Chapter-1

INTRODUCTION, SCOPE AND METHODS

INTRODUCTION

Animal Behaviour is a continuing source of awe and mystery that sparks the imagination of scientists and public alike. Man has always been interested in the Behaviour of animals that surround him, because of his own benefit and recreation and because of his own inherently inquisitive nature. The sense of wonder has always been at the root of scientific understanding.

Living conditions are by no means favorable everywhere on earth and every living being is somehow adapted for maintaining itself in suitable surroundings. The actions of animals are directed toward keeping themselves alive (i.e. individual survival), and reproduction (i.e. species survival). Animal Behaviour is the expression of an animal's effort to adapt or adjust to different internal and external conditions and can be described as an animal's response to a stimulus.

Behaviour can be observed right from the simplest single celled protozoa to the most intelligent and highly developed primates. Behaviour has evolved by natural selection and all animals behave for their own benefit and survival. In fact animals feed, drink, fight and flee to survive; fleeing from danger, fighting for limited resources, caring for the young ones, feed fledge lings, help con specifics and mate to leave progeny. All these are important Behavioural forms for species survival.

ANIMAL BEHAVIOUR: DEFINITION

It is not easy to define Behaviour in totality. A survey of relevant literature reveals that various authors have taken different approaches in defining animal Behaviour. The more common approaches to the definition of animal Behaviour are as follows:

- *Observable and quantifiable events constitute Behaviour. It is directional activity necessary for survival.*
- *The totality of an animal's movements, sound emissions and body postures; also the externally noticeable changes such as color change, secretion of odorous substances that serve bilateral communication and can therefore release the Behaviour of its partner.*
- *The response of living matter to some form of stimulus from the environment and influenced by various internal factors.*
- *All those processes by which an animal senses the external world and adopts itself to the environment.*
- *Movement of the whole animal, because of some external stimulus is known as Behaviour or activities of animal's effecter organs (muscles) are also called Behaviour.*

Behaviour is always a combined result of the actions of many body organs

Ethology: Concept and Definition

The term Ethology is derived from two Greek words '*Ethos*' meaning habit or convention and '*logos*' meaning study. The term ethology was coined by French zoologist **Isidore Geoffroy Saint-Hilaire** (1805–61). **Konrad Zacharias Lorenz,** and **Niko Tinbergen** are regarded to be the founders of ethology and for their work in this field of science, they shared a Nobel Prize in 1973. Ethologists are zoologists; they are basically interested in the biology of a species, and their prime focus is the scientific and objective study of animal Behaviour as it occurs under natural conditions.

As per **Lorenz** (1960)

"Ethology can be defined as the application of orthodox biological methods to the study of Behaviour". The orthodox biological methods referred to include the scientific method – a logical approach to research in all branches of biology".

According to **Eisner and Wilson** (1975)

"Ethology is the study of whole patterns of animal Behaviour under natural conditions, in ways that emphasize the functions and evolutionary history of patterns".

The ethological approach is the result of fitting scientific method to the study of animal Behaviour. According to the Oxford Companion to Animal Behaviour "*Ethology is distinguished from the other approaches to the study of animal Behaviour in seeking to combine functional and causal types of explanation*". The ethological approach seeks to explain Behaviour in terms of hypothesis, which aims to show how natural selection has in past acted as a designing

agent in shaping the evolution of Behaviour. Such explanations account for the Behaviour in terms of function. The alternate form of explanation concerns the way in which proximate causal mechanisms combine to control the Behaviour of animals.

Ethology itself has come a long way in the past few decades, from a largely observational, descriptive science to a modern, quantitative science based on solid foundations of evolutionary biology and quantitative methodology. The aim of ethology is to explain both phylogenetically and physiologically the functional relationships of all factors involved in Behaviour. The touchstone for ethological hypotheses is the reliable prediction of the Behaviour of a living system in any given situation.

Psychology vs Ethology

Psychology defined as "*the scientific study of the human mind and its functions, especially those affecting Behaviour in a given context*" also studies animal Behaviour but there exist a few differences in the overall approach of psychologists and ethologists to the study and analysis of animal Behaviour. Some of these are outlined as follows

- Ethologists have traditionally focused on animal Behaviour per se, where as psychologists have concerned themselves with the relationship among motivation stimuli and Behaviour.
- Psychology researches animal Behaviour in the context of what is known about human psychology, whereas ethology researches animal Behaviour in the context of what is known about animal anatomy, physiology, neurobiology and phylogenetic history.
- Psychologists concentrate on learned Behaviours whereas ethologists focus their attention on innate Behaviours.
- Psychologists research Behaviour in artificial situations, whereas ethologists concentrate on Behaviour in natural situations.
- Psychologists concentrate on gaining extensive knowledge of the Behaviour of very few species. Ethologists on the other hand are more interested in understanding Behaviour in a wide range of species to facilitate principled comparisons across taxonomic groups.

The two approaches are complementary rather than competitive, but they do result in different perspectives and, sometimes, conflicts of opinion about matters of substance.

Significance of the Study of Animal Behaviour

A knowledge and understanding of animal Behaviour has always been a practical matter for early trappers, hunters, traditional shepherds and herdsmen. In the modern context a number of reasons both theoretical and practical can be cited which make the study of animal Behaviour necessary (Lehner 1989). Theoretical reasons for the study of animal Behaviour include curiosity about the living world to gain a better understanding about relationships between animals and

their environment, inquisitiveness about the general principles common to all Behaviours with a desire to better understand our own Behaviour and so on.

The practical significance of the study of animal Behaviour lies in the fact that today an enquiry into varied aspects of animal Behaviour has been instrumental in providing us new insight into some of the most crucial problems faced by the human society. Some of the more important contributions made by animal Behaviour studies as analyzed by Snowdon (2013) are outlined as follows:

1. Environmental monitoring : The Behaviour of animals often provides the first clues or early warning signs of environmental degradation. Studies of natural Behaviour in the field are vital to provide baseline data for future environmental monitoring. For example, the Environmental Protection Agency uses disruptions in swimming Behaviour of minnows as an index of possible pesticide pollution.

2. Pest control : Animal Behaviourists have described variables involved in insect reproduction and host plant location leading to the development of non-toxic pheromones for insect pest control that avoid the need for toxic pesticides. Understanding of predator prey relationships can lead to the introduction of natural predators on prey species.

3. Habitat preservation : An understanding of foraging Behaviour in animals can lead to an understanding of forest regeneration. Many animals serve as seed dispersers and are thus essential for the propagation of tree species and essential for habitat preservation. Knowledge of honeybee foraging Behaviour can be applied to mechanisms of pollination which in turn is important for plant breeding and propagation.

4. Conservation of endangered species : The conservation of endangered species requires that we know enough about natural Behaviour (migratory patterns, home range size, interactions with other groups, foraging demands, reproductive Behaviour, communication, etc) in order to develop effective reserves and effective protection measures. Relocation or reintroduction of animals (such as the one horned rhinoceros) is not possible without detailed knowledge of a species natural history. With the increasing importance of environmental programs and human management of populations of rare species, both in captivity and in the natural habitat, animal Behaviour research becomes increasingly important. Many of the world's leading conservationists have a background in animal Behaviour or Behavioural ecology.

5. Captive breeding : Basic Behavioural studies on reproductive Behaviour have led to improved captive breeding methods for pigmy hog, whooping cranes, golden lion tamarins, and many other endangered species. Captive breeders who were ignorant of the species natural reproductive Behaviour were generally unsuccessful.

6. Animal welfare : Our society has placed increased emphasis on the welfare of research and exhibit animals. Animal welfare without knowledge of animal Behaviour is impossible. Animal

Behaviour researchers look at the Behaviour and well-being of animals in lab and field. Developments in animal welfare require constant input from animal Behaviour specialists. Improved conditions for farm animals, breeding of endangered species, proper care of companion animals all require a strong Behavioural data base.

7. Study of human Behaviour : The methodology applied to study animal Behaviour has had a tremendous impact in psychology and the social sciences. Aspects of experimental design, observation techniques, and attention to nonverbal communication signals were often developed in animal Behaviour studies before their application to studies of human Behaviour. The Behavioural study of humans would be much diminished today without the influence of animal research.

8. Appreciation of factors affecting human Behaviour : The comparative study of Behaviour over a wide range of species can provide insights into influences affecting human Behaviour. For example, the woolly spider monkey in Brazil displays no overt aggressive Behaviour among group members. We might learn how to minimize human aggression if we understood how this species of monkey avoids aggression. Studies of various models of the ontogeny of communication in birds and mammals have had direct influence on the development of theories and the research directions in the study of child language. The richness of developmental processes in Behaviour, including multiple sources and the consequences of experience are significant in understanding processes of human development.

9. Medical and other applications : Research by animal Behaviourists on animal sensory systems has led to practical applications for extending human sensory systems. Griffin's demonstrations on how bats use sonar to locate objects have led directly to the use of sonar techniques in a wide array of applications from the military to fetal diagnostics. Studies of chimpanzees using language analogues have led to new technology (computer keyboards using arbitrary symbols) that have been applied successfully to teaching language to disadvantaged human populations. Basic research on circadian and other endogenous rhythms in animals has led to research relevant to human factors and productivity in areas such as coping with jet-lag or changing from one shift to another. Research on animals has developed many of the important concepts relating to coping with stress, for example studies of the importance of prediction and control on coping Behaviour.

10. Solving problems of human society : Many problems in human society are often related to the interaction of environment and Behaviour or genetics and Behaviour. The fields of socioecology and animal Behaviour deal with the issue of environment Behavioural interactions both at an evolutionary level and a proximate level. Increasingly social scientists are turning to animal Behaviour as a framework in which to interpret human society and to understand possible causes of societal problems viz. many studies on child abuse utilize theory and data from studies on infanticide in animals.

SCOPE OF ETHOLOGY

A. DIMENSIONS AND LEVELS OF STUDY IN ETHOLOGY

Ethology is nearly a limitless discipline and operates along three dimensions (Fig 1), which are as follows :

Individual ⟷ Species

Micro (cellular) ⟷ Macro (whole organism)

Laboratory (highly controlled) ⟷ Field (natural conditions)

***Fig 1.** Three dimensions of ethology*

These are the three directions along which studies can be focused. It has also been customary to analyze, obtain and maintain the Behaviour as it occurs at various organizational levels along the individual-species and macro-micro dimensions (Menzel 1969). An example as to how these levels can be viewed for Canada Geese is shown in Fig 2. The concept of levels of organization is important to the ethologist so that he is able to zoom in and zoom out to and from the aspect of Behaviour he is studying. The concept is of great help in delineating the level at which research needs to be conducted and also helps to integrate into what is known about other levels.

SPECIES – CANADA GEESE

Organizational levels of Behaviour	*Examples*
Species	Species typical courtship
Population	Migration
Family Group	Flying to a food source
Dyad	Eg. Enct. between individual
Individual	Individual swimming
Behavioural type	Ingestion
Behavioural act	Tipping up
Body parts	Legs
Muscles	Gastocnemius
Neurons	Tibial nerve

Fig 2. *Showing the various organizational levels of Behaviour along the micro-macro & individual-species dimensions as undertaken in Ethology* (Lehinger 1979).

B. Areas of study in Ethology

Behaviour is what an animal does. However ethologists do not restrict themselves to examining only what an animal does. According to Lehner (1989) ethology also includes the study of when, how, why and the where of Behaviour

- **What**: A description of the Behaviour of the animal.
- **When**: The temporal component of Behaviour. This can include the occurrence of a Behaviour with respect to the animal's lifetime, the season, time of the day or position in a sequence. The duration of the Behaviour and its contribution to the animal's time budget are considered under this category.
- **How**: This includes the motor patterns used to accomplish a goal-oriented Behaviour9e.g flying from one tree to another) as well as the underlying physiological mechanisms. Studies of the relevant stimuli associated with Behaviour are included in this category. The evolutionary and phylogenetic determinants of Behaviour are also studied to answer how questions e.g. How did flight evolve?
- **Why**: Two concepts underlie the study of why of Behaviour. They are motivation and ecological adaptation.
- **Where**: This is the spatial aspect of Behaviour. Studies include where a Behaviour occurs geographically or relative to other animal or environmental parameters.

Many ethologists however subscribe to Tinbergens (1963) categorization of the following four areas of study in ethology.

- **Function**: This can include the study of proximate and/or ultimate function. The proximate function refers to the immediate effect of the Behaviour on the animal other animals or the environment. The ultimate function refers to the adaptive significance of the Behaviour in terms of improving the individual's fitness and how natural selection operates to maintain Behaviour.
- **Causation**: What are the mechanisms that underlie the Behaviour? What are the contexts in which it occurs? And what are the exogenous and endogenous stimuli that elicit the Behaviour
- **Ontogeny**: How does Behaviour develop in an individual? What maturation and learning processes are important in the development of Behaviour?

- **Evolution**: How did Behaviour develop in the species? This includes a phylogenetic comparative approach

C. **Branches of Ethology :** Some the more important branches of ethology are as follows

- **Ecoethology :** Ecoethology is a comparatively new branch of ethology in which the relationships between the Behaviour of a species and other abiotic and biotic components of an ecosystem are investigated.
- **Ethophysiology:** Ethophysiology or Behavioural physiology deals with the physiological basis of Behaviour.
- **Neuroethology:** Neuroethology deals with the sensory process and the central nervous system that underline a particular Behaviour.
- **Ethoendocrinology:** Ethoendocrinology deals with the relations between hormones and Behaviour.
- **Ethogenetics:** Ethogenetics or Behavioural genetics investigates the genetic basis of Behaviour, using simple concepts of single or multiple gene inheritance. Its goal is to prove empirically the relationship between genetic factors and their influence on Behaviour.
- **Phylogenic ethology:** The phylogeny of Behaviour traces the evolutionary origin and development of Behavioural characteristics and the ontogeny of Behaviour study the development of Behaviour in a species.
- **Behavioural embryology:** This branch of biology deals with the prenatal development of Behaviour patterns.
- **Human ethology :** The goal of human ethology is to study human Behaviour. It emphasizes phylogenetically transmitted and genetically determined regularities and variability of human Behaviour.
- **Sociobiology :** Sociobiology stands between ethology and population biology. Its central concern is to understand how and why animal social Behaviour has evolved. Sociobiology does not have discrete boundaries; it is interwoven with many disciplines, including physiology, embryology and ultimately anthropology, psychology and even history. E.O. Wilson is often regarded as the father of Sociobiology.
- **Comparative ethology :** Comparative ethology makes the evolutionary explanation for many common Behaviours to show that they all share a common ancestor that performed those Behaviours.
- **Cognitive ethology :** Cognitive science is an umbrella term for convergent approaches

to the study of mind in linguistics, artificial intelligence, cognitive psychology, and, increasingly the neurosciences. Cognitive ethology is that it is the marriage of cognitive science and ethology.

- **DEEP ethology :** Consideration of the causes and consequences of a Behavioural pattern from the converging perspectives of Developmental biology, Ecology, Evolutionary biology, and Physiology.
- **Bioacoustics :** It is a field of ethology that investigates the sound production of animals with the help of high quality recording equipments to understand their Behavioural functions

Methods of Ethology

Since both psychology and ethology both relate to Behaviour the study of Behaviour can have two different approaches in animals

- ***With relation to brain and physiology :*** These studies are carried out in the laboratory by utilizing the following methods
  - ❖ Neuroanatomical
  - ❖ Neurophysiological
  - ❖ Neurochemical

The psychologists carry out research in laboratories on animals like cats, rats, pigeons and chimpanzees. They keep the animals in confinement, try surgical procedures, like removing brain, or pass mild electric current through various parts of the brain or induce small amount of currents to evoke Behaviour.

- ***Study of Behaviour in wild or in natural habitat :*** These studies are carried out in relation to environment and ecology. This comprises the **ethological approach.** The ethologists try to study animals in the wild, allowing them to move freely in their natural habitat and conduct studies on a wide variety of animals from weevils to whales.

The method of enquiry into ethology is characterized by the general scientific method as has been outlined in Fig 3. The method can in overall terms be defined as the *hypothetical deductive method* in which descriptive data are gathered and hypothesis are tested. The various steps involved in the method of enquiry into ethology as given in Figure are outlined as follows

I. Choice of subjects : Ethologists conduct the study of particular species for different reasons but generally tread along two different routes. They are mainly interested in

- **Species oriented research :** With special interest in particular species
- **Concept oriented research :** The species that is particularly suited for investigating a particular concept.

These two routes are so intertwined that a researcher may become interested in pursuing a concept after studying various aspects of species Behaviour. Likewise a researcher may initially study a species in pursuit of answers to a conceptual problem and then may become interested with other aspects of species Behaviour. Whatever route an ethologist chooses depends upon his level of interest and problem under investigation.

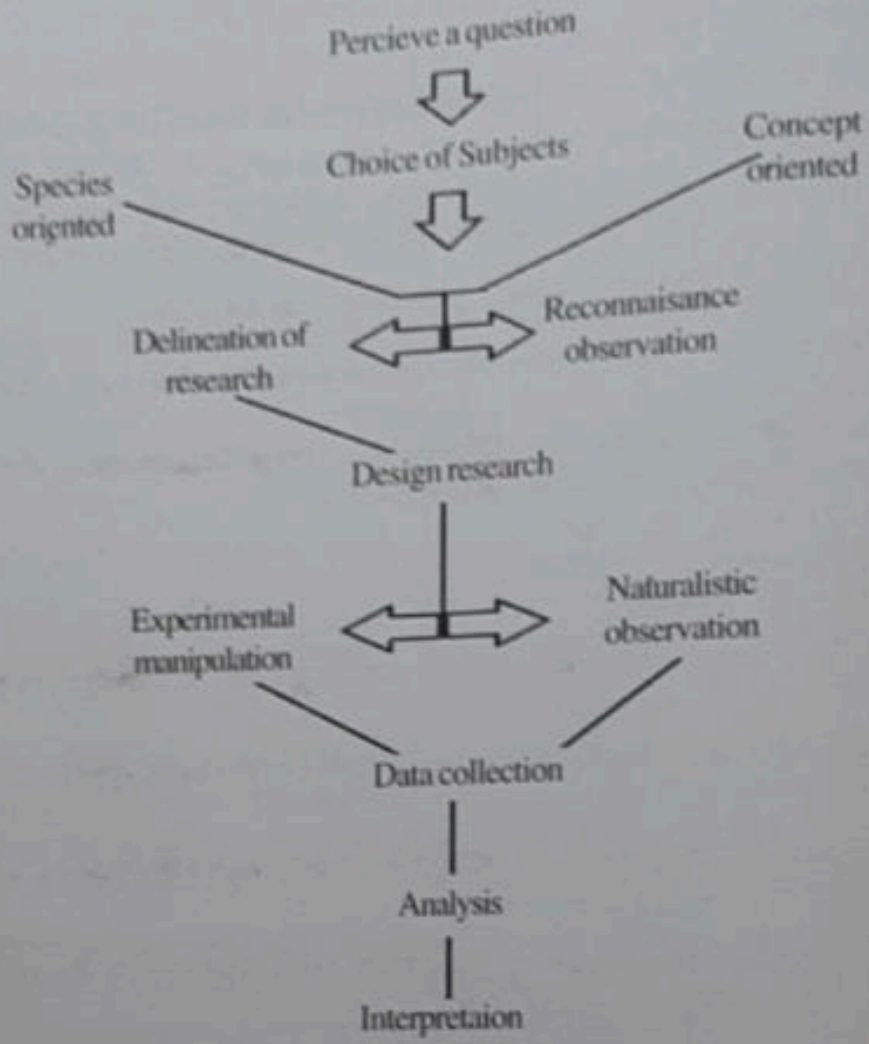

Fig 3. The Ethological approach

II. Reconnaissance observation : An early step in the study of animal Behaviour involves intensive reconnaissance observation. This may occur before one has decided what aspect of Behaviour to study and probably before formulation of any hypothesis. This is the stage when one familiarizes with the animal Behaviour. It is extremely important for no successful research can be launched without the background knowledge

A. Observing Behaviour : Observations in ethology require the development of some special skills and necessary equipment

- ***Watching verses observing* :** Many people watch animals but few really observe them. People who watch animals will be able to say only about animals they see but few can relate any in depth observations about animal Behaviour. An observer is more than a visual researcher. He has to develop and test hypothesis mentally while keeping the animal under observation.
- ***Field notes* :** Field notes are often the best and sometimes the only record of one's activities and observations in the field. The cardinal principle is – "Record observations at once; Do not trust memory". Good field notes are the end result of developing a skill into an art and the basis for learning those skills is knowledge of fundamentals.
- ***Equipment* :** the equipments required by ethologists are basically
  - *Blinds or hides*: to allow observations of animals with as little disturbance as possible
  - *Binoculars or spotting scope*: Of appropriate magnification and resolving power
  - *Cameras*: fitted with zoom and tele lenses
  - *Portable tape recorders*
  - *Stopwatches*
  - *Metronome timers*

B. Describing Behaviour : At the heart of the modern approach to the analysis of Behaviour in animal is the problem of its description

- ***Empirical verses functional description* :** there are two basic types of Behaviour description:
  - ***Empirical* :** Description of Behaviour of in terms of body parts, movements and postures (e.g. baring of teeth)
  - ***Functional* :** Incorporation of reference to Behaviour's function, proximally and distally (e.g. bared teeth threat)

  Familiarity with animal's Behaviour and insight into its functions are continuing processes and lead to the revision of both hypothesis and terminology.
- ***Ethogram* :** An ethogram is a comprehensive description of the characteristic Behaviour patterns of a species (Brown 1975). It results from many hours of observation and description and is the starting point for any ethological research. A catalog of an animal's Behaviour is a list of all that we have observed. This is only a portion of animals repertoire, i.e. all the Behaviours that the animal is capable of performing. We call a catalog an ethogram when we believe that it approximates the complete repertoire. The size of

repertoire will of course vary from species to species as well as between individuals, depending upon age sex and experience.

C. Secondary sources : Before embarking on ones study, one should learn as much about the subject animal as possible. This means collecting information in addition to initial reconnaissance observation from all secondary sources, including available literature, data from other researcher's efforts and films.

III. Delineation of research : Proper delineation of research is the cornerstone for any successful study. Before beginning the actual study one must decide, what one is trying to accomplish. Most of the activities in ethology will be concerned with hypothesis testing in a broad and a specific manner. Broadly defined hypothesis arise from the process of observations and asking questions. Questions and hypothesis are natural products of our thought processes. These thought processes must be allowed to run free during reconnaissance observations but must be held in check during actual data collection. From this perspective, the delineation of research consists of the following steps

- *Formulating the questions*
- *Stating the objective*
- *Stating research hypothesis*

IV. Design of research : Once the research outline has been properly delineated, it must be appropriately designed to select the method of investigation. It includes the following aspects

A. Recognizing Behaviour units : the choice of appropriate Behaviour units to be measured is at once the most important and difficult decisions to be made (Barlow 1977). The choice of appropriate Behaviour unit is generally based on experience, logistics, training and intuition. In isolating Behaviour units for study one needs to work from general categories down to the specifics as follows

- *Behaviour types*
- *Complexity and social interaction*
- *Behaviour patterns*
- *Behavioural acts*
- *Component parts*

B. Recognizing states, events and bouts : After observing animals only for a short period of time, it becomes obvious that most Behaviours can be divided into three categories

- ***State*** **:** The Behaviour, an animal or group is engaged in; an ongoing Behaviour (e.g. a bird flying). Basically a state is a Behaviour which one can time with a stop watch.
- ***Event*** **:** A change of states; it approaches an instantaneous occurrence (e.g. a robin

taking off). An event generally occurs so rapidly that one can only count its occurrence.

- ***Bout*** : The term bout is generally applied to a repetitive occurrence of the same Behaviour (e.g. a bout of pecking) or a relatively stereotyped sequence of Behaviour that occurs in a burst (e.g. a courtship display bout)

V. NATURAL OBSERVATION VS EXPERIMENTAL MANIPULATION : Ethological research can be broken down into two facets

- **Natural observation :** It refers to the approach in which the observer studies the Behaviour of animals as it occurs naturally with as little human intrusion as possible. The objective is to collect facts which may aid in the understanding of phenomenon and/or lead to formulation of hypothesis
- ***Experimental manipulation :*** It usually consists of making an event occur under known conditions where as many external influences as possible are eliminated so that close observation is possible to reveal the relationships between phenomenons. The objective is generally to determine the factors that are important in affecting a particular Behaviour. The factors may be long term (evolutionary and ontogenic) or short term (proximal).

VI. DATA COLLECTION METHODS : Research design and data collection are mutual indicators. The research design chosen will dictate as to what data has to be collected. Likewise, knowledge of the type and amount of data that can be collected will partially dictate the research design to be used. Research design and data collection methods then must complement each other for the study to be effective and the research efficient. The data collection methods for animal Behaviour can best be analyzed under the following headings.

A. Scales of Measurement

B. Sampling methods

C. Locating individuals in the wild

D. Identification and naming of individuals

E. Recording observations

A. SCALES OF MEASUREMENT

Data collection involves the assignment of numbers to observations and observations to categories. This process is often referred to as measurement. Scales of measurement are various levels of refinement (or precision) of measurement. In the scales of measurement, data of less resolution can always be extracted from data of high resolution. There are four basic scales of measurement which are listed below in order from the lowest resolution to the highest

1. Nominal scale : Observations are classified into predetermined, mutually exclusive, qualitatively different categories.

2. Ordinal scale : Same as the nominal scale with the addition that the categories are ordered with respect to each other (e.g. A > B > C) the Behaviours must have a common quantitative property by which they are ordered. The ordering must be stable and it must hold throughout the entire scale. A linear dominance hierarchy holds the criteria e.g. A-B-C-D.

3. Interval scale : Same as the ordinal scale with the addition that the amount of difference between respective categories is known; this necessitates a unit of measurement that permits additivity viz. the length of time it took individuals to fly after an alarm call has been given

A = 2 sec. B = 2.5 sec. C = 1.9 sec. D = 1.7 sec

The zero point is however not known (viz for flight) or arbitrarily defined (viz. the start of an alarm call) on the interval scale.

4. Ratio scale : Same as the ratio scale except that the zero point is known. E.g. in case of songbirds mobbing an owl

Individual A flies 3 m from the owl
Individual B flies 5 m from the owl
Individual C flies 6 m from the owl
Individual D flies 8 m from the owl

B. Sampling Methods

The various methods of sampling Behaviour as proposed by Altman (1974) are presented as follows:

1. Ad Libitum Sampling : As ad libitum implies no restraints are employed in sampling Behaviour with this method. What are recorded are generally the Behaviours of those individuals (or groups) that are most easily observed. It is the type that results in typical field notes. Ad libitum sampling is most often used when an ethologist is recording as much as he can during -

- An unplanned encounter with a species
- During reconnaissance observation for a later study.

However with the observation to be treated as data to enable quantitative comparisons, it is essential that at least different sexes, or age classes along with the Behaviour performed is reflected in the field notes (Lehner, 1979). Ad libitum sampling provides ideas for future research and often reveals rare but significant Behavioural events.

2. Focal-animal sampling : Here, all occurrences of specified actions of one individual are recorded during a predetermined sample period (e.g., one hour). The observer also records the

length of the sample period, and the amount of time the focal animal is in view ("time in"). This method can provide unbiased data relevant to a wide variety of questions, particularly if animals remain in the field of view. In this method though a particular individual receives highest priority for recording the Behaviour, but it does not necessarily restrict the observer to only that individual. Where social Behaviour is recorded a focal animal sample on the individual provides a record of all acts in which the animal is either the actor or the receiver (J.Altmann, 1974).

3. All occurrences : The observer focuses on a particular Behaviour rather than a particular individual. For example, one might count the number of alarm calls given in a group of monkeys. This is a useful method for providing the rate of occurrence of a Behaviour (occurrences per unit time) or for studying the synchrony of Behaviours within a group. All occurrences of selected Behaviours is possible if the following conditions exist -

- Observational conditions are adequate.
- The Behaviours are carefully defines and easily recognized
- The Behaviours do not occur more rapidly than the observer can record them.

This method of sampling can provide the following types of information

- Rate of occurrence of selected Behaviours.
- Restricted sequencing
- Behavioural synchrony.

4. Sequence Sampling : In sequence sampling, the focus is on a chain of Behaviours. This may be performed by single individuals (e.g. courtship displays in male ducks) or they may be Behaviours alternating between two or more individuals (e.g. courtship in the queen butterfly). The initiation of the sample period is usually determined by the beginning of a sequence and the sample period terminates when the observed sequence terminates.

5. One-zero Sampling : It is a method in which the observer scores whether Behaviour occurs (one) or not (zero) during a short interval of time (sample period). It is suitable for recording states and/or events. This method has following features:

- In each sample period the occurrence or non occurrence (not the frequency of occurrence) is scored.
- Behaviours of one or more individuals are recorded in each sample period.
- Occurrence refers to either an event or a state.
- The sample periods are generally short (e.g. 15 sec) and several (e.g. 20) are used in succession.

The major disadvantage of this system is that a large amount of the information about frequency and duration is lost.

6. Instantaneous and Scan Sampling : *Instantaneous sampling* is a special type of one-zero sampling in which the observer scores an animal's Behaviour at predetermined points in time (called time sampling by Hutt and Hutt 1974). This sampling has also been called as

'point sampling' by Dembar (1976) and *'on the dot sampling'* by Slater (1978). It is used to sample states since the probability of scoring events with this method is remote. This method can be used to obtain data on the time distribution of Behavioural states of an individual. *Scan sampling* is a simple form of instantaneous sampling in which several individuals are scanned at predetermined points in time and their Behavioural states scored. The same sample points can be used as in instantaneous sampling. The observer should attempt to be as instantaneous as possible, for the longer he lingers on an individual, the more the sample approximates a series of short focal animal samples of unknown durations. Behaviour categories chosen for study should be clearly delineated to assist quick scoring. Estimates of time spent scanning individuals, as well as groups, should be made. One important use of instantaneous and scan sampling is to estimate the percentage of time that individuals spend in various activities (e.g. Time budgets)

7. Sociometric Matrix : A sociometric matrix is really an experimental design or a way of tabulating data (Table 1). Collection of data for a sociometric matrix can be considered a special type of all-occurrence sampling in which the observer searches for interactions between pairs of individuals. (E.g. groomer- groomee) or record interactions by an individual (focal animal) during a specified sampling period. In the most instances the researchers use a sociometric matrix to test the one sidedness of dynamic interactions.

		Follower				
		I	II	III	IV	V
Initiator	I				1	
	II					
	III	1				1
	IV	1				1
	V				1	

Table 1. ***A Sociometric matrix***

Conclusion on sampling methods **:** Each of the sampling methods described above have their own recommended use. By combining more than one method, a researcher is often able to maximize efficiency of data collection and ensure that proper data are collected for testing the research hypothesis. Altmann (1974) also provided a table to assist in the selection of the proper sampling method shown in Table 2. Different sampling methods produce different types of data. Hence the validity of the research will be affected by the sampling method used.

S/No	Sampling Method	State/EventSampling	Recommended Uses
1	Ad libitum	Either significant evens	Records of heuristic value; suggestive; records of rare but
2	Sociometric Matrix	Event dyads	Asymmetry within
3	Focal Animal	Either	% of time; rates; durations; sequences
4	All occurrences	Usually event	Synchrony; rates
5	Sequence	Either	Sequential constraints
6	One-zero	Usually state	None
7	Instantaneous & Scan	State	% of time; synchrony; sub-groups

Table 2. ***Summary of sampling methods***

C. Locating individuals in the wild

Sometimes it is very essential to follow animals in forest to collect data on various Behavioural processes. There are three main ways to locate and follow the animals

1. Following on foot : The method consists of locating the animal or group of animals early in the morning before they leave their resting site and remain with them day and night. This method however is beset with many difficulties

- At times it may become almost impossible to keep the animals in sight while following on foot.
- The animals may be too shy and may not reveal themselves easily.
- They could live in dense forest where even sighting of animals may be difficult.
- Weather and other factors may provide difficulties for constant monitoring.

For these reasons alternative methods have to be used.

2. Biotelemetry and radio-telemetry : Radio transmitters have been used for locating a variety of species. This is accomplished by installing a small radio-transmitter on the body of an

animal. The animal is then allowed to roam freely in its natural habitat. The experimenter keeps a receiver which is tuned to the transmitter. The receiver set has an antenna used to track down the signal from the transmitter. Simultaneous directional information from two or more receiving stations can then be used to triangulate the location of the individual. Radio-telemetry can also be made completely automatic by transferring time and directional information into a computer where it can be stored.

3. Satellite telemetry systems : This system consists of polar orbiting satellites along with numerous earths based receiving stations and data processing centers. The purpose of the satellite is to collect and process data from radio collared animals on earth. The method has been successfully used for tracking dugongs, manatees, polar bears and many other species of marine mammals (O'Shea and Kochmann 1990). The signals which are given out by the radio transmitter are received by the satellite which directs them to earth to be received by a dish linked to a computer for analysis. For large species that range widely, satellite telemetry is much less expensive than traditional radio telemetry.

D. Identification and Naming of Individuals

A necessary prerequisite for many ethological studies beyond initial reconnaissance stage is that the observer should be able to recognize individuals. Studies of individuals or groups for long periods of time make individual recognition necessary. As more is learnt about the Behaviour of animals it becomes increasingly clear that generalizations are difficult to make. Early naturalists used to talk about the Behaviour of species. We now however know that there are major differences between populations, social units and individuals. This has necessitated individual identification and naming of individuals to aid in easy recognition. This can be achieved on the basis of their natural markings or by artificially marking them after capturing.

1. Natural marks : The best situation an ethologist can have with regards to individual identification is to be studying a species in which morphological differences are sufficiently great to provide easy identification. In some cases the differences are obvious to even the casual observer. These can be as a result of mutilations or mutations. Many species have provided sufficient individual variation for easy recognition viz

- Facial patterns in oryx (Saiz 1975)
- Stripe patterns in zebra (Klengel 1965)
- Spots on each side of body of bottle head sharks (Myrberg and Graber 1974)
- Variations in the dorsal fins of bottleneck porpoise (Wursig and Wursig 1973)
- Patterns of vibrissae spots in lions (Rundai 1973)
- Ear notches in African elephants

Moreover regardless of the physical characteristics selected for use of identifying individuals, photographs of individuals are also always valuable as a continuing field guide.

2. Capture and marking : When natural markings are not available and when individuals are observed only rarely (as in homing and migration studies), it becomes necessary to mark the animal in some way. This generally necessitates the capture of the animal, though some techniques have been developed for marking at a distance e.g. dye darts. Capture and restraint of animals is usually done by trapping, netting, darting and use of drugs whensoever's necessary. Various types of markers have been developed for different species to aid in their easy identification viz.

- Dyes
- Leg bands
- Ear tags (both colored and aluminum)
- Ear notches formed by cutting the pinna
- Collars and radio transmitters
- Beta light etc.

Beta light is a recent development that allows the observer to follow visually the nocturnal movements of individual small rodents, in conjunction with binoculars and spotting scope.

3. Assignment of number or names : Names carry certain connotations and overtones for each of us. Ethologists have named the animals they have studied in four different ways

- Number or by letter – No 117, RG.
- Named for object or physical characteristic – White face
- Named after Behavioural characteristic – Limpy
- Named after person – Rajiv

It is obvious that an individual given a name is remembered longer than the animal which is assigned a number.

E. Recording of observations

The recording of observations can be done in different ways :

1. By the observer using a notebook and pencil : The position of the observer may influence the animal's Behaviour (a so-called operator effect) and it should always be stated whether the observer was in full view of the animals or hidden from them (e.g. in an established hide).

2. Using video-tape recordings : Despite the initial costs of setting up a video system, it is currently the most common technique in long-term studies of animal Behaviour. Topics worth noting when considering the use of video footage in Behavioural studies include

- video can be used under normal lighting conditions but infra-red cameras will be required if a 24-hour record is needed and artificial light would create Behavioural artifacts
- good microphones plumbed into the video recorder are the most convenient means of linking vocalizations with Behavioural patterns.

3. Single-event recorders : They can be an efficient means of creating data from many animals at the same time with-out the need for video analysis. For example, infra-red beam breakage can be recorded for simple Behaviours such as a horse putting its head in a bucket.

VII. Analysis : Analysis is the ordering, breaking down and manipulation of data to obtain answers to the research questions. This is achieved by statistics. Statistics are the measures computed from observations in a sample. The sample statistics commonly used in ethological analysis are as follows

- Sample distributions
- Sample means and medians
- Skewness
- Location
- Variability
- Standard deviation
- Sample means confidence interval
- Coefficient of variation

Furthermore, in order to make statements concerning the results of their research, ethologists need to support their conclusions by statistical tests. The non parametric statistical tests commonly used in ethological analysis are as follows

- F-Max test
- Mann Whitney U test
- Kolmogorov – Smirinov test
- Wald – Wolfowitz test
- Kruskall – Wallis One way analysis of variance
- Wilcoxin test
- Sign test
- Friedmann two way analysis of variance

Other methods of analysis of data used in ethology consist of multivariate analysis, analysis of sequences, rate of Behaviour and also long term spatial analysis of Behaviour.

VIII. Interpretation : The end point of research is not the results of the data analysis, but their interpretation. It consists of accepting or rejecting the null hypothesis, comparing of research with those of other researchers, reevaluation of the entire study so that one is able to revise, restate and generate new hypothesis. This again puts one at the beginning of the ethological approach cycle, ready to begin again, but it needs to be understood that this time the approach would be wiser and more experienced one

PRACTICE QUESTIONS :

- *Multiple choices*

1. Animal Behaviour includes
   a. Sound emissions and body postures
   b. Response to stimulus
   c. Secretion of odorous substances
   d. All of the above

2. The term ethology was coined by
   a. Saint Hilare b. Lorenz
   c. Tinbergen d. Wilson

3. Which of the following statements about ethology is not correct?
   a. Ethology focuses on phylogenetic history
   b. Ethology concentrates more on learned Behaviour
   c. Ethologists study wide variety of species
   d. Ethologists study Behaviour under natural conditions

4. Ethology concerns itself with
   a. Cause of Behaviour b. Function of Behaviour
   c. Evolution of Behaviour d. All of the above

5. The study of artificial intelligence is the concern of
   a. Sociobiology b. DEEP Ethology
   c. Bioacoustics d. Cognitive ethology

6. All Behaviours that a animal is capable of performing are called its
   a. Ethogram b. Catalog
   c. Repertoire d. None of the above

7. The Behaviour in which an animal is engaged in at any moment of time is called
   a. State b. Event
   c. Bout d. None of the above

8. The sampling method in which the observer scores whether or not a Behaviour occurs during a sample period is called
   a. Ad libitum sampling b. Scan sampling
   c. One zero sampling d. Sequence sampling

9. Instantaneous sampling is a special type of
   a. Ad libitum sampling b. Scan sampling
   c. One zero sampling d. Sequence sampling

10. Individual elephants in the wild state are generally distinguished by their
    a. Vibrissae
    b. Facial patterns
    c. Spots on body
    d. Ear notches

11. Ethology is:
    a. Studying of interaction between animals and human being
    b. Study of animal Behaviour in natural habitat
    c. Study of animals under controlled laboratory conditions
    d. None of the above

- ***Very short answer type***

1. Who are the founder fathers of ethology?
2. What is meant by ethogram?
3. Name the equipments used by ethologists.
4. What approaches are utilized in analyzing the physiology of Behaviour?
5. What is meant by ethological approach?
6. What is DEEP ethology?
7. What is meant by empirical description of Behaviour?
8. How are individual lions distinguished in the wild?
9. Name two methods used for marking captured animals.
10. How are observations taken in the ordinal scale while studying Behaviour?

- ***Differentiate between***

1. Ethology and Psychology
2. Natural observation and experimental manipulation
3. Focal animal sampling and instantaneous sampling
4. Empirical and functional description of Behaviour
5. Watching and observing Behaviour.

- ***Write short notes on***

1. Areas of study in ethology
2. Behaviour units
3. Focal animal sampling
4. Sociometric matrix

- ***Long answer type***

1. Define ethology? How do ethologists locate and identify individuals in the wild? Comment on the uniqueness of the ethological approach.

2. How do ethologists describe Behaviour? Write a note on the different data collection methods in the field study of animal Behaviour.