep cycles compared to other stages.
- **Stage 3 of non-REM sleep** is the period of deep sleep that is crucial for feeling refreshed in the morning. It predominates during the first half of the night's sleep. During this stage, your heartbeat and breathing reach their lowest levels during sleep. Your muscles remain relaxed, and it becomes challenging to wake you up. Brain waves become even slower during this stage.
- **REM sleep**, which typically occurs around 90 minutes after falling asleep, is characterized by rapid eye movements beneath closed eyelids. Brain wave activity during REM sleep becomes more similar to that observed during wakefulness, exhibiting a mixture of frequencies. Your breathing becomes faster and irregular, and your heart rate and blood pressure increase to levels comparable to wakefulness. Most dreaming occurs during REM sleep, although some dreams can also happen during non-REM sleep. Temporary paralysis affects your arm and leg muscles during REM sleep, preventing you from physically acting out your dreams. As you age, the proportion of time spent in REM sleep decreases. It is believed that memory consolidation requires both non-REM and REM sleep.

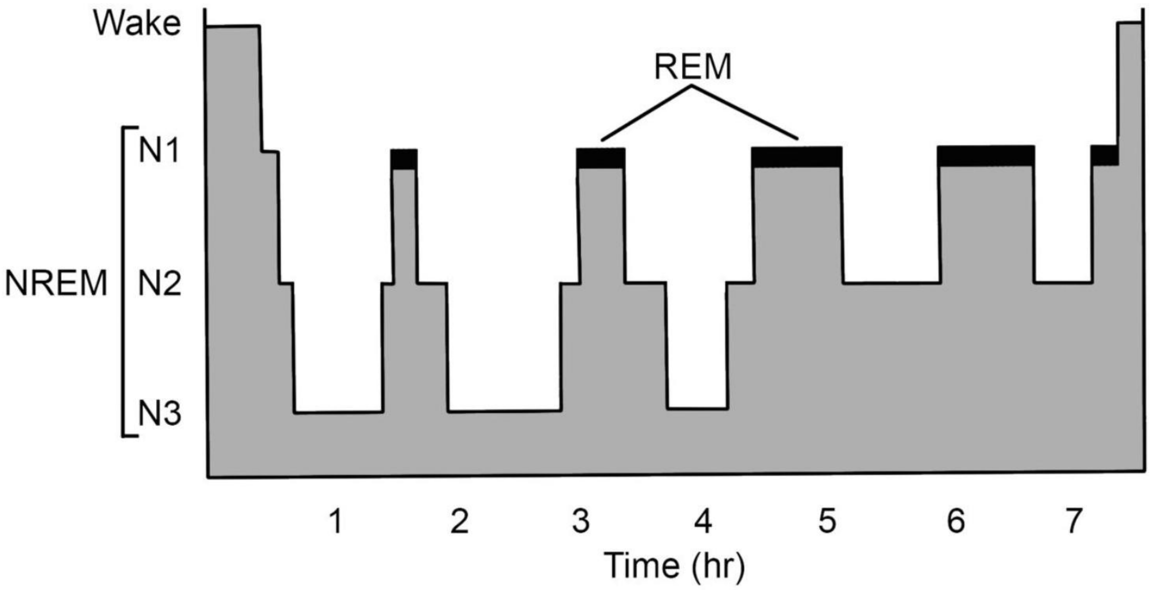
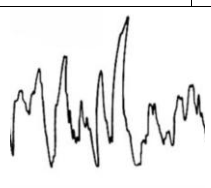


Fig.5.6. Duration of different stages of sleep

	Wake	**NREM sleep**	**REM sleep**
Physiological features	Variable Sympathetic tone	Low sympathetic tone, roving eye movements in light NREM sleep	Variable Sympathetic tone. Bursts of fast saccadic eye movements
Psychological feature	Varying amount of alertness and attentiveness	Unconscious or bland thoughts	Vivid, story like dreams
EEG pattern (5 sec)			
Developmental changes	Short wake bouts in infants and	Deep NREM sleep	Abundant in infants, steady

	young children	abundant in children, but gradually decreases across adulthood	level across

Table. 1 Physiological, psychological, EEG pattern and developmental changes at different stages of sleep

5.7.4. Sleep Mechanisms

The regulation of wakefulness and sleep is governed by two internal biological mechanisms: circadian rhythm and homeostasis, which operate in coordination.

- **Circadian rhythms: C**ircadian rhythms govern a broad range of functions, including daily fluctuations in wakefulness, body temperature, metabolism, and hormone release. They play a crucial role in determining your sleep-wake patterns, making you feel sleepy at night and naturally awakening in the morning without the need for an alarm clock. These rhythms are regulated by your body's biological clock, which operates on approximately a 24-hour cycle. While circadian rhythms can synchronize with external cues like light and temperature to align with the actual time of day, they persist even in the absence of these cues.

  Body's biological clock, which adheres to a 24-hour day, exerts control over most circadian rhythms. These rhythms impact various functions, including body temperature (depicted as the white line in the chart above). Melatonin, a hormone released by the pineal gland, promotes drowsiness when the lights are dim. The fluctuations in melatonin levels (shown as the gold line in the chart) are crucial for aligning your body's circadian rhythm with the external cycle of light and darkness.

- **Sleep-wake homeostasis**: Sleep-wake homeostasis maintains a balance and regulates the need for sleep. The homeostatic sleep drive prompts the body to sleep after a specific duration and regulates the depth of sleep. As you stay awake, this sleep drive intensifies, leading to longer and deeper sleep following a period of sleep deprivation.

Several factors influence sleep-wake requirements, including medical conditions, medications, stress levels, sleep environment, and dietary habits. Among these factors, light exposure holds significant influence. Specialized cells in the retinas of your eyes process light and relay information to the brain, indicating whether it is day or night. This light input can either advance or delay our sleep-wake cycle and make it challenging to fall asleep or return to sleep upon awakening.

Individuals who work night shifts often experience difficulty falling asleep when they go to bed, as well as struggle to stay awake while working due to disruptions in their natural circadian rhythm and sleep-wake cycle. In the case of jet lag, circadian rhythms become desynchronized from the local time when traveling across different time zones, creating a is match between the internal body clock and the actual time.

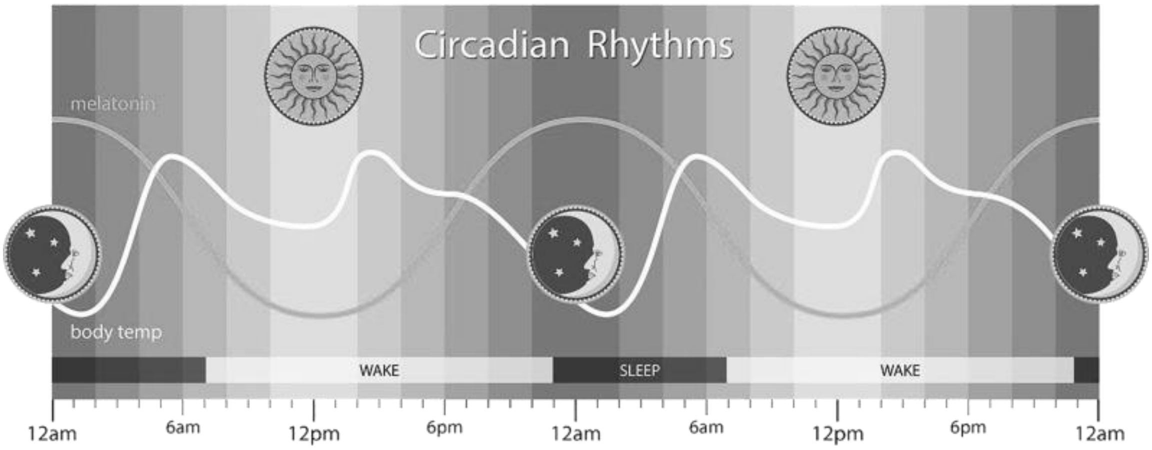


Fig. 5.7. Amalgamation of circadian and sleep wake homeostasis in regulation of sleep pattern.

5.8 Summary

Biological rhythms are recurring patterns of changes in bodily substances or functions, which can be influenced by internal or external factors and categorized based on their duration. Circadian rhythms, with a roughly 24-hour cycle, are particularly significant and involve physiological changes in response to stimuli such as light, exercise, and temperature.Organisms possess biological clocks, which are inherent timing mechanisms consisting of specific proteins that interact within cells. These clocks generate circadian rhythms and are found in various tissues and organs. The brain's "master clock," known as the suprachiasmatic nucleus (SCN), coordinates and synchronizes these biological clocks. The SCN regulates sleep and temperature rhythms and controls the production of melatonin by the pineal gland. Biological rhythms can be categorized into circadian (around 24 hours), infradian (longer than 24 hours, e.g., menstrual cycles), and ultradian (shorter than 24 hours, e.g., sleep cycles) rhythms.

Animals exhibit different behaviours related to orientation, movement, and response to stimuli. Orientation refers to an animal's position relative to gravity or a resource, while kinesis is the movement in response to stimuli. Taxis describes an animal's orientation in relation to a stimulus in space, and different types of taxis exist based on the nature of the stimulus. Migratory animals rely on navigation and homing abilities, using cues like celestial bodies, landmarks, and odors to navigate through different terrains.Masking refers to the immediate effects on biological rhythms caused by seasonal changes, complementing the entrainment of the biological clock. It involves two mechanisms: entrainment and masking itself. Entrainment determines an organism's activity during the day or night, while masking bypasses the pacemaker's activity through alternative pathways. Sensory pathways can influence behaviour independently of the biological clock, leading to masking effects. Studying the entrainment of the biological clock and the impact of external cues (zeitgebers) presents challenges, as these cues influence the biological clock and affect the circadian system's response. Masking effects occur naturally due to seasonal changes and impact the circadian rhythms of organisms. Different masking mechanisms have been explored, categorized based on changes in locomotor activity induced by light. Masking plays a crucial role in organisms' adaptation to the environment, facilitating quick responses to environmental changes, optimizing evolution and adaptation to temporary niches, and increasing chances of survival.

Sleep in humans involves the interaction of two main systems: the circadian system and the sleep homeostat. The circadian system, regulated by the suprachiasmatic nucleus, controls the timing of sleep and wakefulness based on external cues, primarily light. The sleep homeostat monitors the need for sleep based on prior wakefulness. Neurotransmitters like serotonin, dopamine, and norepinephrine play important roles in regulating sleep stages. Sleep consists of alternating cycles of non-rapid eye movement (NREM) and rapid eye movement (REM) sleep, each serving different functions. NREM sleep promotes physical restoration and memory consolidation, while REM sleep is crucial for cognitive processes and dreaming. Disruptions in sleep biology can lead to sleep disorders such as insomnia, sleep apnea, and narcolepsy. Understanding sleep biology is essential for promoting healthy sleep and addressing sleep-related issues in humans.

In conclusion, biological rhythms, including circadian rhythms and sleep cycles, play a fundamental role in regulating bodily functions and behaviours. Biological clocks and masking effects ensure the synchronization of physiological processes with the environment, allowing organisms to adapt and survive. The interaction between the circadian system and the sleep homeostat governs the timing and quality of sleep in humans, with neurotransmitters and alternating sleep stages serving specific purposes. Understanding the biology of sleep is crucial for maintaining optimal health and addressing sleep-related disorders.

5.9 Terminal question

Q1. Differentiate between exogenous and endogenous rhythm with example.

Q2. Explain orientation behaviour in animals and its significance.

Q3. Briefly describe the sleep and under lying mechanism behind this.

Q4. Write short notes on navigation in birds.

Q5. Write short note on masking effect and phase shift.

Q6. Write a short note on biological clock.

Q7. Differentiate between circadian and circannual rhythm.

Q8. Explain orientation in animals.

SAQ1

Match the following

1.Zeitzeber	a. synchronize internal rhythm
2.Ultradian rhythm	b. dreaming stage
3.REM	c. external cues
4.Exogenous rhythm	d. pineal gland
5.Infradian rhythm	e. more than 24 hours
6.Master clock	f. less than 24 hours

SAQ2

Fill in the blanks

1. External cues that synchronize the exogenous cycle is called_______________.
2. Setting of biological clock is called _____________________.

3. Orientation in birds with respect to celestial body is called_______________.

4. Movement of animal between different habitats like grasslands, forests, deserts, or mountains, it is referred to as__________________.

5. Orientation based on memory is referred to as ___________________.

SAQ3

State whether true or false

1.REM sleep last for about 90 minutes.

2. master clock is located in pineal gland.

3. Type III masking arises when physiological or biochemical changes modify the neural output of the biological clock, which conveys time-related information.

4. The impact of temperature changes on the rate of most biochemical reactions is typically quantified by a Q10 value.

5. The amygdala, an almond-shaped structure involved in processing emotions, becomes more active during REM sleep.

SAQ4

Multiple choice question

1.The sleep wake cycle in human follows__________rhythm.

a. infradian

b. circadian

c. ultradian

d. circannual

2. which of the following is true for circadian rhythm

a. they are the artificial inventions of time keepers

b. they are internally driven and externally regulated cycles

c. they are the consequences of events that occurs once during a month

d. they occur on the same schedule regardless of the changes from day to night

3. Scientist are able to study sleepthrough the recording of brain wavesaccomplished by the use of

a. MRI

b. PET

c. ECG

d. EEG

4. The consolidation of memories occurs during slow wave sleep with which region of the brain?

a.Prefrontal cortex

b.Pons and medulla

c.Amygdala

d.Hippocampal circuits

5. why do shift workers often experience obesity, diabetes and increased risk of accidents?

a. their SCN has become impaired

b. their melatonin levels are highest at around 3-4 am

c. they lack slow wave sleep

d. their circadian rhythms are impaired due to changes in sleep wake cycle

Unit-6: Pheromones and behavior

Structure

6.1 Introduction

Objectives

6.2 Pheromones and hormones

6.3 Pheromones and behaviour

- **Discovery of pheromones**
- **Types of pheromones**
- **Chemical nature of pheromones**
- **Pheromones in animals**
- **Pheromones in invertebrates**
- **Pheromones in vertebrates**

6.4 Roles of pheromones

- **In invertebrates**
- **In vertebrates**

6.5. Pheromones for the welfare of mankind

6.6 pheromones in human

6.7 Summary

6.8 Terminal Question

6.1 Introduction

In the intricate tapestry of the animal kingdom, a secret language weaves through the air, communicating messages imperceptible to our human senses. This captivating dialect is carried by pheromones, the chemical messengers that orchestrate a symphony of responses in the realm of animal biology and behaviour. From the buzzing dance of bees to the intricate courtship rituals of peacocks, pheromones hold the key to unlocking the enigmatic code of interspecies communication. In 1944, Hediger initially observed the significance of communication order, encompassing olfaction, tactility, and pheromonal signalling. The chemical signals can be perceived through gustatory receptors, the nasal epithelium, or specialized anatomical structures. Pheromonal or olfactory communication is considered a rudimentary modality, as animals have progressively relied more on sophisticated and species-specific visual, auditory, and vocal communication as part of their evolutionary development.In this chapter, we embark on a captivating expedition to explore the intricate world of pheromones, delving profoundly into the underlying biological mechanisms governing their synthesis, perception, and transmission among animals.

Moreover, we investigate the intriguing interplay between genetics, environment, and pheromonal communication, unravelling the delicate balance that shapes animal societies. Through the lens of pheromones, we illuminate the profound influence these chemical cues exert on individual behaviour, collective decision-making, and the survival of entire species.

As we embark on this enthralling exploration, we invite you to immerse yourself in the captivating world of pheromones. Together, we will unravel the mysteries of this hidden language, shedding light on the remarkable interplay between animal biology and behaviour, and forever transforming our understanding of the intricate web of life that surrounds us.

Objectives

After studying this unit you should be able to know-

- Pheromones, hormones and behaviour
- Discovery and Types of pheromones
- Chemical nature of pheromones
- Pheromones in human

6.2. Pheromones and hormones:

Pheromones:

Interspecies communication plays a crucial role in the well-being of animals. Chemical communication, mediated by endogenous glandular secretions, is utilized by nearly all organisms. Pheromones, defined by Karlson and Luscher (1959), refer to chemicals released into the environment by an individual that elicit behaioural responses in conspecifics. The term "pheromone" stems from the Greek words "pherein," meaning "to carry," and "harman," meaning "to excite." Initially, the term was coined to describe insect sex attractants, but its scope has since expanded to encompass a diverse range of chemicals that are emitted and function in various ways across animal taxa.

Pheromones are highly specific to each species and are predominantly produced by exocrine glands. These ectohormones, released in minute quantities, exert profound effects by acting as chemical messengers. They serve as chemo-signals in intraspecific communication, conveying vital information among individuals of the same species.

When chemical signals are utilized for intra-specific communication, they are termed pheromones. In rare circumstances when they are employed to communicate with individuals of different species, they are classified as kairomones. In cases where only the sender of the chemical signal benefits, they are known as synomones. Conversely, synomones benefit both the sender and the receiver. Necromones, composed of oleic and linoleic acid emitted by decaying or diseased organisms, enable crustaceans and hexapods to detect the presence of deceased conspecifics.By understanding the profound impact of pheromones, we gain a fresh perspective on the diverse strategies animals employ to navigate their environment and interact with conspecifics. We witness the remarkable adaptability of species as they harness the power of pheromones to synchronize their behaiour, convey warnings, and establish social hierarchies.

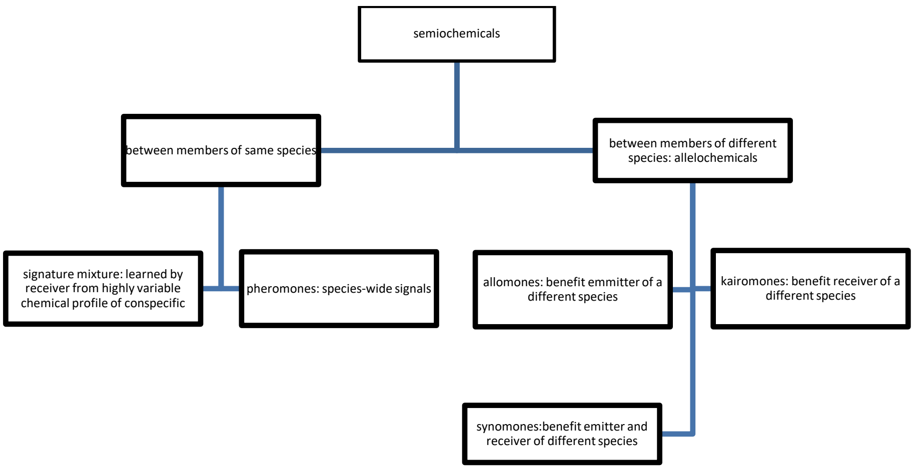


Fig. 1: The relationships between different kinds of semiochemicals

Hormones and pheromones serve as chemical signalling molecules produced by animals. These signalling molecules are primarily composed of proteins. Hormones and pheromones are endogenously generated within the organism's body. The fundamental distinction between hormones and pheromones lies in their mode of action: hormones exert their effects internally, altering an animal's functions and behaviour, while pheromones elicit behavioural changes in other individuals of the same species. Examples of hormones include abscisic acid, auxins, cytokinins, pituitary hormones, and male and female sex hormones. On the other hand, examples of pheromones encompass sex pheromones, trail pheromones, signal pheromones, releaser pheromones, alarm pheromones, and aggregation pheromones.

6.3. Pheromones and behaviour

Discovery of pheromones:

During the 18th century, the serendipitous discovery of pheromones occurred. An incidental observation by a French biologist named Bonnet revealed the fascinating behaviour of ants. Bonnet arranged a colony of ants at one end of a table while placing a small mound of sugar at the opposite end.

To his amazement, Bonnet noticed that the ants emerging from the colony traversed the table, reaching the sugar heap, collecting the sweet substance, and returning to the colony with it. Strikingly, the ants adhered strictly to a specific pathway, without any deviations or detours, as they shuttled back and forth.

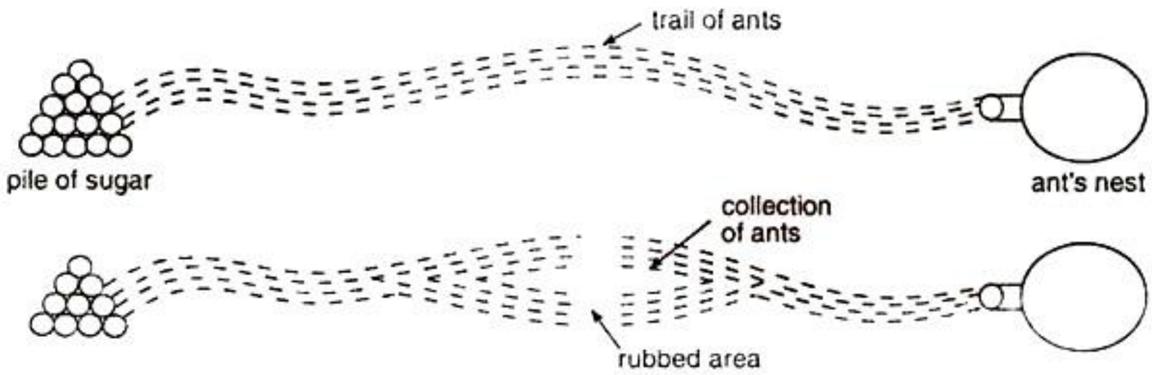


Fig. 6.1.: Bonnet’s experimental setup with ants

Inquisitive about the ants' unwavering adherence to their defined trail, Bonnet devised an experiment to unravel the mystery. He deliberately interrupted the continuity of the path by running his finger along the line of ants. Upon encountering the disruption, the ants halted their progression and began exploring the rubbed area. They engaged in a behaviour where they waved their antennae in the air and tapped them on the ground. Over time, a gathering of ants amassed on both sides of the affected region.

In due course, a few bold ants ventured across the rubbed area. Interestingly, upon meeting ants from the opposite side, they recognized each other and continued their journey without hesitation. From this experiment, Bonnet deduced that the ants' path was, in fact, a chemical trail that the ants could detect and diligently follow.

Types of pheromones:Pheromones can be classified into three main types:

A. Releaser pheromones:

Releaser pheromones elicit immediate and reversible behavioural responses. They directly affect the central nervous system and serve various purposes, such as species recognition, attraction between males and females, signalling sexual status, inducing or inhibiting aggression, initiating milk ejection, marking trails, and acting as alarm substances. Bronson (1971) referred to releaser pheromones as signalling pheromones, emphasizing their role in immediate motor responses.

Examples:

1. In mammals, releaser pheromones are found in urine and footpads. Footpad pheromones can trigger aggressive behaviour in mice when they encounter an unfamiliar male. The urine of male mice, deer, dogs, horses, etc., contains releaser pheromones used to attract females or stimulate aggressive activity. Vaginal secretions in sheep, hamsters, rhesus monkeys, etc., can also function as releaser pheromones.

Certain fish possess specialized flask-shaped skin cells that release alarm pheromones when encountering intruders, causing fear and aversion. Both marine and freshwater fish produce such alarm pheromones.

2. When an antelope is frightened, it secretes alarm pheromones from large glands hidden in the fur of the sacral region, emitting an odour that warns others of potential danger. Ants, on the other hand, produce formic acid as an alarm pheromone from their abdomen to protect themselves from enemies.

3. Honey bees release alarm pheromones along with venom when stinging an enemy. After stinging, the bee informs other members of the colony by displaying her stinger and fluttering her wings, agitating her fellow bees.

In summary, releaser pheromones play a crucial role in triggering immediate behavioural responses and are involved in a variety of functions across different species.

B. Priming Pheromones:

Priming pheromones evoke prolonged or long-term endocrine or physiological responses in recipients. These responses are mediated through neuroendocrine pathways or direct effects on target organs. Priming pheromones can trigger the production of estrogen and progesterone, influencing estrus cycles (inducing or inhibiting), pregnancy termination, and sexual maturation cycles.

Examples:

- In 1961, Hilda M. Bruce conducted research at the National Institute of Medical Research in London, where she made an interesting observation regarding female mice. She found that the odour of a male mouse who was unfamiliar to a newly impregnated female mouse inhibited her pregnancy. However, the odour of the original male with whom she had mated did not disrupt the pregnancy. The presence of the unfamiliar male's odour suppressed the secretion of the hormone prolactin, leading to the restoration of normal estrous cycles. This phenomenon became known as the "Helen Bruce effect." Notably, physical contact between the male and female was not necessary for this effect to occur. The Bruce effect could be observed by placing the female in an empty box that had previously housed an unfamiliar male. However, the female's sensitivity to the presence of an unfamiliar male extended only up to a maximum of 5 days following the initial copulation. After 6 days, the Bruce effect ceased to occur.

- In ants, termites, and honey bees, members of the same colony share a distinct pheromone that distinguishes them from individuals of other colonies of the same species.

- Queen honeybees maintain their dominance by releasing a pheromone called queen substance, which keeps worker bees sterile and inhibits the construction of new royal chambers or queen cells.Social pheromones, produced by a reproductive pair of termites (king and queen), regulate the colony size and caste system in termites.

- In 1955, Ven Der Lee and L.M. Boot, mammalian endocrinologists, made an intriguing discovery regarding female mice. They observed that when multiple female mice were housed together in a cage, their estrous cycles became synchronized. Additionally, they noticed that when female mice were isolated from males for an extended period, their estrous cycles ceased entirely. However, the introduction of the scent or pheromone from a male mouse could trigger the resumption of the estrous cycle in a female mouse. Based on these findings, the scientists concluded that male mice secrete pheromones that are detected by female mice, consequently influencing the reproductive physiology and behaviour of the females. In further investigations, the researchers observed that when female mice were kept in groups of four, there was an increased occurrence of spontaneous pseudopregnancies. However, this effect could be prevented by either removing the olfactory bulbs or isolating the females. This phenomenon was subsequently termed the "**Lee boot effect**."

- In 1959, Whitten conducted a study revealing an interesting phenomenon related to female mating behaviour. He discovered that when female mice were housed together in a group, they did not mate as rapidly when exposed to a male compared to females that had been isolated. This effect was subsequently termed the "**Whitten effect**". However, Whitten also observed that the Whitten effect could be reversed by introducing a male into the all-female group, resulting in a restoration of normal mating behaviour.

C. Imprinting Pheromones:

Imprinting pheromones exert their influence during critical developmental periods, leading to permanent changes in adult behaviour. This type of pheromone has been observed in certain rodents such as mice and rats.

- **Chemical Nature of Pheromones:**

Pheromones are chemical compounds that play a significant role in communication. They are particularly well-developed in insects and mammals. These chemical signals can be categorized as volatile or non-volatile. Volatile signals are short-lived and tend to have low molecular weights. For example, ants use volatile chemicals to signal alarm, but these signals fade within a minute or even less.

On the other hand, non-volatile signals are designed to persist for a longer time, allowing the message to remain even in the absence of the signaller. An example of non-volatile chemical signals is the territory marker pheromones of spotted hyenas, which are secreted by sub-caudal scent glands.

Isolating and extracting pheromones is a laborious process. Robert T. Yamomoto, for instance, identified the sex attractant of cockroaches

(*Periplaneta americana*) by running a stream of air through cans containing thousands of female cockroaches for eight months. The vapour emitted by the females was trapped by freezing it with dry ice. After such painstaking work, only a small amount (12-2 mg) of pure sex attractant was obtained. This pheromone was identified as 2,2-dimethyl 3-iso-propylidene cyclopropyl propionate, a volatile yellow substance with a strong floral odour. Male cockroaches are attracted to this odour and respond by raising their wings and attempting to mate.

Similar work has been done on female silk moths (*Bombyx mori*), where only 12 mg of pure pheromone, known as bombykol, was obtained from the abdomens of five million females. Other extracted attractants include gyplure (gypsy moth), queen substance (honey bee), civetone (civet), and muskone (musk deer). The chemical compositions of various pheromones extracted from different animals are listed in Table 6.1.

Table 6.1: Chemical composition of pheromones in different animal and their sources

Animal species	**Source of pheromones**	**Chemical composition**
Tropical bug	Special duct in male	2-hexenol acetate
Ant	Abdominal gland	Formic acid
Honey bee	Mandibular glands of queen	C_{10} $H_{16}O_3$(9-keto-2-decenoic acid)
Silk moth	Lateral gland in female abdomen	$C_{16}H_{30}O$-trans-10-cis-12 hexadeca-dienol (Bombykol)

Gypsy moth	Lateral gland in female abdomen	$C_{16}H_{34}O_3$(10-acetoxyl1-hydroxycis-7-hexadécane)
Cockroach	Corpora alata or female	2,2-dimethyl 3-isopropylidene cyclopropyl propionate
Mouse	Urine of male	2-sec-butyl 4, 5-dihydro thiazoleand dehydroexobrevivomin
Rabbit	Inguinal gland	Phenyl acetic acid
Mongoose	Anal gland secretion	Lipids
Indian sheath tailed bat	Gular glands	Lipids and protein
Mongolian gerbil	Ventral abdominal gland	Phenyl acetic acid
Black tailed deer	Tarsal gland secretion	Unsaturated lactone
Prong horn	Male subauricular gland secretion	Isovaleric acid
Antelope	Inter digital gland secretion	Methyl ketones
Musk deer	Lower side of abdomen	Muskon
Primate	Vaginal secretion	Propionic, isobutyric,

(rhesus)		n-butyric and isovaleric acid
Human being	Female vaginal secretion	Copullins
	Male sweet	X-androstenol

- **Pheromones in Animals:**
- **Pheromones in Invertebrates:**

A. Glands Responsible for Pheromone Production:

Pheromones are synthesized and released by specific glands, which vary in structure and location throughout the body of invertebrate animals. These glands, which produce pheromones, have been extensively studied in the case of insects:

(a) Locusts:

In mature male locusts (Schistocerca), the acceleration of maturation in other less mature locusts of both sexes is mediated by the secretion of pheromones. These pheromones are synthesized and secreted by epidermal cells.

(b) Lepidoptera:

- In Lepidoptera species such as butterflies and moths, males produce scent from glands known as androconia. These glands are located in the wings and are associated with scales. Androconia have an elongated structure that terminates in a row of fine processes called fimbriae. Pheromones produced by these glands evaporate through the fimbriae

- In the queen butterfly, *Danaus gilippus*, the male releases pheromones which are then transferred to the female using brush-like structures called hair pencils located at the tip of the abdomen.
- *Amauris*males have small scent patches on each side of their hind wings. These patches contain specialized structures known as scent cups. The scent cups have a central pore, and beneath them, there is a scent gland. Scent is dispersed from these patches through scent brushes associated with the genitalia.
- In *Plaodia*, pheromones are secreted from invaginated glands that open on either side of the last abdominal segment. The scent is dispersed by the evagination of these glands.
- Female silk moths emit a sex pheromone called bombykol from a pair of sacs called sacculi lateralis. These sacs are located on the last abdominal segment.

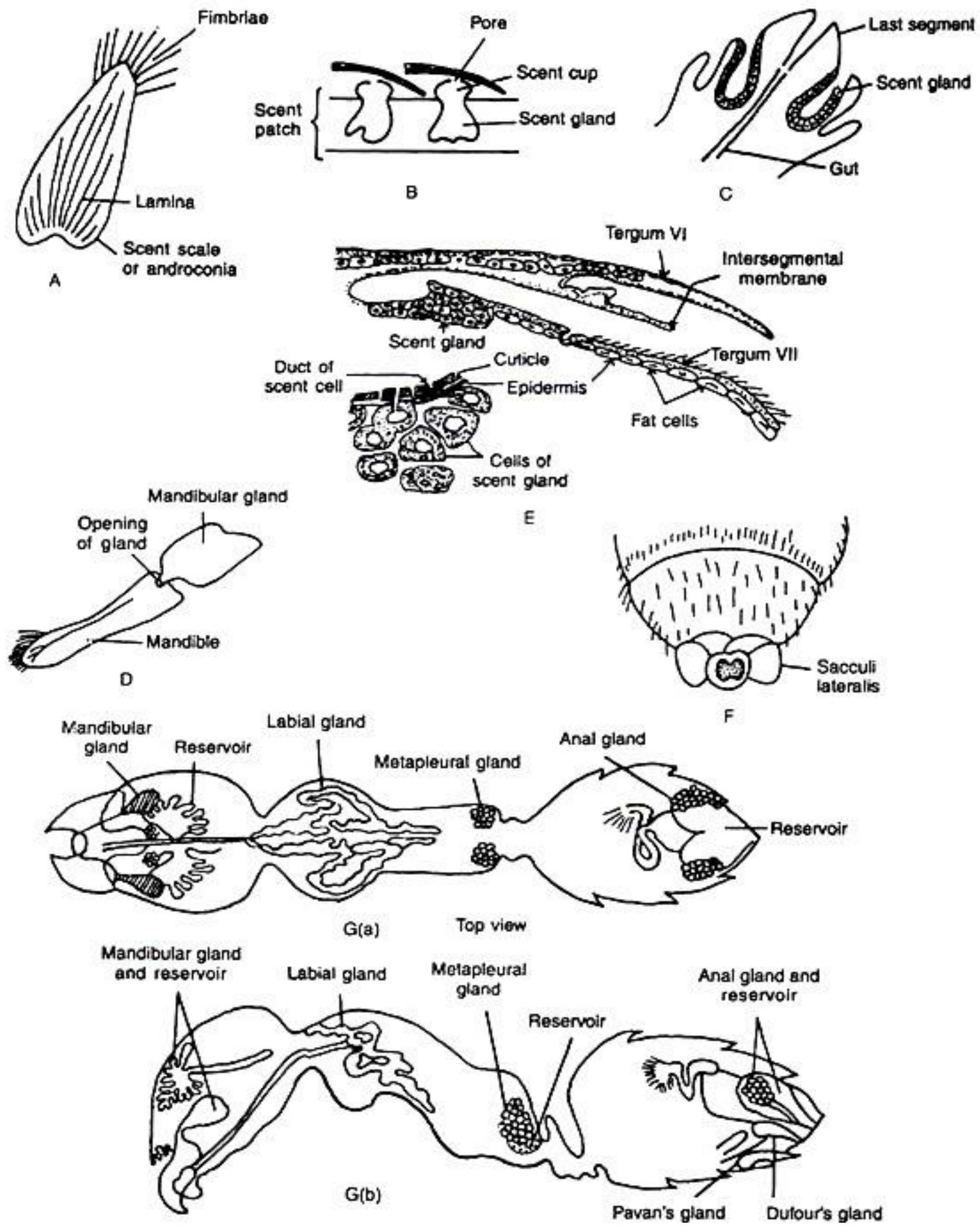


Fig.6.2. Pheromones producing glands in insect. Androconia of butterflies and moths B. scent cups of *Amaurismales*. C. Invaginated scent gland in *Plaodia*. D. mandibular gland of honey bee. E. Nassanoff's's gland of honey bee. F. Sacculi lateralis of silk moth. G. (a) and (b) top and side view of Saint producing glands in ants.

(c) In Hymenoptera:

(i) Honey bee:

Pheromones in honey bees are released from two glands: the mandibular gland and Nanoff's gland.

Mandibular gland:

The mandibular glands are located in the head region. They are sac-like structures, and their ducts open at the base of the mandible. These glands are well-developed in the queen and workers but reduced in drones.

Nassanoff's gland:

Nassanoff's gland, named after the Russian biologist who discovered it in 1882, is situated below the inter-segmental membrane (arthrodial membrane) between the 6th and 7th abdominal segments. This gland consists of several large cells that open to the exterior through small ducts.

(ii) Ants:

In ants, pheromones play a crucial role in controlling their social behaviour, including mating, feeding, exploiting food resources, recruiting nest mates for battles, and warning about enemies.

Ants possess numerous scent glands that are used for releasing different types of pheromones. Trail pheromones, for example, are released by *Solenopsis* from its Pavan's gland, by *Myrmica* from the poison gland, and by *Lasius* from the rectal gland.

When forager ants return to the nest, they use another pheromone to recruit other ants to collect food. *Myrmica rubra,* for instance, utilizes pheromones from its Dufour's gland for this purpose. If a large food source requires the assistance of many workers, *Solenopsis* releases mass-acting pheromones.

Ant pheromones are released as volatile liquids. Ants perceive these pheromones through their antennae and rely on both antennae to maintain the correct direction. They navigate by balancing the concentration of pheromones on the right and left sides. If the concentration increases on the left side, they turn in that direction until both antennae sense equal concentrations, guiding them straight along the odour trail

Recruit pheromones:

Recruitment pheromones serve multiple purposes beyond food collection. They are also utilized to assemble armies for territorial conflicts and, in certain species like *Formica subintegra*, for slave raids. During slave raids, the pheromones from the ant's Dufour's gland coordinate the actions of the attacking ants (slave-makers) and confuse the defending worker ants in the nest.

Once the slave ants are successfully brought back to the nest, it becomes crucial for the ants to distinguish their own team members from ants belonging to other nests. This distinction is achieved through colony odour, which is conveyed by specific pheromones. Each ant nest possesses its unique and recognizable scent.

Alarm pheromones are secreted by ants to alert their nest mates about potential threats or enemies. Upon detecting the alarm pheromone, an ant may exhibit various responses, including fleeing from the source of the scent, remaining motionless and feigning death, or rushing towards the source to confront nearby enemies. Different alarm pheromones likely elicit these distinct responses in ants. Weaver ants, such as *Oceophyllalonginoda*, demonstrate a remarkable diversity of messages in their alarm pheromones, utilizing over 30 different chemicals.

In the case of weaver ants, the alarm pheromones trigger a range of reactions among their nest mates. Another intriguing pheromone is emitted by the larvae of African driver ants, known as larval pheromone. This pheromone plays a nurturing role for the larvae

B. Structures for Sensing Pheromones:

In the late eighteenth century, Auguste Forel, a Swiss entomologist, documented various structures found on the antennae of ants and other insects that appeared to be involved in detecting chemical substances.

These insect structures could be flat, cup-shaped, or resemble short, stubby hairs (Fig. 6.3A). They are all equipped with nerve endings. The specialized structures perceive chemical messages, which are then transmitted to the central nervous system. Certain animals have protruding antennae that are specifically designed to sense pheromones. For example, the male silk moth detects pheromone signals through specialized structures located on the surface of its antennae. These structures come in two types: sensillaecoeloconicae, which are pit-like, and sensillaebasiconicae, which are short and rod-like (Fig. 6.3 B). These structures function as chemoreceptors, allowing the detection of pheromones.

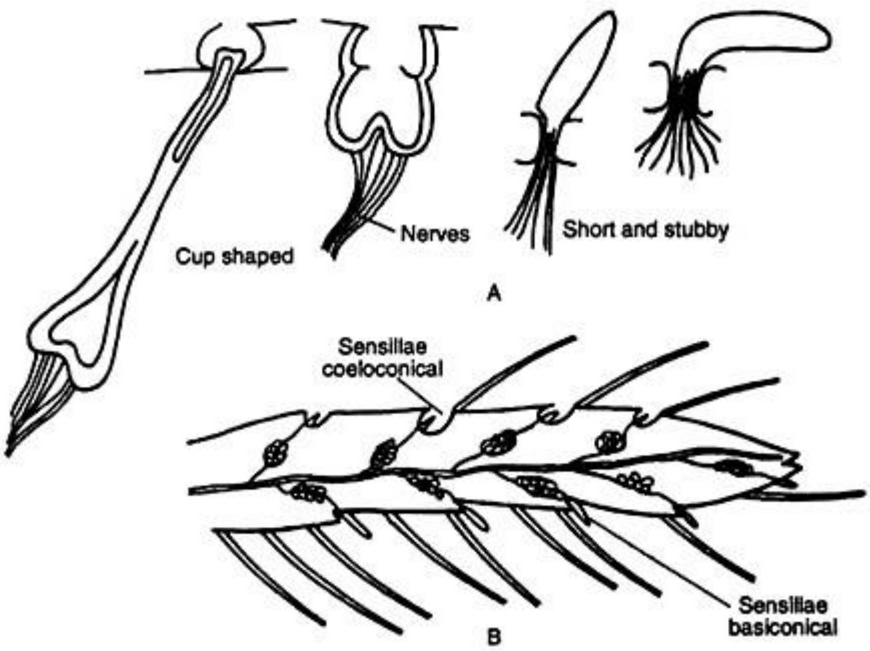


Fig.6.3. Pheromones perceiving organs: A. structures receptors in insects perceiving pheromones B. antennae of male silkworm moth

- **Pheromones in Vertebrates:**

A. Reptiles:

Female garter snakes leave chemical trails that are followed by males. As the female snake moves, she rubs against certain objects, leaving her scent in the direction she travels. The male snake uses its forked tongue to test each side of these objects and determines which side the female has pushed against.

B. Mammals:

(a) Urine and faecal markings:

Many mammals communicate through pheromones present in their urine and/or faeces. These pheromones are used to mark a core area, home range, or territory. Animals also utilize urine and faeces to mark pathways, resting areas, feeding grounds, and sleeping sites. Additionally, they use these markings to indicate dominance over rivals, opponents, or defeated animals.Different mammals employ pheromones in the following ways:

1.Hippopotamus males mark their pathways between aquatic resting places and feeding grounds by defecating while walking and vigorously moving their tails from side to side. This causes the faeces to splash and be deposited on vegetation above ground level, making the scent more noticeable at nose height.

2. Male tigers select specific locations to mark their territories using a pheromone called tiger-amine. This milky, thick fluid with a strong smell is released along with their urine.

3. Mainland serows, a goat antelope species found in Northern India, have established pathways that they mark by depositing droppings. By

following the scent, they can easily navigate these pathways, while also deterring other animals.

4. Adult males of pronghorn and sambar mark their areas during the mating season using their droppings and urine.

5. Male skunks and giant rats elevate their hind limbs above the ground, supported against a solid object, while standing on their forelimbs to place their droppings above ground level. They also urinate in the same manner

Fig.6.4. Male skunk uses urine and faeces for scent marking above ground level

6. Foxes, coyotes, and dogs rely on urine to mark their territories. The pheromones present in their urine provide various details, such as the individual's identity, gender (male or female), dominance status (dominant or subdominant), age (adult or sub-adult), and the freshness of the marking.

7. Bears employ two different methods to mark their territories. Firstly, they scratch and chew the bark of trees, marking them. Subsequently, they urinate on the marked tree to reinforce the territorial marking.

8. Male lions, leopards, and other large and small cats mark their territories using pheromones present in their urine. They choose a suitable object, turn their back to it, extend their hind legs, and raise their tail while urinating. The urine is released as a fine jet between their hind legs.

9. Some lemurs mark their territories by smearing their faeces on branches.

10. The greater bush baby, while urinating, places one partially cupped hand in front of the urine and rubs it onto tree branches.

11. Adult capuchin monkeys (found in South Central America) engage in "urine washing" by soaking their feet and hands in their urine and then smearing it on foliage. This behaviour is also observed in slender lorises.

12. The common squirrel monkey (found in Northern South America) marks its own territory by soaking its body, especially its tail, in urine and smearing it on leaves.

(b) Scent marking through special glands:

To overcome the limitations associated with pheromone release through faeces and urine, some animals have evolved special glands that produce pheromones. These glands offer the advantage of controlled production and release. Several species possess such specialized glands, including:

(i) Anal glands:

- The most common scent-producing glands are the anal glands, found in monotremes, marsupials, and certain placental mammals. These animals rub the secretion from their anal glands on the ground or objects to leave a scent mark.
- The spiny anteater rubs its cloaca on the ground to leave a scent mark.

- Male Tasmanian devils rub their anal glands on objects like stones, branches, and the ground to protect their females and offspring.
- Brush-tailed opossums and sugar gliders possess two types of cloacal glands, which they use to mark their nests.
- The yellow-footed marsupial mouse marks its small territory by rubbing its cloacal secretion on twigs and branches.
- The black and red tamarin releases a strong-smelling scent from its anal gland to deter others.
- Brown hyenas have two separate anal glands that produce distinct pastes (one brown, the other white) placed next to each other on stalks of grass, conveying different messages.
- Male beavers mark their dams, lodges, and feeding trails with pheromones secreted from their anal glands, effectively keeping other male beavers away from their territory.
- Ring-tailed lemurs have scent glands on their forearms, anus, under the chin, and on the penis. Both males and females rub these glands to mark their territory and attract mates during the mating season.
- The brown hare of Europe, living solitarily, marks its territory with strong-smelling secretions from anal glands. Additionally, it possesses glands around its face and inside its cheeks, which play a role in attracting mates during the mating season

(ii) Salivary glands:

- Some mammals, including bears, dogs, pigs, and rats, utilize saliva produced by their salivary glands as a means of marking.
- Several marsupials mark the foliage of their territory by depositing saliva on twigs through chewing.
- Boars possess steroids in their saliva that elicit a standing response, which is crucial for prolonged mating.

- Female rats lick their nipples, depositing saliva and leaving scent marks to guide their blind pups to locate them.

(iii) Miscellaneous glands:

There are various other glands in mammals that produce scents used for marking purposes. These glands include:

- Roe deer stags (found in Europe and northern Asia) mark their territories using secretions from glands located on their forehead, metacarpals, as well as urine and anal glands.
- Black-tailed deer possess five distinct scent-producing glands situated in different parts of their body (Fig. 6.5). These glands generate different pheromones serving various functions

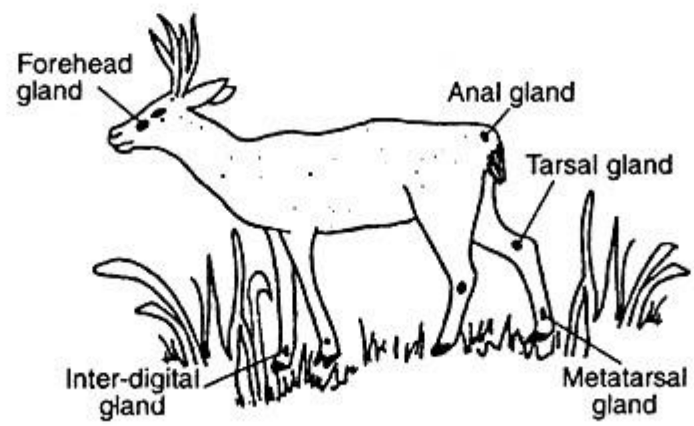


Fig. 6.5. Black tailed deer showing location of different scent glands

- Male musk deer utilize scent secreted from a sac on their belly to mark their territorial boundaries and attract females.
- Black bucks and sambar rub their facial glands, located just below their eyes, against trees within their territory.
- Thomson gazelles, found in Africa, mark their territory with a scented tar-like substance produced by glands situated just below their eyes.

- Bulls of elephants possess temporal glands that produce a scent indicating their readiness to mate and their search for a female elephant during the breeding season.
- Dominant male reindeer have scent glands between their hind toes, which help leave scent trails for other members of the herd.
- Camels have scent glands situated on their necks, which they rub against objects to mark and play a significant role in mating.
- Marmots have scent glands located between their eyes and ears, which they use for marking their territory and attracting mates.

6.4 Roles of Pheromones

Pheromones serve various functions in different animals:

- **In invertebrates:**

A. Sex attractants:

Pheromones are used by many animals to attract the opposite sex for mating.

(a) Female pheromones:

Female insects typically release pheromones from specific glands. These pheromones are released at specific times of the day, depending on the animal's diurnal or nocturnal nature. The released scent excites approaching males and serves as a guide to locate the female.

For example, the queen bee attracts drones by releasing pheromones from her mandibular and Nassanoff's glands. These pheromones allow her to control a colony of 6,000-8,000 individuals for 5 to 7 years. Male Emperor moths (*Endiaparvonia*) can detect the female's sex attractant from distances as far as 13 kilometers, even though the female carries less than 0.001 part of a milligram.

(b) Male pheromones:

Instances of males producing sex attractants are relatively rare in the animal kingdom. Male beetles (*Harpobittacus*), for example, release a scent from their posterior abdominal segments that excites females for mating. They do this while feeding on prey. When a female arrives, the male presents her with the remainder of the prey and proceeds to mate with her while she is occupied with eating.

B. Communication in social insects:

Many ant species lay scent trails to navigate their surroundings. Fire ants, for instance, rely on pheromones for communication. A forager ant, upon discovering a food source, returns to the nest, leaving a trail behind.The forager ant, when encountering another worker, rushes toward it and attempts to draw its attention to the trail substance. Initially, the trail consists of a series of scent spots created by the forager ant touching the ground with its abdomen as it returns to the nest.Over time, as more worker ants join in, the spots they produce may merge into a continuous trail. The trail of fire ants is formed by substances secreted in minute amounts from Dufour's gland located on the abdominal edge.The trail serves not only to guide them to food but also for other purposes such as routine passage or emergency exits. Alarm pheromones from mandibular or anal glands can attract other members of the colony to come to the rescue.

In social insects, alarm pheromones serve three main functions:

- Alerting the colony.
- Releasing aggression.
- Marking the target to be attacked

Pheromones used for marking trails or territories have lower volatility, whereas distress pheromones are highly volatile. In the event of being stung by a bee, if the bee is killed as a reflex action, the sting of the dead bee may release alarm and distress pheromones, triggering a mass attack from the hive.

Worker bees are attracted to each other through the scent emitted from the Nassanoff's gland. The secretion from this gland can be released in various situations, including during feeding, the formation of a new hive, marking a water source, marking the hive for recognition, and maintaining the cohesion of the swarm during flight.

C. Maintenance of social structure:

(a) The queen bee produces pheromones that help control the social structure of her colony. If the queen is removed or dies, the workers become restless and start building emergency queen cells or royal chambers. The larvae within these cells are fed with Royal jelly.

The first emerging queen stings the remaining sisters to death. However, in the presence of the queen, the workers' behaviour of building new royal chambers is kept under control by a pheromone produced by the mandibular gland.

(b) The queens of certain Vespine wasps, which live in smaller colonies, produce pheromones that maintain the stability of the colony.

(c) In termites, the number of a particular cast is regulated by multiple pheromones. In the absence of the queen, a replacement is produced within a week. In termites, multiple queens are also produced. As soon as the first queen emerges, the developing queens are consumed by the workers. Even when the old queen stops producing pheromones, it is also consumed by the workers.

D. Trapping prey:

Some insects employ pheromones to lure and trap their prey. For instance, the bola spider deceives male moths searching for mates. To attract the moths, the bola spider secretes a scent that resembles the scent emitted by female moths. The male moth is drawn to the scent and subsequently becomes the spider's prey.

E. Pest control:

The species-specific nature of pheromones can be utilized to attract and capture specific target animals. For example, traps containing the scent from female Japanese beetles can be employed as a pest control method to attract males.

F. Inhibitory pheromones:

These pheromones impede the action of other pheromones produced by the same species. For instance, Verbenon reduces the response to sex attractant pheromones in *Dendroctonus* (beetle), thereby preventing excessive aggregation of this species and avoiding overcrowding on the host plant

- **In vertebrates:**

A. Sense of belonging and self-confidence:

In animals, any unfamiliar object initially causes unease until it is marked and considered safe. Pheromones play a role in increasing the self-confidence of animals. During the breeding season, African elephants, when confronted by a rival, sometimes turn their trunks and smell their own temporal gland. This behaviour appears to enhance the elephant's self-confidence.

B. Sexual behaviour:

Pheromones play two roles in sexual behaviour:

(a) Marking male territories:

Male animals first acquire territories through fights and then mark their territories with scent (typically by urinating), which deters potential rivals. Examples include deer, antelope, and other animals. These marked territories are saturated with the animal's scent, indicating that no further fights are necessary. Male tigers, cats, dogs, and other animals also tend to urinate to mark various objects within their territories.

(b) Sex attractants:

Pheromones are used to attract the opposite sex for mating in most vertebrates.

C. Trail marking:

Similar to insects, vertebrates also mark their trails as a way of leaving a record of their movements. This marking is intended for the animals themselves and subsequent visitors, as observed in cases of hippopotamuses and rhinoceroses. These markings act as signposts that are regularly visited and inspected by neighbours. They enable each animal to monitor the movements of its fellows without actually seeing them. Furthermore, these markings help conserve energy by eliminating the need to find the way anew each time they move. Additionally, any intruder can be detected and challenged.

D. Avoiding interbreeding:

Recent studies on mice have revealed the use of smell to distinguish mates that are genetically similar or genetically different from themselves. The major histocompatibility complex (MHC), a group of genes originally associated with recognizing "foreign bodies," has been found to affect both cellular recognition and behaviour. As a result, mice can detect mates that differ genetically from themselves through their sense of smell and thus avoid interbreeding.

E. Marking fellow animals:

- Males sometimes mark their mates with scent. For example, male rabbits mark their mates with secretions from their chin gland.
- Defeated rivals in the case of hamsters are marked, causing them to retreat. Mice and rats also mark defeated opponents with urine.

- A mother sniffs her newborn calf to form a permanent olfactory bond with her offspring. Similarly, the calf sniffs the odour of its mother.
- Mammals such as bighorn sheep and dogs often sniff and smell each other, allowing them to discern the sex, group affiliation, and readiness for mating. A male can perceive the readiness of a female through pheromones produced by her vagina. For example, a pheromone called copulin is produced by the vagina of female rhesus monkeys. Before mating, male rhesus monkeys would sniff the female's vagina.

6.5. Pheromones for the welfare of mankind

Pheromones can be utilized for the benefit of mankind.

(a) Captive breeding:

Pheromones are valuable in the captive breeding of domestic and wild animals. They also aid in improving breeds of poultry, horses, cattle, dogs, pigs, goats, sheep, and more. During heat, a sow recognizes a boar by the scent emitted from his saliva. For artificial insemination, if pressure is applied to the back of a sow (similar to the mounting behaviour of a boar), and an artificial boar pheromone is sprayed, the sow allows the insertion of the spiracle and semen.

(b) Insect pest control:

The utilization of pheromones to control various life stages of pest species is one approach to pest management in an eco-friendly manner. Beet armyworms, a significant pest in cotton-growing regions of the United States, caused multimillion-dollar losses in Texas alone in 1995. In 1997, researchers achieved success in disrupting mating processes between male and female beet armyworms by saturating 35-acre cotton field plots with sex attractant pheromones. With an overwhelming presence of female scent, the males were unable to locate females for over 100 days. Certain pheromone traps have been developed and are commonly used by homeowners. Indian meal moths, also known as pantry moths, are attracted to a pheromone contained in a small box lined with a sticky substance, allowing them to be captured and disposed of

6.6. Pheromones in humans:

Human pheromones, specifically sex pheromones, are chemical signals released by organisms to attract individuals of the opposite sex and encourage interaction or perform other functions closely related to sexual reproduction. While humans heavily rely on visual cues, smells also play a role in sociosexual behaviour when in close proximity. A challenge in studying human pheromones is the requirement for cleanliness and lack of odour in human participants. Experiments have focused on three classes of potential human pheromones: axillary steroids, vaginal aliphatic acids, and stimulators of the vomeronasal organ.

Axillary steroids: Axillary steroids are produced by the testes, ovaries, apocrine glands, and adrenal glands. These chemicals are not biologically active until puberty when sex steroids influence their activity. The changes in activity during puberty suggest that humans communicate through odours. Several axillary steroids have been identified as potential human pheromones, including androstadienol, androstadienone, androstenone, androstenol, and androsterone.

Androstenol: In a 1978 study by Kirks-Smith, individuals wearing surgical masks treated with androstenol or untreated were shown pictures of people, animals, and buildings and asked to rate the attractiveness of the pictures. Those with masks treated with androstenol rated the photographs as "warmer" and "more friendly." The most well-known case study involves the synchronization of menstrual cycles among women based on unconscious odour cues, known as the McClintock effect, named after the primary investigator Martha McClintock of the University of Chicago. In a 1971 study, a group of women were exposed to the scent of perspiration from other women collected before, during, or after ovulation. There was an association between the recipient women's menstrual cycle and whether it sped up or slowed down. The study proposed two types of pheromones involved, one produced prior to ovulation that shortens the ovarian cycle, and the second produced at ovulation that lengthens the cycle. However, recent studies and reviews have raised questions about the validity of these results.

It is postulated that androstenone is secreted only by men as an attractant for women and is also believed to positively affect their mood. The effects of androstenone on women seem to vary depending on the phase of their menstrual cycle, with the highest sensitivity to it during ovulation. In a 1983 study, participants exposed to androstenone showed changes in skin conductance. Androstenone has been found to be perceived as more pleasant to women during ovulation, and it is hypothesized that this may be a way for males to detect an ovulating female who may be more receptive to sexual interaction.

Copulin is a female pheromone that, when released, causes an increase in testosterone levels in men. Similar to how male pheromones work to increase attraction and sexual appeal in men, copulin functions in a similar way for women. Additionally, it has been suggested that in the evolution from unicellular prokaryotes to multicellular eukaryotes, primordial pheromone signalling between individuals may have evolved into paracrine and endocrine signalling within individual organisms.

6.7 Summary

Pheromones are chemical substances that play a crucial role in communication and behaviour among animals. This chapter provides an overview of pheromones, exploring their various types and highlighting their significance in shaping animal behaviour.Pheromones and chemical cues play a predominant role in mediating interactions throughout the animal kingdom, surpassing other forms of communication. A wide array of compounds serves as pheromones, often with different functions across species. Animals utilize signature mixtures as learned templates to recognize individuals or members of their colony. Pheromones are typically innate and their evolution is facilitated by the design of the olfactory system, which favours odour cues promoting reproductive success or survival. Pheromones can originate from compounds initially serving other purposes, such as hormones, odours emitted by host plants, injury-related chemicals, or waste products. Alternatively, signals may evolve to match pre-existing sensitivities of the receiver. Natural selection favours pheromones with features like longevity and specificity, while receivers' senses and responses also undergo evolutionary changes. Although once believed to have notable differences, vertebrates and invertebrates share similar pheromone production and the range of behaviours influenced by pheromones. Given the prevalence of chemical communication in the animal world, pheromones and chemical cues are likely to emerge as crucial factors influencing mate choice.In conclusion, pheromones are vital chemical signals that facilitate communication and shape behaviour within animal populations. Understanding the various types of pheromones and their roles provides valuable insights into the complexities of animal social interactions and reproductive strategies.

6.8 Terminal questions

Q.1. Define pheromones and discuss its various types.

Q.2 Write short notes on a)Bruce effect b) Whitten effect c) Lee Boot effect.

Q.3 Discuss the difference between the hormones and pheromones and discuss role of pheromones in invertebrates.

Q.4 Describe the role of pheromone in vertebrates.

Q.5 Explain the types and role of Pheromone in human.

Q.6 Write short note on discovery of pheromones.

Q.7 Differentiate between allomones and kairomones.

Q.8 Explain the method of scent marking through special glands in vertebrates.

SAQ1 match the following

a)	Primer effect	i)Nassanoff's gland
b)	Honey bee	ii)Lee boot effect
c)	Male lepidopteran	iii)Androconia
d)	Bruce effect	iv)urine and faeces
e)	vertebrate	v)Hilda M. Bruce

SAQ 2 fill in the blanks

1. body structure perceiving pheromones are________________.
2. Nassanoff's glands are present in________________.
3. ______________have significant effect in maintaining mother child bond.

4. Urine and fecal matter are used by the vertebrates to mark their__________.

5. __________and _____________are the process where pheromones are used for the welfare of mankind.

SAQ 3 State true or false

1. Production of delayed effect in receiver by pheromone is called releaser effect
2. Male*Amauris* has scent cups
3. Monotremes Scent mark by anal gland
4. Nassanoff's glands are found in queen bee
5. Pheromones were earlier called ectohormones

SAQ 4 multiple choice question

1. Chemicals that are released by organisms as a means of communication between members of the same species are:

a) Pheromones

b) Releaser Pheromones

c) Primer Pheromones

d) All answers are correct

2. Pheromones are examples of

a) Hormones

b) Visual signals

c)Instinctive behaviour

d) Homeostasis

3. Which of the following is not a function of pheromones

a) Colony structure maintenance

b) Reproduction

c) Communication

d) Digestion

Unit-7: Anatomy and physiology of the time photoperiodic time measurement

Structure

7.1 Introduction

Objectives

7.2 Physiology and Behaviour changes in environment

7.3 Properties and Different Types of Biological rhythms

7.4Proximate and Ultimate factors

7.5Regulations of Seasonal Migration

7.6 Summary

7.7 Terminal Questions

7.8 Answers

7.1 Introduction

Animals confront with environmental changes that are cyclical in nature such as days, seasons, tides etc. They maintain some sort of internal rhythm to predict the onset of the periodic changes and to prepare for them. All internal rhythms of body remain linked together and contribute a clock like system called biological clock. Many aspects of reproductive physiology and behaviour occur on a circannual basis such as hibernation, migration etc. Lunar and tidal rhythms occur in numerous marine animals in addition to circadian and circannual rhythms.

Objectives

After studying this unit you will be able to know:

- Types and properties of biological rhythms
- Geophysical environment season: proximate and ultimate factors
- Regulations of seasonal migration

7.2 Physiology and behaviour changes in environment-

There are three basic ways of synchronizing physiology and behaviour to changes in environment.

- Direct response to various changes in exogenous (external) geo- physical stimuli.
- Endogenous (internal) rhythm that programs the animal's behaviour in synchrony with the circadian (circa = about; dies day or 24 hours) or a circannual (circa about; annual year or 365 days) or lunar or tidal rhythms.
- The synchronization mechanisms may be a combination of above all.

7. 3 Properties and different types of biological rhythms

Organisms possess a physiological mechanism for measuring time. This is known as biological clock.

Each biological rhythm is comprised of repeating units called cycles. The length of time required to complete on entire cycle is the rhythm's period. The magnitude of the change in activity rate during a cycle is called the amplitude and any portion of the cycle is called a phase.

Biological clocks or biological rhythms may be characterized by following properties-

- Whereas temperature changes alter the rate of most chemical reactions and cellular processes, biological rhythms are temperature compensated.
- Biological clocks are generally unaffected by metabolic pathways or inhibitors that block biochemical pathways within cells.
- The periods of biological rhythms occur with approximately the same frequency of one or more environmental features.
- Biological rhythms are self-sustaining, maintaining their normal cycle even in the absence of environmental cues.
- The biological rhythms can be entrained to environmental cues. The self-sustaining mechanisms may be set and adjusted according to input from the external environment.

(A) External Rhythms:

- External periodicity such as circadian (Day night or light dark cycle of 24 hours), circannual (annual cycle of 365 days), seasonal cycle (summer, winter, spring etc), lunar (movement of moon in cyclic order) and tidal (tides of sea water); invlove slow acting physiological changes, somewhat equal to acclimatization.

- Mechanism or function of biological clock.
- In higher animals above mentioned cycles influence the hypothalamus through sense organs. Hypo- thalamus secrete neuro-hormones which influence Pituitary gland.
- Pituitary secrete various kinds of hormones. These hormones stimulate and control functions of other endocrine glands besides other organs of the body.
- The secretion of different endocrine glands influence the different behaviour and functions of body. Thus all metabolic functions of body form a kind of clock like system called biological clock.

(B) Regulatory factors of biological clock - Many physical and chemical factors control the biological clock. The factors are as follows:

1. Atmospheric gases. Numerous atmospheric gases such as nitrogen, oxygen, carbon, dioxide, hydrogen etc. influence the physiological cycle of body of all living being.

2. Circadian Rhythm. It is day, night or dark light cycle. Duration of this cycle is 24 hours. Functions which co-ordinate with the day night cycle is called circadian rhythm. It may also refer the ability to time and repeat functions at about 24 hours interval. Its rhythmic activity is about 24 hours and is locked into the daily light-dark cycle generated by the rotation of the earth of its axis.

Diurnal and nocturnal both types of animals show circadian rhythm as they are directly concerned with light/dark reactions. Flying squirrel (Glaucomys) and white leged rat (Peromyscus), cockroaches, etc. are nocturnal as they remain hidden in day time. Man is diurnal as it remains active in day time. Long photoperiod increases the temperature and decreases the humidity. Both factors have definite influence on physiological functions of body.

- Effect of photoperiod on different Physiological functions of body:

- Effect of long and short photoperiod on various animals have been studied both in nature and laboratory. Fishes kept in aquarium were placed under constant dark or light condition and it was observed that there was marked variation in their Physiological condition such as oxygen consumption, endocrine activity, RBCs number, Hb%, PCV, MCH, MCV, MCHC, values etc.

- Photoperiod also determines the physiological sequence in the body of organism such as moulting, fat deposition, migration, breeding etc. Animals of temperate region regulate their physiological functions according to environmental temperature which determine their day cycle.

- Photoperiodism in certain insects provides a sort of birth control. Long day length of late spring and early summer stimulate the 'brain' to produce a neurohormone that brings on the production of a diapause or resting eggs that will not hatch until next spring, no matter how favourable are food, temperature and other conditions. Thus population growth is halted before, father than after, the food supply becomes critical. Honeybee native to Brazil use the sun as a compass in foraging. They can be trained to search food in a particular compass direction. When they move from one locality to another, they continue to forage in the same compass direction, irrespective of the time of day. Thus, bees native to Brazil are capable of compensating for the anticlockwise motion of the sun. However, northern hemi sphere bees transported to Brazil are initially unable to make the appropriate compensation. In the norther hemisphere the sun appears to move in a clockwise direction, and the bees have to learn to adjust to the changed conditions in Brazil (Lindauer, 1960; Saunders, 1976). Similar abilities are also reported in fishes (Hasler and Schwassmann, 1960) in birds (Schmidt Koenig, 1979).

(C) Circannual rhythm: It is annual cycle of approximately 365 days. It is also called seasonal cycle. Many physiological and behavioural changes are influenced due to changes in season. Prasad D. Prasad S. and Pandey B.N. (1979) tried to show some of the Physiological changes such as Hb%, RBCs number, PCV, MCH, MCV, MCHC value, Oxygen consumption, endocrine activity etc. in Macrognathus aculeatus due to circannual rhythm.

The average day length and temperature of every month has also been taken into consideration:

Following are the effects of circannual periodicities on different functions of animal body:

- **Effect on reproduction**. Seasonal climatic changes exert influences upon the reproductive success of many animals. Among birds, the availability of food for the young appears to be the main determinants of breeding success (Lack, 1968). Birds at middle and high latitudes have a seasonal reproductive pattern in which the eggs are usually laid during the spring, a pattern that enables the young to mature sufficiently to withstand the winter conditions or to endure a long migratory flight. For example, sandpipers, breed in Arctic regions while make nest and incubate in spring when the snow is still on the ground. The eggs usually hatch when the snow melts and the area become rich of insect life to provide food for the young (West and Norton 1975).
- The reproductive physiology of seasonal breeding is geared to the annual cycle of environmental change so as to anticipate either peak abundance of food or adverse climatic conditions. There are two main ways in which this is done. First, changes in surrounding

temperature, day length, or other environmental clues induce physiological change at a particular time of year. Second, the physiological changes are programmed on a seasonal basis by means of an endogenous circannual clock.

- The most important seasonal change in the environment is the fluctuation of day length. The photic stimuli are converted to chemical messages by neurosecretory cells. In some mammals the pineal body, on the dorsal surface of the brain, may act as a light transducer (Wurtman et al. 1968). The influence of light on mammalian reproduction appears to be primarily via the retina to the hypothalamus. The control of reproductive physiology involves the complex interaction of a number of hormones. In addition to seasonal cycles of sexual activity, many mammals have a much shorter estrous cycle, or "heat" Rad fox (vulpes vulpes), have only one period of heat annually. Domestic dogs, have two; other have more Man donot follow the estrous cycle.

- Reproductive pattern of many species is influenced both by photoperiodic factors and by the endogenous circannual clock. Two me chanisms may interact with each other. Animals occupying dry desert environment may depend upon the beginning of rainfall to trigger the process of reproduction (Marshall 1970). Reproductive activities, (territorial defense, courtship, mating and parental care) put extra physiological burdens on the animal. Therefore the reproduction is abandoned for next year. Some equatorial species show a marked breeding rhythm that appears to be unconnected with seasonal changes. Several sea birds, brown booby (*sulaleucogaster*), sooty term (*sterna fuscata*) and the lesser noddy tern (*Anaustenuirostris*) breed at intervals of 8-10 months.

(a) Effect on hibernation. Some animals may migrate to avoid unfavourable seasonal variations but others survive unfavourable periods by entering a prolonged phase of dormancy, called hibernation (winter sleep) at low temperatures and estivation (summer sleep) at high temperatures. Some desert rodents, such as ground squirrels (citellus) become inactive during the summer and enter aestivation state in which the body temperature falls and a general reduction in physiological activity occurs. This means that energy expenditure is lowered and that the animal can stay alive for long periods without feeding. Many species of European earthworm become dormant during the summer. Some mammals, including the golden-mantled ground squirrel (citellus lateralis) and the woodchuck (Marmota monax), have a marked circannual rhythm underlying their seasonal hibernation. Phenomena of both hibernation and estivation occurs in Indian frog (Rana tigrina). Pengelley and Asmundson (1974) injected, blood serum of a hibernating ground squirrel, into a non-hibernating squirrel and found that hibemation is induced. The experiment suggests that the basic physiological mechanism responsible for controlling hibernation is driven by an endogenous biological clock entrained to the rhythm of external events by a particular external trigger. This has been demonstrated in the woodchuck, which shows a circannual rhythm of hibernation.

- **Effect on diapause**. A period of dormancy in response to unfavourable climate also occurs among insects and is given the name diapause. Insects that avoid freezing by supercooling can survive very cold conditions in diapause, in which the body fluids freeze at temperatures well below 0°C. Baraconcephi, a canadian wasp, may lower its freezing point 10-46°C by increasing the concentration of glycerol in the blood. Larva of pink cotton ballworm of south America undergoes in diapause during September and october. They remain in this condition for whole winter season. On the arrival of spring season (when day length increased) they come out of diapause and metamorphose into adult. They metamorphose into adult even in winter season when kept 13-15 hours in light in a day in laboratory.

- Phenomenon of diapause has been studied in the eggs of grasshopper. Eggs laid in soil develop upto blastoderm. Later development depends on the availability of definite temperature. In Kharpa beetle development in egg occurs slowly below 30° C temperature. But diapause ceased above 30° C to 35° C.
- **Effect on development.** Light influences the metabolism process of living organisms. There is an indirect influence of light on the growth and development of organism. Larva of Salmon metamorphoses rapidly in longer day length. Larva of mytilus metamorphoses rapidly in longer dark length.
- **Effect on migration.** Migration between two habitat on seasonal basis is shown by many species of animals, including butterflies, locusts, Eel, salmon, tortoises, birds, bats and antelopes. The locust (Schistocerca gregaria) inhabits seasonally arid areas. Depending upon their degree of crowding, the insects may develop into one of three adult types of these, the gregaria individuals aggregate into dense swarms that migrate downwind into areas of low barometric pressure, where they are most likely to encounter rain. They fly by day and stop migrating when they encounter wet conditions. Sexual maturation, copulation, and deposition of eggs then occur. Locust swarms describe seasonal circuits, but the generation time is too short for individuals to complete the entire circuit.

Songbird species within the genera phylloscopus and sylvia exhibit seasonal migration. In the typical long distance migrants such as the garden warbler (s. robin), the subalpine warbler (s. cantillans) and the willow warbler

(P trochilus), there are marked seasonal change in body weight, testis size, moult, nocturnal restlessness, and food preferences etc.

There is also evidence that endogenous factors control not only the onset of migratory activity but also its pattern. Many species have migra- tory routes characteristic of particular breeding populations. For example, white storks (ciconiaciconia) that breed in Western Europe Fly to their wintering grounds in Africa by a Westerly route over Spain and Gibral- ter, whereas those that breed in Eastern Europe take an easterly route. Young storks of eastern Europe were kept in captivity, but released in western Europe, fly in the easterly direction characteristic of storks of eastern Europe. Similar experiments with other species indicate that the direction of migration is influenced genetically.

(D) Lunar rhythm. The lunar cycle of 29.5 days influence a variety of aspects of animal behaviour.

Eunice viridis, the salmoanpalaloworm or southern Pacific Ocean swarm during first and third quarter of lunar periodicity. The lunar periodicity displayed by the palaloworm is the most striking phenomenon there is a direct relationship of number of conjugants of parasitic ciliates found in the gills of fresh water mussels and the lunar periodicity. Maxi- mum number is found one day after regular appearance of moon. There is no relation between number of conjugants and other factors such as heat, humidity, season etc. Burmuda cire worm swarm in the evening on full moon night.

Lunar periodicity has been observed in Grunion fishes also. Thousands of Grunion fishes assemble near the bank of Californea on full moon night to lay eggs. High tide carries the eggs of Grunion fish to those places where day to day tide do not reach. These eggs remain hidden in sand. Hatching takes place on arrival of high tide in full moon night. Hightides carry the hatchings into the sea.

Lunar rhythms are also known in terrestrial animals. Jamaican fruit bats have a pattern of feeding that involves leaving the day roost in the evening and feeding throughout the dark nights during the period of the new moon. During the full moon, however, they depart from their day roost at the normal time in the evening, but return there when the moon is high, even when obscured by clouds, suggesting that they make use of an endogenous lunar clock to time their foraging and feeding behaviour.

(E) Tidal rhythm. The tides result from changes in the combined gravitational pull of the sun and moon. The tide raising force of the sun is only about 5/11th of that of the moon because the distance of the sun is much greater from the earth. The moon is much closer to earth than the sun, It exerts a force twice during the lunar cycle. The gravitational pull of the sun and the moon each cause two bulges in the water of the oceans. Such bulges of water is called tides and it usually consists of a regular rhythmic cold shock appears to restart the tidal clock, perhaps because it resembles the experience of a beach stranded crab that is eventually reached by a high tide. In one experiment, shore crabs were raised in the laboratory from eggs to adulthood under a day-night regime without tidal influences. These crabs showed only a circadian rhythm of activity. However, a tidal rhythm appeared after the crabs were given a single cold-shock treatment. It seems that the endogenous tide clock has been dormant until started by the cold shock (Palmer 1973).

Superposition of circadian and tidal rhythms can enable an animal to adapt to the irregular changes of high and low tide that occur in some parts of the world. On the coast of California, a period of 13.80 hours between high tide is followed by one of 10.43 hours. The intertidal crustacean synchelidium has a pattern of swimming activity that closely follows this tidal pattern.

While studying functional mechanism and regulatory factors of bio-logical clock we have come across two terms exogenous and endogenous periodicity. These two periodicity actually influence the animals to migrate.

- **Theory of exogenous periodicity.** According to this theory changes occurring in biosphere such as photoperiod, barometric pressure, temperature, humidity, season etc. affect animals. These geo-physical factors are always cyclic which coordinate the behaviour of animals.
- **Theory of endogenous periodicity.** According to this theory every individual has got many internal biological clock which determines the physiological and behavioural changes. External stimuli bring only temporary changes in physiological condition so that adjustment of organism may be maintained with external physical conditions. Biological clock not only coordinate external and internal periodicity rather they even assume the external changes in physical condition. Nocturnal rat after coming from burrow remains alert with the help of internal physiological system ie. biological clock. During travel in space man assume the circadian periodicity Travel by plane from one part to other part of earth disturbs the circadian periodicity of man. This causes indigestion, sleeplessness, forget- ness etc. In another word, the biological clock of man becomes disturbed. It takes atleast one or two days to become normal physiological condition.

Endogenous periodicity helps to know the appropriate time. Honey-bee has great power to know the time because some flowers blossom once in a day in a definite time. They reach there with the help of their own biological rise and fall of water twice a day over a range of several meters.

Tides occur on opposite sides of the earth at the same time. Intervals between successive rises of the tide are about 12 hours 25% minutes. This is the same interval as the average daily passage of the moon across the meridian, it is almost certain that the moon is the principal regulator of tides.

Since a moon day is 51 minutes longer than a sun day, there is constant change in the relationship of moon and sun tides. Indicate that in new and full moon, the attraction of sun and moon on tides reinforce each other, and cause the tide to rise higher at high water and fall lower at low water. These are called spring tides. At first and last quarters of the moon, the forces oppose each other and the daily fluctuations are much smaller due to the neutralizing effect of the force. These are called neap tides.

Many marine animals show rhythms of behaviour that coincide with the tidal cycle and have been shown to be governed by an endogenous clock. For example, the shore crab (Carcinusmaenas) has a daily rhythm of activity is superimposed upon a tidal rhythm. The tidal rhythm ensures that the activity is synchronized with high water. This rhythm persists under constant laboratory conditions for about a week before it fades away, and can be restored by cooling the crab to near freezing for about six hours. This clock. Many birds and insects assume the time with the help of position of sun.

7.4 Proximate and Ultimate Factors

In biology, **adaptation** is defined a heritable behaioural, morphological, or physiological trait that has evolved through the process of natural selection, and maintains or increases the fitness of an organism under a given set of environmental conditions. Adaptive traits are those that produce more copies of the individual's genes in future generations.

Ultimate explanations

1. Function (adaptation)

Darwin's theory of evolution by natural selection is the only scientific explanation for why an animal's behaiour is usually well adapted for survival and reproduction in its environment. However, claiming that a particular mechanism is well suited to the present environment is different from claiming that this mechanism was selected for in the past due to its history of being adaptive.The literature conceptualizes the relationship between function and evolution in two ways. On the one hand, function and evolution are often presented as separate and distinct explanations of behaviour.

On the other hand, the common definition of adaptation, a central concept in evolution, is a trait that was functional to the reproductive success of the organism and that is thus now present due to being selected for; that is, function and evolution are inseparable. However a trait can have a current function that is adaptive without being an adaptation in this sense, if for instance the environment has changed. Imagine an environment in which having a small body suddenly conferred benefit on an organism when previously body size had had no effect on survival.

A small body's function in the environment would then be adaptive, but it wouldn't become an adaptation until enough generations had passed in which small bodies were advantageous to reproduction for small bodies to be selected for. Given this, it is best to understand that presently functional traits might not all have been produced by natural selection. The term "function" is preferable to "adaptation", because adaptation is often construed as implying that it was selected for due to past function.

Proximate explanations

3. Mechanism (causation)

In examining living organisms, biologists are confronted with diverse levels of complexity (e.g. chemical, physiological, psychological, social). They therefore investigate causal and functional relations within and between these levels. A biochemist might examine, for instance, the influence of social and ecological conditions on the release of certain neurotransmitters and hormones, and the effects of such releases on behaviour, e.g. stress during birth has a tocolytic (contraction-suppressing) effect.

Some prominent classes of causal mechanisms include:

- The brain: Broca's area, a small section of the human brain, has a critical role in linguistic capability.
- Hormones: chemicals used to communicate among cells of an individual organism. Testosterone, for instance, stimulates aggressive behaviour in a number of species.
- Pheromones: chemicals used to communicate among members of the same species. Some species (e.g., dogs and some moths) use pheromones to attract mates.

(sources: https://bio.libretexts.org/workbench/gGenral_Ecology)

How questions about-proximate causes:

For the wing reaction of an Autonuris with following question can be considered

1- How do the moth’s muscles make its wings move and what controls those muscles?
2- How does the moth know when it has been touched?
3- Did the foods the moth ate as a caterpillar influence how it behaves as an adult?
4- Did the moth inherit this behaviour from its mother or father?

Subdivision of proximate causes into complementary groups:

1- It deals with the interactive effects of heredity and environment on the development of the mechanisms underlying wing-flipping.

2- Other one deals with how the fully developed physiological mechanisms actually operate when the behaviour occurs.

SAQ

1. Types of Migration- .... and ....-
2. Migration is useful to the birds in following respects protects the birds ....and ....or from excessive heat of the reason.
3. Migration is harmful effects because ....in weather
4. Biological clock is not endogenous completely because ...., magnetic field etc.

7.5 Regulations of Seasonal Migration

Migration has been defined as "The periodic swing of an animal population or a part rt of population from a breeding and nestling quarter to a feeding and nestling quarter". It is a regular movement, either annual or seasonal, of at least a part of the population from its breeding place to non-breeding place either for obtaining food and shelter or to pass the unfavourable climate and again its return to the same breeding ground for breeding and nestling.

From very early times bird migration has been fascinating not only for Ornithologists but even for a casual observer of animal life, still it remains a zoological riddle. On certain points more facts are needed and even where facts are abundant they are imperfectly understood.

Majority of birds have the habit of moving from one region to another on the change of seasons. These birds are known as 'migratory birds. The remaining birds do not migrate at all. These are known as 'resident birds'.

The migratory birds exhibit every gradation between those who migrate only a few miles to those who cover thousands of miles.

Types of Migration

Broadly speaking, every migratory bird throughout the world leaves a warmer climate or zone to breed in the cool climate. The direction of migration differs and on the basis of direction the migration is differentiated into-

5. **Latitudinal or vertical migration**
6. **Longitudinal migration-**

Routes of Migration

The migratory birds follow their own definite routes. The route followed may be the same while going and returning back or may be different. The various routes followed are as under-

(A) Sea Routes-The sea routes are followed by marine birds. The land birds are known to cross as much as 400 miles of ocean in a stroke but if there are intermediate islands the distance covered may be more. The birds are seen crossing the Atlantec Ocean between Azores and Portugal (900 miles) and the ocean between the continents of North America and Burmuda etc.

(B) Coastal routes-The coastal routes afford migration highways for a larger number of migrants. These are East Atlantic coast line, West Atlantic coast line, East Pacific coast line, West Pacific coast line, East Indies coast line and West Indies coast line.

(C) River valley routes-While moving from plains to hill and from hills to plains the migratory birds cross rivers and river valleys falling in the way.

(D) Mountain range-Very rarely the birds cross mountain ranges.

The river valleys, mountain ranges and coastal routes afford good landmarks for the migrating birds, which enable the birds to recognize, and remember the routes and entrances to the countries.

Problem of Route Finding

It is still a riddle what guides the young ones of migratory birds to migrate and follow the same course which their parents had taken. An Arctic tern born within 10° of North Pole leaves home at the age of 6 weeks and finds its way to Antarctic region near about 1,000 miles away, and after passing winter again return back through the same route Following explanation have been put forward-

- They utilize various natural structures, such as mountains, rivers, valleys, etc., as the landmarks during flight.
- Birds during flight are guided by the magnetic effect and are always aware of the direction of pole.
- Migration is regarded as a social behaviour and those who have followed for years become the leaders in due course of time. But this is not applicable in every case and if possible may be a secondary factor.
- Migration is an instinct developed due to cumulative inheritance gained by experience.
- The Germa ornathologist Gustav Kramer suggests that birds guide themselves since the birds in cage exhibit restlessness at the time of migration. He said that birds orient themselves in a direction they wanted to migrate and take their route independently and do not learn it from their elders. During night the direction is determined by moon and star patterns. It has also been regarded that birds possess an unusual degree of sense for tracing the direction or are guided by the instincts which impress upon their nervous system in some way or the other

Causes of Migration

Several theories have been put forth to explain the causes of migration in birds. A few of them are as under-

- **Gonadial stimuli-**It is said that the ripening of sex organs in bird causes a physiological change, which leads to an impulse for migration and the bird is evoked to leave its winter quarters and reach the breeding grounds. Rowan (1922) proposed that the migration is stimulated by the hormones secreted by the testes and ovaries.
- **Environmental stimuli-**The heat, glare and drought also provoke migration. The external stimuli, like growing scarcity of food, decrease of day- length or sun-glare, increased cold and stormy weather etc., excite birds to migrate to the better suited place.
- **Thyroid hypothesis-**The hormones secreted by thyroid gland regulate the metabolic activities of the bird are at the time of migration the thyroid hormone produces necessary changes in the metabolic activities which compel the birds to migrate.
- **Antipituitary hormone-**The antipituitary hormone regulates the migration and instinct to migrate
- **Metabolic aspect**-Prior to migration fat deposition occurs due to changed metabolic processess. These changed metabolic conditions provoke migration.

Significance of Migration

Migration is useful to the birds in following respects-

1. Protects the birds from cold and stormy weather or from excessive heat of the reason.

2. Provides long hours of day for searching food.

3. Provides abundant food supply.

4. Provides suitable breeding grounds.

But migration is harmful in the following respects-

1. A journey without rest is tiresome for the birds and most of the passive birds succumb at sea.

2. Sudden changes in weather, ie, pouring of heavy rain or snow or blowing of stormy wind sometimes perish a number of migrants.

3. The young and defenceless birds are exposed to various natural enemies.

4. The telegraphic wires and lighthouses sometime take a great tole of the migratory birds

7.6Summary

- Migration is useful to the birds in following respects protects the birds from cold and stormy weather or from excessive heat of the reason.
- Migration is harmful in the following respects- A journey without rest is tire some for the birds and most of the passive birds succumb at sea. Sudden changes in weather, ie, pouring of heavy rain or snow or blowing of stormy wind sometimes perish a number of migrants.
- Biological clock is not endogenous completely because animals kept in laboratory cannot be detatched from circadian rhythm, magnetic field etc.
- Organisms are capable of knowing the geophysical conditions of the biosphere with the help of biological clock.
- Biological clocks are generally unaffected by metabolic pathways or inhibitors that block biochemical pathways within cells.
- Biological rhythms are self-sustaining, maintaining their normal cycle even in the absence of environmental cues.

7.7 Terminal Questions-

Q.1. Describe in details different types and properties of biological rhythms.

Q.2. Describe in details of proximate factors.

Q.3. Describe in details of ultimate factors.

Q.4. Describe in details regulation of seasonal migration.

7.8 Answer:

1. Latitudinal or vertical migration and Longitudinal migration-
2. from cold and stormy weather
3. sudden changes
4. animals kept in laboratory cannot be detatched from circadian rhythm,

Course Introduction

This course covers details of Animal Behaviour and Wild Life Biology. Scientific study of animal behaviur is known as ethology. This field of biology is most interesting and has made most notable advances during last two decades. All behaviour shown by organisms (irritability, movement, change in shape, posture, reflexes, instincts, learning etc.) may be grouped under two major heads (I) Innate behaviour (inborn or inherited behaviour), (II) Learned behaviour (Acquired behaviour)

The study of animal behaviour encompasses a wide range of topics and approaches from understanding and underlying mechanisms to exploring the ecological and evolutionary significance of behaviour.

Innate behaviour are instinctive and genetically programmed, while learned behaviours are acquired through experience and can be modified by the environment.

Animals use various forms of communication, including visual signals (body language, coloration), auditory signals (vocalizations) chemical signals (pheromones) and tactile signals (touch) to convey information to other individuals.

Many animals exhibit complex social structure and engage in behaviours such as cooperation, competition, aggrission, mating systems.

This course on Animal Behaviour and wild life biology has been divided into three blocks.

Block I- Animal Behaviour-I

Block II- Animal Behaviour-II

Block III- Wild Life Biology

Block I- Animal Behaviour-I This block has been divided into 03 units.

Unit-1 This unit deals with the factors affecting survival behavior, choice of breeding

sites, habitat selection, determinants of habitat preference.

Unit- 2 It deals with Evolutionary and neurological basis of behavior, Innate behavior, Stereotype and acquired behavior, Neural and hormonal control of behavior. It also deals with patterns of communication (chemical, visual, light, audio, Species specificity of songs, evolution of language with respect to primates).

Unit-3 This unit deals with flocking in birds, herding in mammals, group selection, kin selection, altruism, reciprocal altruism, inclusive fitness, social organization in insects and primates. It also deals with social structure and behavior, Parental care with reference to fish, amphibians and birds, territorial behavior

Objectives:

After studying this block you will be able to know:

- selection of habitat
- evolutionary and neurological basis of behavior

- social behavior

Block-II- Animal Behaviour-II

In previous block you have studied about the Animal behaiour-I (selection of habitat, evolutionary and neurological basis of behavior and social behavior). This block deals with the Animal behaviour-II. This block comprises of 4 units (unit 4, 5, 6 and 7). Including flowing topics.

Unit-4 It deals with the sexual behaviour: (courtship, sexual selection, mating patterns). Monogamy, polygamy, polyandry. It also deals with the sexual conflict, parental investment, Infanticide. Female choice, male quality and courtship. Sexual behavior in animals is a complex and fascinating topic that has intrigued researchers for centuries. The study of animal mating behavior has provided important insights into the mechanisms that drive sexual selection, reproductive success, and species diversity.

Unit- 5 This unit deals with circadian and circannual rhythms, orientation and navigation. masking and entrainment, phase shift, Phase response curves (PRC) and phase transition curves (PTC). It also deals with Biological rhythms and human health, sleep, neural mechanisms of sleep.

Unit-6 This unit deals with pheromones and hormones, hormones and behavior and role of pheromones.

Unit-7 It deals with types and properties of biological rhythms, geophysical environment Seasons; proximate and ultimate factors and regulation of seasonal migration.

Objectives:

After studying this block student will be able to know:

- sexual behavior
- biological rhythms
- pheromones and behavior
- anatomy and physiology of the time photoperiodic time measurement

Uttar Pradesh Rajarshi Tandon Open University

Master of Science

PGZY-103(N)

Animal behaviour and Wild Life Biology

Block

3 Wild Life Biology

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PGZY – 103 (N) : Animal behaviour and Wild Life Biology
ISBN-

In previous block (block-II) you have studied about the (sexual behavior, biological rhythms, pheromones and behavior & anatomy and physiology of the time Photoperiodic time measurement). In this block comprises of 5 units (unit 8, 9, 10, 11 and 12) including flowing topics.

Unit-8 It deals with the brief history of wild life in India, biodiversity, level of biodiversity and Importance of wild life, vanishing wild life.

Unit-9 It deals with the Indian threatened mammals, Indian threatened birds, Indian threatened reptiles and IUCN red list of animals

Unit-10 It deals with the endangered species and their distributions, project tiger and its evaluation and other animal projects and their updates

Unit-11 It deals with the important national parks, important national sanctuaries, important national biosphere reserves, zoological gardens and museums.

Unit-12 It deals with the habitat managements, reintroduction in wild, mass education and awareness, promulgation of laws, wild life organizations, Red data book, problems of wildlife managements in India and wildlife health and population management.

Objectives:

After studying this block student will be able to know:

- introductory wild life biology
- protected Indian wild life
- important Indian wild life
- national Parks, sanctuaries, and biosphere reserves
- methods of wild life conservation

UNIT 8: INTRODUCTORY WILD LIFE BIOLOGY

8.1 Introduction

The history of wild life in India is unique as it is mix of diverse species, forests, land and protection of species and population since time immemorial. The history relates to nature, how people feared and respected it and then eventually tried to dominate it. It is believed that history of wild life is associated with long names & dates, news of rare species and conflicts over threatened habitats.

In Vedic periods there is existence of 250 species of birds has been reported in medical treatises of Sushrutra & Charaka. The blackbuck, Indian koel & house crow was very common in Aryavarta, who were present in the northern part of Vindhya Mountains. The 2000 years old Gajashastra, written in pali script describe the training of captured elephant. This has been reported in Indus Valley civilization.

During the 3rd & 4th centuries BC, the rulers of Maurya dynasty altered their attitudes towards wild beasts, in their attempts to protect animals forests. A large number of lions, tigers & elephants were protected by the Mauryas. They served innumerable purposes for the rulers particularly during wars. So elephant and horses are treated as royally. Elephants & horses had played crucial roles in the defeat of Alexander’s general, Seleucus. Kautilya’s Arthashastra provide information about them. After embracing Buddhism king Ashoka had implemented laws for the conservation of wild animals. According to Edicts of Ashoka claim that he made a rule to people would be fined 100”panas” for poaching deer inside the royal hunting ground.

The Mugal emperors Jahangir & Babur made regular observations of wildlife. Babur was fond of hunting and many animals were killed near Kolkata. Jahangir recorded the number of animals (about 28,532) hunted by him, in which 35 swamp deer, 889 blue bulls, 86 tigers, 9 foxes, otters, hyenas, leopards etc. were victims. It is believed that Ustad Mansur, who was a court artist of Jahangir in 17th century, had painted a wonderful portrait of a Siberian crane.

During pre-colonial & post colonial eras, various species of rare insects were brought to India. Two clear events mark the history of Indian wild life. The first, Impact of British, whose intrusion into the world of the wild were far more extensive than those of its predecessors. The history of Indian wildlife shows that princes and middle class Indian were contented with the British as far as hunting was concerned. The second event was unleashing of the wide spread destructive forces, including the state sponsored slaughtering of certain wild animals and harnessing of forest for industrial raw materials and military supplies. In history of Indian wildlife was a creation of legal & government apparatus to administer large stretches of forest.

After Independence, a large no of groups emerges in India to approaches to nature, keeping view in this certain laws & regulation has been made to protected wild life & conserves it.

Objectives

After studying this unit you will be able to know:

- Biodiversity, Level of biodiversity
- Importance of wild life, vanishing wild life

8.2 Biodiversity, Level of biodiversity

Earth having diverse forms of living organisms which are present in aquatic and terrestrial habitat. The living organisms include plants & animals from microscopic to macroscopic forms. It is believed that as many as 500 millions species of plants, animals and micro-organism inhabiting the earth. All the living form plants and animals exhibit great variety or diversity, which is called biodiversity. So biodiversity is defined as the sum of total of species richness i.e. the number of species of plants, animals and micro-organisms occurring in a given habitat.

The convention of biodiversity takes place in June 1992 at Rio de Janerio, Brazil, under the aegis of united nation conference on Environment & development. In this convention laid tremendous stress on global biological diversity and emphasized the importance of preserving it for future generations. According to convention biodiversity is define as biological diversity means variety and variability among living organism from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystem and the ecological complex in which they are part. This includes diversity within species, between species and of ecosystem.

Magnitude of Biodiversity

It represents the number of species in a given habitat. It represents the diversity of organism sharing the same habitat. A combination of equitability/ evenness and species richness is used to known that diversity prevalent within community or habitat. It is predicted that the number of total species varies from 5 – 50 million. It is describe as follows

Taxonomic group	Number of species
Viruses	**1550**
Bacteria	**4000**
Mammals	**4650**
Amphibians	**4780**
Reptiles	**7150**
Birds	**9700**
Nematodes and worms	**25,000**

Fish	**26,959**
Protozoa	**40,000**
Crustaceans	**43,000**
Molluscs	**70,000**
Insects	**1,025,000**
Others	**1,10,000**

According to the International union for conservation of Nature (IUCN), India is a mega diverge country with only 2.4% of the world land area, accounts for 7 – 8% of all recorded species including species of plants & species of animal. The India has 10 biogeographical regions Trans Himalaya, Himalaya desert, semi-arid, western Ghat, Deccan peninsula, gangetic plain, coasts, North–east and islands. India has 89 national parks, 492 wild life sanctuaries, 14 biosphere reserve, 6 wetlands and 5 world heritage sites. It also has 27 tiger reserve.

India largest biogeographical region is the northeast are regions richest in biodiversity. About 33% of flowering plant, 10% of mammals, 36% reptiles, 60%of amphibians and 53% of freshwater fish are endemic. The Himalayas and Western Ghats are richest regions.

Levels of Biodiversity

In an ecosystem there exist a wide variety of organism, complex ecological relationship among organisms and genetic diversity within species. If one could understand the concept of biodiversity, then he can conserve the biodiversity. There are 3 levels of biodiversity which are inter-related with each other.

(i)Genetic Diversity : Every living species possess certain number of genes e.g. *E.coli* 4000, *Drosophilia melanogaster* 13,000, man 35000 – 45000. Genetic diversity refers to the variation of genes within species. This constitutes distinct population or varieties with a species. Two individual are even not similar. The differences between two individuals are because of their variation in genetic material which is present in all organisms. This genetic material is passed on from one generation to another generation. Diversity in individual is also due to variation caused by environmental influence on each individual organism, so environment also play a important role in variation in genetic material. Genetic material is principally a function of sequence variation in the four base pairs making up nucleic acids or DNA. New genetic variation results due to gene and chromosome mutation in Individual.

A species with more genetic diversity can adopt better to the changed environmental conditions while a species with low genetic diversity results into uniformity.

The genetic diversity within a species often increases with environmental variability. A community with more biodiversity has greater genetic diversity than the community having less biodiversity.

(ii)Species Diversity: Species diversity refers to the variety in the number and richness of the species of a particular region. Species richness is the number of species present per unit area. Biodiversity at its most basic levels includes the full range of species from micro-organism to the multicellular. It is possible to count the number of species in a particular region or site in country. It is also more easy to count number of species of common animal e.g. birds & mammals in a particular region. This gives the idea of species richness in that region i.e. biodiversity. This will be easy to compare the biodiversity at different regions.

Geographical condition is another factor are also responsible for species richness for e.g. the area of warmer climatic condition contains species diversity or richness is always more. While colder conditions restrict the species diversity. Wetter areas also show more species than dry or desert conditions. It has been observed that varied topographical and climatic conditions. Sometimes in a particular area the species which are unique and not found anywhere called endemic species for e.g. islands have fewer species which are unique and not found on other regions.

Odum *et.al.* in the year 1960 calculated species diversity as several species per thousand individuals where as Menhinick in the year 1964 calculated it as the number of species about the square root of a total number of individuals.

(iii)Community and Ecosystem Diversity : The community diversity is of the three types :-

- **Alpha Diversity :** It exist within community diversity. It is species diversity that is dependent upon species richness and evenness. Amongst the members of the same community, there is a lot of competition, adjustments and inter-relationship. Here variations are limited.
- **Beta Diversity :** It exists between communities. It appears along a gradient of habitat within the geographical area. Due to differences in microhabitat, niches and environmental conditions, there may occur changes in communities that could lead to the replacement of species.
- **Delta Diversity :** It is the diversity that is present in ranges of communities as represented by the diversity of habitats or ecosystems over a total land scape of the complete geographical area.

Ecosystem Diversity: It refers to the variation in the biological communities in which species live. This is the diversity of ecological complexity showing variations in tropic structure, food webs, nutrients cycling etc. The physical parameters like altitude, temperature, moisture, precipitation are also variable in an ecosystem and hence occur tremendous diversity within the ecosystems due to these parameters. The diversity in any ecosystem developed because of million years of evolution. If the biodiversity gets destroyed then the ecological balance gets disturbed. It is irreversible process and cannot be replaced.

8.3 Importance of wild life, Vanishing wild life

The undomesticated animals living in their natural habitat are known as wild animals and represent wild life of animals. It includes mammals, reptiles, birds and fishes etc. Some of the importance of wildlife is as

(1)Economic Importance : Many products can be obtain from wild life like gum, resins, tannins, several drugs, essential oils, spices, silk, honey, hair, feathers, guano (the dung of sea-fishes used as manure or manure made from fish), leather, musk, ivory etc. after death of wild animals, but now it is illegally banned and not practice.

(2)Gene bank : The wild life serves as a gene banks for breeding improved varieties in animals husbandry & fishery.

(3)Ecological balance : All the living things on the earth remain are interlinked food chain and maintain ecological equilibrium through

- Regulation of population of different species.
- Food chains through series of populations comprising producers, consumers and micro-organisms.
- Circulation of nutrients between biotic and Abiotic environments.

(4)Cleaning of Environment : The scavenger and decomposers wild animals like eagles, vultures, hyenas, jackals etc. as well as micro-organism which feed upon dead animals, convert them into different nutrients and release energy back to the nature, increasing fertility of the soil. They do very important work of cleaning the environment.

(5)Perennial fresh water

(6)Maintenances of Climate

(7)Scientific Importance : For research purpose and studies of anatomy, physiology, ecology, evolutionary aspects.

(8)Soil Erosion: It is prevented by plant cover, litter, mixing of litter by movement of wild animals and conversion to spongy humus by micro-organisms.

(9)Experimental animals : Many animals are used in research purpose like monkey, rabbits, Guinea pig, Rat etc.

Benefits of wild life

Benefits to Science, Agriculture & Medicine

The genetic diversity can be preserve by wildlife and wildlife habitat. In medicine, development of new drugs and treatments are largely dependent on wildlife and wildlife habitat. Most pharmaceutical products are a result of discovering or developing wildlife species.

Benefits to Natural Processes

Wildlife plays a key role in the ecological and biological processes to help the life. The normal functioning of the biosphere depends upon interactions between animals, plants and microorganisms. This will enhances human life. Agriculture, forestry, fisheries and other endeavors are vital ecological process that supports human life. Pollination, germination, seed dispersal, soil generation, nutrient cycling, predation, habitat maintenance, waste breakdown and pest control are biological process, where wildlife plays a key role.

Benefits to People

Nature and wildlife have been associated with humans for numerous emotional and social reasons. Since prehistoric times animals have been highly useful to us in providing food, clothing and source of income.

Vanishing wild life

The beauty of nature is our wildlife, which is found everywhere on earth. Now it has been observe that there is continuous decline in the population of wild life. The largest decline in wildlife population in 1970 -2016 period has been in Latin America (94%) and in Asia –Pacific (45%). The situation of India is also very worrying. According to one report about 12% of our wild mammals and 3% of bird species are on the verge of extinction. 19% of Indian amphibians are threatened or critically endangered. Many fresh water mammals, birds, amphibians, reptiles and fishes are also placed in vulnerable categories. According to report of WWF, vanishing of wild life is only due to human activity for destruction of wildlife population & habitat. Forests are being burned down to make them suitable for human habitation or convert them into agricultural land. Decline in their natural habitat, the wild animals are boxed into shrinkage habitats. They are under tremendous pressure from habitat loss. Due to overfishing in ocean or river water, the population of fishes decline. So destruction of ecosystem and species over exploitation, human caused climate change bring about decline in wildlife population. Any species of animals are not able to adapt in changed conditions, so they perish.

Killing for commercial and food purpose of wildlife, threaten various cat, whales, sea turtles and certain other creatures. Dodo once thrived on the

Mauritius island. Many dodo were killed for food. The worst threat came from the rats and pigs that ate away the eggs of the dodo from their nests.

Wolves and tiger population has also declined. Many men have invaded the forests and destroyed the wilderness of the habit of wolves and tigers. Destruction of habitat is greatest threat of wild life. The other form of threats are overgrazing by live stock, population of air and water deforestation, establishment of towns and factories.

SAQ.

Complete the following sentences by inserting appropriate words in the blanks.

(i) United nation conference on Environment & development take place -------

(ii) ---------------diversity exists within community.

(iii) -------------- diversity exists between communities.

(iv) Dodo egg are eaten by animals --------

8.4 Summary

In this unit there is study about history of wild life in India. There is also study about biodiversity, magnitude of biodiversity and level of biodiversity. This unit also contains importance of wild life, vanishing wild life in very detailed manner**.**

8.5 Terminal Question

Q1. Explain Biodiversity.

Q2. Explain about Species Diversity.

Q3. Explain about Ecosystem Diversity.

8.6 Answers

SAQ

(i) 1992

(ii) Alpha

(iii) Beta

(iv) Rat and pigs

Terminal Question

Ans 1.

Earth having diverse forms of living organisms which are present in aquatic and terrestrial habitat. The living organisms include plants & animals from microscopic to macroscopic forms. It is believed that as many as 500 millions species of plants, animals and micro-organism inhabiting the earth. All the living form plants and animals exhibit great variety or diversity, which is called biodiversity. So biodiversity is defined as the sum of total of species richness i.e. the number of species of plants, animals and micro-organisms occurring in a given habitat.

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Ans 2.

Species diversity refers to the variety in the number and richness of the species of a particular region. Species richness is the number of species present per unit area. Biodiversity at its most basic levels includes the full range of species from micro-organism to the multicellular. It is possible to count the number of species in a particular region or site in country. It is also more easy to count number of species of common animal e.g. birds & mammals in a particular region. This gives the idea of species richness in that region i.e. biodiversity. This will be easy to compare the biodiversity at different regions.

Geographical condition is another factor are also responsible for species richness for e.g. the area of warmer climatic condition contains species diversity or richness is always more. While colder conditions restrict the species diversity. Wetter areas also show more species than dry or desert conditions. It has been observed that varied topographical and climatic conditions. Sometimes in a particular area the species which are unique and not found anywhere called endemic species for e.g. islands have fewer species which are unique and not found on other regions.

Ans 3.

Ecosystem Diversity refers to the variation in the biological communities in which species live. This is the diversity of ecological complexity showing variations in tropic structure, food webs, nutrients cycling etc. The physical parameters like altitude, temperature, moisture, precipitation are also variable in an ecosystem and hence occur tremendous diversity within the ecosystems due to these parameters. The diversity in any ecosystem developed because of million years of evolution. If the biodiversity gets destroyed then the ecological balance gets disturbed. It is irreversible process and cannot be replaced.

UNIT 9: PROTECTED INDIAN WILD LIFE

9.1 Introduction

A large number of mammals are suffering from their verge of extinction, so it is necessary for them to conserve it, government of India has introduce various project like project tiger, project hangul, project lion, project snow leopard for their conservation and to increase their population. Some of the Indian threatened mammals are discussed below

Himalayan Brown Bear (*Ursus arctos isabellinus*)

It is distributed in Nepal, Tibet, and Northern part of India & North Pakistan. The Himalayan brown bears inhabit the high altitude region of the Himalayas. They have thick fur that is mostly often sandy or reddish brown in colour. The shades of the brown fur vary from dark pale to reddish brown according to the variation in season. Some of the bear also provided with silvery grey with white tip to the fur. They grow up to 2.2 meter long and weigh up to 250 kg. They are nocturnal and their sense of smell is actually developed and believed to their principal means of finding food. Brown bear are omnivorous and feed on berries, young sprouts of grass, back wheat, wild fruits, rats and insects. Sometimes it takes larger animals also as food. Their breeding take place in the months of early summer and they usually give two cubs.

Due to habitat encroachment, tourism and grazing pressure are responsible for declining population of bears. According to one estimation that only 500 -750 bears left in India. According to one study predicts a decline of about 73% of their habitat by 2050 in the western Himalayas. Due to all these threat conservation should focus on habitat, preservation, creating biological corridors & promoting responsible waste management to minimize human bear conflicts.

Threat

- Human animal conflict

- Rapid habitat loss
- Poaching for fur, claws & organs
- In some cases bear baiting

Fig 9.1.: Himalayan Brown Bear

Pygmy Hog (*Sus salvanis*)

It is world smallest wilding wild pig. It is one of the most useful indicators of the management status of grassland habitats. The grasslands where the pygmy hog resides are crucial for the survival of other threatened species such as Indian rhinoceros, swamp dear. Earlier it was distributed across India, Nepal & Bhutan. But now only found in Assam (Manas wildlife sanctuary). It is about 70cm in length and 30 cm in tusks and ears. It tail is about 3 cm in length. The body is covered with scattered hairs of black-brown colour. It has well developed teeth with upturned canine and molars with rounded cusps. The pygmy hog is diurnal animal, generally found active between dawn to midmorning. They dig their burrows usually at dusk. It is omnivorous and it feed on roots, tubers, variety of birds, insects and monitor lizard etc. They are solitary in habit and meet the sows only during mating season. Breeding occurs seasonally before the monsoons and after a gestation period of 100 days female give birth to litters ranging between 2 – 6 offspring.

Threat

- ➢ Loss of degradation of habit due to livestock grazing, commercial forestry and planting of trees in the grassland, Aforestation of grassland.
- ➢ Hunting the pygmy hog for meat by the native tribes of Assam is also responsible for decline its population.
- ➢ Dry season burning.

In the year 1977 about 14% of pygmy hogs were killed by poachers. So to save this endangered species, a suitable environment should be prepared in sanctuaries for the breeding. The pygmy hog conservation breeding programme was formed in 1995.

Kondana Rat (*Millardia kondana*)

It is distributed only from the small sinhagarh Plateau (about one km^2) near Pune in Maharashtra. It is nocturnal burrowing rodent that is found only in India. Due to overgrazing of vegetation and disturbance from tourism and recreational activities there population decline.

Fig 9.2.: Kondana Rat

Large Rock Rat or Elvira rat (*Cremnomys Elvira*)

It is a medium sized nocturnal and burrowing rodent. It is only found in India. Its habitat is tropical dry deciduous shrub, land forest, seen in rocky areas. Its distribution is only from Eastern Ghats of Tamil Nadu, recorded from an elevation of about 600 m above mean sea level.

Threats

- Habitat loss
- Conservation forest
- Fuel wood collection

Fig 9.3: Elvira rat

Andaman White toothed Shrew

It is distributed only in India i.e. endemic to the South Andaman Island of India. They are usually active by twilight or the night. It is critically endangered species of mammals.

Threats

- Habitat loss due to selective logging
- Natural disasters such as tsunami and drastic weather changes are thought to contribute to current population decline

Fig 9.4: Andaman White toothed Shrew

Sumatran Rhinoceros (*Dicerorhinus sumatrensis*)

It is the smallest and most endangered of the five rhinoceros. It is now thought to be regionally extinct in India though it once occurred in the foothills of the Himalayan and north east India. The Java Rhinoceros is also believed to be extinct in India and only a small number survive in Java & Vietnam.

Threats

- Poaching
- Loss of Habitat

Fig 9.5 : Sumatran Rhinoceros

Kashmir Stag / Hangul

It is subspecies of Red deer, which is native to India. It is distributed in dense riverine forests, high valleys and mountains of Kashmir valley (Dachigam wildlife sanctuary) and northern Chamba (Gamgul wildlife sanctuary) district of Himachal Pradesh, state animal of Jammu & Kashmir. The hangul is the only surviving species of the Asiatic member of the red deer family. The male hangul has antlers which can have around 11 to 16 points on them.

Threats

- Poaching by both civilian and military personnel was identified as the main cause of the decline of the Hangul in the past & present.

- Lack of patrolling to prevent the wild life crimes.
- Difficulty in implementing protection activities adequately due to security issue in the parts of Dachigam National Park.
- The incursion of nomadic livestock, herders and predation of fawns by their guard dogs is reported also a significant problem that is not being effectively dealt with.
- Competition for grazing grounds with livestock and the associated risk of disease transmission are also potential threat to hangul.
- An imbalance in the male & female ratio.

Conservation

For conservation of hangul a project “Project Hangul” was started in 1970, the joint efforts of the expert, especially Dr. Fred kurt and Jammu & Kashmir government have ensured the survival of Hangul

Discontinuing the release of problem leopards & Asiatic black bear in the area could also help reduce predation on hangul fawn and increase survival.

Namdapha Flying squirrel (*Biswamoyapterus biswasi*)

It is the unique (only one in its genus) flying squirrel that is restricted to a single valley in the Namdapha National Park or tiger reserve in Arunachal Pradesh. It is found in tropical forest only.

Threats

- Hunted for food

Fig 9.6 : Namdapha Flying squirrel

Malabar Civet (*Viverra civettina*)

It is endemic to India and was first reported from Travancore Kerala. It is nocturnal in nature and found exclusively in the Western Ghats. It is mainly found in wooded plains and hill slopes of evergreen forest.

Threats

- Deforestation and commercial plantation are major threat

Fig 9.7: Malabar Civet

Slender Loris (*Loris tardigradus*)

It is found in Sri Lanka & Southern part of India like Tamil Nadu, Kerala, Karnataka and Andhra Pradesh. It is small primate with slender body. It has long limbs, well developed index finger, large ears and thin appearance. It is tailless and 25 cm in length. The body colour is dark grey or earthy brown with beautiful ornamental silvery hairs. It is nocturnal in habit. During day period it remains hidden among foliage and start moving from tree to tree at dusk. It feeds on berries of *Lantana*, Lizard, tree frogs, insects & small birds. Kadavur slender Loris sanctuary was declared as India first slender Loris sanctuary. It is located in Karur & Dindigul district of Tamil Nadu.

Threats

- Heavy killing for medicinal use in eye disease and as an experimental animal.

Fig 9.8 : Slender Loris

Slow Loris (*Nycticebus coucang*)

In India it is found in tropical rain forest, south of the Brahmaputra river in Northern India and in eastern Bangladesh and Burma to far east, Slow Loris body and limbs are stout with rounded head and dark brown encircled rounded eyes. The length of body is 30 – 40 cm. The body of slow Loris is covered by dense fur which are silvery white on the head and shoulder regions but grey on the flanks and rump. There is a brown strip on the middle of its back which terminate on the crown. It is nocturnal animal. It is arboreal and rarely comes to the ground. It sleeps during day time in the holes or crevices of tree and comes out during night in search of food. It is omnivorous, feed on fruits, young shoots, leaves and insects, small birds, reptiles.

Threat

- Due to destruction of habitat it is place in vulnerable category

Fig 9.9: Slow Loris

Asiatic lion (*Panther leo persica*)

Earlier Asiatic lion are found in many parts of India, but now it is restricted in a small area of 1515km^2 in Gir forest of Gujarat. The Indian lion height 105 – 110cm, length 200 – 280cm, weight 110-190 kg, life span 18 - 20yrs. The Asiatic lion have a very unique longitudinal fold of skin that run along their belly. They wander in a group called Pride generally comprising of 7 – 14 lions. The Asiatic lion having sharp canine teeth of 10 cm. The Asiatic lion are smaller than African lions and have shorter manes. The four year lion is an adult. The lioness becomes a mother at the age of two and half year to three years. The lioness gives birth of 2 or 3 cubs at a time. It is seen that their population of Asiatic lion has increase.

Threats

- Human wildlife conflict

- Natural prey decline
- Habitat loss
- Climate change
- Wildlife trade
- Hunting

Tiger (*Panthera tigris tigris*)

Indian tiger is found though out India from Himalayas to cape comorin except in Punjab, deserts of Rajasthan, cutch & Sind. It has breed successfully in captivity. The Indian tiger is rich coloured well striped animal; with a short coat. To protect the tiger, the project tiger was initiated as a central sector scheme in 1973 state.

Threats

- Poaching
- Human wildlife conflict
- Natural prey decline
- Habitat loss
- Climate change
- Wildlife trade

Red Panda : (*Ailurus fulgens*)

It is distributed in Himalayan region including India, Nepal, China, Bhutan & Myanmar. In India it is found Sikkim, Arunachal Pradesh and West Bengal (khangchendzonga and Namdapha national Park). The Red Panda has soft thick fur rich reddish brown above and black underneath. The face is white with a stripe of red brown from each eye to corners of the mouth and the bushy tail is faintly ringed. The head and body length of red panda is 50 – 65cm and tail is 30 – 50 cm and weight is 3 – 6.2 kg. The feet have hairy soles and claws are semi-retractile.

Threats

- Poaching
- Human wildlife conflict
- Habitat loss and degradation
- Climate change

Indian Panther (*Panthera pardus*)

Panther is distributed in various parts onf India. In Uttarkhand Jim Corbet National park, Govind Pashu Vishar, Rajaji Sanctuary, Motichur sanctuary, Nanda Devi sanctuary, In Uttar Pradesh Dudhwa National park, Kishnnapur sanctuary, Chandraprabha sanctuary, Katarniaghat sanctuary, Ranipur sanctuary, Mahavir Swami sanctuary. It has a well developed tail, short ears ad strong legs. Their eyes are yellowish grey ocular bulbs. Its spots fade towards the underbelly and the lower part of the legs. The white-tipped tail is 60 -100 cm long. It size of male is 127 -142 cm and female is 104 – 117 cm. Tail length is 75 – 91 cm. Weight of male is 50 – 77 kg & female is 29 -34 kg.

Threats

- Human wildlife conflict
- Habitat loss
- Poaching for illegal trade of body part

Snow Leopard (*Panthera uncia*)

Snow leopard is distributed in Himalayan range from Kashmir to Bhutan. It is protected in Dachigam wildlife sanctuary in Jammu & Kashmir. The snow leopard fur is whitish to grey with black spots on head and neck, with larger rosettes on the back, flanks and bushy tail. The belly is whitish. Its eyes are pale green or grey in colour. Its muzzle is short and its forehead domed. Its nasal cavities are large. The fur is thick with hairs between 5 – 12 cm long. Its body is stocky, short-legged and slightly smaller than the other cats of the genus "Panthera", reaching a shoulder height of 56 cm and ranging in head to body size from 75 – 150 cm. Its tail is 80 – 105 cm long. It weighs between 22 and 55 kg with an occasional large male 75 kg and small female of under 25 kg. Its canine teeth are 28.6 mm long and are more slender than those of other "Panthera" species.

Threats

- Habitat loss
- Poaching for illegal trade of body part

Fig 9.10: Snow Leopard

Indian Elephant (*Elephas maximus*)

The Indian elephant is distributed in the forest of western Ghats, Assam, Karnataka, West Bengal, Odisha, Bihar, Uttar Pradesh, Uttarkhand, Kerala & Tamil Nadu. The Indian elephants are greyish-black colour. They are about 6.6 to 11.5 ft in height and weigh about 6000 to 11,000 pounds. They have long trunk and completely boneless.

Project Elephant was launched in 1992 by the Government of India Ministry of Environment and Forests to provide financial and technical support to wildlife management efforts by states for their free-ranging populations of wild Asian Elephants.

Threat

- Prevent illegal trade of ivory
- Hunters and poachers
- Unnatural causes of elephant's death

Project Elephant – MIKE Programme

MIKE (Monitoring of illegal killing of Elephant) was started in South Asia in 2003. The aim of MIKE was to provide the information required by the elephant range countries for proper management and long-term protection of their elephant populations.

Swamp Deer or Barasinga (*Cervus duvauceli*)

Swamp Deer is distributed from North to South India. In North it is found in Tarai Uttar Pradesh, Assam & sundarbans. It has 12 horns or antlers.

Black buck (*Antilope cervicapra*).

The blackbuck or Indian antelope It can be seen in Velavadar National Park Gujarat. It is well developed muscles & spiral horns up to 15 cm long. The male blackbuck is almost black, while the inner parts of the legs, belly and chin are white and their is also white patch around its eyes. It speed up to 80 to 96 km/hours

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Fig 9.11: Black buck

Rhinoceros (*Rhinoceros unicornis*), The Indian one horned rhinoceros is distributed to low marshlands on the banks of Brahmaputra, small area of Bengal and low Tarai land along the river Rapti & Narayani in western central Nepal. The tall elephant grasses of kaziranga serve as shelter for rhino. The rhinoceros (*Rhinoceros unicornis*) is a Greek word rhino mean nose & ceros mean horn, so they have horn in nose. The Indian rhinoceros has a thick grey brown skin with pinkish skin fold, one horn on its snout. Indian rhino's have single horn is present in males and female but does not new born calves. The horn is use as weapon. At present their population is 3700 in India. There are 5 types of rhinoceros found in world

(i)Black rhinoceros

(ii)White rhinoceros

(iii)Sumatran rhinoceros

(iv)Javan rhinoceros

(v)Indian rhinoceros

The black and white rhinoceros have two horns at snout. The Sumatran and Javan rhinoceros have single horn at snout. The Indian rhinoceros also called great one horn rhinoceros. The one horned rhinoceros are found in Nepal, Bhutan, Pakistan & India and in India it is in Assam, west Bengal & Uttar Pradesh.

Threat of Rhinoceros

- **Sport hunting**
- **Poaching** : Rhinoceros horn are used in Chinese medicine, wall hanging, Hookah used for smoking, skin are used for making bags, balls & shoes etc. are under threat of poachers. Between 2013 to 2018 year nearly 100 rhino were poached in India.
- **Habitat loss or human-rhino conflict** – Habitat of Indian rhinos is deteriorating as a result of human activities and natural disasters

such as floods, resulting in a large numbers of deaths. The Indian rhino population range is limited with 70% of population concentrated in a single kaziranga National Park, if any unexpected catastrophic such as disease, natural disaster or habitat loss will have a severe impact on rhino's population. Due to this since 1986 rhinos have been moved annually from Chitwan to Bardia and Shuklaphanta National Park to ensure their survival in the event of an epidemic.

Steps taken to conservation of rhino in India

- Restoring landscapes
- Working with locals
- Reducing illegal trade
- Monitoring and census
- Reinforcing the law enforcement
- Indian Rhino vision 2020

Musk deer (*Moschus moschiferus*)

The Himalayan musk deer is distributed in forest adjoining alpine meadows & alpine scrubs. It is distributed in Afghanistan, Pakistan, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Uttarkhand, Nepal, Sikkim, Bhutan, Arunachal Pradesh &Burma. In India, Garhwal (Govind Pashu Vishar Uttarkashi), Nanda Devi National Park (chamoli), Valley of flower National Park & Kedar Nath Sanctuary. The musk deer family differs from cervids or true deer by lacking antlers and preorbital glands. They also possessing only a single pair of teats, a gall bladder, a caudal gland, a pair of canine tusks and of particular economic importance to humans a musk gland.

Threat

- Habitat destruction

- Large scale illegal hunting to meet their commercial demand.

Fig 9.12 : Musk deer

Thamin ((*Cervus eldi*)

The Thamin deer is found in keibul lamjao National park in Manipur. It lives in high bush or reeds, rests during the heat of the day under cover, comes out for grazing early in the morning. The male is dark brown where as female is light brown coloured. The male pursue the female just before the start of the breeding season.

Fig 9.14 : Thamin

Hoolock Gibbon (*Hylobates hoolock*)

It is only ape in India. The hoolock gibbon is distributed in the hill forests of Assam and Chittagong. Hoolock gibbons are tailless and arms are much longer than the legs. In this males and females are black but on reaching maturity a female becomes yellows gray.

Fig 9.13: Hoolock Gibbon

Blue Sheep (*Pseudois nayaur*)

It is also known as Bharal sheep. It is commonly found in kumaun, Ladakh, Nepal & Sikkim. The adult male Bharal have a slate blue coat colour. In a winter this colouration becomes more prounced, while in summer the coat becomes red brown especially in females and young, serving as better camouflage. The tail is short and dark. The males horn are very characteristic and curve outward, backward and then downward in a crescent formation. Females are one third the size of the male. It is hunted for mutton.

Fig 9.15: Blue Sheep

Chiru (*Pantholops Hadgsoni*)

They are distributed in Ladakh & Kashmir. The chiru comes down to Ladakh in summer for grazing. The chiru male has carry thin, long horns that curve slightly forward and female are hornless. On each side of the blunt muzzle are two small bulges that contain air sacs used in vocalization. The adult male is about 83 cm height and 40 kg weight while female is 74 cm height and 25 kg of weight. The stocky body stands on long, slim legs indicative of swift running. Chiru feed on low alpine grasses, forbs and shrubs. The pasham wool is obtained from this chiru which is used to prepare soft & costly shawl.

Fig 9.16: Chiru

Nilgiri Tahr (*Hemitragus hylocrius*)

These are distributed from the Nilgiri to the Anaimalai and western Ghat of India. The Nilgiri tahrs are sharped eyed and sure footed animals and at the time of danger they disappear into dense forest. Its height is about 100 cm and weight is 80 -100 kg. The horns of males are longer than those of female. The adult male is provided with white colour on the back and neck and a white spot on the knee. They generally found in flocks of 6 -12. They graze on grasslands on mountain top and slopes early in the morning and late in the afternoon. These are well seen in Periyar wild life sanctuary.

Fig 9.17 : Nilgiri Tahr

Gangetic Dolphin (*Platanista gangetica*)

It is distributed in river Ganga, Brahamputra and Indus rivers and their tributaries. The body of gangetic dolphin is fusiform provided with a pair of triangular pectoral flippers, rudimentary dorsal fin and horizontal tail fluke. The head is elongated forming compressed rostrum. The rostrum of male is smaller than female. For breathing purpose they regularly comes out of water. The main food is fishes & crustaceans. Their population decline due to loss of habitat and pollution of water.

Fig 9.18: Gangetic Dolphin

Sperm Whale (*Physeter catodon*)

It is distributed in tropical & subtropical seas. It is commonly found in Bay of Bengal & SriLanka. It has enormous square cut head which is provided with a blow hole at its tip. The lower jaw is shorter than upper jaw and the lower jaw has nearly 30 teeth. The length of male is 15 – 18 meters while female are 8 – 10 meter. The flippers are rounded and broad and dorsal fin is a round hump. The tail of sperm whale is wide, notched and horizontal in position. The colour of body is from grey to dark bluish grey and black. They are killed for various products like sperm oil from blubber, spermaceti from head can be obtain.

Fig 9.19 : Sperm Whale

9.2 Indian threatened birds

Bustard (*Choriotis nigriceps*)

The great Indian Bustard is an endangered bird. It is found in Saurashtra and Thar Desert of Rajasthan. It is also seen in Bikaner and Jodhpur zoo of Rajasthan. The bustard is a large bird with a horizontal body and long bare leg, giving it an ostrich like appearance. This bird is among the heaviest of the flying birds. Its height is of about 1 meter and weight is 15 kg. Males and females can be distinguished by the colour of their feathers. The feathers on the top of the head are black in males, which also possess a whitish neck, breast and under parts along with brown wings highlighted by black and gray markings. Males also have a small narrow band of black feathers across the breast. The female possess a smaller black crown on the top of the head and the black breast band is either discontinuous or absent. In 2012 the government of India launched project bastard to protect the great Indian bustard.

Fig 9.20: Great Indian Bustard

Jungle Fowl (*Gallus gallus*)

The red jungle fowl is distributed in the Himalayan foothills to eastern Assam and South to the Godawari river in eastern Madhya Pradesh. The male jungle fowl are significantly larger than females and have brightly coloured decorative feathers. The male's tail is composed of long, arching feathers that initially look black, but shimmer with blue, purple and green in direct light. He also has long, golden hackle feathers on his neck and on his back. The female's plumage is typical of this family of birds in being cryptic and adapted for camouflage. She alone looks after the eggs and chicks. She also has a very small comb and wattles (fleshy ornaments on the head that signal good health to rivals and potential mates) compared to the males. The jungle fowl are omnivorous eating a variety of leaves, plant matter, invertebrates such as slugs and insects and occasionally small mice and frogs. These are large birds with colourful plumage in males, but are nevertheless difficult to see in the dense vegetation they inhabit.

Fig 9.21: Red jungle fowl

Peacock Pheasant (*Itheginis cruentus*)

The Peacock Pheasant is distributed in eastern Himalayas, ranging across India, Nepal, Bhutan, China and Northern Myanmar. It measure about 64 cm in length. It is grayish brown with a long tail and an erect crest of hair like feathers. The mantle, wing-coverts and the tail are marked with violet greenish blue ocelli with white rims. The colour of female is almost similar to that of male but the colour of female is slightly dull. The main food is seeds, grain, berries, figs, snail, grubs etc. Their population decline due to rapid destruction of its habitat and are killed for flesh.

Fig 9.22 : Peacock Pheasant

White winged wood Duck (*Cairina scutulata*)

White winged wood Duck is distributed only in Assam and Arunachal Pradesh. It mostly resides in dense tropical evergreen forest and is known to prefer inaccessible swampy areas formed by numerous rivers, streams, etc. It has a black body, a white head i.e. thickly spotted with black conspicuous white patches on the wings and red or orange eyes. Its average length is about 81 cm. The sexes are more or less alike, the male having more glossy on the plumage and being much larger and heavier. It loves shade and spends most of the day in secluded jungle pools, occasionally perching on the trees during the day. It is a crepuscular bird as it is most active at dusk and dawn. The adults are largely omnivorous. The food consists of plant and animal material, aquatic plants, seed of wild and cultivated plants, aquatic insects, crustaceans, molluscs, frogs, snakes and fishes. It breeds in the hollows of trees, during summer months.

The severe decline in the population is due to the destruction, degradation and disturbance of riverine habitats including loss of riparian forest corridors. The resultant small, fragmented populations are vulnerable to extinction due to loss of genetic variability, disturbance, hunting and collection of eggs and chicks for food or pets..

Fig 9.23 : White winged wood Duck

Nicobar Megapode (*Megapodius freycinet*)

Nicobar Megapode distributed in Nicobar Islands. It is large, brownish bird with a small gray head and massive legs and feet. Forages on the ground in coastal forests in the Nicobar Islands. They builds a large mound for a nest, from where the newly-hatched chicks dig themselves out and become immediately independent. The population is decline due to hunting and collection of eggs exists, the main threat to megapodes is loss of habitat mainly due to conversion of coastal forest, the megapode's primary nesting habitat to coconut plantations. Expanding urbanization and construction of coastal roads are other serious problems. The single largest threat is a proposal to make Great Nicobar a free-trade port which if implemented, will destroy the Andaman and Nicobar islands. The 2004 tsunami is believed to have wiped out populations on some islands and reduced populations on several others.

Fig 9.24 : Nicobar Megapode

Black necked crane (*Grus nigricollis*)

Black necked crane is distributed in Sangti Valley in west kameng district, Chug valley and Zemithang provinces of Arunachal Pradesh. It is also found in Ladakh and Bhutan. It measures about 156 cm in height. It is a pale ashy grey crane with black head and neck. The crown and lores are bare and dull red coloured. The tail is covered by drooping black plumes. The female is smaller than male but both are similar in colouration. It inhabits reed beds and open fallow paddy field in the winter quarters. They breed on the shores of high altitude lake areas and swampy bogs between 4300 to 5600m. The main food of this bird are fallen grains, roots, tubers, insect and small vertebrates. The breeding season is between May to July. It is considered as endangered species.

Fig 9.25: Black necked crane

Siberian crane (*Grus leucogeranus*)

They are native of Siberia. The Siberian crane currently breeds in only two areas, one in northeastern Siberia (between the Yana and Kolyma Rivers) and the other in western Siberia on the lower reaches of the Ob River. The northeastern region features the majority of the cranes, about 3,000 breed there. In winter, they migrate to Boyang (Poyang) Lake in southeast China. The Ob River population which numbers is less than 20, divides and migrates in winter to two different sites i.e. the Keoladeo Ghana Bird Sanctuary in Bharatpur Rajasthan, Sultanpur Haryana India and the lowlands in northern Iran near the Caspian sea, in order to escape the harsh winter conditions of their native country.. The Siberian crane inhabits shallow marshlands and wetlands and will often forage in deeper water than other cranes. They show very high site fidelity for both their wintering and breeding areas, making use of the same sites year after year. The Siberian crane is a beautiful and rare wading bird. In the morning hey salute each other by sending out sharp and laud calls “Turr” for morning greeting. It has long, reddish pink legs, a reddish orange face and a snowy white body with black markings on its wings. An average Siberian crane stands 119 - 140 cm high. While young cranes eat insects, frogs and small rodents, adults feed mainly on the roots and tubers (swollen underground stems) of aquatic plants.

Greater Flamingo (*Phoemicopterus ruber*)

Flamingoes are found in large flocks and their breeding ground in India is Great Rann of Kutch. India it is commonly called as Hans. The greater flamingo is white in colour and its wings coverts are more white and red than lesser flamingo. Flamingo feeds on worms, insects and larvae, seeds of marshy plants etc.

Fig 9.26: Greater Flamingo

Bar headed goose(*Raja hansa*)

Bar headed goose is distributed in India, Pakistan, Nepal, Kazakhstan, Bangladesh, Myanmar, Japan. The bird is pale grey and is easily distinguished by the black bars on its head. A mid-sized goose measures about 71–76 cm in length and weighs 1.87–3.2 kg.

Fig. 9.27:Bar headed goose

Himalayan Beard Vulture (*Gypaetus barbatus*)

Himalayan Beard Vulture is distributed in high mountains in Southern Europe, East Africa, India subcontinent, Tibet. The beard vulture is a large bird, measuring 90 – 120 cm in length and weighing 4.5 -7 kg. The wingspan is 230 – 280 cm. The female vulture is slightly larger than male. The adult bird is mostly dark grey, rusty and whitish in colour. It is grey-blue above. The head is orange to rusty colour. The beard vulture have a small bread of blackish feathers at the base of bill. The creamy coloured forehead contrast against a black band across the eyes. The eye is red and the irides are creamy-yellow. The tail is long and wedge-shaped. The vulture calls is a shrill whistle and also make twittering sounds. It feed on carrion, preferably bones and marrow. They also feed on small mammals, birds and reptiles. The bearded vultures breed during November to June in the Indian subcontinent. They build a large nest with sticks and animals remains. The nest is built in caves and on ledges and rock outcrops. The clutch usually has one or two eggs. Both the parents take part in rearing the chicks.

Fig 9.28 : Himalayan Beard Vulture

Cheer Pheasant (*Catreus wallichii*)

Cheer Pheasant is distributed in western Himalayas in India, Nepal and Pakistan. Cheer pheasant is large pale with a long tail, an untidy crest, and red skin around the eye. The male is pale gray, barred throughout with thick black bands on the tail, a rust-colored lower back and a dark belly. The female is browner with white streaks on the body, white bars on the tail, a rust-colored belly and black spots on the breast. It was on the verge of extinction due to many threats such as poaching, hunting, grass burning and shrinking of habitats.

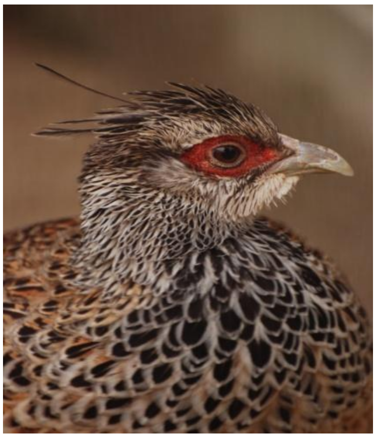

Fig 9.29: Cheer Pheasant

Great Pied Hornbill (*Buceros bicornis*)

Great Pied Hornbill found in the foothills of the Himalayas and parts of northeast India and Western Ghats. The great hornbill is a large bird measuring of 95 – 130 cm long with a 152 cm wingspan and a weight of 2 - 4 kg. Females are smaller than males and have bluish-white instead of red eyes, although the orbital skin is pinkish. They have prominent "eyelashes". The most prominent feature of the hornbill is the bright yellow and black casque on top of its massive bill. The casque appears U-shaped when viewed from the front and the top is concave, with two ridges along the sides that form points in the front. The back of the casque is reddish in females, while the underside of the front and back of the casque is black in males. The call is usually a loud series of deep grunts. It is predominantly frugivorous, but is an opportunist and will prey on small mammals, reptiles and birds.

Fig 9.30: Great Pied Hornbill

SAQ

Complete the following sentences by inserting appropriate words in the blanks.

(i) Dachigam wildlife sanctuary is famous for -------------

(ii) MIKE (Monitoring of illegal killing of Elephant) was started in South Asia in ----------

(iii) The zoological name of is Indian Desert Monitor is ------------.

(iv) The zoological name of is Green sea turtle is -------

9.3 Indian threatened reptiles

Crocodile

Crocodile is considered as critically endangered species on the IUCN red list. There are 3 species of crocodile. All the three species of crocodiles are found in odisha.

(1)*Crocodile porous* : Salt water or estuarine crocodile and are found generally in mangrove area of Sunderban, West Bengal.

(2)*Crocodylus palustris* : Fresh water or swamp crocodile commonly called Muggar.

(3)*Gavialis gangeticus* : Found in fresh water Ganga river commonly called as Ghariyal.

Ghariyals is dark brown on dorsal and pale coloured on the ventral surface. They are provided with long snouts. They can attain a length of about 30 feet. Ghariyal feeds any living or dead creature present in water or on ground nearby. It mates during January to February. The female attains adulthood after 10 years of age.

The muggar are dark brown on the dorsal surface but the ventral part is pale coloured. The average length is 10 – 12 feet. The snout is short and broad. The top of the head is rough a with ridge. Mugger feeds any living or dead and also fisheater. Male and female cannot be distinguished.

Their population is decline due to Illegal hunting of crocodile for their valuable skin and medicine purpose, Destruction or degradation of their natural habitat, Leopards and panthers kill & eat them, Eating of crocodile eggs by human & other animals, depletion of fish resources and Entanglement in fish nets.

Fig 9.31: *Gavialis gangeticus*

Indian Desert Monitor (*Varanus griseus*)

It is distributed in Maharashtra, Punjab, Rajasthan & Madhya Pradesh in India. Its body length is about 50cm and tail is 80cm in length. The body also have horizontal bands on either back or tail along with yellow spots across their back. The young are normally a brightly coloured orange and have distinctive bands across their backs, which may lost as they mature. The nostrils are slits like located farther back on their snouts. The digits are elongated. The tail is whip like and rounded. The males are generally larger and more robust than female. The skin of India desert monitor is adapted to the desert environment where they live and are excellent swimmer and drivers and have been known to enter the water occasionally to hunt for food. It feeds on grasshoppers, crickets, locust and small vertebrates. The eggs are laid in sand in a clutch of 15 – 20 egg. The population of Indian desert monitor is decline due to hunting for its valuable skin.

Fig 9.32 : Indian Desert Monitor

Common Indian Monitor (*Varanus bengalensis*)

They are distributed in Afghanistan, India, Nepal, Sri Lanka, Pakistan, Bangladesh & Burma. It inhabit desert, forest, bank of river, side of nullah, tide creek, marshy land and sea coast. It lives in hollows of trees, burrows, dense vegetation, cracks and crevices. It is good swimmer & climber. The body is of medium sized, dark brown and measuring from 70 – 75 cm in the head and body length. It has 100 cm long, strong & compressed tail. Males are generally larger than females. The young monitor lizards are more colourful than adults. The young have a series of dark cross bars on the neck, throat and back. The belly is whiter, banded with dark crossbars and are spotted with grey or yellow. On the dorsal surface body there is series of yellow spots with transverse bar connecting them. As they mature the ground colour becomes light brown or grey and dark spots. The snout is convex terminally and are provided with acute, long, sharp and recurved teeth. The tongue is forked, very long and protrusible. It feeds on small terrestrial vertebrate, ground birds, eggs, arthropods and fishes. The breeding season is from July to September. It lays 20 – 30 eggs in clutch in the holes, which are covered with leaves, sand & rubbish. The population of common India monitor is decline is due to excessive exploitation of the adults for its valuable skins.

Fig 9.33: Common Indian Monitor

Green sea turtle (*Chelonia mydes*)

It is distributed in tropical and subtropical waters. In India it is more common in the area of Andaman Island. The green turtle is the largest hard shelled sea turtles and is only herbivore and eating mostly sea grasses and algae. Due to greenish colour of their cartilage and fat is called green turtle. The carapace of turtle is flat, heart shaped is never completely ossified. Its rounded head is very small in comparison to the body. Neither its head nor leg can be pulled under the shell. Its flippers are long. The carapace of adult is about 105 cm in length and its colour is green, olive, brown or black. Its weight is generally 150 – 175 kg.

For breeding and food search it migrates up to great distance. It mates in the months of May – July at sandy beaches. For egg laying the females are congregated in large numbers on sandy beaches between June to November. A single female green turtle lays 350 – 600 eggs. The eggs are laid during early night in 60 cm deep hole dug by female turtle. After laying eggs female fill the dug with sand. The incubation period is 40 – 50 days.

The population of green turtle is decline is due to overharvesting of their eggs, hunting of an adult, being caught in fishing gear, loss of nesting beach site. They are also used as food who lived near sea shores & Island.

Fig 9.34: Green sea turtle

Olive Ridley Turtle (*Lepidochelys olivacea*)

It is distributed in the tropical waters of Pacific, Indian and south Atlantic oceans. It is found both in coastal water as well as open sea. The length of the carapace is 65 – 70 cm. The head is large & triangular and different bones do not fuse completely until late in life of turtle. The plastron consists of paired gular, pectoral, humeral, abdominal femoral & scutes. There are one or two claws in the limbs. The head is grey brown, carapace olive grey, shield is yellow white and the plastron is creamy yellow in colour. The main foods are shrimps, crabs, fishes, jelly fishes, mollusca and marine algae. It breeds in September to March. The female lays about 100 – 135 eggs. The incubation period is 50 – 60 days. The population of Olive Ridley Turtle is decline due by catch in fishing gear, climate change, direct harvest of turtles and eggs. Loss and degradation of nesting and foraging habitat, ocean pollution, predation of eggs and hatchling, vessel strikes.

Fig 9.35: Olive Ridley Turtle

9.4 IUCN red list of animals

The International union for the conservation of Nature (IUCN) is the world's main authority for the conservation status of species. A series of regional red lists are produced by countries or organization which assess the risk of extinction to species. The IUCN red list is based upon precise criteria to evaluate the rate of extinction of thousands of species and subspecies. The IUCN red list provides taxonomic data, conservation status and distribution information on species that are facing a high risk of global extinction. There are 9 categories in the IUCN red list.

- **Extinct (EX)** – No known individuals remaining
- **Extinct in the wild (EW)** – Known only to survive in captivity or as a naturalized population outside its historic range.
- **Critically Endangered (CR)** – Extremely high risk of extinction in the wild. In critically endangered population decline more than 90% in last 10 years or three generations.
- **Endangered (EN)** – High risk of endangerment in the wild. In case of endangered the population decline 70% in the last 10 years or 3 generation.
- **Vulnerable (VU)** – High risk of endangerment in the wild. In case of vulnerable the population decline 50% in the last 10 years or 3 generation.

- **Near Threatened (NT)** – Likely to become endangered soon.
- **Least concern (LC)** – Lowest risk.
- **Data deficient (CD)** – Not enough data to assess its risk of extinction.
- **Not evaluated (NE)** – Has not yet been evaluated against the criteria.

At present there are more than 1,50,300 species on the IUCN red list with more than 42,100 species threatened with extinction. It includes 41% of amphibian, 37% of Sharks and rays, 36% of reef building corals, 34% of conifers, 27% of mammals & 13% of birds.

List of critically endangered animals in India

Fishes

- Large-tooth Sawfish
- Pondicherry Shark
- Knife-tooth Sawfish
- Ganges Shark
- Long-comb Sawfish

Amphibians

- Kaikatt's Bush Frog
- Great Bush Frog
- Munnar Bush Frog
- Sacred Grove Bush Frog
- Shillong Bubble Nest Frog
- Tiger Toad
- Resplendent Shrub Frog
- Sushil's Bush Frog

- Amboli Bush Frog
- Chalazodes Bubble-nest Frog
- Small Bush Frog
- Anamali Flying Frog
- Kottigehar Bubble-nest Frog
- Kerala Indian Frog
- Green-eyed Bush Frog

Reptiles

- Sispara Day Gecko
- Red-crowned Roofed Turtle
- River Terrapin
- Leatherback Turtle
- Gharial
- Hawksbill Turtle

Birds

- Sender-billed Vulture
- White-backed vulture
- Jerdon’s courser
- Long-billed Vulture Red-headed Vulture
- Forest Owler
- Great Indian Bustard
- Sociable Lapwing
- Siberian Crane
- Himalyan Quail Pink-headed Duck

Mammals

- Sumatran Rhinoceros Javan Rhinoceros

- Namdapha Flying Squirrel
- Large Rock Rat or Elvira Rat
- Kandana Rat
- Malabar Civer
- Pygmy Hog
- Nicobar White-tailed Shrew
- Jenkin's Andaman Spiny Shrew

9.5 Summary

In this unit there is detailed study about Indian threatened mammals, Indian threatened birds, Indian threatened reptiles and IUCN red list of animals. There is also discussion about reason of threaten of different species.

9.6 Terminal Question

Q1. Define about Himalayan Brown Bear**.**

Q2. Explain about Chiru.

Q3. Explain about Olive Ridley Turtle.

9.7 Answers

SAQ 1 (i)Snow leopard

(ii) 2003

(iii) *Varanus griseus*

(iv) *Chelonia mydes*

Terminal Question

Ans 1.

Himalayan Brown Bear is distributed in Nepal, Tibet, Northern part of India & North Pakistan. The Himalayan brown bears are inhabiting the high altitude region of the Himalayas. They have thick fur that is mostly often sandy or reddish brown in colour. The shades of the brown fur vary from dark pale to reddish brown according to the variation in season. Some of the bear also provided with silvery grey with white tip to the fur. They grow up to 2.2 meter long and weigh up to 250 kg. They are nocturnal and their sense of smell is actually developed and believed to their principal means of finding food. Brown bear are omnivorous and feed on berries, young sprouts of grass, back wheat, wild fruits, rats and insects. Sometimes it takes larger animals also as food. Their breeding take place in the months of early summer and they usually give two cubs.

Ans 2.

Chiru are distributed in Ladakh & Kashmir. The chiru comes down to Ladakh in summer for grazing. The chiru male has carry thin, long horns that curve slightly forward and female are hornless. On each side of the blunt muzzle are two small bulges that contain air sacs used in vocalization. The adult male is about 83 cm height and 40 kg weight while female is 74 cm height and 25 kg of weight. The stocky body stands on long, slim legs indicative of swift running. Chiru feed on low alpine grasses, forbs and shrubs. The pasham wool is obtained from this chiru which is used to prepare soft & costly shawl.

Ans 3.

Olive Ridley Turtle is distributed in the tropical waters of Pacific, Indian and south Atlantic oceans. It is found both in coastal water as well as open sea. The length of the carapace is 65 – 70 cm. The head is large & triangular and different bones do not fuse completely until late in life of turtle. The plastron consists of paired gular, pectoral, humeral, abdominal femoral & scutes. There are one or two claws in the limbs. The head is grey brown, carapace olive grey, shield is yellow white and the plastron is creamy yellow in colour. The main foods are shrimps, crabs, fishes, jelly fishes, mollusca and marine algae. It breeds in September to March. The female lays about 100 – 135 eggs. The incubation period is 50 – 60 days. The population of Olive Ridley Turtle is decline due by catch in fishing gear, climate change, direct harvest of turtles and eggs. Loss and degradation of nesting and foraging habitat, ocean pollution, predation of eggs and hatchling, vessel strikes.

UNIT 10: IMPORTANT INDIAN WILD LIFE

10.1 Introduction

Endangered species are those animals or plants which are declined to a critical level or are at the verge of extinction. This extinction of species is due to due to many reasons

- **(i)** **Industrialization:** Due to expansion of industry in forest area causes decrease in forest land.
- **(ii)** **Hunting :** It is practice of seeking pursing, capturing or killing wildlife or feral animals.
- **(iii)** **Poaching :** It is the illegal trafficking and killing of wildlife.

(iv) Human growing activity : Entry of human in forest area bring about interfere the activity of wild life.

- **(iv)** **Business :** For the expansion of business purpose more and more forest are cut.
- **(v)** **Medicinal purpose :** Killing of animals & plants for medical purpose.

Causes of Endangered Species

(i)Habitat destruction

(ii)Introduction of exotic species

(iii)Over exploitation

(iv)Diseases

(v)Pollution

(vi)Limited distribution

How to protect Endangered Species

(i)*Conserve Habitats*

(ii)*Make space for our wildlife*

(iii) *Recycle, Reduce & reuse*

(iv) *Plant native plants that area control introduced plants and animal join an organization.*

(vi) *Slow down when driving*

List of endangered species & their distribution

(1)Asiatic lion : Earlier Asiatic lion (*panther leo persica*) are found in many parts of india, but now it is restricted in a small area of 1515km^2 in Gir forest of Gujarat. The Indian lion height 105 – 110cm, length 200 – 280cm, weight 110-190 kg, life span 18 -20yrs. The Asiatic lion have a very unique longitudinal fold of skin that run along their belly. They wander in a group called Pride generally comprising of 7 – 14 lions. The Asiatic lion having sharp canine teeth of 10 cm. The Asiatic lion are smaller than African lions and have shorter manes. The four year lion is an adult. The lioness becomes a mother at the age of two and half year to three years. The lioness gives birth of 2 or 3 cubs at a time. It is seen that their population of Asiatic lion has increase.

Fig 10.1: Asiatic lion

(2)Tiger : Indian tiger (*Panthera tigris tigris*) is found though out India from Himalayas to cape comorin except in Punjab, deserts of Rajasthan, cutch & Sind. It has breed successfully in captivity. The Indian tiger is rich coloured well striped animal; with a short coat. To protect the tiger, the project tiger was initiated as a central sector scheme in 1973 state.

Some of important tiger reserves are

(i)Manas, Assam

(ii)Palamau, Bihar

(iii)Similipal Odisha

(iv)Kanha, Madhya Pradesh

(v)Jim Corbett, Uttarkhand

(vi)Melghat, Maharashtra

(vii)Ranthambhor , Rajasthan

(viii)Sundarban, west Bengal

According to estimation of tiger in India in 2018 was 2967 of which the top 5 state having maximum no of tiger is as

(i)Madhya Pradesh - 526 Tigers

(ii)Karnataka - 524 Tigers

(iii)Uttarkhand - 442 Tigers

(iv)Maharashtra - 312 Tigers

(v)Tamil Nadu - 264 Tigers

Fig 102 : Indian tiger

(3)Red Panda : According to zoological survey of India Red Panda has two subspecies and both are found in India.

(i)Himalayan Red Panda (*Ailurus fulgens*)

(ii)Chinese Red Panda (*Ailurus styani*)

It is distributed in Himalayan region including India, Nepal, China, Bhutan & Myanmar. In India it is found Sikkim, Arunachal Pradesh and West Bengal (khangchendzonga and Namdapha national Park).

Fig 10.3: Himalayan Red Panda

(4)Indian Panther : Panther (*Panthera pardus*) is distributed in various parts onf India. In Uttarkhand Jim Corbet National park, Govind Pashu Vishar, Rajaji Sanctuary, Motichur sanctuary, Nanda Devi sanctuary, In Uttar Pradesh Dudhwa National park, Kishnnapur sanctuary, Chandraprabha sanctuary, Katarniaghat sanctuary, Ranipur sanctuary, Mahavir Swami sanctuary.

Fig 10.4 : Indian Panther

(5)Snow Leopard : Snow leopard (*Panthera uncia*) is distributed in Himalayan range from Kashmir to Bhutan. It is protected in Dachigam wildlife sanctuary in Jammu & Kashmir.

Fig 10.5 : Snow leopard

(6)Indian Elephant : The Indian elephant (*Elephas maximus*) is distributed in the forest of western Ghats, Assam, Karnataka, West Bengal, Odisha, Bihar, Uttar Pradesh, Uttarkhand, Kerala & Tamil Nadu.

Fig 10.6 : Indian elephant

(7)Swamp Deer or Barasinga : Swamp Deer (*Cervus duvauceli*) is distributed from North to South Insdia. In North it is found in Tarai Uttar Pradesh, Assam & sundarbans. It has 12 horns or antlers.

Fig 10.7: Swamp Deer or Barasinga

(8)Black buck : The blackbuck or Indian antelope (*Antilope cervicapra*). It can be seen in Velavadar National Park Gujarat. It is well developed muscles & spiral horns up to 15 cm long. The male blackbuck is almost black, while the inner parts of the legs, belly and chin are white and their is also white patch around its eyes. It speed up to 80 to 96 km/hours.

Fig 10.8: blackbuck or Indian antelope

(9)Rhinoceros : The Indian one horned rhinoceros (*Rhinoceros unicornis*), is distributed to low marshlands on the banks of Brahmaputra, small area of Bengal and low Tarai land along the river Rapti & Narayani in western central Nepal. The tall elephant grasses of kaziranga serve as shelter for rhino.

Fig 10.9: Indian one horned rhinoceros

(10) Musk deer : There are 3 species of Musk deer

(i)*Moschus moschiferus* (Eastern Russia, Northern China & Korea)

(ii)*Moschus berezovskii* (Southern China & North Vietnam)

(iii)*Moschus Chrysogaster* (Western China, Tibet &Himalayans)

The Himalayan musk deer is distributed in forest adjoining alpine meadows & alpine scrubs. It is distributed in Afghanistan, Pakistan, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Uttarkhand, Nepal, Sikkim, Bhutan, Arunachal Pradesh &Burma. In India, Garhwal (Govind Pashu Vishar Uttarkashi), Nanda Devi National Park (chamoli), Valley of flower National Park & Kedar Nath Sanctuary.

Fig 10.9 : Musk Deer

(12)Thamin : The Thamin deer (*Cervus eldi*) is found in keibul lamjao National park in

Manipur.

Fig 10.11 : Thamin deer

(13)Pigmy Hog : The pigmy hog (*Sus salvanius*) is distributed in tarai areas of the eastern Himalaya, covering a part of Bhutan and western Assam.

Fig:10.12: PigmyHog

(14) The Hangul : It is also called Kashmir stag. The hangul (*Cervus elephus hanglu*) is distributed to the Dachigum Wildlife sanctuary Kashmir, Gamgul Wildlife sanctuary, Chamba Himachal Pradesh.

Fig 10.13: Hangul

(15) Bustard: The great Indian Bustard (*Choriotis nigriceps*) is an endangered bird. It is found in Saurashtra and Thar Desert of Rajasthan. It is also seen in Bikaner and Jodhpur zoo of Rajasthan.

Fig 10.14: Great Indian Bustard

(16) Crocodile : The three species of Crocodile is

(i)*Crocodylus porosus* : Salt water or estuarine crocodile found in mangrove area of Sundarbans.

(ii)*Crocodylus palustris* : Fresh water or swamp crocodile (Mugger).

(iii)*Gavialis gangeticus* : Ghariyal is found in river Ganga and its tributaries like Ramganga, & jamuna. It is also found in river Mahanadi in Orissa.

Due to decline in the population of ghariyal population the government of India has initiated crocodile breeding project in 1975.

Fig 10.15 : *Gavialis gangeticus*

(17)Jungle Fowl : The red jungle fowl (*Gallus gallus*) is distributed in the Himalayan foothills to eastern Assam and South to the Godawari river in eastern Madhya Pradesh.

Fig 10.16 : Red jungle fowl

(18)Slender Loris : The slender loris (*Loris tardigradus*) is distributed in Western Ghats of India and Sri lanka. It is found in open tree jungle.

Fig 10.17: Slender Loris

(19)Hoolock Gibbon : It is only ape in India. The hoolock gibbon (*Hylobates hoolock*) is distributed in the hill forests of Assam and Chittagong. Hoolock gibbons are tailless and arms are much longer than the legs. In this males and females are black but on reaching maturity a female becomes yellows gray.

Fig 10.18 : Hoolock Gibbon

(20)Peacock Pheasant : The Peacock Pheasant (*Itheginis cruentus*) is distributed in eastern Himalayas, ranging across India, Nepal, Bhutan, China and Northern Myanmar.

Fig 10.19: Peacock Pheasant

(21)White winged wood Duck : White winged wood Duck (*Cairina scutulata*) is distributed only in Assam and Arunachal Pradesh.

Fig 10.20: White winged wood Duck

(22)Nicobar Megapode : Nicobar Megapode (*Megapodius freycinet*) distributed in Nicobar Islands.

Fig 10.21: Nicobar Megapode

(23)Black necked crane : Black necked crane (*Grus nigricollis*) is distributed in Sangti Valley in west kameng district, Chug valley and Zemithang provinces of Arunachal Pradesh. It is also found in Ladakh and Bhutan.

Fig 10.22: Black necked crane

(24)Bar headed goose : Bar headed goose (*Raja hansa*) is distributed in India, Pakistan, Nepal, Kazakhstan, Bangladesh, Myanmar, Japan.

Fig: Bar headed goose

(25)Himalayan Beard Vulture : Himalayan Beard Vulture (*Gypaetus barbatus*) is distributed in high mountains in Southern Europe, East Africa, India subcontinent, Tibet.

Fig 10.23 : Himalayan Beard Vulture

(26)Cheer Pheasant : Cheer Pheasant (*Catreus wallichii*) is distributed in western Himalayas in India, Nepal and Pakistan

Fig 10.24 : Cheer Pheasant

(27)Great Pied Hornbill : Great Pied Hornbill (*Buceros bicornis*) found in the foothills of the Himalayas and parts of northeast India and Western Ghats.

Fig 10.25 : Great Pied Hornbill

Objectives:

After studying this unit you will be able to know:

- Endangered Species and their distributions
- Project Tiger and its evaluation
- Other animal Projects and their updates

10.2 Project Tiger and its evaluation

The India tiger (*Panthera tigris*) has been declared as endangered animal because due to continuous declining in the number of tiger population in India.

Due to decline in population of tiger, the government of India in April 1973 has taken step on project tiger for conservation programme of tiger. The tiger project t in their natural habitat, protecting them from extinct and preserving area of biological importance as a natural heritage forever. The project task force visualized this tiger reserve as breeding . This tiger project tiger also allocate funds for the habitat protected and rehabilitation under this project. The project also responsible for doing census of tigers to known their population growth and any danger of extinction. The National tiger conservation authority done this project.

Objective of Tiger project

It has following objective

(i)To stopped the extinction and reduction of tiger population giving them a natural habitat.

(ii)To recovered the damage done in the habitat by habitat growth with proper management.

(iii)Conservation and protection of tiger population in natural habitat.

(iv)Protection of tigers from hunting & poaching.

(v) To ensure a tiger population for economic scientific cultural and ecological value.

Management of Tiger Project

Project tiger was administrated by national tiger conservation auther under the control of ministry of forest and environment government of India. The authors is monitored by a community headed by a director and Assisted by a group of field officer and technical personal.

Project tiger in India

The project tiger was started in 1973 in India and for first time it was introduce in Jim Corbett National Park. In 1972 the population of tiger was 1827 but now it has increased up to 3682. Here are some of project tiger are as follows.

(i)North east tiger conservation project

(ii)Sundarban conservation project

(iii)Sariska conservation project

(iv)Western ghat conservation project

(v)Eastern ghat conservation project

(vi)Central India conservation project

(vii)Kaziranga conservation project

(viii)Terai tiger conservation project

Tiger Reserve in India

There are about 53 tiger reserve in India, spread about 75,796 square km i.e. covering 2.3% of India total land area, which are governed by project tiger administrative by National tiger conservation authority (NTCA), established in 2005. Now a day 75% of world tiger population is found in India.

The important tiger reserves are

Sr. No.	Name of Tiger reserve	State
1.	Jim Corbett Tiger Reserve	Uttarkhand
2.	Bandipur Tiger Reserve	Karnataka
3.	Kanha Tiger Reserve	Madhya Pradesh
4.	Manas Tiger Reserve	Assam
5.	Palamu Tiger Reserve	Jharkhand
6.	Simlipal Tiger Reserve	Odisha
7.	Sundarban Tiger Reserve	West Bengal
8.	Panna Tiger Reserve	Madhya Pradesh
9.	Ranthambhore Tiger Reserve	Rajasthan
10.	Tadoba-Andheri Tiger Reserve	Maharashtra
11.	Bandhavgarh Tiger Reserve	Rajasthan
12.	Dudhwa Tiger Reserve	Uttar Pradesh
13.	Periyar Tiger Reserve	Kerala
14.	Melghat Tiger Reserve	Maharashtra
15.	Dampa Tiger Reserve	Mizoram
16.	Indravati Tiger Reserve	Madhya Pradesh

On the occasion of Global Tiger Day i.e. July 29 a detailed report on the All India tiger Estimation 2022 was released. This report was prepared by National Tiger conservation Authority (NTCA). The National Tiger conservation Authority conducts tiger census in partnership with state forest departments, conservation (NGO's) and wildlife institute of India. According to this Indian tiger population has increased to 3682 in 2022. Therefore the annual growth rate is 6.1 % per annum.

Year	No of Population of Tigers in India
2006	1411
2010	1706
2014	2226
2018	2967
2022	3682

The largest tiger population in India state wise as per 2022 report

State	No of tigers population
Madhya Pradesh	785
Karnataka	563
Uttarkhand	560
Maharashtra	444

The highest tiger Population in tiger reserves are as per 2022 report

Tiger Reserve	No of tigers population
Jim Corbett	260
Bandipur	150
Nagarhole	141
Bandhavgarh	135
Dudhwa	135
Mudumalai	114
Kanha	105
Kaziranga	104
Sundarban	100
Tadoba	97
Sathyamangalam	85
Pench	77

State having decrease in number of Tiger as per 2022 report

State	No of tiger as per 2018 census	No of tigers as per 2022 census
Arunachal Pradesh	29	9
Odisha	28	20
Jharkhand	5	1
Chhattisgarh	19	17
Telangana	26	21

As per Report 2022 In Arunchal Pradesh there is decrease of 70% population of tiger.

According to report 2022 Nagaland has no tiger.

10.3 Other animal Projects and their updates

Crocodile Conservation Project

Crocodile is considered as critically endangered species on the IUCN red list. There are 3 species of crocodile.

(1) ***Crocodile porous*** **:** Salt water or estuarine crocodile and are found generally in mangrove area of Sunderban, West Bengal.

(2) ***Crocodylus palustris*****:** Fresh water or swamp crocodile commonly called Muggar. It is listed as vulnerable by IUCN. The mugger crocodile in India is most common species. Their average size is about 13-14 feet. During British period in India crocodile were never critically endangered. Afterward, a Indian biologist (American origin) named Romulus Whitaker established the Madras crocodile bank conservation & breeding of crocodiles.

(3)***Gavialis gangeticus*** **:** Found in fresh water Ganga river commonly called as Ghariyal. It is listed as critically endangered by IUCN. The male gharial has a distinctive boss at the end of the snout. The largest ghariyals in the wilderness was a specimen which measured 19.5 feet and was found River Girwa, at katarniaghat wildlife sanctuary. It is the rarest crocodilian species. Only four were left in 1975, when Romulus Whitaker started a breeding programme of ghariyals, their population has increased up to 1000.

All the three species of crocodiles are found in odisha.

Threat of crocodile life

(i)Illegal hunting of crocodile for their valuable skin and medicine purpose.

(ii)Destruction or degradation of their natural habitat.

(iii)Leopards and panthers kill & eat them.

(iv) Eating of crocodile eggs by human & other animals.

(v)Survival rate of the crocodile hatching in nature is low because of predation.

(vi) Depletion of fish resources

(vii) Entanglement in fish nets.

(viii)Grazing by livestock & Riparian agriculture disrupts ghariyal behavior and may even force local populations to desert the area.

Crocodile conservation Project

Crocodile conservation was started in 1975 with the support of UNDP & FAO. This programme was supervised under the technical guidance of Dr. H.R. Bustard. In this project ghariyal eggs were collected and taken for incubation. They were hatched and successfully reared at Tickerpada in Dhenkanal district of odisha for the first time in June 1975.

The fund and technical support for crocodile conservation project came from United nation development programme / food & Agriculture organization & government of India.

Crocodile project programme include

- To rebuild the population quickly through captive breeding (Rear & release).
- To protect the crocodile population in their natural habitat by creating sanctuaries.
- For manufacturing proper population of crocodile certain process should be done.

- Collection of eggs from natural nest as soon as they are laid.
- Incubation of these eggs under ideal temperature & humidity to maintained in artificial hatcheries
- Hatching and rearing the young crocodilians in ideal captive husbandry condition.
- Marking and releasing young crocodile is protected area.

➢ To take up research to improve management.

➢ To build up a level of trained personnel for better continuity of the project sites and through the central crocodile breeding & Management training institute Hyderabad.

➢ To involve local people in the project.

Protected Area for Ghariyals in India

❖ National Chambal Sanctuary, Uttar Pradesh

❖ Corbett National park, Uttarkhand

❖ Katarniyaghat sanctuary, Uttar Pradesh

❖ Ken Sanctuary, Madhya Pradesh

❖ Satkosia George Sanctuary, Odisha

❖ Son Sanctuary, Madhya Pradesh

Captive Breeding centers for Ghariyal

❖ Nandankanan Biological park, Odisha

❖ Kukrail Crocodile Rehabilitation Centre, Lucknow

❖ Madras Crocodile Bank, Tamil Nadu

Other Project of Crocodile

(i)Baula Project

(ii)Muggar Project

(iii)Ghariyal Project

(i)*Baula Project* : Baula project is for salt water crocodile. This take places at Dangmal in Bhitarkanika sanctuary, odisha. In this salt water crocodile eggs have been collected locally and young crocodiles have been released in the creeks and estuaries. It has been more than 2200 crocodiles have been released in phases since 1977.

This project has been reasonably successfully and the crocodile population in the Bhitarkanka river has gradually been built up. More the 50 female salt water crocodile have been released to breed successfully and are laying eggs in the wild.

(ii)Mugger Project : This project is for mugger crocodile and take place at Ramatirtha centre, odisha. Initially start with eggs and juveniles of mugger procured from Tamil Nadu. Since 1984 breeding of Muggars and the release of young ones into the nature in similipal have been carried out, and so far more than 600 crocodiles have been released in similipal.

(iii)Ghariyal Project : It take place in Tikarpada, odisha. In this project ghariyal eggs were obtained at different points of time from Narayani and kali rivers in Nepal and Chambal sanctuary in Madhya Pradesh, Rajasthan and Uttar Pradesh.

Some hatchlings of ghariyals were obtained from eggs incubated in Royal Chitwan National Park of Nepal and Katarniyaghat sanctuary in Uttar Pradesh. All ghariyals released at Tikarpada and those produced from captive breeding at Nandankanan zoo, numbering more than 700, were released in the river Mahanadi between Boudh & katrang.

Project Elephant

Project Elephant was started in February 1992. This project was centrally sponsored scheme, to which central provide financial, technical support to states having free ranging of population of wild elephants and to ensure long term survival of identified viable populations of elephant in their natural habitats. This project play a vital role in the increasing the population of elephants.

There are 3 subspecies of Asian elephant which are found in India, Sumatran & Srilanka. According to IUCN red list it is endangered. World Elephant day was celebrate on 12th August every year. The government of India in year 2010 declared elephant as the National Heritage animal.

The project tiger and project elephant in India have been merged under a new division called Project tiger and Elephant division by Ministry of Environment, forest & climate change (MoEFCC), aim is to rationalize funding and improve conservation by reducing overlap in areas with both programs.

Aims and objective of Project Elephant

- To develop and promote scientific and planned management strategies for Elephant conservation.
- To ensure ecological restoration of the natural elephant habitats and their migratory routes.
- To prevent illegal trade of ivory and ensure elephant protection from hunters and poachers.
- To reduce and remove domestic livestock grazing, the pressure of humans and their activities in important elephant habitats.
- To develop strategies to prevent unnatural causes of elephants death in India.
- To mitigate and prevent the increasing conflict in elephant habitats between humans and elephants.
- To promote scientific research on issues related to elephant conservation and educating the public on these issues.

- To facilitate veterinary care for proper breeding and health care of domestic elephants and to facilitate Eco-development for the elephants.

Threat of elephant

- Prevent illegal trade of ivory
- Hunters and poachers
- Unnatural causes of elephant's death

Project Elephant – MIKE Programme

MIKE (Monitoring of illegal killing of Elephant) was started in South Asia in 2003. The aim of MIKE was to provide the information required by the elephant range countries for proper management and long-term protection of their elephant populations.

***Haathi mere Saathi* Campaign**

The Haathi mere Saathi campaign was launched in Delhi on 24th May 2011 by combined partnership of Ministry of Environment and forests and Wildlife trust of India. The main aim of the campaign was to increase public awareness and develop friendships between elephants and the local population. The campaign Haathi mere Saathi was for the welfare of the elephants, to conserve and protect the elephants in India.

Protected Area & Elephant Reserve in India

In India 32 Elephant Reserve are present. The first elephant reserve was Singhubham Elephant Reserve, Jharkhand in our country. The Largest elephant Reserve is Bandipur National Park, Karnataka.

Table:10.1: list of Elephant reserve

Sr. No.	Name of Elephant Reserve	State	Date of notification	Total Area
1	Rayala Elephant reserve	Andhra Pradesh	09/12/2003	766
2	Kameng Elephant Reserve	Arunchal Pradesh	19/06/2002	1892
3	South Arunachal Elephant Reserve	Arunchal Pradesh	29/02/2008	1957.50
4	Sonitpur Elephant Reserve	Assam	06/03/2003	1420
5	Dihing-Patkai Elephant Reserve	Assam	17/04/2003	937
6	Dhansiri-Lungding Elephant Reserve	Assam	19/04/2003	2740
7	Chirang-Ripu Elephant Reserve	Assam	07/03/2003	2600
8	Kaziranga-karbi Anglong Elephant Reserve	Assam	17/04/2003	3270
9	Mayurjharna Elephant Reserve	West Bengal	24/10/2002	414
10	Badalkhol-Tamor Pingla Elephant Reserve	Chhattisgarh	15/09/2011	1048.30
11	Lemru Elephant Reserve	Chhattisgarh	2022	450
12	Singhbhum Elephant Reserve	Jharkhand		
13	Eastern Dooars Elephant Reserve	West Bengal	28/08/2002	978
14	Shivalik Elephant Reserve	Uttarkhand	28/10/2002	5405
15	Uttar Pradesh Reserve	Uttar Pradesh	09/09/2009	744
16	Terai Elephant Reserve	Uttar Pradesh	2022	3049
17	Mayurbhanj Elephant Reserve	Odisha	29/09/2001	3214
18	Sambalpur Elephant Reserve	Odisha	27/03/2002	427
19	Mahanadi Elephant Reserve	Odisha	20/07/2002	1038
20	Baitami Elephant Reserve	Odisha		
21	Garo Hills Elephant Reserve	Meghalaya	31/10/2001	3500
22	Khasi-hills Elephant Reserve	Meghalaya		
23	Intanki Elephant Reserve	Nagaland	28/02/2005	202
24	Mysore Elephant Reserve	Karnataka	25/11/2002	6724
25	Nilambur Elephant	Kerala	02/04/2002	1419

	Reserve			
26	Wayanad Elephant Reserve	Kerala	02/04/2002	1200
27	Anamudi Elephant Reserve	Kerala	02/04/2002	3728
28	Periyar Elephant Reserve	Kerala	02/04/2002	3742
29	Srivilliputhur Elephant Reserve	Tamil Nadu	19/09/2003	1249
30	Agsthyamalai	Tamil Nadu	12/08/2022	1197.48
31	Annamalai Elephant Reserve	Tamil Nadu	19/09/2003	1457
32	Coimbatore Elephant Reserve	Tamil Nadu	19/09/2003	566
33	Nilgiri Elephant Reserve	Tamil Nadu	19/09/2003	4663

Table:102: The population of Elephants in state during (2017-18)

Sr. No.	State	No of Elephants
1	Karnataka	6049
2	Assam	5719
3	Kerala	3054
4	Tamil Nadu	2761
5	Odisha	1976
6	Uttarkhand	1839
7	Meghalaya	1754
8	Arunchal Pradesh	1614
9	Jharkhand	679
10	Nagaland	446
11	Chhattisgarh	247
12	Uttar Pradesh	232
13	West Bengal	194
14	Tripura	102
15	Andhra Pradesh	65
16	Bihar	25
17	Gujarat	10
18	Madhya Pradesh	7
19	Mizoram	7
20	Maharashtra	6

Project Rhinoceros

The rhinoceros (*Rhinoceros unicornis*) is a Greek word rhino mean nose & ceros mean horn, so they have horn in nose. The Indian rhinoceros has a thick grey brown skin with pinkish skin fold, one horn on its snout. Indian rhino's have single horn is present in males and female but does not new born calves. The horn is use as weapon. At present their population is 3700 in India.

There are 5 types of rhinoceros found in world

(i)Black rhinoceros

(ii)White rhinoceros

(iii)Sumatran rhinoceros

(iv)Javan rhinoceros

(v)Indian rhinoceros

The black and white rhinoceros have two horns at snout. The Sumatran and Javan rhinoceros have single horn at snout. The Indian rhinoceros also called great one horn rhinoceros. The one horned rhinoceros are found in Nepal, Bhutan, Pakistan & India and in India it is in Assam, west Bengal & Uttar Pradesh.

Threat of Rhinoceros

(i)Sport hunting

(ii)Poaching : Rhinoceros horn are used in Chinese medicine, wall hanging, Hookah used for smoking, skin are used for making bags, balls & shoes etc. are under threat of poachers. Between 2013 to 2018 year nearly 100 rhino were poached in India.

(iii)Habitat loss or human-rhino conflict – Habitat of Indian rhinos is deteriorating as a result of human activities and natural disasters such as floods, resulting in a large numbers of deaths. The Indian rhino population range is limited with 70% of population concentrated in a single kaziranga National Park, if any unexpected catastrophic such as disease, natural disaster or habitat loss will have a severe impact on rhino's population. Due to this since 1986 rhinos have been moved annually from Chitwan to Bardia and Shuklaphanta National Park to ensure their survival in the event of an epidemic.

Objective of Project Rhino

The project Rhino was launched in a year 1987 in Kaziranga wildlife sanctuary in Assam. It has following objectives

- To bring the Indian rhino to the light of knowledge
- To spread awareness regarding their essence and right to survive.
- To uplift their conservation
- To save lesser one horned rhinoceros from extinction
- Poaching is strictly restricted under this scheme or project.

Steps taken to conservation of rhino in India

- Restoring landscapes
- Working with locals
- Reducing illegal trade
- Monitoring and census
- Reinforcing the law enforcement
- Indian Rhino vision 2020

Indian Rhino Vision 2020

The Indian Rhino Vision 2020 was implemented by a collaborative effort between various organization includes

(i)The Assam forest department

(ii) Bodoland Territorial council

(iii)World wide fund of Nature (WWF)

(iv)International Rhino foundation

(v)US fish & Wildlife service

The Indian Rhino Vision 2020 was launched in 2005 and its goal was an ambitious effort to attain a wild population of at least 3000 of great one horned rhinoceros spread over seven protected area in the Indian state of Assam by the year 2020. The seven protected area are

- Kaziranga National park
- Pobitora Wild life sanctuary
- Orang National Park
- Manas National park
- Loakhowa Wild life sanctuary
- Dibru Saikhowa wild life sanctuary
- Burachopori Wild life sanctuary

The Indian Rhino Vision 2020 programme is consider as one of the biggest conservation successes in the region, which helped in bringing back rhinos to Manas national Park.

Vulture Conservation Project

Vultures are most important as it has ecological, social & cultural significance as they scavenging on carcasses of animals and thereby helping keeping the environment clean and the disposable of dead bodies as per the religious practices of the Parsi community. Their population was very good up to 1980 after that their population decline by 95% between 1990 to 2000. So it is necessary for conservation of vulture, otherwise they become to extinct. Keeping view in this government of India launched Project vulture in 2006 to increase the population of vultures.

There are 23 type of vulture found in world, of which only 9 species of vultures found in India,. These are as follows

(i)Oriental White-backed Vulture (*Gyps bengalensis*)

(ii)Slender billed Vulture (*Gyps tenuirostris*) (iii)Long billed Vulture (*Gyps indicus*)

(iv)Egyptian Vulture (*Neophron percnopterus*)

(v)Red Headed Vulture (*Sarcogyps calvus*)

(vi)Indian Griffon Vulture (*Gyps fulvus*)

(vii)Himalayan Griffon (*Gyps himalayensis*)

(viii)Cinereous Vulture (*Aegypius monachus*)

(ix) Bearded Vulture or Lammergeier (*Gypaetus barbatus*)

The population of 3 resident Gyps species i.e. White-backed Vulture, Slender billed Vulture and Long billed Vulture in the wild has declined drastically between 1990 to 2000 year. Due to decline population of these 3 species, they are listed by IUCN in 2000 as critically Endangered.

Initially it was thought that decline population of vulture is due to a lack of food (dead livestock) or unknown viral epidemic disease, but it was later confirm that the decline in population of vulture was caused by the ***drug diclofenac***. The vultures are unable to break down diclofenac drug suffer from kidney failure when they consume the carcass of animals that have received this diclofenac drug. *Neck Drooping* behavior exhibited by vultures for several weeks before collapsing and falling out of trees, just before death. It is only visible behavior sign that birds are ill. In May 2006 government of India prohibited the use of diclofenac in veterinary medicine. There is another drug Meloxicam which is tested for vulture safety.

National Action plan for Vulture conservation 2020- 2025

Vulture is slow breeding birds, so it conservation is very difficult. The National Action plan for vulture 2020 to 25 has been approved by National board for wild life. The plan has suggested that new veterinary non-steroidal anti-inflammatory drugs to be tested on vultures before they are commercially released.

Vulture care centre (VCC) was set up in Pinjore Haryana in 2001 and it was upgraded to First vulture conservation and breeding centres (VCBC) India. The vulture conservation centres is responsible for looking after the vultures and breed them in captivity and when its population is increased they are released into the wild. The national plan can involve both ex-situ and in-situ conservation. For this vulture conservation and breeding centre can be established in 5 state i.e. Uttar Pradesh, Tripura, Maharashtra, Karnataka, Tamil Nadu. There is also establishment of rescue centre in Pinjore (Haryana), Bhopal (Madhaya Pradesh, Guwahati (Assam) & Hyderabad (Telangana)

Project Snow leopard (*Panthera unica*)

Snow leopard is distributed in the Himalayas from Kashmir to Bhutan. In India it is distributed in five states of Jammu & Kashmir, Himachal Pradesh, Uttarkhand, Sikkim and Arunachal Pradesh. Snow leopard is placed in the list of 21 critically endangered species for recovery programme and now their population has increases and they are categorized as “Vulnerable” by IUCN and in the Schedule I of the Indian wildlife (protection) Act 1972.

Snow leopard has slightly smaller the ordinary leopard but has longer tail. It preys on wild sheeps, wild goats, musk deer, hares etc. This animal is killed by poacher for their beautiful fur.

There was a project snow leopard was launched in 2009 to promote an inclusive and participatory approach to conserve snow leopards and their habitat.

The important threat factor responsible for decline their population includes reduction in prey populations, illegal poaching and increased human population infiltration into the species habitat and illegal trade of wildlife parts and products.

The snow leopard conservation breeding programme is under taken at Padmaja Nadu Himalayan Zoological Park, Darjeeling and West Bengal.

The important protected areas are

- Sacred Himalayan Landscape
- Kibber Wildlife sanctuary at Lahaul Spiti. Himachal Pradesh
- Pin Valley National Park at Lahaul Spiti. Himachal Pradesh
- Great Himalayan National Park at Kullu, Himachal Pradesh
- Dibang Wildlife Sanctuary near Anini, Arunachal Pradesh
- Hemis National Park in Ladakh

Fig 10.26: Snow leopard

SAQ 1.

Complete the following sentences by inserting appropriate words in the blanks.

(i) The highest tigers in which state reserve is -------------.

(ii)According to 2022 tigers census, what is the number of tiger in India - ---------

(iii)When was project Elephant started ------------.

(iv)When was project Rhino started -------

10.4 Summary

In this unit there is detailed study about endangered species and their distributions. This unit also contain about project tiger and how they are converse in India in very detailed manner. The conservation of other animals like elephant project, rhino project and vulture project is also study in very detailed manner.

10.5 Terminal Question

Q1. Describe Red panda as endangered species.

Q2. Describe Aims and objective of Project Elephant.

Q3. What is National Action plan for Vulture conservation 2020- 2025.

10.6 Answers

SAQ 1 (i) Madhya Pradesh

(ii) 3682

(iii) 1992

(iv) 2005

Terminal Question

Ans 1. Red Panda : According to zoological survey of India Red Panda has two subspecies and both are found in India.

(i)Himalayan Red Panda (*Ailurus fulgens*)

(ii)Chinese Red Panda (*Ailurus styani*)

It is distributed in Himalayan region including India, Nepal, China, Bhutan & Myanmar. In India it is found Sikkim, Arunachal Pradesh and West Bengal (khangchendzonga and Namdapha national Park).

Ans 2.

- To develop and promote scientific and planned management strategies for Elephant conservation.
- To ensure ecological restoration of the natural elephant habitats and their migratory routes.
- To prevent illegal trade of ivory and ensure elephant protection from hunters and poachers.
- To reduce and remove domestic livestock grazing, the pressure of humans and their activities in important elephant habitats.
- To develop strategies to prevent unnatural causes of elephants death in India.
- To mitigate and prevent the increasing conflict in elephant habitats between humans and elephants.

- To promote scientific research on issues related to elephant conservation and educating the public on these issues.
- To facilitate veterinary care for proper breeding and health care of domestic elephants and to facilitate Eco-development for the elephants.

Ans 3.

Vulture is slow breeding birds, so it conservation is very difficult. The National Action plan for vulture 2020 to 25 has been approved by National board for wild life. The plan has suggested that new veterinary non-steroidal anti-inflammatory drugs to be tested on vultures before they are commercially released.

Vulture care centre (VCC) was set up in Pinjore Haryana in 2001 and it was upgraded to First vulture conservation and breeding centers (VCBC) India. The vulture conservation centres is responsible for looking after the vultures and breed them in captivity and when its population is increased they are released into the wild. The national plan can involve both ex-situ and in-situ conservation. For this vulture conservation and breeding centre can be established in 5 state i.e. Uttar Pradesh, Tripura, Maharashtra, Karnataka, Tamil Nadu. There is also establishment of rescue centre in Pinjore (Haryana), Bhopal (Madhya Pradesh), Guwahati (Assam) & Hyderabad (Telangana)

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UNIT 11 : NATIONAL PARKS, SANCTUARIES, AND BIOSPHERE RESERVES

11.1 Introduction

A National Park is the place that is strictly protected with the aim of improving wildlife and biodiversity. The area of National park establish under section 35(4) of the wildlife (protection) act 1972 of government of India. In national park there is protection of entire ecosystem i.e. plants, animals, land, water in that area. In national parks, any kind of development, forestry, poaching, hunting or grazing on agriculture land is prohibited. Wild life sanctuary is the area demarcated for the protection of a important plants and animals species. The people living inside these areas have limited activity for allowing livestock grazing.

Objectives

After studying this unit you will be able to know:

- Important National Parks and Sanctuaries
- Important National Biosphere Reserves
- Zoological gardens and Museums

11.2 Important National Parks

A National Park is the place that is strictly protected with the aim of improving wildlife and biodiversity. The area of National park establish under section 35(4) of the wildlife (protection) act 1972 of government of India. In national park there is protection of entire ecosystem i.e. plants, animals, land, water in that area. In national parks, any kind of development, forestry, poaching, hunting or grazing on agriculture land is prohibited.

National parks can be declared both by the central Government and state government. No alternation of the boundaries of a national park shall be made except on a resolution passed by the state Legislature.

In India first national park was Jim Corbet national park, established in 1936 as Hailey National park to protect the endangered Bengal tigers. It is located in Nainital district of Uttarkhand and was named after Jim Carbett, naturalist.

The largest national park in India is Hemis National Park (Ladakh) covers area of 3350 square km.

The smallest national park in India is South Button Island National Park (Andaman and Nicobar) covers 5square km.

The recent National Park was established in India on 5th June 2021was Raimona National Park in Assam.

The first National Park in world is in United state of America established on 1st March 1872 by President Ulysses S. Grant as Yellow stone National Park.

In 2022, a total of 106 National parks in India that occupy an area of 44,378 km^2 or 1.35% of the nation's total land area.

Table:11.1: The important national park in India

Sr. No	State/Union Territory	Total Parks	National Parks Name	Establishment Year	Area (Km^2)
1	Andaman & Nicobar Islands	9	Campbell Bay National Park	1992	426.23
2			Galathea Bay National Park	1992	110
3			Mahatama Gandhi Marine (Wandoor) National Park	1983	281.5
4			Middle Button Island National Park	1987	0.44
5			Mount Harriett National Park	1987	46.62
6			North Button Island National Park	1987	0.44
7			Rani Jhansi Marine National Park	1996	256.14
8			Saddle Peak National Park	1987	32.54

9			South Button Island National Park	1987	0.03
10	Andhra Pradesh	3	Papikonda National Park	2008	1013
11			Rajiv Gandhi (Rameswaram) National Park	2005	2.4
12			Sri Venkateswara National Park	1989	353.6
13	Arunachal Pradesh	2	Mouling National Park	1986	483
14			Namdapha National Park	1983	1808
15	Assam	7	Dibru-Saikhowa National Park	1999	340
16			Kaziranga National Park	1974	859
17			Manas National Park	1990	500
18			Nameri National Park	1998	200
19			Rajiv Gandhi Orang National Park	1999	78.81
20			Raimona National Park	2021	422
21			DihingPatkaio National Park	2021	234
22	Bihar	1	Valmiki National Park	1989	335.65
23	Chhattisgarh	3	Guru Ghasidas (Sanjay) National Park	1981	1440.7
24			Indravati (Kutru) National Park	1982	1258.4
25			Kanger Valley National Park	1982	200
26	Goa	1	Mollem National Park	1992	107
27	Gujarat	4	Vansda National Park	1979	23.99
28			Blackbuck (Velavadar) National Park	1976	34.53
29			Gir National Park	1975	258.71
30			Marine (Gulf of Kachchh) National Park	1982	162.89
31	Haryana	2	Kalesar National Park	2003	46.82
32			Sultanpur National Park	1989	1.43
33	Himachal Pradesh	5	Great Himalayan National Park	1984	754.4
34			Inderkilla National Park	2010	104
35			Khirganga National Park	2010	710
36			Pin Valley National Park	1987	675
37			Simbalbara National Park	2010	27.88
38	Union Territory of Jammu and Kashmir	3	City Forest (Salim Ali) National Park	1992	9
39			Dachigam National Park	1981	141
40			Kishtwar National Park	1981	425
41	Union Territory of Ladakh	1	Hemis National Park	1981	3350

42	Jharkhand	1	Betla National Park	1986	226.33
43	Karnataka	5	Anshi National Park	1987	417.34
44			Bandipur National Park	1974	874.2
45			Bannerghatta National Park	1974	260.51
46			Kudremukh National Park	1987	600.32
47			Nagarahole (Rajiv Gandhi) National Park	1988	642.39
48	Kerala	6	Anamudi Shola National Park	2003	7.5
49			Eravikulam National Park	1978	97
50			Mathikettan Shola National Park	2003	12.82
51			Pambadum Shola National Park	2003	1.318
52			Periyar National Park	1982	350
53			Silent Valley National Park	1984	89.52
54	Madhya Pradesh	10	Bandhavgarh National Park	1968	448.85
55			Dinosaur Fossil National Park	2011	0.8974
56			Fossil National Park	1983	0.27
57			Indira Priyadarshini Pench National Park	1975	292.85
58			Kanha National Park	1955	940
59			Madhav National Park	1959	375.22
60			Panna National Park	1981	542.67
61			Sanjay National Park	1981	466.88
62			Satpura National Park	1981	585.17
63			Van Vihar National Park	1979	4.45
64	Maharashtra	6	Chandoli National Park	2004	317.67
65			Gugamal National Park	1975	361.28
66			Nawegaon National Park	1975	133.88
67			Pench (Jawaharlal Nehru) National Park	1975	257.26
68			Sanjay Gandhi (Borivali) National Park	1983	86.96
69			Tadoba National Park	1955	116.55
70	Manipur	1	Keibul-Lamjao National Park	1977	40
71	Meghalaya	2	Balphakram National Park	1985	220
72			Nokrek Ridge National Park	1986	47.48
73	Mizoram	2	Murlen National Park	1991	100
74			Phawngpui Blue	1992	50

			Mountain National Park		
75	Nagaland	1	Intanki National Park	1993	202.02
76	Odisha	2	Bhitarkanika National Park	1988	145
77			Simlipal National Park	1980	845.7
78	Rajasthan	5	Mukundra Hills National Park	2006	200.54
79			Desert National Park	1992	3162
80			Keoladeo Ghana National Park	1981	28.73
81			Ranthambhore National Park	1980	282
82			Sariska National Park	1992	273.8
83	Sikkim	1	Khangchendzonga National Park	1977	1784
84	Tamil Nadu	5	Guindy National Park	1976	2.82
85			Gulf of Mannar Marine National Park	1980	6.23
86			Indira Gandhi (Annamalai) National Park	1989	117.1
87			Mudumalai National Park	1990	103.23
88			Mukurthi National Park	1990	78.46
89	Telangana	3	Kasu Brahmananda Reddy National Park	1994	1.43
90			Mahaveer Harina Vanasthali National Park	1994	14.59
91			Mrugavani National Park	1994	3.6
92	Tripura	2	Clouded Leopard National Park	2007	5.08
93			Bison (Rajbari) National Park	2007	31.63
94	Uttar Pradesh	1	Dudhwa National Park	1977	490
95	Uttarakhand	6	Corbett National Park	1936	520.82
96			Gangotri National Park	1989	2390.02
97			Govind National Park	1990	472.08
98			Nanda Devi National Park	1982	624.6
99			Rajaji National Park	1983	820
100			Valley of Flowers National Park	1982	87.5
101	West Bengal	6	Buxa National Park	1992	117.1
102			Gorumara National Park	1992	79.45
103			Jaldapara National Park	2014	216.51
104			Neora Valley National Park	1986	159.89
105			Singalila National Park	1986	78.6
106			Sunderban National Park	1984	1330.1

11.3 Important National Sanctuaries

Wild life sanctuary is the area demarcated for the protection of a important plants and animals species. The people living inside these areas have limited activity for allowing livestock grazing. The wildlife sanctuary of India is classified as IUCN category IV protected area.

According to repot January 2023 the total 567 wild life sanctuary exist in India, which cover an area of 122564.85 square km (3.73%) of the total area of land.

Kutch wildlife sanctuary is the largest wild life sanctuary in India.

Andaman & Nicobar Island has the highest wildlife number of wild life sanctuary.

The oldest wildlife sanctuary is Vedanthangal bird sanctuary (Chennai, Tamil Nadu).

The largest wildlife sanctuary in India is Kaziranga National park in Assam.

The second largest wildlife sanctuary in India is Wayanad wildlife sanctuary in Kerala.

The smallest wildlife sanctuary in India is Mayureshwar wild life sanctuary, Baramati of Pune Maharashtra.

The Abohar-Fazilka reserve is the Asia largest open wildlife sanctuary.

Table: 11.2: List of Wild life sanctuary

Sr. No.	State	Number	Name of Wild life sanctuary
1	Assam	5	Nambor Wild life sanctuary
2			Dihing Patkai Wild life sanctuary
3			East Karbi Anglong Wild life sanctuary
4			Chakrashila Wild life sanctuary
5			Amchang Wild life sanctuary

6	Andhra Pradesh	10	Kawal Wild life sanctuary
7			Nellapattu Wild life sanctuary
8			Krishna Wildlife Sanctuary
9			Sri Lankamalleswara Wildlife Sanctuary
10			Rollapadu Wildlife Sanctuary
11			Sri Penusila Narasimha Wildlife Sanctuary
12			Eturnagaram Wild life sanctuary
13			Nagarjuna Sagar Wild life sanctuary
14			Pranahita Wild life sanctuary
15			Pakhal Wild life sanctuary
16	Bihar	9	Kaimur Wild life sanctuary
17			Gautam Budha Wild life sanctuary
18			Pant (Rajgir) Wild life sanctuary
19			Valmiki Wild life sanctuary
20			Barela Jheel Salim Ali Bird Sanctuary
21			Kusheshwar Asthan Bird Sanctuary
22			Nagi Dam Wild life sanctuary
23			Udai Wild life sanctuary
24			Vikramshila Gangetic Dolphin Wild life sanctuary
25	Chhattisgarh	8	Achanakmar Wild life sanctuary
26			Pamed Wild Buffalo Wild life sanctuary
27			Semarsot Wild life sanctuary
28			Tamor Pingla Wild life sanctuary
29			Bhairamgarh Wild life sanctuary
30			Badalkhol Wild life sanctuary
31			Bhoramdev Wild life sanctuary
32			Udanti Wild life sanctuary
33	Goa	2	Bondla Wild life sanctuary
34			Madei Wild life sanctuary
35	Gujarat	13	Kutch Wild life sanctuary
36			Porbandar Wild life sanctuary
37			Jambugodha Wild life sanctuary
38			Wild Ass Wild life sanctuary
39			Ratanmahal Wild life sanctuary
40			Thol Lake Wild life sanctuary
41			Sasan Gir Sanctuary
42			Mitiyala Wild life sanctuary
43			Kachchh Desert Wild life sanctuary
44			Marine (Gulf of Kutch) Wild life sanctuary
45			Nal Sarovar bird Wild life sanctuary
46			Jessore Sloth Bear Wild life sanctuary
47			Hingolgadh Wild life sanctuary
48	Haryana	3	Bhindawas Wild life sanctuary
49			N. Khaparwas Wild life sanctuary
50			Kalesar Wild life sanctuary
51			Bandli Wild life sanctuary
52			Daranghati Wild life sanctuary

53	Himachal Pradesh	13	Dhauladhar Wild life sanctuary
54			Talra Wild life sanctuary
55			Pong Dam Wild life sanctuary
56			Nargu Wild life sanctuary
57			Renukji Wild life sanctuary
58			Shikari Wild life sanctuary
59			Shimla water Catchment
60			Trithan Wild life sanctuary
61			Rupa Bhaba Wild life sanctuary
62			Manali Wild life sanctuary
63			Kanawar Wild life sanctuary
64	Jharkhand	3	Lawalong Wild life sanctuary
65			Parasnath Wild life sanctuary
66			Palkot Wild life sanctuary
67	Karnataka	13	Someshwara Wild life sanctuary
68			Bhadra Wild life sanctuary
69			Bhimgad Wild life sanctuary
70			Bramagiri Wild life sanctuary
71			Cauvery Wild life sanctuary
72			Pushpagiri Wild life sanctuary
73			Sharavathi Valley Wild life sanctuary
74			Attiveri Wild life sanctuary
75			Cauvery Wild life sanctuary
76			Chimcholi Wild life sanctuary
77			Talakaveri Wild life sanctuary
78			Nugu Wild life sanctuary
79			Jogimatti Wild life sanctuary
80	Kerala	11	Periyar Wild life sanctuary
81			Chinnar Wild life sanctuary
82			Aralam Wild life sanctuary
83			Chimmony Wild life sanctuary
84			Idukki Wild life sanctuary
85			Malabar Wild life sanctuary
86			Aralam Wild life sanctuary
87			Neyyar Wild life sanctuary
88			Peppara Wild life sanctuary
89			Thattekad Wild life sanctuary
90			Wayanad Wild life sanctuary
91	Madhya Pradesh	12	Bori Wild life sanctuary
9			Gandhi Sagar Wild life sanctuary
2			Ken Gharial Wild life sanctuary
93			National Chambal Wild life sanctuary
94			Orcha Wild life sanctuary
95			Pachmarhi Wild life sanctuary
96			Gangau Wild life sanctuary
97			Phen Wild life sanctuary
98			Sailana Wild life sanctuary
99			Kheoni Wild life sanctuary

100			Sardarpur Wild life sanctuary
101			Singhori Wild life sanctuary
102	Maharashtra	10	Koyana Wild life sanctuary
103			Painganga Wild life sanctuary
104			Bhimashankar Wild life sanctuary
105			Tungareshwar Wild life sanctuary
106			Great Indian Bustard Wild life sanctuary
107			Andhari Wild life sanctuary
108			Bor Wild life sanctuary
109			Ghodazari Wild life sanctuary
110			Isapur Wild life sanctuary
111			Melghat Wild life sanctuary
112	Manipur	1	Yangoupokpi-Lokchao Wild life sanctuary
113	Mizoram	5	Dampa Wild life sanctuary
114			Ngengpui Wild life sanctuary
115			Baghmara Pitcher Plant Wild life sanctuary
116			Tavi Wild life sanctuary
117			Tokalo Wild life sanctuary
118	Nagaland	2	Fakim Wild life sanctuary
119			Rangapahar Wild life sanctuary
120	Odisha	7	Baisipalli Wild life sanctuary
121			Chilika (Nalaban) Wild life sanctuary
122			Hadgarh Wild life sanctuary
123			Satkosia Wild life sanctuary
124			Badrama Wild life sanctuary
125			Lakhari Wild life sanctuary
126			Kapilash Wild life sanctuary
127	Punjab	6	Abohar Wild life sanctuary
128			Harike Wild life sanctuary
129			Jhajjar Wild life sanctuary
130			Bir Bhadson Wild life sanctuary
131			Jhajjar Bacholi Wild life sanctuary
132			Nangal Wild life sanctuary
133	Rajasthan	5	Keoladeo Bird Sanctuary
134			Jawahar sagar Wild life sanctuary
135			Mount Abu Wild life sanctuary
136			Ramsagar Wild life sanctuary
137			Shergarh Wild life sanctuary
138	Sikkim	3	Fambong Lho Wild life sanctuary
139			Kitam (Bird) Wild life sanctuary
140			Maenam Wild life sanctuary
141	Tamil Nadu	5	Indira Gandhi (Annamalai) Wild life sanctuary
142			Karaivetti Wild life sanctuary
143			Pulicat Lake Wild life sanctuary

144			Vedanthangal Wild life sanctuary
145			Kalakad Wild life sanctuary
146	Tripura	3	Gumti Wild life sanctuary
147			Rowa Wild life sanctuary
148			Trishna Wild life sanctuary
149	Uttarkhand	5	Askot Musk Deer Wild life sanctuary
150			Binsar Wild life sanctuary
151			Govind Pashu Vihar Wild life sanctuary
152			Kedarnath Wild life sanctuary
153			Sonanadi Wild life sanctuary
154	Uttar Pradesh	6	Hastinapur Wild life sanctuary
155			Ranipur Wild life sanctuary
156			Sohagibarwa Wild life sanctuary
157			Sur Sarovar Wild life sanctuary
158			Chandraprabha Wild life sanctuary
159			National Chambal Wild life sanctuary
160	West Bengal	6	Sunderbans Wild life sanctuary
161			Chintamani Kar bird Wild life sanctuary
162			Haliday Island Wild life sanctuary
163			Ballavpur Wild life sanctuary
164			Lothian Island Wild life sanctuary
165			Mahananda Wild life sanctuary

State/ Union territory	**Number of Wildlife Sanctuary**	**State Area Covered by Km^2**	**Total State Area Covered**
Andaman & Nicobar	96	377.83	4.58 %
Assam	17	1728.95	2.20 %
Andhra Pradesh	13	6771.40	4.23 %
Arunchal Pradesh	13	7614.56	9.09 %
Bihar	12	2851.67	3.03 %
Chhattisgarh	11	3760.28	2.78 %
Chandigarh	2	26.01	22.82 %
Delhi	1	19.61	1.32 %
Dadar & Nagar Haveli	1	92.17	18.77 %
Daman & Diu	1	2.19	1.96 %
Gujarat	23	16618.42	8.48 %
Goa	6	647.91	17.50 %
Himachal Pradesh	28	6115.97	10.99 %
Haryana	7	118.21	0.27 %
Jharkhand	11	1955.82	2.45 %
Jammu & Kashmir	14	1729.03	1.06 %

Kerala	18	2156.21	5.55 %
Karnataka	35	7923.23	4.13 %
Ladakh	2	9000	15.22 %
Lakshadweep	1	0.01	0.03 %
Manipur	7	708.14	3.17 %
Mizoram	9	1359.75	6.45 %
Meghalaya	4	94.11	0.42 %
Maharashtra	48	7861.70	2.55 %
Madhya Pradesh	24	7046.19	2.29 %
Nagaland	4	43.91	0.26 %
Odisha	19	7094.65	4.56 %
Puducherry	1	3.90	0.81 %
Punjab	13	326.6	0.65 %
Rajasthan	25	5592.38	1.63 %
Sikkim	7	399.1	5.62 %
Tripura	4	603.64	5.76 %
Tamil Nadu	31	6292.07	4.84 %
Telangana	9	5672.7	4.94 %
Uttarkhand	7	2690.12	5.03 %
Uttar Pradesh	26	5822.2	2.42 %
West Bengal	16	1440.18	1.62%

11.4 Important National Biosphere Reserves

Biosphere reserves are large areas of protect land for the conservation of wild life, flora & fauna resource. It also conserves the traditional life of the tribal living in that area.

or

Biosphere reserves are special environments for both people & nature and are living example of how human beings and nature can co-exist while respecting each other's need.

The biosphere reserve was launched in 1971 by UNESCO after the initiation of Man & biosphere program (MAB)

Aim & Function Biosphere Reserve

Conservation

(i)To ensure the conservation of landscapes, ecosystem species and genetic variations.

(ii)To understand the patterns and processes of functioning of ecosystem.

(iii)To encourage the traditional resources use systems.

(iv)To monitor the natural and human caused changes on spatial and temporal scales.

Development

(i)To promote to the local level for economic development which is culturally, socially and ecologically sustainable.

(ii)To develop the strategies leading to improvement and management of natural resources.

Logistics

(i)Supporting development through research, monitoring, education & training.

The first biosphere reserve is Nilgiri biosphere Reserves established in 1986 in Tamil Nadu, Kerala & Karnataka.

The largest biosphere reserve is Gulf of Kutch in Gujarat.

The smallest biosphere reserve is Dibru- Saikhow in Assam.

Sr. No.	**Name**	**State/ Union Territory**	**Establish**
1.	Great Runn of Kutch	Gujarat	29/01/2008
2.	Dehang-Dibang	Arunachal Pradesh	02/09/1998
3.	Dibru-Saikhowa	Assam	29/07/1997
4.	Manas	Assam	14/03/1989
5.	Cold Desert	Himachal Pradesh	28/8/2009
6.	Panna	Madhya Pradesh	25/08/2011
7.	Seshachalam	Andhra Pradesh	20/09/2010
8.	Khangchendzonga	Sikkim	07/02/2000
9.	Nilgiri	Tamil Nadu, Kerala & Karnataka	01/08//1986
10.	Agasthyamalai	Kerala & Tamil Nadu	102/11/2001
11.	Gulf of Mannar	Tamil Nadu	18/02/1989
12.	Sundarban	West Bengal	29/03/1989

13.	Nanda Devi	UttarKhand	18/01/1988
14.	Great Nicobar	Andaman & Nicobar	06/01/1989
15.	Simlipal	Odisha	21/06/1994
16.	Nokrek	Meghalaya	01/09/1988
17.	Pachmarhi	Madhya Pradesh	03/03/1999
18.	Achanakmar (Amarkantak)	Madhya Pradesh	30/03/2005

Great Runn of Kutch biosphere reserve

It is established in 2008. It is present in part of Kutch, Morbi, Surendra Nagar and Patan district of Gujarat. It is largest biosphere reserve in India. The important fauna is India wild Ass.

Pachmarhi biosphere reserve

It is established in 1999. It is present in Satpura range of Madhya Pradesh. The Protected Area in this biosphere reserve are Bori Sanctuary, Pachmarhi Sanctuary, Satpura National Park. The important fauna are Giant squirrel, Spilornis cheela (crested serpent eagle).

Cold Desert biosphere reserve

It is established in 2009. It is present in western Himalaya region in Himachal Pradesh. The protected areas are Pin valley National Park, Chandratal wild life Sanctuary, Sarchu wild life Sanctuary, Kubher wild life Sanctuary. The important fauna is Snow leopard.

Achanakmar biosphere reserve

It is established in 2005. It is located in Madhya Pradesh (Anuppur & Dindori) and in Chhattisgarh (Bilaspur).The protected area is Achanakmar wild life sanctuary. The important fauna are four horned antelope, Indian wild dog, Saras crane, Asian white backed vulture, sacred grove bush frog.

Simlipal biosphere reserve

It is established in 1994. The protected area is Similipal tiger reserve, part of Mayurbhanj elephant reserve, Hadgrah wildlife sanctuary, Kuldiha wildlife sanctuary. The Important fauna are Bengal tiger, Asian elephant, Gaur and Chausingha.

Sundarbans biosphere reserve

It is established in 1989. It is world Natural Heritage site. It is located in part of delta of Ganga & Brahmaputra river system in West Bengal. It has largest mangrove area. It protected area are Sundarbans national park, Sajnekhal Wildlife Sanctuary, Lothian Wildlife Sanctuary, Haliday Wildlife Sanctuary. The important Fauna is Royal Bengal Tiger.

Nilgiri biosphere reserve

It is established in 1986. It is world natural Heritage site. It is located in Tamil Nadu, Kerala, Karnataka. The protected area are Mudumali Wildlife Sanctuary, Wyanand Wildlife Sanctuary, Bandipur National Park (Karnataka), Nagarhole National park (Karnataka), Mukurthi National park (Tamil Nadu), Silent Valley (Kerala). The important fauna are Nilgiri tahr, Nilgiri Langur, Lion tailed Macaque.

Gulf of Mannar biosphere reserve

It is established in 1989. It is first marine biosphere reserve in India, It is located in Tamil Nadu part of Laccadive sea in Indian Ocean. Its protected area is Gulf of Mannar. The important fauna are Sea cow (dugong), Sea Anemone, Sea cucumber, Sea turtles.

Great Nicobar biosphere reserve

It is established in 1989. It is located in Andaman & Nicobar i.e. Great Nicobar in the southernmost island of the Nicobar Islands Archipelago. The protected areas are Campbell bay national Park, Galathea national Park. The important fauna are long tailed Macaque, Nicobar scrub fowl, Nicobar tree Shrew and Edible nest swiftlet salt water crocodile.

Panna biosphere reserve

It is established in 1981. It is located in Vindhya Mountain range in Panna & Chattatarpur district of Madhya Pradesh. The Protected areas are Panna National park and Ken Gharial wildlife sanctuary. The important fauna are Tiger, Leopard, Chital, Chinkara, Nilgai, Sambar & Sloth bear.

Agasthyamala biosphere reserve

It is established in 2001. It location are Southern most end of the western Ghat in Kerala & Tamil Nadu. The protected areas are Shendumey Wildlife Sanctuary, Peppara Wildlife Sanctuary, Neyyar Wildlife Sanctuary & Kalakkad Mundanthurai tiger Reserve. The important fauna are Bengal Tiger, Asian Elephant & Nilgiri tahr.

Seshachalam Hill biosphere reserve

It is established in 2010. It location is Southern Eastern Ghat in Seahachalam Hill ranges covering parts of Chittor & kadapa district, Andhra Pradesh. The important fauna are slender loris.

Khangchendzonya biosphere reserve

It is established in 1977. It is located in Sikkim. It is first mixed heritage site of India. It has 34 biodiversity hot spots. . The important fauna are Musk deer, snow leopard, Himalayan tahr.

Nanda Devi biosphere reserve

It is established in 1988. It is located in Uttarkhand. The protected areas are Nanda Devi national Park, & Valley flower national park. The important fauna are endangered mammal species, snow leopard, Himalayan black bear, brown bear, Musk deer.

11.5 Zoological gardens and Museum

India has large no of zoological garden or park with having large number of animal species. Of which few are describe below

Arignar Anna Zoological Park

It is largest and oldest Zoological Park in India. It is present in Vandalur Chenni Tamil Nadu. It has opened in 1855 year. It has spread in 1490 acres. It has 171 numbers of species and nearly 2644 number of animals. The important animals are snake, lion, leopard, rhino, different types of birds etc.

Nandankanan Zoological Park

It is the second largest and famous zoo in India and present in district Bhubaneswar, Odisha. It has open in 1960 and has an area of 1080 acres. This zoo has 157 numbers of species and nearly 3517 number of animal is present. This zoo is famous internationally for successfully breeding of black panthers, gavials and white tigers in captive. It has also butterfly park and many other animals.

National Zoological Park

The national Zoological Park is also established in New Delhi 1959. The land area is about 175 acres. It has 127 numbers of species and it is home of about 1350 animal. The important animals are chimpanzee, hippopotamus, spider, monkey, zebra etc.

Indira Gandhi Zoological Park

It is situated is Visakhapatnam of Andhra and is surrounded by scenic eastern ghat on three sides and Bay of Bengal on other side. It has open in 1977 and covering an area of about 625 acres. It has 75 numbers of species and 850 numbers of animals. It has different sections of primates, pythons, king cobra, rat snake, Indian turtle, water monitor, green iguana, crocodile, gravils.

Jawaharlal Nehru Zoological Park

It is present in Bokaro, Jharkhand. It is the largest zoological Park in Jharkhand. This zoo has different varieties of animals & birds which have been brought from different parts of world.

Srivenkateswar Zoological Park

It is situated in Triputi, Andhra Pradesh. This zoo having pea fowl, Mrugarani, Vrukarihar along with parakeets, manias, ducks, geese and a variety of other birds like flamingoes, swans, pelicans, raptors.

Sanjay Gandhi Jaivak Udyan

It is oldest zoo in India, present in Patna. It has opened in 1973 and covers 153 acres of land. The Sanjay Gandhi Jaivak Udyan having 110 numbers of species and 800 number of animals. Some important animals are tigers, leopards, crocodiles, Himalaya black bears & Hippopotamus etc.

Nehru Zoological Park

It is situated in Hyderabad, Telangana. It has open in 1963. It covers 380 acres area of land. It has 100 species of animal. The important animals are Indian rhino, Asiatic lion, Bengal tiger, panther, gaur, slender Loris, python, deer antelope etc.

Sakkarbaug Zological Park

It is present in Junagadh Gujarat. It has pure breed of Asiatic lion for the Indian endangered species captive breeding program. The Asiatic lions are today found only in the nearby Gir forest.

Padmaja Naidu Himalayan Zoological Park

It is situated in Darjeeling, West Bengal. It is the largest high altitude zoo in India and has successful captive breeding program for the snow leopards, critically endangered Himalayan wolf and the Red Panda.

Amirthi Zoological Park

It is situated in Vellore of Tamil, Nadu. This zoo is a half jungle with beautiful waterfalls and tourist spot and the other half is developed as wild life sanctuary with animals such as spotted deer, mongoose, hedgehog, foxes, monkey, pythons & eagles.

Rajiv Gandhi Zoological Park

It is situated in katraj Pune Maharashtra. It is also known as katraj snake park and is one of the, most famous snake park in India. It has open in 1999 and it covers 130 acres of land. It has 66 numbers of species and nearly 362 numbers of animals. It has large collection of reptiles, mammals and some birds but has a large number of snakes and reptiles including Indian rock, python, cobra, snakes, viper and Indian crocodiles.

Mysore Zoological Park

It is located in Mysore Karnataka. It is also called Chamarajan Zoo. It has open in 1892 and it covers 270 acres of land area. It has 168 numbers of species and 1320 numbers of animals. The important animals are green Anaconda, giraffe, zebra, lion, white rhino, tiger, baboon etc.

Zoo Cum Botanical Garden

It is also called Guwahati Zoo. It has opened in 1958 and spread over 432 acres of land. It has 113 numbers of species and 865 numbers of animals. The important animals are one horned Indian rhino, tiger, leopard golden langoor, Gibbon, elephant, Loris, deer, black bear, leopard cat & jungle cat.

Museum

Museum is a place used for storing, preservation and exhibition of flora & fauna. The function of museum is acquisition of material, recording of materials, research, exhibition of material and education.

Smithsonian is the world largest museum. It is the museum, education & research complex and consists of 19 galleries, 9 research centre.

The largest museum in India is established in 1814 at the cradle of Asiatic society of Bengal, Kolkata. This museum is earliest and multipurpose museum. This museum has six sections consisting of 35 galleries of cultural & scientific artifacts.

Jim Corbett museum

Jim Corbett museum is situated in Nanital, Uttarkhand. This museum is established to impart awareness and to make people understand the importance of the environment and its resources.

Regional Museum National History, Mysore

It is situated in Siddhartha Nagar Mysore. It was initiated in 1995, located on the bank Karanji Lake and with the backdrop of chamundi hills. This museum was established with the vision of making people aware of flora, fauna and ecological wealth of the southern region of India.

Rajiv Gandhi Museum of Natural History, Rajasthan

It is situated in Ramsinghpura, sawai madhopur in Rajasthan. It was inaugurated in 2014. This museum has vital centre for environmental education and public awareness on conservation of nature & natural resources.

Natural History Museum, Thiruvananthapuram

It is situated in Palayam, Thiruvananthapuram in 1964. This museum has rich collection of ethnographic items, animals skeletons, stuffed animals as well as birds from different part of the country. It also has a galleries for mammals, birds, vertebrates, invertebrates as well as the skeletons.

Baghel Museum, Madhya Pradesh

It is situated in Bandhavgarh, Madhya Pradesh. This museum is famous for stuffed body of first white tiger.

Kanha Museum, Madhya Pradesh

It is situated near the kisli gate of kanha National Park.

Regional Museum of Natural History, Bhubaneswar

It is situated in Acharya Vihar, Bhubaneswar. It is opened for public in 2004. The museum was set up with the aim to inculcate the awareness about the importance of flora & fauna and conservation of natural resources. This museum has a skeleton of Baleen whale which is believed to be the largest for any museum in India.

Natural History Museum, Telangana

It is situated inside Nehru zoological Park in Bahadurpur, Telangana. The museum displays stuffed dummies of the extinct as well as the living animals and artifacts that are related with animals.

Natural History Museum, Chandigarh

It is situated in Chandigarh. This museum having features of section on dinosaurs, which are the extinct animals of the planet. In this museum there is also section for focuses on the Evolution of Man, which shows, different stages of primate evolution. It also has another sections showing evidences and Models from the Cycorama-The evolution life, in this it shows the origin of earth, evolution of life from unicellular to multicellular plants and animals through the Archeaozoic, Paleozoic, Permian, Devonian, Triassic, Jurassic, Oligocene, Myocene & Pleistocene periods.

Bengal natural History Museum, Darjeeling

It was established in 1915 in Darjeeling. It is one of the oldest museum in India. It has collection of butterflies and birds of the area. It also has huge collection and specimens of varieties of birds with nest and egg, insects, fishes, reptiles and mammals. All the specimens are real creatures that were captured and preserved. It also has varieties of birds like Himalayan brown wood owls, Northern spotted owlets, Northern brown fish owl, pheasants, fly catchers, wood peckers. It has 35 species of snakes, 57 species of fishes are also seen in this museum.

SAQ.

Complete the following sentences by inserting appropriate words in the blanks.

(i) Sohagibarwa Wild life sanctuary is situated in -------------

(ii)The Kaziranga National Park is situated in ----------

(iii) Arignar Anna Zoological Park is situated in ------------.

(iv) ***Baghel Museum*** is present in -------

11.6 Summary

In this unit there is detailed study about important national parks, important national sanctuaries, important national biosphere reserves, zoological gardens and museums. Each and every section has very detailed study with reference to their habit, location and area.

11.7 Terminal Question

Q1. Define National Park in detailed.

Q2. Explain the Agasthyamala biosphere reserve.

Q3. Explain the Bengal natural History Museum, Darjeeling.

11.8 Answers

SAQ 1 (i)Uttar Pradesh

(ii) Assam

(iii) Tamil Nadu

(iv)Madhya Pradesh

Terminal Question

Ans 1.

A National Park is the place that is strictly protected with the aim of improving wildlife and biodiversity. The area of National park establish under section 35(4) of the wildlife (protection) act 1972 of government of India. In national park there is protection of entire ecosystem i.e. plants, animals, land, water in that area. In national parks, any kind of development, forestry, poaching, hunting or grazing on agriculture land is prohibited.

National parks can be declared both by the central Government and state government. No alternation of the boundaries of a national park shall be made except on a resolution passed by the state Legislature.

Ans 2.

Agasthyamala biosphere reserve is established in 2001. It location are Southern most end of the western Ghat in Kerala & Tamil Nadu. The protected areas are Shendumey Wildlife Sanctuary, Peppara Wildlife Sanctuary, Neyyar Wildlife Sanctuary & Kalakkad Mundanthurai tiger Reserve. The important fauna are Bengal Tiger, Asian Elephant & Nilgiri tahr.

Ans 3.

Bengal natural History Museum, Darjeeling was established in 1915 in Darjeeling. It is one of the oldest museum in India. It has collection of butterflies and birds of the area. It also has huge collection and specimens of varieties of birds with nest and egg, insects, fishes, reptiles and mammals. All the specimens are real creatures that were captured and preserved. It also has varieties of birds like Himalayan brown wood owls, Northern spotted owlets, Northern brown fish owl, pheasants, fly catchers, wood peckers. It has 35 species of snakes, 57 species of fishes are also seen in this museum.

UNIT 12 : METHODS OF WILD LIFE CONSERVATION

12.1 Introduction

Wildlife habitat is a natural environment of animal. It can be created naturally through forest successional processes. Habitats generate in a forest landscape, a variety of herbaceous & shrub species, which will yield a wide variety of vertebrate & invertebrate species. Habitat management refers to the deliberate planning and manipulation of natural environments to promote the conservation and enhancement of ecosystem and the species that inhabit them. Managing habitats for wildlife mainly involves influencing the successional stage and physical structure of vegetation to benefit particular species or assemblage of species. The succession in the process by which assemblages of plants and animals changes overtime in the absence of disturbance.

Objectives

After studying this unit you will be able to know:

- Habitat Managements, reintroduction in wild
- Mass education and awareness, Promulgation of Laws
- Wild life organizations, Red data book
- Problems of wild life managements in India

12.2 Habitat Managements, reintroduction in wild

The habitat management practice is crucial in mitigating the negative impacts of habitat loss and fragmentation caused by human activities such as urbanization & agriculture.

The habitat management can also include

- ➢ Minimizing the effects of damaging human activity.
- ➢ Manipulations to specially increase the abundance and accessibility of prey.
- ➢ Provision of nest sites.

Habitat management can in some cases include planting vegetation, although this is more usually carried out during habitat restoration. Many species are dependent on early successional habitats those that have been subject to recent disturbance. In fully natural systems the rate and direction of succession is influenced by vegetation removal and other physical disturbance

- Grazing, browsing, trampling and other physical disturbance by larger herbivores
- Physical disturbance events, particularly fires, storms, drought and variations in water levels
- Periodic large-scale herbivores by insects

In majority of the areas all natural habitats have been highly modified by past human activity. The remaining fragments of modified vegetation are usually referred as semi-natural. The natural processes of vegetation removal and other physical disturbance usually either no longer operate in there semi-natural habitat or if they do only at an inappropriate scale or frequency to maintain the desired assemblages of species. In these situations, habitat management can be used to mimic the effects of these natural processes to provide suitable conditions for species that depend on these form of disturbance. Most of the remaining fragments of semi-natural habitat have only survived until now because they have been subject to a long history of human resource use.

The principal aspect of habitat management

(i) Biodiversity conservation: The main objective of habitat biodiversity is to maintain and restore biodiversity. Biodiversity is the very basis of life, either in wild or domesticated forms biodiversity is the sources for most of humanity food, medicine, clothing and housing. Now man has realized the importance of biodiversity, because loss of biodiversity may threaten the very extinction of life. Hence man has taken steps to conserve the biological resources in different.

- To make the list of biological resources in different parts of the country including the island ecosystem.
- Biodiversity conservation can be undertaken through network of projected area including national Parks, sanctuaries, biosphere Reserves, marine reserves, gene banks, wetlands coral reefs etc.
- Rehabilitation of tribal's displaced due to creation of protected areas.
- Control of over exploitation through various organizations
- Protection of domesticated plant and animal species to converse indigenous genetic diversity.
- There should be protection and sustainable use of genetic resources or germplasm through appropriate laws and practices.
- There should be corridors between different nature reserves for the purpose of migration.
- Emphasis can be given for traditional skills and knowledge of conservation.
- Avoid monoculture plantation.
- Avoid introduction of exotic species without enough investigations.

There are two basic method of conservation of biodiversity i.e. in situ conservation & ex-situ conservation.

(a)*In-situ conservation*: Conservation of plants or animals in their natural habitat is called as in-situ conservation, so in in-situ conservation there is protection of wildlife animals and plants in their own habitats. So the best strategies for long term protection of biodiversity are preservation of natural communities and population in the wild state. So in-situ conservation are the best site for natural conservation, there 75 National Park, 751 wildlife sanctuaries, 12 tigers reserve as well as 14 biosphere. It has been observed that due to in-situ conservation the population of tiger, elephant, hangul, and crocodile has been significantly increases. For in-situ conservation, certain measure to be take for good result area as

- Establishment inter linkage between plants & animals species
- Quantitative assessment of conservation status of the species.
- Setup applied research laboratories for conservation of living resource.
- Ecological restoration of degraded micro& macro habitats.
- By the use of biotechnology, multiplication & restoration of endangered, rare and endemic species.
- Assessment of the impact of exotic species on ecosystem.
- Impact of climate change on diversity.

(b)*Ex-situ conservation* : When conservation is done outside the natural habitat is called ex-situ conservation. Conservation of wild and domesticated species can be done in zoological park, wildlife safari park, aquaria and captive breeding programme.

(ii) Ecosystem Health : Healthy ecosystems provide essential services like clean air and water, and carbon sequestration. Habitat management aims to ensure the ecological functions of habitats are maintained or restored.

(iii) Invasive Species Control : Invasive species can outcompete native species and disrupt ecosystems. Habitat management strategies often involve controlling or eradicating invasive species to protect native biodiversity.

(iv) Restoration: Many habitats have been degraded or lost over time. Habitat management may involve habitat restoration efforts such as reforestation, wetland restoration or the creation of wildlife corridors to reconnect fragmented habitats.

(v) Human Wildlife Conflict Mitigation : Man-animal conflict refers to negative interactions between humans and wild animals that have negative consequences for both humans and their resources on the one side and wildlife and their habitats on the other. Man-Animal conflict, which is caused by human-wildlife competition for natural resources has an impact on human food security and the well-being of both humans and animals. The number of these conflicts has increased in many regions in recent decades as a result of human population growth and land use change.

Causes of Man-Animal Conflict

- Human-Wildlife Conflict is caused by humans coming into contact with wildlife's natural habitats.
- The other factors include large-scale habitat destruction caused by deforestation, overgrazing by livestock and the expansion of human settlements and agriculture.
- The destruction of wild animal's homes is known as habitat disturbance. Humans kill or pursue wild animals in their natural habitat by digging, cutting, sealing with stones and smoking.
- Interactions between humans and wild animals are becoming more common as the human population grows and biodiversity increases.
- Some other causes include :
    - Climate factors
    - Land use change

- Species habitat loss, degradation and fragmentation
- Wildlife population growth as a result of conservation programmes
- Growing interest in ecotourism and increased access to nature reserves
- Human population growth
- Abundance and distribution of wild prey

Impacts of Man Animal Conflict

- Man-Animal conflict has the greatest direct impact on wildlife and the communities that live nearby.
- Human-wildlife conflict is a development and humanitarian issue as well as a conservation concern, affecting the income of farmers, herders, and artisanal fishers, particularly those with incomes below the poverty line.
- While human-wildlife conflict can lead to species decline and extinction, communities can suffer financial losses as well as threats to health and safety, livelihoods, food security and property.
- Some other impacts include:
    - Wildlife injuries
    - Habitat destruction
    - Human life is lost
    - Predation on livestock
    - Human injuries
    - Animal deaths

Reintroduction in wild

Reintroduction of species into the wild is a conservation strategy aimed at re-establishing populations of endangered or extirpated species in their natural habitats. This process involves careful planning and execution to ensure the successful adaptation and survival of the reintroduced individuals. Important steps for species reintroduction include :

(i) Habitat Assessment : Before reintroduction thorough assessments of the target habitat are necessary. This involves evaluating factors such as food availability, shelter, water sources, and the presence of potential threats.

(ii) Captive Breeding : In many cases, individuals for reintroduction are breed in captivity to ensure genetic diversity and health. Captive breeding programs are crucial for species with critically low wild populations.

(iii) Pre-Release Conditioning : Reintroduced individuals may go through a period of conditioning to enhance their survival skills. This can include predator avoidance training, foraging lessons, and socialization with conspecifics.

(iv) Monitoring and Research : Post-release monitoring is essential to assess the success of the reintroduction. Researchers track the behavior, health, and reproductive success of the reintroduced individuals.

(v) Adaptive Management : Reintroduction plans should be flexible and adaptive. If challenges arise, adjustments may be needed, such as supplementary feeding or habitat modifications.

(vi) Public Education and Out-reach : Engaging local communities and raising awareness about the importance of species reintroduction can garner support and reduce potential conflicts.

12.3 Mass education and awareness

Mass education and awareness campaigns play a pivotal role in shaping societies, driving positive change and addressing a wide range of social, environmental and public health issues. These campaigns are designed to inform, engage and empower large audiences making them a potent tool for fostering awareness and driving collective action. The important aspect of Mass Education and Awareness are

(i) Public Engagement : Beyond simply providing information, mass awareness campaigns aim to engage the public emotionally and intellectually. They may use storytelling, testimonials, or interactive elements to resonate with the audience.

(ii) Target Audience : These campaigns often target diverse audience segments including different age groups, socio-economic backgrounds and cultural contexts. Tailoring messages to specific audiences is crucial for effectiveness.

(iii) Behavioral Change : One of the primary objectives of mass education and awareness is to influence behavior positively. For instance, campaigns on public health might encourage healthy habits such as regular exercise or vaccination, while environmental campaigns may promote sustainable practices

(iv) Measuring Impact : Evaluating the effectiveness of these campaigns is essential. This involves tracking metrics such as audience reach, message retention and most importantly the actual behavioral changes or actions taken as a result of the campaign.

(v) Advocacy and Activism : Mass awareness can mobilize communities to become advocates for change. These campaigns often encourage people to take action, whether it's signing petitions, participating in protests or volunteering for causes they care about.

(vi) Information Dissemination : Mass education and awareness initiatives primarily involve the widespread distribution of information through various mediums including television, radio, print media, social media and community events. The information shared can relate to critical topics such as health, environment, human rights and civic responsibilities.

Examples of Mass Education and Awareness Campaigns:

(1) Social Justice Movements : Mass education has been at the heart of movements for gender equality, racial justice.

(2) Public Health Campaigns : Initiatives promoting vaccination, HIV/AIDS awareness, smoking cessation, and hygiene practices have saved countless lives by educating the public on health risks and preventative measures.

(3) Disaster Preparedness : Mass education and awareness can save lives by educating communities about disaster preparedness, evacuation procedures, and early warning systems.

(4) Environmental Awareness : Campaigns advocating for conservation, recycling, reducing plastic use, and combating climate change raise public awareness about the importance of protecting the environment.

(5)Political Engagement : Awareness campaigns encourage voter registration, civic participation, and political activism playing a vital role in democratic processes.

Mass education and awareness campaigns have the power to transform societies, promote positive change and address pressing global challenges. They are a potent tool for empowering individuals and communities with knowledge, inspiring action and fostering a sense of collective responsibility for building a better more informed and socially conscious world.

12.4 Promulgation of Laws

The promulgation of laws is a critical step in the legislative process of a democratic system. It is the formal act of making a law or legal provision known to the public and putting it into effect. The promulgation process ensures transparency, compliance with constitutional requirements, and the enforcement of legal provisions. The important point of Promulgation of Laws are :

(1)Passage of Legislation : Before promulgation, a bill must go through a series of legislative steps. This typically includes introduction, committee review, debate, and voting in the legislative body, whether it's a parliament, congress, or other governing body.

(2)Presidential or Executive Approval : In many countries with a separation of powers, the head of state, often the president, may need to approve the bill. This approval may be in the form of signing the bill into law or allowing it to become law without a signature.

(3)Publication : Once a bill is approved, it is published in an official government gazette or a designated public repository. Publication is a fundamental aspect of promulgation, as it ensures that the law becomes accessible to the public.

(4)Effective Date : Laws typically specify when they will come into effect. This can vary, with some laws taking effect immediately upon publication, while others may have a delayed effective date to allow for preparations or compliance.

(5)Public Notice : In some cases, additional steps are taken to notify the public about new laws. This can include public announcements, dissemination of information through government websites, and outreach efforts to relevant stakeholders.

(6) Enforcement : After promulgation, government agencies responsible for enforcement must be prepared to uphold the law. This may involve developing regulations, guidelines, or procedures to implement and enforce the law effectively.

(7) Education and Compliance : Promulgation also involves educating the public about the new law's provisions and implications. Efforts are made to ensure that citizens and organizations understand their rights and responsibilities under the law.

The promulgation of laws is a vital step in the legislative process of any democratic society. It ensures that laws are accessible, understood and effectively enforced, thereby upholding the principles of transparency, accountability and the rule of law.

Environmental Laws

Forest & Wildlife

Indian Forest Act 1927

National Forest Policy 1952 & 1988

- **National Forest policy 1952**
  - 33% land to be cover under forest
- **National Forest policy 1988**
  - Environmental stability
  - Ecological balance
  - Sustenance of all forms of life
  - Management & conservation of forest
  - Involvement of local communities

- In-situ conservation
- Maintaining Biological Diversity
- Checking soil Erosion
- Study sand Dunes
- Tracking fuel wood & other resources.

Wildlife (Protection) Act 1972

Six Schedules

- ❖ HV-Protection of Animals & Birds and Penalty on violation
- ❖ V-Venomous species and their killing
- ❖ VI - Plants prohibited from cultivation and planting

New Institutional set up

- ❖ Central Zoo Authority.
- ❖ Wildlife Crime Control Bureau
- ❖ National Tiger Conservation Authority
- ❖ National Board for wildlife
- ❖ State Wildlife Advisory Boards.

Prevention of cruelty to Animal Act 1960

Forest conservation Act 1980

Biological Diversity Act 2002

- ➢ To Implement the CBD, Nagaya Protocol (2010)
- ➢ To check Biopiracy and protect biological diversity
- ➢ To set up National Biodiversity Authority, State Biodiversity Boards, Biodiversity Management committees.
- ➢ To protect indigenous knowledge system.
- ➢ To regulate genetically modified crops.
- ➢ IPR related issues.

Water

Water (Prevention and control of Pollution) Act 1974

- To control the flow of sewage and industrial effluents discharge by approving, rejecting granting consent to on discharge.
- State Pollution Control Boards (SPCBs)
- Central Pollution Control Boards (CPCB)

Water (Prevention and control of Pollution) Cess Act 1977

Water (Prevention and control of Pollution) Cess Rules 1978

Ganga Action Plan

National Water Policy (1987, 2002, 2012)

Interstate River Water Dispute Act

Krishna Water Dispute Tribunal

Godavari Water Dispute tribunal

Air

Public Liability Insurance Act 1991

Air (Prevention and control of Pollution) Act 1981

- To regulate the discharge of Lead, Carbon Monoxide, Sulfur dioxide, Nitrogen oxide and other volatile organic compounds and toxic substances.

Air (Prevention of Pollution) Union Territories Rules 1983

National Green Tribunal Act 2010

Environment

Environment (Protection) Act 1986

- After Bhopal Gas Tragedy 1984.

- To enforce international agreements and their compulsions under Article 253
- National Coastal Zone Management Authority was setup which later transformed to National Ganga Council under Ministry of Jal Shakti.
- The Public Liability Insurance Act & Rules 1991 (Amended 1992)
- The National Environment Tribunal Act 1995
- The National Environment Appellate Authority Act 1997.
- The Biomedical waste (Management and Handling) Rules, 1998
- The Environment (sitting of Industrial projects) Rules 1999
- The Municipal solid waste (Management and Handling) Rules 2000
- The Ozone Depleting Substances Rules, 2000
    - To prohibit CFCs, Halons, ODS such as Carbon tetrachloride, Methyl chloroform, SFCS excepts in inhalers or medical purpose.
- The Batteries (Management & Handing) Rules 2001
    - Covered Manufacturer, imposter, Ré-conditioner, Dealer, Auctioneer, Consumer, Bulk consumers
    - Safe disposal of Batteries
- Recycled Plastic, Plastic manufacture and usage Rules 1999
- Hazardous waste (Management and Handling) Amendment Rules 2003
- Construction and Demolition waste management Rules 2016

Energy Conservation Act 2001

- Energy consumption standards for equipment and appliances.
- Codes to commercial buildings and their energy efficiency.
- Instituted : Bureau of Energy Efficiency (BEE) as a statutory body

Scheduled Tribes and other Traditional Forests dwellers (Recognition of Forests Rights) Act 2006

- Two types of people : Forest welling Scheduled Tribe (FDST) and other Traditional forest Dweller (OTFD).
- Identified 4 types of Rights
  - Title Rights
  - Use Rights
  - Relief and Development Rights
  - Forest Management Rights.

Noise Pollution (Regulation and Control) Amendment Rules 2010

- Regulation of Loudspeaker during cultural an festival occasions.
- Public area noise control
- Silence Zones and Residential Areas.
- Sound emitting construction equipment shall not be operated during nights.

12.5 Wild life Organizations, Red data book

A large number of wildlife animal species like lions, crocodile, rhinoceros etc. are hunted for their skin, nails, horns and meat. Human being killing these animals only to fulfill their needs, which are unnecessary and can be fulfilled by other alternatives, so preventing wildlife species from uneven poaching and killing is called wildlife conservation. It is good approach for protecting the wild life on Earth and their habitat so that their future generation can exist without any fear. So to protect the wildlife organizations are crucial entities dedicated to the conservation and protection of wild animals, their habitats and biodiversity as a whole. These organizations play a vital role in safeguarding endangered species, restoring ecosystems, conducting research, and raising awareness about wildlife conservation. The important functions and roles of Wildlife Organizations are:

(i)Conservation Efforts: Wildlife organizations work to protect endangered and threatened species through habitat preservation, captive breeding programs and anti-poaching efforts.

(ii)Research and Data Collection: They conduct scientific research to better understand wildlife behavior, population dynamics and habitat requirements. This research informs conservation strategies.

(iii)Advocacy and Policy Influence: These organizations often advocate for stronger environmental laws and policies at local, national, and international levels. They also work to hold governments and industries accountable for their impact on wildlife and ecosystems.

(iv)Education and Outreach: Wildlife organizations educate the public about the importance of biodiversity and conservation. They often engage in outreach activities such as school programs, public events and awareness campaigns.

(v)Rescue and Rehabilitation: Many wildlife organizations operate wildlife rehabilitation centers, caring for injured, orphaned animals with the goal of releasing them back into the wild.

(vi) Collaboration: They collaborate with other conservation entities, government agencies and communities to maximize their impact and share resources and expertise.

Important wildlife organizations are

(1)World Wildlife fund (WWF) : It is the largest voluntary organization set up in 1961. Its headquarter is at Gland, Switerzerland, since 1979. The official symbol is Giant Panda. They are responsible to board for the administration of the fund and also supervise raising and disbursement of fund etc. The mission of WWF is "*To conserve nature and reduce the most pressing threats to the diversity of life on Earth*". The WWF work on

- In the areas of climate, food, forest, freshwater, oceans and wildlife primarily.
- It runs several projects in various fields in the partnership with people, bodies and government worldwide.
- In species conservation, the focus on tigers, elephants, gorillas, giant pandas, sea turtles, polar bears, rhinos and whales.
- Through its various projects, the organization aims to check the degradation of the earth's natural environment and create a future in which human being lives in harmony with nature.

(2)WWF India: It was founded in 1969 and headquarters is at Mumbai. Its main aims are conservation, education and research. Its main activities in India involve financing, specific conservation projects and related research studies, promoting conservation, creating public awareness. Some of the important project are under supervisions of WWF India are

- Crane conservation project
- Crocodile breeding project
- Ecological survey of western ghat
- Sloth bear project

(3)Wildlife preservation society of India: It is founded in 1958 at Dehradun by non-government organization. The main aims are

- ➢ To co-operate with the government in the matter of wildlife protection
- ➢ To assist in enforcing wildlife protection act
- ➢ To promote wildlife tourism
- ➢ Advise and help the government and administrator in the formation, maintenance and protection of National Parks & Sanctuaries.

(4)Bombay Natural history Society: It is a private organization set up in 1986 by seven residents at Bombay. The society collects information and specimens of flora & fauna from India, Myanmar and Sri Lanka. The society focuses official and public attention to the need for proper understanding, conservation and development of the rich and varied biodiversity of wildlife of India through publications, lectures, films and field visits. It surveyed mammals and birds of India from 1911 to 1923.

(5)Convention of International trade in Endangered species of wildlife fauna and flora (CITES) : In order to prevent over-exploitation of wild fauna and flora through international trade, a convention on international trade in endangered species of wild fauna & flora (CITES) was signed at 3rd March 1973 which came into existence on 1st July 1975. The government of India becomes a party to it from 18th Oct 1976. Under this convention inspector General of forests and director of wildlife preservation are the management authorities in India, supported by Director, Zoological survey of India (ZSI), Director, Botanical survey of India (BSI) and Director, Central Marine fisheries Research Institute.

(6)Indian Board of Wildlife (IBWL) : It is advisory body that advices government of India in regard to wildlife policy in the country. It was founded in 1952. Its function are as follows

- Broad takes decisions for the management of wildlife through legislative and practical measures under which it can declare certain species as protected animals and prevents the indiscriminate killing of particular species.

- It promotes and sponsors the wildlife reserves through country.
- It creates public interest in the conservation of wildlife.
- It advises central government while making the policy regarding the export of wildlife products.
- It encourages for establishing the wildlife societies in the country and helps in their activities.

(7)International Union for conservation of Nature and Natural Resources (IUCN) : It is an international non-government organization was founded in 1948. Its aim is wildlife conservation. IUCN has more than 475 member organizations and 116 governmental agencies in 110 countries IUCN prepares Red data book for endangered species.

Red Data Book

The special survival commission (SSC) comes under IUCN. Its aim is to conserve biological diversity, save, restore and manage species and their habitat. The special survival commission prepare Red data book for endangered species and it is modified every year on the basis of species become unproved and comes out of endangered category is removed from the list of the book.

The red data book contain colour-coded information sheets, which are arranged according to the extinction risk of many species and subspecies.

- Black represents species that are confirmed to be extinct.
- Red represents species that are endangered.
- Amber represents species whose status is considered to be vulnerable
- White represents for species that are rare

- Green represent for species that were formally endangered, but their numbers have started to recover.
- Grey represent for the species that are classified as vulnerable, endangered or rare but sufficient information is not available to be properly classified.

Advantages of Red data book

- It helps in identifying all animals, birds and other species about their conservation status.
- It is used to evaluate the population of a particular species.
- The data available in this book can be used to evaluate the taxa at the global level.
- With the help of this book, we can estimate the risk of taxa becoming globally extinct.
- Provides a framework or guidelines for implementing protective measures for endangered species.

Red data book of India

Red data book of India includes the conservation status of animals, which are endemic to the Indian subcontinent. The data for this book is provided through surveys which are conducted by the zoological survey of India, under the guidance of the Ministry of Environmental, forest & climate change. According to Red data book the following animals are as

Critically Endangered fishes

- Large-tooth Sawfish
- Pondicherry Shark
- Knife-tooth Sawfish
- Ganges Shark
- Long-comb Sawfish

Critically Endangered Amphibians

- Kaikatt's Bush Frog
- Great Bush Frog
- Munnar Bush Frog
- Sacred Grove Bush Frog
- Shillong Bubble Nest Frog
- Tiger Toad
- Resplendent Shrub Frog
- Sushil's Bush Frog
- Amboli Bush Frog
- Chalazodes Bubble-nest Frog
- Small Bush Frog
- Anamali Flying Frog
- Kottigehar Bubble-nest Frog
- Kerala Indian Frog

Critically Endangered Reptiles

- Sispara Day Gecko
- Red-crowned Roofed Turtle
- River Terrapin
- Leatherback Turtle
- Gharial
- Hawksbill Turtle

Critically Endangered Birds

- Sender-billed Vulture
- White-backed vulture
- Jerdon’s courser
- Long-billed Vulture Red-headed Vulture

- Forest Owler
- Great Indian Bustard
- Sociable Lapwing
- Siberian Crane
- Himalyan Quail Pink-headed Duck

Critically Endangered Mammals

- Malabar Civet
- Kashmir stag
- River Dolphin
- Sumatran Rhinoceros Javan Rhinoceros
- Namdapha Flying Squirrel
- Large Rock Rat or Elvira Rat
- Kandana Rat
- Pygmy Hog
- Nicobar White-tailed Shrew
- Jenkin's Andaman Spiny Shrew

Critically Endangered Mammals

- Rameshwaram Parachute spider
- Peacock Tarantula

12.6 Problems of wild life managements in India

The problem of wild life management has several complex challenges due to greater exploitation of natural resources and deforestation for more land for agriculture, industrial and building. A large scale of cutting of forests and eradication of marshes and wetland decreases or shrinkage areas of wildlife animal movement. The wildlife animal are pushed into small unproductive, unsafe habitat, so these animals faces scarcity of food & water and exposed to poachers, which cause the decline in the population of wildlife animals. Some of the important problem of wildlife management are as follows.

(1)Habitat loss : It is one of the most important loss of natural habitats. Habitat loss refers to the reduction in the amount of space where a particular species or group of species can survive and reproduce. Habitat loss is a consequence of human activities such as urbanization, infrastructure development, resources extraction, alteration of the sea floor due to trawling (fishing) or the release of pollutants. Habitat loss can also occur due to environmental changes, such as volcanic eruption or tsunamis or changes in climate or sea level, which activities. Habitat loss can decrease biodiversity and alters species ranges and interactions.

(2)Human wildlife conflict : The human wildlife is defined as "Any interaction between humans and wildlife that results in negative impacts of human social, economic or cultural life, on the conservation of wildlife populations or on the environment. The following are the factor responsible for human wildlife conflict.

- With a rapidly increasing human population and high biodiversity interactions between people and wildlife animals are becoming more and more prevalent.
- Other factors include large scale habitat destruction through deforestation, overgrazing by livestock and expansion of human settlement and agriculture.

Human Wildlife conflict

Elephant	**2019-20**	**2020-21**	**2021-22**
Human killed by Elephants	585	461	533
Death of Elephants by Trains	19	14	12
Deaths of Elephants by electrocution	81	76	65
Deaths of Elephants by poaching	06	09	14
Elephants death by Poisoning	06	09	14

Tigers	2019-20	2020-21	2021-22
Human killed by Tigers	50	44	31
Natural Deaths of tigers	44	20	04
Poaching Deaths of Tigers	17	08	04
Unnatural Deaths of Tigers (Excluding poaching)	03	00	02
Tigers death under scrutiny	22	71	104
Seizure	10	07	13

(3)Illegal Wildlife Trade : India is a hotspot for illegal wildlife trade, driven by the demand for exotic pets, traditional medicine, and wildlife products. Tigers, leopards, elephants, and various species of birds and reptiles are among the most targeted species for illegal trade.

(4) Poaching and Illegal Killing: The poaching is defined as the illegal killing of wild animals for the purpose of eating, recreation or obtaining rare product like fur, skin, ivory and horns. The woolly mammoths for their fur, tigers for their skin, deer for their skin and horn. Elephants for their tusk, crocodiles for their skin, rhinos and leopards are also poached. The demand for these naturally occurring items is very great and the poachers profit significantly from their sales.

As a result of illegal hunting and poaching the population of animal has dramatically decreased. Due to illegal hunting, some species including tigers and rhinoceros are now threatened. Poaching has a negative indirect impact on the ecological balance of the environment and the food chain.

(5) Inadequate Resources : Many protected areas in India lack sufficient resources, including manpower and funding, for effective conservation. This affects monitoring, anti-poaching efforts and habitat management.

(6)Lack of Connectivity : Fragmentation of wildlife habitats reduces genetic diversity and poses long-term threats to species' survival. Creating wildlife corridors to connect fragmented areas is challenging due to land-use conflicts and infrastructure development.

(7)Climate Change : Climate change is altering habitats and migration patterns, affecting the distribution and behavior of wildlife. Species may struggle to adapt to these changes, leading to declines in populations.

(8)Invasive Species : The introduction of invasive species, often unintentional, can disrupt ecosystems and harm native flora and fauna. Controlling invasive species can be challenging and expensive.

Recent studies show the aquatic biodiversity of Kerala has been threatened by the invasive species of **North African Catfish**. This species was introduced all over the world during the 1980s for aquaculture purposes. It has a survival edge over other fish species due to its ability to thrive in oxygen depleted and shallow muddy waters.

(9)Lack of Public Awareness : The people are a not aware about the wildlife conservation. Raising awareness among the public about the importance of wildlife conservation is an ongoing challenge. Many people may not understand the ecological significance of preserving biodiversity.

(10)Corruption and Weak Law Enforcement : Corruption at various levels can undermine efforts to combat poaching and illegal wildlife trade. In some cases, law enforcement agencies lack the necessary resources and training to effectively tackle these issues.

(11)Conflict Between Conservation and Development : Balancing the need for economic development with conservation goals can be challenging. Infrastructure projects, mining and industrialization often encroach on critical wildlife habitats.

(12) Data Deficiency : Lack of comprehensive and up-to-date data on wildlife populations and habitat conditions can hinder evidence-based decision-making in conservation efforts.

Due to these problems requires a multi-pronged approach, including stronger law enforcement, community involvement, habitat restoration and a greater focus on public awareness and education. India has made significant strides in wildlife conservation, including successful tiger and rhino conservation programs, but ongoing efforts are essential to safeguard the country's diverse wildlife heritage.

12.7 Wildlife Health and Population management

In the conservation of wildlife, wildlife health and population management play a important role. These practices aim to maintain and restore the well-being of wild animal populations, ensuring their long-term survival while also contributing to the overall health and stability of ecosystems.

Wildlife Health Management

Each species contributes to the balance of the ecosystem they live in. The health of wildlife is deeply entwined with the health of the other animal, environment and even humans. By protection wildlife health, we safe guard biodiversity and invest in a healthier, more sustainable future. It provides basic understanding of the various topics of wildlife which will be useful for biologist, zoologist, veterinarians working in forest, zoos or at field level where they use to get wild animals for post mortem or for treatment. It also provides helpful information to forest officers, zoo managers for critical care management and for doing needful things before approaching a veterinarian to save the life of animal or collect biological material useful for diagnosis.

(1)Disease Monitoring : Regular monitoring of wildlife health is crucial to detect and manage diseases that can affect both animal and human populations. Surveillance programs help identify emerging diseases and prevent potential outbreaks.

(2)Veterinary Care : In cases of injured or diseased animals, wildlife veterinarians provide medical care and rehabilitation to facilitate their recovery. This is essential for both individual animal welfare and the preservation of genetic diversity within populations.

(3)Research and Disease Management : Scientists conduct research on wildlife diseases, studying their transmission, impacts and potential mitigation strategies. When necessary, interventions such as vaccination or disease management plans may be implemented.

(4)Zoonotic Disease Prevention : Many wildlife species carry zoonotic diseases (diseases that can be transmitted from animals to humans). Managing and preventing these diseases are essential for human health.

Wildlife Population Management

Wildlife population management refers to any strategy that seeks to maintain a target population at a level that can be supported by the ecosystem. This can involve protecting a threatened population from declining further in numbers or even re-stocking a population. Conversely, when the numbers of a target population have become too great to be sustained by the food or territory available, then predators can be introduced or a human-mediated cull can be done. Culls have also been done when an infectious disease is present in a population, the deliberate killing of the infected animals can help protect other members of the population as well as other species in the same habitat. The another way is the management strategies focus on the habitats of the species of concern. Wildlife population management can also use the legal system to prosecute those found responsible for illegally hunting or trapping species.

(1)Population Monitoring : Accurate population data are essential for informed decision-making. Techniques like camera traps, aerial surveys, and genetic analysis are used to estimate population sizes and track trends over time.

(2)Habitat Management : Preserving and restoring habitats are fundamental to supporting healthy wildlife populations. This includes measures like habitat restoration, controlled burns, and the creation of wildlife corridors to connect fragmented areas.

(3)Genetic Diversity : Maintaining genetic diversity within populations is critical to their long-term viability. Inbreeding can lead to reduced fitness and vulnerability to diseases. Genetic management may involve translocations or breeding programs.

(4)Species Recovery Programs : Endangered species often require active management and recovery efforts. Captive breeding programs, reintroduction into the wild and habitat protection are key strategies.

(5) Human-Wildlife Conflict Mitigation : Efforts are made to reduce conflicts between humans and wildlife such as installing wildlife-friendly fencing, using non-lethal deterrents and providing compensation for crop or livestock losses.

(6) Legal Protection : Laws and regulations are essential to protect wildlife populations from illegal hunting, poaching, and habitat destruction. Enforcement is crucial to deter illegal activities.

Wildlife health and population management are vital for the conservation of species and the maintenance of healthy ecosystems. These practices require a combination of scientific research, habitat preservation, disease management and public engagement to ensure the long-term survival of wildlife while also addressing the broader goals of ecosystem health and human well-being.

SAQ.

Complete the following sentences by inserting appropriate words in the blanks.

(i) Wildlife (Protection) Act in year --------

(ii) Air (Prevention and control of Pollution) Act -----------

iii) The official symbol of World Wildlife fund **----------------**

(iv) Wildlife preservation society of India was founded in -------------

12.8 Summary

In this unit there is study about habitat Managements, reintroduction in wild. This unit also contain about Mass education and awareness. It also deal about Promulgation of Laws and different type of Act to conserve and protection of wildlife. This unit also contains about Wild life organizations and red data book in very detail manner. It also contains problems of wild life managements in India and Wildlife Health and Population management in detailed manner.

12.9 Terminal Question

Q1. Explain about Biodiversity conservation.

Q2. Explain Impacts of Man Animal Conflict.

Q3. Explain about World Wildlife fund (WWF)

12.10 Answers

SAQ 1 (i) 1972

(ii) 1981

(iii) Giant Panda

(iv) 1958

Terminal Question

Ans 1.

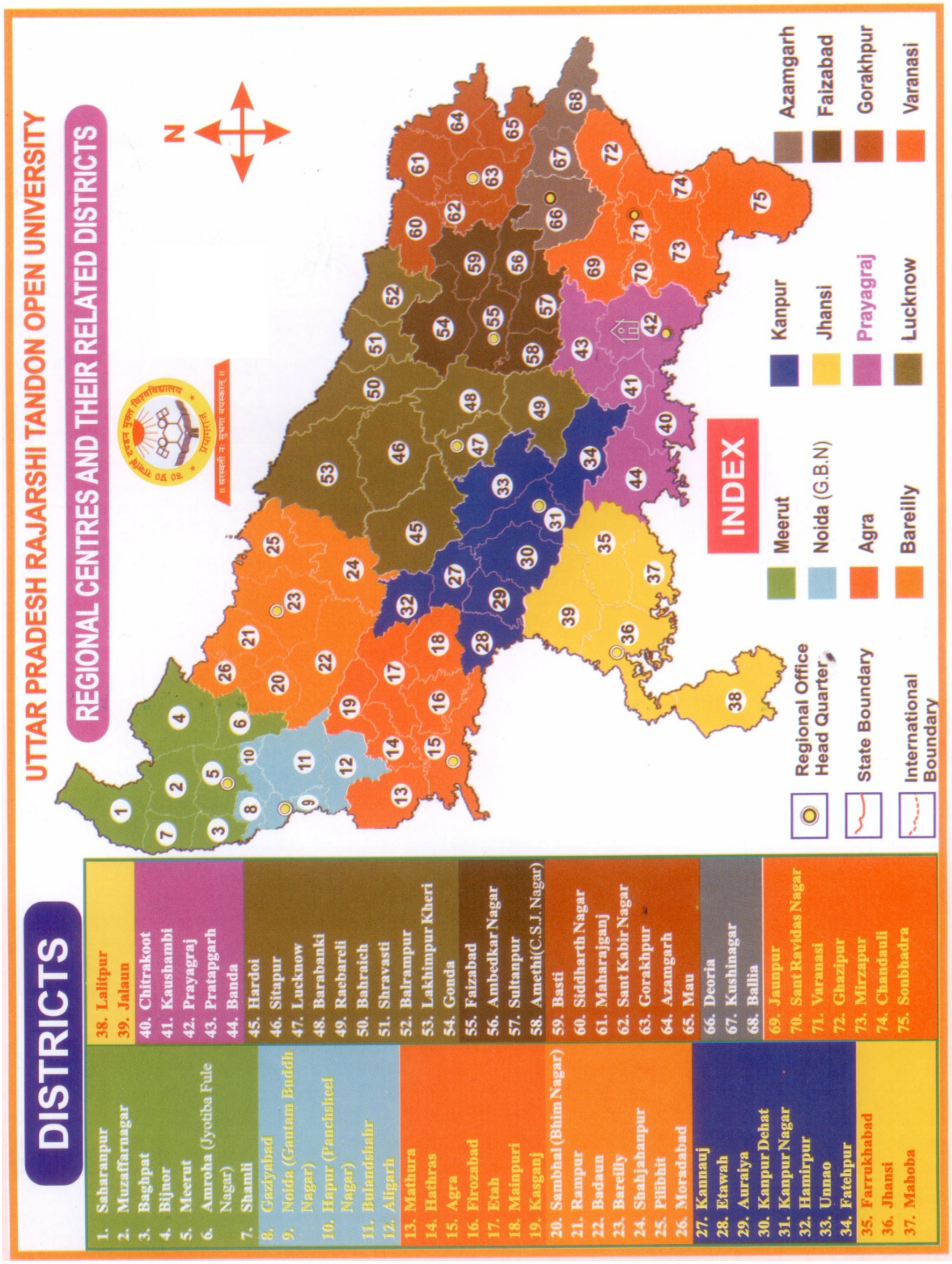
Biodiversity conservation: The main objective of habitat biodiversity is to maintain and restore biodiversity. Biodiversity is the very basis of life, either in wild or domesticated forms biodiversity is the sources for most of humanity food, medicine, clothing and housing. Now man has realized the importance of biodiversity, because loss of biodiversity may threaten the very extinction of life. Hence man has taken steps to conserve the biological resources in different.

- To make the list of biological resources in different parts of the country including the island ecosystem.
- Biodiversity conservation can be undertaken through network of projected area including national Parks, sanctuaries, biosphere Reserves, marine reserves, gene banks, wetlands coral reefs etc.

- Rehabilitation of tribal’s displaced due to creation of protected areas.
- Control of over exploitation through various organizations
- Protection of domesticated plant and animal species to converse indigenous genetic diversity.
- There should be protection and sustainable use of genetic resources or germplasm through appropriate laws and practices.
- There should be corridors between different nature reserves for the purpose of migration.
- Emphasis can be given for traditional skills and knowledge of conservation.
- Avoid monoculture plantation.
- Avoid introduction of exotic species without enough investigations.

Ans 2.

- Man-Animal conflict has the greatest direct impact on wildlife and the communities that live nearby.
- Human-wildlife conflict is a development and humanitarian issue as well as a conservation concern, affecting the income of farmers, herders, and artisanal fishers, particularly those with incomes below the poverty line.
- While human-wildlife conflict can lead to species decline and extinction, communities can suffer financial losses as well as threats to health and safety, livelihoods, food security and property.
- Some other impacts include:
    - Wildlife injuries
    - Habitat destruction
    - Human life is lost



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"अपने भाइयों को मै सचेत करना चाहता हूँ कि मोम न बनें और आसानी से पिघल न जायें। छोटी-छोटी सी बातों के लिए ही हम अपनी भाषा को या संस्कृति को न बदलें।"

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- Predation on livestock
- Human injuries
- Animal deaths

Ans 3.

World Wildlife fund (WWF) is the largest voluntary organization set up in 1961. Its headquarter is at Gland, Switerzerland, since 1979. The official symbol is Giant Panda. They are responsible to board for the administration of the fund and also supervise raising and disbursement of fund etc. The mission of WWF is “To conserve nature and reduce the most pressing threats to the diversity of life on Earth”. The WWF work on

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- In species conservation, the focus on tigers, elephants, gorillas, giant pandas, sea turtles, polar bears, rhinos and whales.
- Through its various projects, the organization aims to check the degradation of the earth’s natural environment and create a future in which human being lives in harmony with nature.