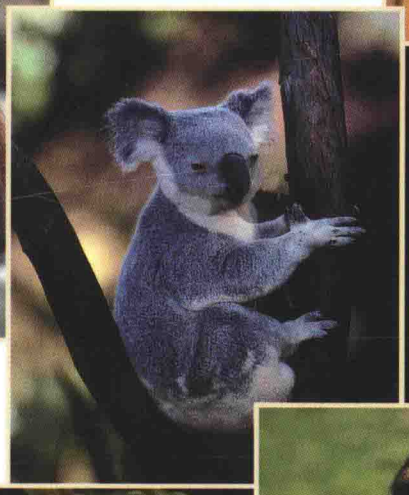
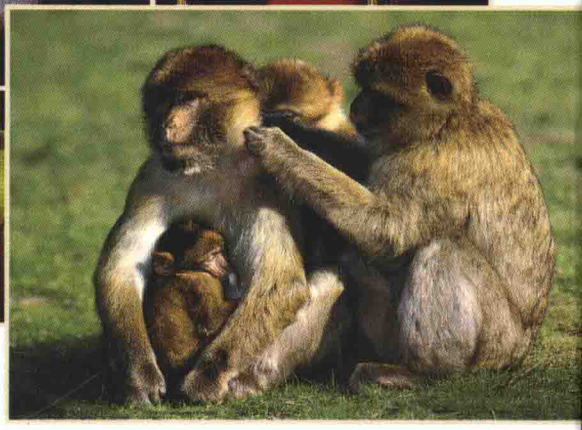
Fundamentals of Animal Behaviour





J.P. Shukla

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This book is
humbly dedicated to
my respectable teacher
Dr. Kamleshwar Pandey

Preface

Importance of the study of animal behaviour was not realized earlier because the ideas, concepts and revelations related to it were not adequately presented and documented. However, with the advancement in our modern analytical concepts and experimentations, this field of study has made considerable progress during the last two decades. There is hardly any denial that this branch of biological science is going to translate many scientific fictions and fantasies into reality by unravelling many mysteries so far unexplored and is likely to render correlative benefits to humanity in terms of health, knowledge and possibly comfort.

The book covers almost all the important aspects of animal behaviour like innate and learning behaviour, social behaviour, courtship and mating of animals, migration, parental care, behavioural genetics, biological clock, etc. Besides, the book also includes the recently emerging offshoots dealing with several behavioural intricacies, such as neuro-endocrine regulation of behaviour, pheromones, behavioural ecology and toxicology, nervous and hormonal regulation of animal behaviour, adaptational behaviour (coloration and mimicry), wildlife and human behaviour.

The book attempts to provide an overall basic information and practical applications on animal behaviour to undergraduate and postgraduate students of universities in India that would help in understanding the principles of animal behaviour and their implications.

I wish that common people should also read this book to understand the enigmatic phenomena of the animal world and their relationships with them in order to develop the concept of co-existance. The text has been sufficiently supplemented with figures, charts, diagrams and tables to facilitate understanding by the students. The book has been written in simple style and easy-to-understand language. Sample questions—objective and subjective—have been provided at the end of each chapter, which will definitely help the students to assess their understanding.

I sincerely thank my colleagues, students and publishers for their help extended during the preparation of this book. Illustrations and ideas, not of my own, are gratefully acknowledged. I also acknowledge the deep affection of my family members as also their co-operation and support rendered during the writing of the book.

J.P. Shukla

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Introduction and Scope to the Study of Animal Behaviour

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Introduction

The scientific study of the characteristic behaviour patterns of animals is called "Ethology", a term coined by Niko Tinbergen. Behaviour i.e. Ethology is a branch of biology that analyses the reactions of an animal to its environment, trying to determine specific cause and effect relationships between the animal's actions and events and conditions experienced by the animal. Thus, behaviour is the study of what animals do as they react to their environment with particular patterns of muscular and glandular activity. An animal's behaviour is of primary importance, particularly for its survival, it must find food and shelter, it must escape predators, and should compete successfully with others of its kind. Failure in any of these areas, may become hazardous.

A scientific study of animal behaviour involves a variety of approaches. It can be explained in terms of its evolutionary history, in terms of the benefit, it brings to the animal, in terms of psychological mechanisms. The consideration of any one of the approaches depends upon aspect of animal behaviour, which one wants to know about. For a psychologist, behaviour means more than just bodily movements and includes feelings, attitudes, thoughts and other mental processes. While a zoologist includes suitable relationship between an organism and the abiotic environment i.e. physical or non-living, and also with other organisms of its own kind or different kinds. How an animal reacts or changes with changes in its environment and how it behaves with the other organisms around, is also behaviour. Behavioural changes are not passive, they are directed actions, i.e. actions promoting survival, and they are reversible. There are, however, two factors which determine the way an animal responds in a particular circumstance. One of these factors is the animal's genetic make-up and the other is the animal's

previous exposure to similar circumstances. Much of every animal's collection of behavioural responses is derived from information programmed directly in the animal's genes, and may be responsible for stereotyped behaviour in a given circumstance. Such behaviour, as suckling of a new born baby, is said to be *innate.*

Most of the animals can show responses which have been developed from previous experience. A dog for the first time when is sprayed by a shunk knows to leave it alone only the second time. These are said to be *learned responses.* Learning is often used to modify *innate responses,* tailoring those responses to the particular stimulus perceived by the animal. In general, the extent to which learning plays a role in determining an animal's behaviour depends on the degree of differentiation of its nervous system. The animals with the most highly developed brains learn most easily and quickly.

Historical Outline of Animal Behaviour

Aristotle (340-322 B.C.) was the keen observer of animal behaviour. He produced excellent description of animal behaviour in his book *Historia Animalium.* He collected a great deal of information on pet animals and concluded that animals possess Insight and Love for families and their masters. After a long dark ages, the pioneer thought about animal behaviour came into existence by a book entitled *Utopia* written by Thomas More in 1518, in which he described various behavioural patterns in some animals. After a long gap, Geoffroy Saint Hillaire coined the term Ethology to describe the relationship of animals with environment, family and society. Since the beginning of 20th century, the term "Ethology" is restricted only to the study of behaviour of animals. However, Konrad Lorenz (1903-1989) established ethology and may be regarded as father of ethology. Ethology is one of the newest disciplines involved in the struggle to understand the scientific bases of animal behaviour. However, in eighteenth century, naturalists like Gilbert White (1720-1793), Charles Leroy (1723-1789) and Charles Darwin (1809-1882) have described certain aspects of animal behaviour. Darwin influenced the development of ethology in three main ways. First and the foremost his theory of natural selection set the stage for consideration of animal behaviour in evolutionary terms, a key aspect of modern ethology. Second, Darwin's view on instinct can be regarded as a direct forerunner of those of the founders of classical ethology. Third, Darwin's observations on behaviour were important, especially those derived from his belief in the evolutionary continuity of man and other animals. In his, *The Descent of Man and Selection in Relation to Sex* (1871), for instance, Darwin writes: "We have seen that the senses and intuitions, the various emotions and faculties such as love, memory, attention, curiosity imitations, reasoning etc., of which man boasts, may be found in an incipient or even sometimes a well-developed condition in the lower animals." In his book *The Expression of the Emotions in Man and the Animals* (1872), Darwin elaborates on this theme: "With mankind some expressions, such as bristling of the hair under influence of extreme terror, or the uncovering of the teeth under that of furious rage (hormonal) can hardly be understood, except on the belief that man once existed in a much lower and animal like condition."

Darwin's friend and disciple George Romanes curiously persuaded Darwin's work on animal behaviour and his *Animal Intelligence* (1882) was the first authentic treatise on comparative psychology. However, Romanes was not very critical in his evaluation of evidence.

He credited animals with mental abilities, such as reasoning and with feelings, such as jealousy or envy. This resulted in a revolt, led by Conway Lloyd Morgan. In his book entitled *Introduction to Comparative Psychology* (1894), he pronounced his famous belief: "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of one which stands lower in the psychological scale". This attitude culminated in a vast improvement in the control of experiments and the assessment of results and evidence. This much doubtful approach to animal behaviour laid the foundations for the Behaviourist School of Psychology initiated by John Watson (1913). Charles Whitman, Oskar and Heinroth are known as the founders of the modern discipline of Ethology.

The modern approach to animal behaviour includes many features derived from both the behaviourist and the early ethological views. In addition, modern ethology draws upon the physiological tradition with its emphasis on the explanation of behaviours in terms of the activity of the nervous system.

Milestones in Ethology (Behaviour)

The identification of the field of animal behaviour is actually a recent development in Zoology. It is an area in which much work is currently being done, though most of the basic concepts are still to be clearly defined. Some outstanding milestones are presented here.

1894. Concept of Animal Behaviour

Conway Lloyd Morgan (1852-1936) emphasised that an animal's behaviour should not be interpreted in human terms (anthropomorphism) but that it should be interpreted in terms of the simplest neural process necessary to produce the observed behaviour.

1904. Behavioural Patterns in Protozoa

H.S. Jennings (1868-1947) developed many of our concepts concerning taxes, trophism, and trial-and-error behaviour.

1904. Concept of Classical Conditioning

Ivan Pavlov experimentally described the concept of classical conditioning and was awarded Nobel Prize.

1910. Imprinting as a Type of Behaviour

O. Heinroth described imprinting as a special kind of learning that can be easily demonstrated in many birds.

1918. Discovery of Time-measuring Ability in Animals

J.S. Szymanski demonstrated that animals have some means of measuring time without reference to light or temperature cycles. This he demonstrated by keeping animals in total darkness under constant temperature conditions. His studies formed the basis of modern studies concerning the *Biological Clock*.

1920. Territorial Behaviour in Birds

H.E. Howard described how birds establish and defend a territory from others of the same species during the breeding season.

1922. Peck-order Behaviour

T. Schjelderup-Ebbe described social dominance-subordinance behaviour in birds.

1924. Symbiotic Relations between Termites and their Intestinal Flagellates

L.R. Cleveland studied this type of relationship.

1925. Gonadal Hypothesis of Bird Migration

W. Rowan determined experimentally the effect of length of day on size of gonads and migration behaviour in birds.

1927. Innate Behaviour in Salamanders

G.E. Coghill demonstrated the correlation between embryonic nerve connections and coordinated movements and showed the probable phylogenetic development of behavioural patterns.

1931. Theory of Instinctive Behaviour

K. Lorenz and N. Timbergen formulized the theory that instinctive behaviour patterns control innate behaviour.

1938. Measurement of Motivation in Behaviour

B.F. Skinner developed a technique for measuring the effect of motivation on behaviour.

1948. Communication Pattern in Honey Bees

Karl von Frisch, in working with bees for 50 years, found mechanisms by which bees communicated such complex concepts as direction and distance of food supplies.

1949. Concept of Stress Syndrome

H. Selye summarized his many experiments involving reactions to stress situation. Continued stress, beyond the capacity of the body to react normally, results in serious degenerative disorders.

1957. Celestial Navigation by Birds

F. Sauer demonstrated that birds are able to use stars as guides during migration.

1980. Behavioural Responses in Certain Freshwater Teleosts during Solar Eclipse

K. Pandey and J.P. Shukla observed behavioural responses in freshwater teleosts during solar eclipse (2 hours and 18 minutes).

Definition of Behaviour

Actually, it is very much difficult to put a precise definition of the term *behaviour*. However, various ethologists have defined behaviour in various ways.

According to Dethier and Stellar (1958), behaviour is largely a matter of a stimulus triggering a response, or of a pattern of stimuli triggering a sequence of responses. Thus, all behaviours directly or indirectly involve a sequence of *stimulus-conduction-response*. Therefore, behaviour is strongly influenced and in large part determined by receptors and conductors and further by associative mechanisms when these are present in the conductor system. It is also necessarily influenced and in part determined by the effectors.

According to Simpson and Beck (1965), *behaviour is externally directed activity.* Activity is behaviour if it is related to the surroundings of the organism and if it brings about some external change in the relationship between organism and environment. Although, we define behaviour as involving an external change, it arises from within the organism. It may be *direct response* through an internal mechanism to an *external stimulus,* or to a change in the environment and it almost always likes this in plants and lower animals. In higher animals, particularly the behaviour may not have any immediate outer stimulus.

Boughey (1973) interprets behaviour as a *capacity for mobility,* and its study may in a simplistic way be defined as observation of the movement. Thus, behaviour may be described in terms of *motion* and the relationship of motions to the circumstances in which they occur. The motion may involve movement of the entire organism from one place to another, then it is called locomotion. It may, however, involve movement of only a small part of the organism. In behaviour, therefore, the effectors of primary importance are those that produce motion either of a part or of the whole of an organism. In sensitive plants e.g., *Mimosa,* there are little swellings, called *pulvini* at the base of each leaf attachment (petiole) and also at the base of each branch within the compound leaf. When the leaf is touched, the cells of the pulvinus lose water and become less turgid. The leaf then bends towards the side of less turgidity. Indeed it is not customary to speak of plants as having behaviour in the usual sense of the term.

Behavioural motion occurs in almost all *protists* and *animals.* Most of the behavioural motions are either amoeboid, ciliary, flagellary or muscular. In all the animals above the level of porifers, a muscle is the usual effector. Among other effectors, coelentrates have special cells, called stinging cells that explode when touched. They shoot out threads or darts, some of which aid the animal to adhere to a surface, while others cling to prey or pierce it and inject toxins. These discharges undoubtedly constitute behaviour, externally directed activity and they involve a different kind of motion. The light producing and electric organ's effectors in fish are modified muscles. The discharge may involve as much as 2000 watts at 200 volts and should be considered behaviour. But it is one of the few kinds of behaviour that does not necessarily involve motion. In nutshell, behaviour is what an individual does. It is the response of an individual towards the external as well as internal stimuli. The response to stimuli is called irritability.

Scope of the Study of Animal Behaviour

In general, behaviour can be defined as the way an organism reacts when it has been exposed to some change in its environment. Such environmental changes are usually termed *stimuli.* It is immediately evident that stimuli may be of different types, but certainly not restricted to changes in light, temperature, humidity, pressure and the physical location of things in the environment. Furthermore, in a broad sense, the environment includes situations within the body of the living organisms. Unicellular organisms react to stimuli and the more complex multicellular associations of cells, especially in animals, have certain specialized cells or groups of cells that possess lower thresholds to stimuli and are adapted to pass these stimulus to other parts of the body (= *complex multicellular*). Such specialized cells are known as neurons. In still more complex animals, the neurons are increased in number and are associated with other cells or organs (*receptors*) that have some particular sensitivity to light (*Photoreceptors*), sound (*Phonoreceptors*), chemicals (*Chemoreceptors*), or other stimuli.

The simplest response to a stimulus is *Kinesis*, i.e. an increase in the activity of the individual. Several types of organisms show increased activity in the absence of light, while many others in the presence of light. Increased duration of light used by poultrymen as a means of increasing egg production is one of the example.

Opposite to Kinesis, immobilization inhibits the activity. Night flying moths, for example go to sleep when exposed to light.

Depending upon the complexity of the system and its part within the given organism for receiving and evaluating stimuli, following types of behaviour can be recognized. *Stereotyped behaviour* (including *taxes, reflexes,* and *instinctive behaviour*), *Learning behaviour* (including *imprinting, habituation, conditioning,* and trial-and-error learning), *Complex behaviour* (such as *reasoning* and *social behaviour*). Complex behaviour results in many distinctive types of activity viz., rhythmic activity, circadian rhythms, movements around in a definite region or home range, a return to home range when moved elsewhere a process known as homing, and various seasonal activities including hibernation and aestivation and also migration. The distribution of all these aforementioned behaviours has been illustrated in Fig. 1.1.

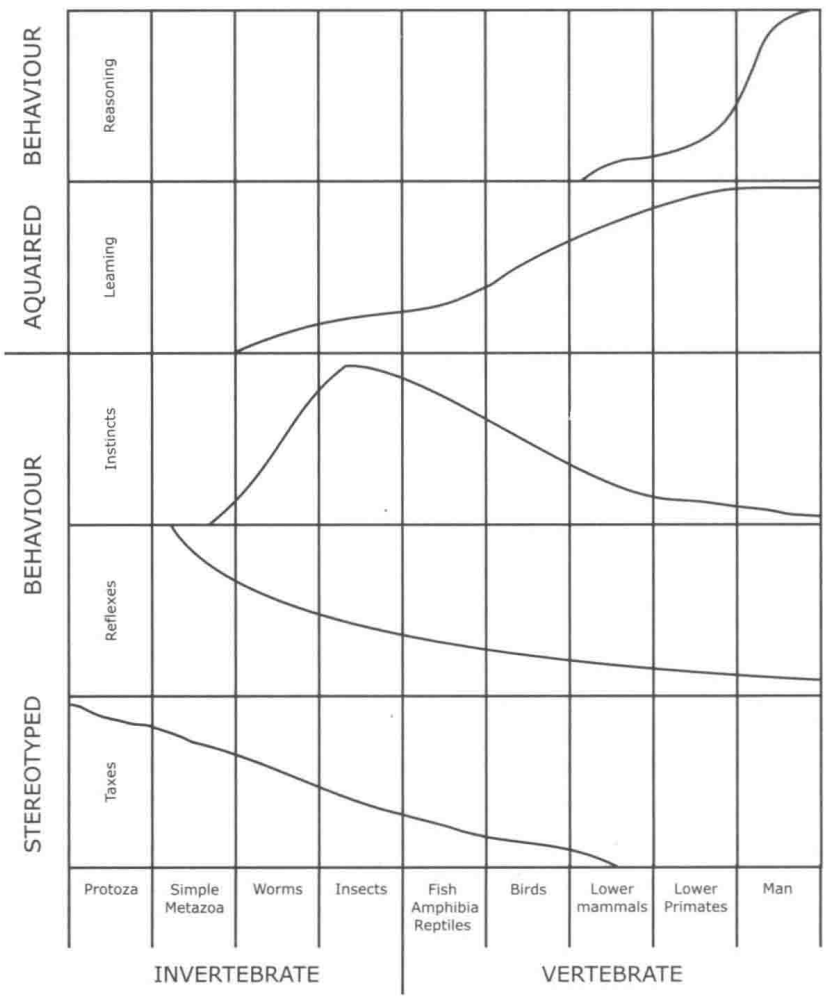

Fig. 1.1. Distribution of types of behaviour in the animal kingdom.

The problem of understanding and interpreting the behaviour of other organisms is so complicated that it led to develop a rational approach in the recent years. We ordinarily look only the external aspects of behaviour whereas an environmental stimulus and the response of some effectors may actually be observed. Sometimes, observations in the form of ectodes are interpreted *anthropomorphically* (Gr. "Man form" i.e., interpretation of nonhuman behaviour in terms of human behaviour). According to Morgan's Canon, the actions of an animal should be interpreted in terms of the simplest possible mental process. When a dog looks at his master, the normal behaviour is that the dog wags its tail. According to Morgan's Canon, this behaviour is no more than an established reflex: *Stimulus* (sight of master)—*Conduction* (from eyes to tail muscles)—*Response* (wag). But we know that recognition of the master has been built up by learning and is equally possible by different clues, not only sight but also sound, and above all, smell. We also know that the dog responds to the master in various ways, not only by tail wagging but also by running, barking, cringing, picking up its leash, or otherwise, depending upon the situation. Since the dog has a complex brain, one can determine that on seeing the master, there is activity in the cortex of the brain and not in reflex conductors. This clearly explains that the behaviour can not be studied only through responses. By use of a suitable electrical equipment, it is possible to determine precisely as to where the nervous activity is taking place. Surgical interference with the nervous system can also help to determine the parts which are involved in the perception of stimulus and production of a given response (behaviour).

This example explains the way to apply the principle of *occam's razor,* according to which, if several different explanations are possible, the simplest one should be considered the most probable.

Modern study of behaviour follows the principles of good experimentation applicable in any field. Tests are made in a standardized situation kept as uniform as possible expect in one respect. One environmental factor is varied, which is the *controlled stimulus.* Responses, mainly motions, are observed. Stimuli are varied in kind and intensity in successive experiments. Finally, the mechanisms between stimulus and response are also studied by their anatomical relationships by their activities and by the effects of interference with them at various points.

Purpose and Importance of Study of Behaviour

In all animals, the adaptive nature of behaviour is well known. It then helps when an animal achieves food, avoids enemies and not only finds but wins a mate. Behaviour serves purposes, and benefits the species not because animals are sensible or because their behaviour is planned to help them. The reason is quite simple; *behaviour* is adaptive because it has to be. A species with inadaptive behaviour would not survive or live long. In nut shell, it may be said that all types of behavioural activities give biological advantages to the organisms, giving a better chance for survival and reproduction. So much so behaviour may be regarded as homeostatic and adaptive mechanism.

Branches of Ethology

The principal branches of ethology are as follows:

1. **Ethophysiology:** It deals with the physiological aspects of animal behaviour. It is further divided into two branches:
   (a) Ethoendocrinology: It deals with the relations between hormones and behaviour of animals.
   (b) Neuroethology: It deals with the relationship between sensory processes and nervous system with a particular act of behaviour of animal.
2. **Ethogenetics:** It is also called as "Behavioural Genetics". It deals with the genetic basis of behaviour.
3. **Ecoethology:** It is also called as "Behavioural Ecology". It deals with the environmental influences on animals and their behavioural changes.
4. **Ecotoxicolog:** It is also called as "Behavioural Toxicology". It deals with the effects of various xenobiotics/chemicals/pollutants/poisons on the behavioural patterns of animals on account of acute or subacute toxicity.
5. **Sociobiology:** It is a fascinating branch of ethology standing between ethology and population biology, where social behaviour of an animal is studied.
6. **Human Ethology:** It is a recent branch of ethology dealing with the human behaviour, since evolutionary time.
7. **Behavioural Embryology:** Parental development of behaviour pattern.

Behaviour as a Homeostatic and Adaptive Mechanism

In fact, the behaviour of an animal enables it to find food, water, shelter and allows it, in many cases, to adjust its internal conditions by moving to suitable places in its environment. Since these activities assist to maintain animal's metabolism within necessary limits, such behaviour serves a *homeostatic function.* For example, animals that lack an internal temperature regulating mechanism (the so-called cold-blooded animals) rely almost entirely on behaviour to control body temperature. A snake will actively seek out sunlight to task in or shade to hide in, depending on the temperature in its surrounding. Further, when an animal's stomach begins to empty, hormonal and nervous signals are sent to control centers in the brain. In response, these control centers send out the necessary signals to initiate a complex pattern of behaviour leading to the acquisition of food. Most animals must go out and find food, although some sedentary ones simply lie and wait until a suitable prey is available. The searching behaviour of an animal is characteristic of predators that may have to search over a wide area until the prey is found. Once suitable food is discovered and recognized, the animal must then catch and eat it. This may be a complex operation, involving considerable learning and coordination, e.g. when a tiger stalks, pursues and captures an antilope, or when several animals in a troop cooperate to bring down prey. Some very complex patterns of behaviour can be initiated by stimulating areas of the brain responsible for maintaining homeostasis. For example, portions of the hypothalamus can detect very small changes in blood temperature, and when the temperature decreases, signals are sent that cause shivering. This response can be duplicated in

a laboratory rat by artificial cooling of the hypothalamus. Generally, shivering generates body heat that is carried by the blood to the control center. The control center then stops sending the signals responsible for the shivering reflex. If the shivering reflex is inadequate to raise the rat's body temperature to a sufficiently high level, the rat will go on to build a nest or add insulation to an existing one.

The animal's behaviour is also important in protecting it from predators, enabling it to capture prey, to find and successfully court a mate, and to reproduce. Since the animals activities help it to survive and interact successfully with its environment, behaviour serves as an adaptive function. For example, "mole crickets" dig burrows several centimeters into the soil and the male mole cricket "sings" from the base of the burrow by rubbing his forewings together very rapidly, and females thus flying overhead are attracted due to the sound to the male at the base of the burrow. After the female arrives, the crickets mate and the next generation is later produced.

Three Basic Concepts of Ethology

From the work various ethologists, numerous concepts have been formulated to explain the behaviour of animals. Amongst these, three seem to be much relevant.

1. Appetitive and Consumatory Behaviour

Keeping complex behavioural pattern of animals in view, Wallace Craig concluded that each complex behavioural pattern of animals has two parts: Appetitive and Consumatory. Appetitive part is variable in which animal gets excited by external or internal stimuli and orients itself towards the stimulus. Rest part i.e. consumatory part is definite and stereotyped. A change in the animal's state is sensed by the brain and it leads to built up a *drive* to perform the appropriate behaviour. The *drive* gives rise to appetitive part of behaviour followed by consumatory part. It seems important to mention here that specific motivation is often called a *drive*. *Drive* directs the animal to search goal.

2. Fixed Action Pattern (FAP)

It is an innate and highly stereotyped response and is species specific. For example, making hive by worker honey bees, weaving net by spiders, etc.

3. Sign Stimulus (SS) or Key Stimulus (KS) or Releaser

It is a specific external stimulus that triggers specific FAP.

IMPORTANT QUESTIONS

Long Answer Type Questions

1. Define Ethology. Give historical outline and important milestone in ethology.
2. Define Ethology. Give study and scope of study of Animal Behaviour.
3. Describe "Behaviour as a Homeostatic and Adaptive Mechanism"

Short Answer Type Questions

1. Describe briefly the following:
   (i) Branches of ethology.
   (ii) Behaviour as a homeostatic mechanism.
   (iii) Behaviour as an adaptive mechanism.
   (iv) Scope of study of ethology.
   (v) Historical outline of ethology.
2. Write briefly the contributions of following ethologists:
   (i) C.L. Morgan
   (ii) H.S. Jennings
   (iii) I. Pavlov
   (iv) O. Heinroth
   (v) J.S. Szymanski
   (vi) H.E. Howard
   (vii) W. Rowan
   (viii) K. Loranz
   (ix) N. Timbergen
   (x) B.F. Skinner
   (xi) K.V. Frisch
   (xii) H. Selye

Objective Type Questions

a. *True or False*

(i) Konrad Lorenz established ethology and known as founder father of ethology.
(ii) Ethology was coined by N. Tinbergen.
(iii) Frish worked with greyleg geese.
(iv) Lorenz, Tinbergen and Frish shared nobel prize in 1973.
(v) Cleveland studied peck order behaviour.

Answers (i) T (ii) T (iii) F (iv) T (v) F

b. *Fill in the blanks*

(i) Concept of animal behaviour was given by_____ in 1894.
(ii) Behavioural pattern in Protozoa was studied by _____.
(iii) _____ described imprinting as a special kind of learning.
(iv) Discovery of time measuring ability in animals was studied by_____ in 1918.
(v) Modern discipline of ethology has been founded by _____.
(vi) _____ described territorial behaviour in birds.
(vii) Gonadal hypothesis of bird migration was given by _____ in 1925.
(viii) Communication pattern in Honey bees was studied by_____ in 1948.
(ix) Behaviour responses in freshwater teleost during solar eclipse in India was first and foremost studied by_____ in 1980.
(x) Celestial navigation by birds was observed by _____ in 1957.

Answers (i) C.L. Morgan; (ii) H.S. Jennings; (iii) O. Heinroth; (iv) J.S. Szymanski; (v) Whitman and Oskar Heinroth; (vi) H.E. Howard; (vii) W. Rowan; (viii) Karl von Frisch; (ix) K. Pandey and J.P. Shukla; (x) F. Saur.