pheromone was a volatile yellow coloured substance with a strong floral odour. Male cockroaches responded to the odour with intense excitement, raising their wings and making mating attempts. This pheromone was identified as 2, 2-Dimethyl 3-isopropylidene, cyclopropyl propionate. Another team of chemists at the Institute of Chemistry in Munich isolated the sex attractants of the female silk moth, *Bombyx mori*. They extracted the abdomens of five million females to obtain a tiny amount (12 mg) of the pure pheromone which they named as **Bombaykol**. The other attractants which have been isolated are **Gyplure** (gypsy moth), **Civetone** (civet), **Muskone** (musk deer), **Honey bee queen substance** (bee).

Adolf Friedrich Johann Butenandt (1903-1995) had identified first insect pheromone. He won a Nobel Prize in Chemistry in 1939 for his work on sex pheromones.

The identification and extraction of pheromones has moved with a slow pace. Till 1976 only six mammalian pheromones could be identified but, with the advent of knowledge and technology it has been possible to identify the chemical compositions of a few more pheromones produced by different animals. Skunk, a carnivore found from Canada to northern Mexico produces a very foul smelling secretion (allomone) from its anal gland. The secretion has three sulphur compounds methyl crotyl sulphide, crotyl and isopentyl mercaptan and its main function is to repel predators and human beings. The musk deer and civet cat emit muscopyridine. The other acids which form active ingredients of pheromones are volatile carboxylic acids (red fox), unsaturated lactone (black tailed deer), phenylacetic acid (mongolian gerbil), isovaleric acid (male proghorn-a ruminant), mixture of acetic acid, propionic acid, isobutyric acid, n-butyric acid and isovaleric acid (female rhesus). **Brahmchay** (1981) worked extensively on a pheromone produced by tigers which he called **Tigeramine**. He noticed it as a milky thick fluid with a strong smell passed out along with urine in tigers. He further investigated that all male Tigers produce pheromones to mark their respective territories, he collected various samples and found out that Phenylethylamine was the main and common constituent among pheromones of different tigers; the chromatographic studies revealed that other amines differed from tiger to tiger which makes it typical of that individual and that helps them identifying their own territory from others.

Effect of Pheromones

A pheromone affects behaviour in two ways (i) It stimulates the central nervous system (CNS) of the recepient and produces an immediate change in its behaviour, it is known as **releaser effect**. (ii) If a pheromone alters a set of physiological reactions in the recipient which in turn prepares the animal for a particular behavioural pattern to be released later by an appropriate stimulus, is known as **primer effect**.

Suppose a pheromone is released by an animal (a), and it is perceived by animal (b), the pheromone acts on CNS of (b) and this releases the behaviour immediately in animal (b). This kind of quick action is called the **releaser effect**. Crush one snail by the side of a river or pond and the crushed cells emit a fear pheromone which sends other snails immediately back into water; a mother rat licks her nipples so that her blind pups can follow the scent of her saliva to the milk, wash the nipples, and the pups are lost; termites discovering a breach in their- mound emit an alarm scent that brings masons to work, who immediately start repairing the crack. Pheromones that produce a releaser effect are widely spread in the animal kingdom. Sex attractants in insects constitute a large number of this category, trails of ants are also consequences of releaser's effect; similarly you crush a bee and within no time you will be attacked by hundreds of them.

On the other hand, in **primer effect** a pheromone is released by animal (a), it is perceived by animal (b), the pheromone acts on CNS of (b), which brings about changes in physiological reactions and prepares CNS of (b) for a particular behaviour, which is then released by an appropriate stimulus. It is a delayed effect of pheromone and is unlike releaser effect.

There are fewer but interesting examples to explain primer effect of pheromones. In 1955 mammalian endocrinologists. **Van der Lee** and

L.M. Boot, discovered several unexpected effects on the female mouse. They observed that when many female mice were left in a cage to live together their estrous cycles were syncronized. They further observed that if female mice were kept away from males for a long time, their estrous cycle stopped completely. Further, scent or pheromone of a male mouse could initiate the estrous cycle of a female mouse. These scientists came to the conclusion that pheromones secreted by male mice are perceived by female mice which gradually affect the reproductive physiology of female mice and consequently its reproductive behaviour. They further investigated that when female mice were kept in groups of four, there was an increase in the number of spontaneous pseudopregnancies, which could be prevented by removing olfactory bulbs or by isolating the females. They called it **Lee-Boot effect**. A still more surprising primer effect was studied by **Helen Bruce** (1961) of the National Institue for Medical Research in London. She observed that the odour of a strange male mouse blocked the pregnancy of a newly conceived female mouse. The odour of the original male left pregnancy undisturbed. While the odour of the strange male suppressed the secretion of the hormone prolactin so that normal estrous was restored, this is known as **Helen-Bruce effect**. In this, physical contact between male-female is not necessary, the Bruce effect could be seen by placing the female in an empty box that formerly housed a strange male. However, female is sensitive to the presence of a strange male only upto a maximum of five days after the first copulation; after six days Bruce effect does not occur.

Another scientist **Whitten** (1959) found that females that have been grouped together, do not mate as quickly when left with male as do females that have been isolated, this is known as the **Whitten effect**, this effect can be reversed by introducing a male into the all female group. The other examples of primer effect come from social insects. Honeybees, termites and ants have been most widely studied for this purpose. Among social insects, members of the same colony share a common pheromone which differs from that of the other colonies within the same species. The queen bee preserves her monarchy by exuding pheromone that inhibits worker bees from making new royal chambers of queen cells. Termite caste production is regulated by the number of individuals of the caste that are already present *e.g.*, the presence of a pair of reproductive termites inhibits the production of other reproductive termites and hence the size of the colony is controlled by a pheromone released from the anus, all these examples involve delayed primer effect.

Knowledge of pheromones in the animal kingdom is well known since 1970's; manufactures are marketing them for pest control; pheromones are used to lure and/or repel animals and bugs to prevent crop damage. The discovery of human sex pheromones was published in 1986 by **Dr. Cutler** and her colleagues. They provided the proof that women and men released pheromones into the surrounding that influences behaviour. There are several kinds of human pheromone; Androstenol which makes the wearer seem more approachable and friendly; Androstenone which projects a dominant and aggressive aura and has a strong and sharp smell; Androsterone, creates an aura of protection usually associated with peaceful alpha males; Androstadienone, increases caring feelings and closeness; and Copulins-female pheromones that can increase testosterone levels in men. Some of the lesser known pheromones include Androstadienol and Estratetraenol.

PHEROMONES IN INVERTEBRATES

Pheromones play an integral part in the secret lives of invertebrates as already evident from the earlier pages of this chapter. The invertebrates have special scent producing glands and structures to receive the chemical messages.

Production and Perception

Glands producing pheromones. Pheromones are produced by definite glands. The location and structure of these glands on the body varies in different animals. The insects have been most

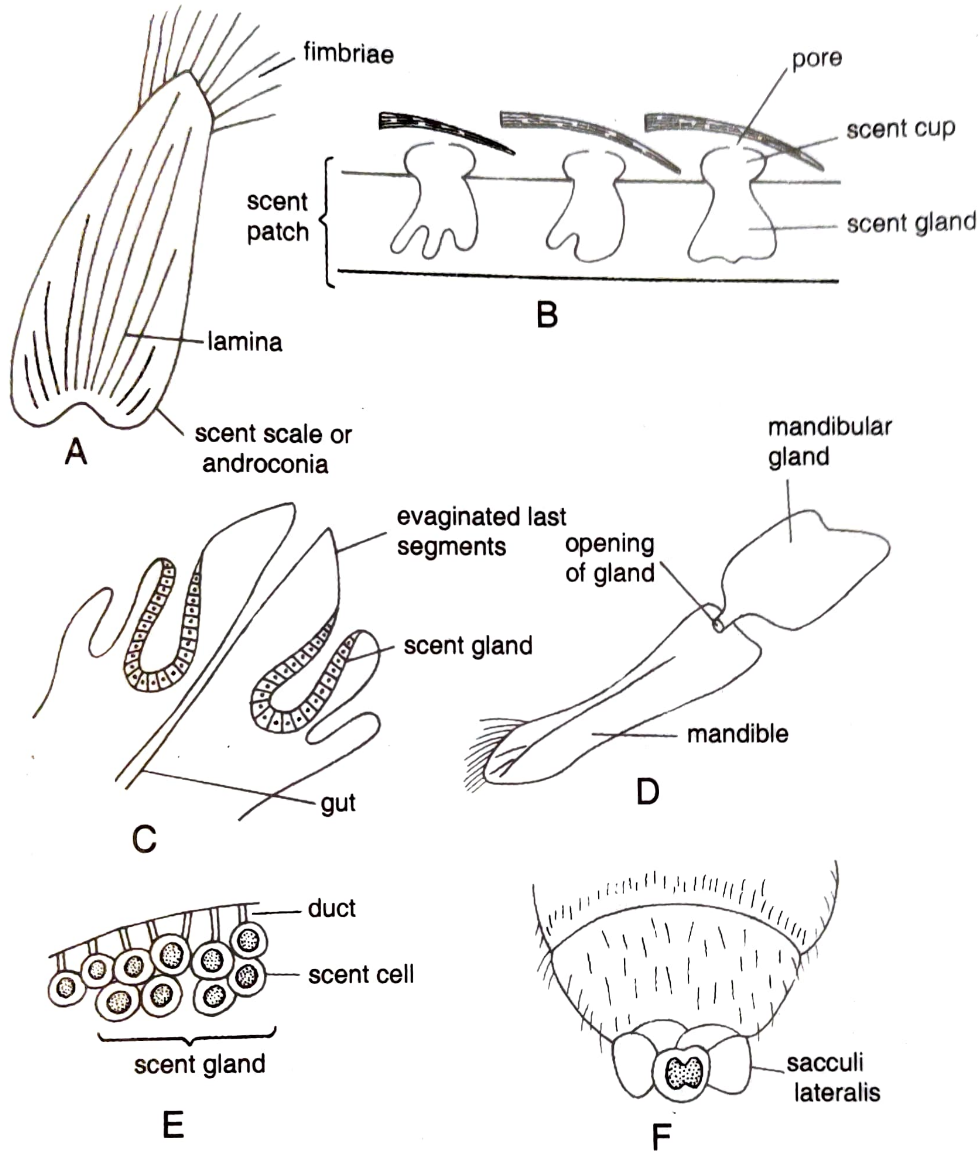
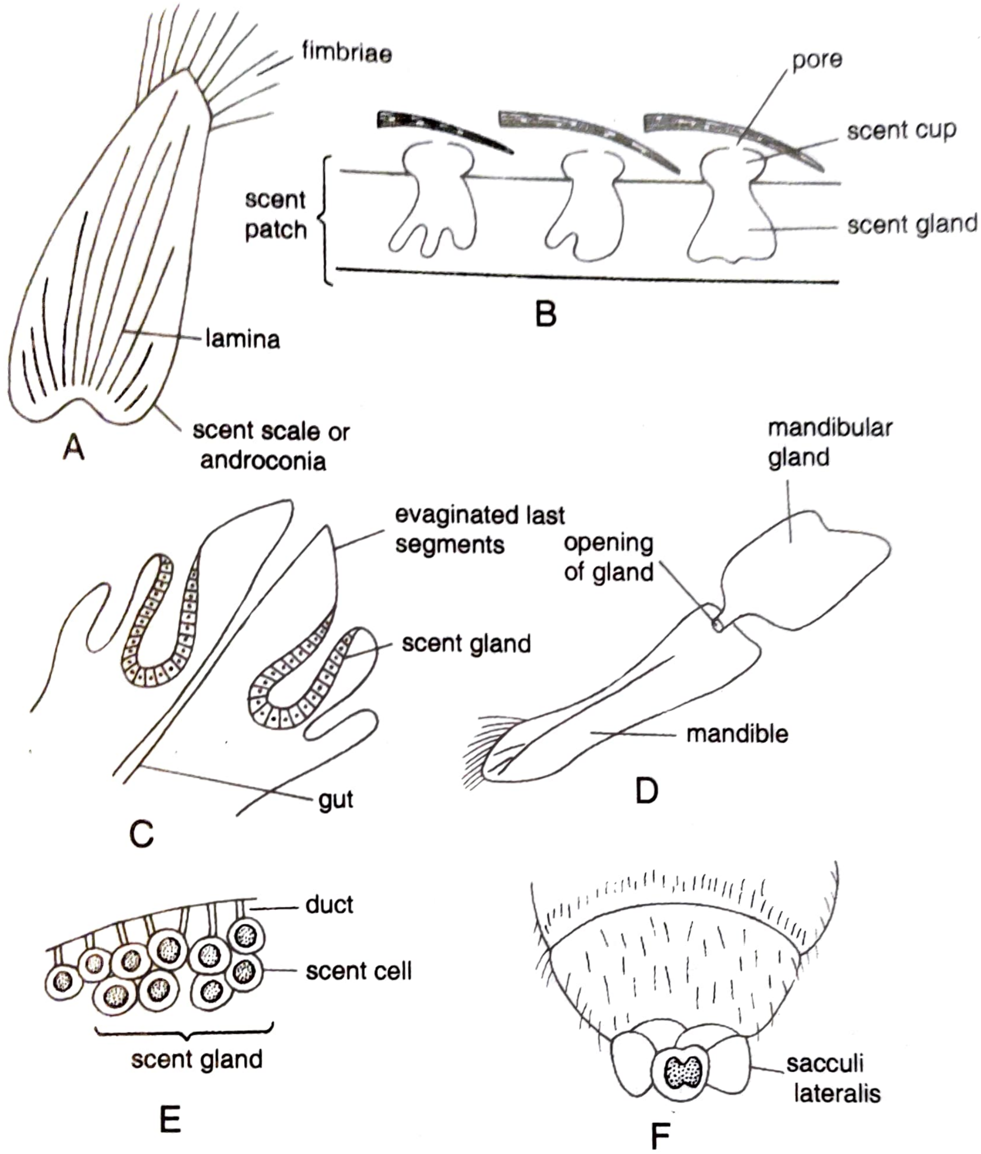


Fig. 3. Scent producing glands.

extensively studied for their pheromones and structures related to their production and perception.

Male Lepidopterans (butterflies and moths) are often able to produce scent from glands which are commonly associated with scales, these scales are known as **androconia** and are located on wings, these scent scales have an elongated form and terminate in a row of processes of fimbriae [Fig. 3 (A)]. The pheromones produced by these structures evaporate through these fimbriae. Males of *Amauris* have a small scent patch on each of the hind wings. These patches contain highly modified structures called **scent cups** [Fig. 3 (B)], each scent cup has a median pore and below each cup is found a scent gland. Scent from these **scent patches** is dispersed by scent brushes associated with genitalia. In order to disperse the scent the insect lands with its wings spread and then bends towards one side and the scent organs are brushed. In certain insects like *Plaodia,* there are invaginated glands which open on either sides of the last abdominal segment [Fig. 3(C)]. The scent is dispersed by evagination of the gland. Honey bees have two main glands which produce pheromones. The mandibular glands in the head



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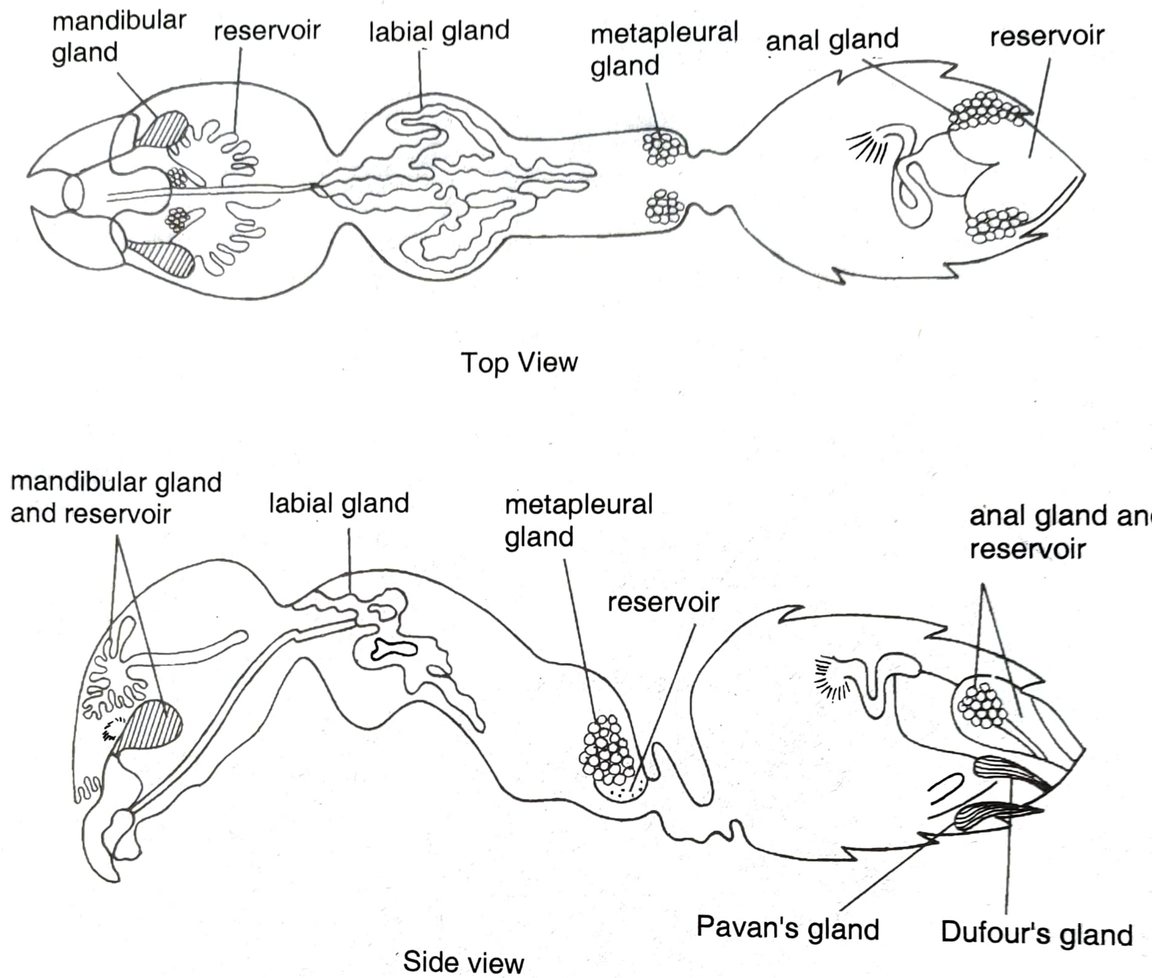

Fig. 4. Scent producing glands in ant.

and nassanoff's or nasnov (named after the Russian who first described it in 1882) gland in the abdomen. **Mandibular gland** is a sac like structure [Fig. 3(D)], whose duct opens at the base of the mandible. These glands are well developed in the queen and workers, but generally reduced in the drones. **Nassanoffs' gland** is found below the inter segmental membrane (arthrodial membrane) between 6th and 7th abdominal segments, which is exposed by bending the tip of abdomen. This gland is made up of a number of large cells which open to exterior by small ducts [Fig. 3(E)]. Female silkworm moth emits a sex pheromone from a pair of sacs [Fig. 3(F)], called **sacculi lateralis** that are found on the last abdominal segment. Ants have many pheromone producing glands *viz.* mandibular gland and its reservoir, labial gland, metapleural gland, pavan's gland, dufours glan anal gland and its reservoir (Fig. 4).

Structures perceiving pheromones. Grea Swiss entomologist **Auguste Forel** found toward the end of 18th century various structures on a ant's antennae and on other insects which seeme to be particularly well adapted for receivin chemical substances. These structures were flat i some insects, cup shaped in others while in som they were in the form of short stubby ha (Fig. 5). All these structures were supplied b nerves. The pheromones released by a conspecifi are perceived by these specialised structures an the messages are sent to central nervous syster Despite many variations, all chemically sensitiv structures share a basic plan : the receptor cel and nerves, the receptor cells are positioned

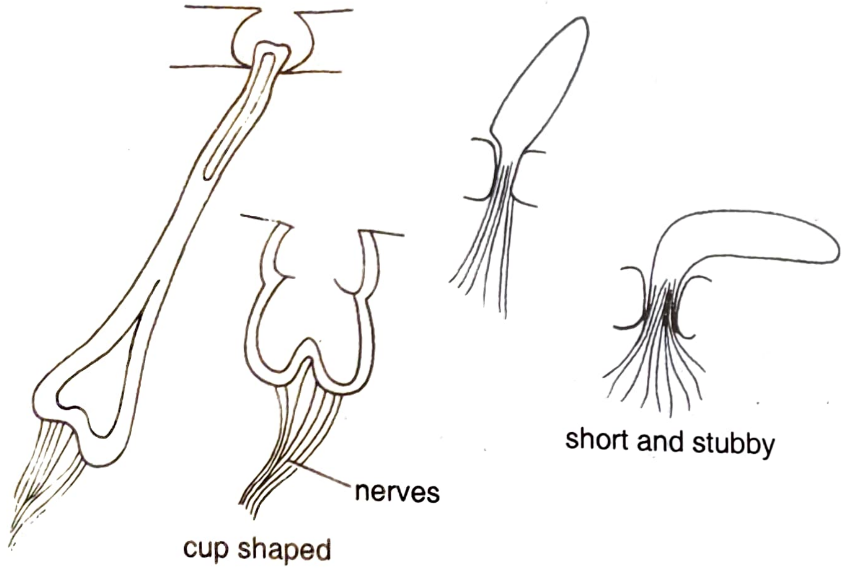

Fig. 5. Structures perceiving pheromones.

such a way that stimulus - substance molecules from the surrounding medium can easily reach the special areas of cell membrane. Some animals will have projecting antennae specially designed to receive pheromones.

Studies done by the German physiologist, **Dietrichschneider** and his associates demonstrated that the male silkworm moth receives the stimulus of pheromones by specialized structures located on their antennae which act as chemoreceptors. They further discovered two specialized sensory structures on the surface of the antenna - **sensillae coeloconicae** which were pit like and short rod like **sensillae basiconicae** (Fig. 6).

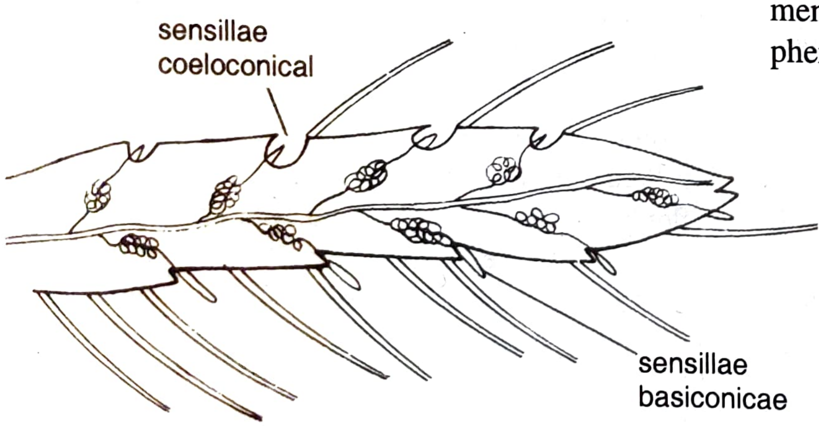

Fig. 6. Antenna of male silkworm moth.

FUNCTIONS OF PHEROMONES

Pheromones perform a variety of functions among different animals. The main functions are mentioned below :

Pheromones as Sex Attractants

Pheromones are employed by a large number of insects in bringing the sexes together for mating. These pheromones are known as sex attractants.

Pheromones of females. Pheromones in female insects are usually released by exposing the glands by movements of abdomen. Normally, scent is released at particular times of a day, depending upon the nocturnal or diurnal nature of animal. The effect of scent is to excite the male and to promote take off towards her. Eventually, as the male approaches the female, there is continuous increase in the concentration of the chemical attractant and this serves as a guide for the remaining distance. How far and in which direction the pheromone spreads, depends largely on the wind direction.

The queen bee attracts drones by a pheromone, the principal component of which is 9 oxodecenoic acid produced in the mandibular gland. The power of this pheromone is almost unbelieveable. As mentioned earlier, the queen bee chiefly produces pheromones from two glands *viz.* mandibular and nassanoff's she rules over a colony of 6000-8000 individuals for 5 to 7 years, it is assumed that the variety of odours she can pass around to make those 8000 individuals work, is controlled by producing varied concentrations of pheromones from just two glands. She decides the number in a caste, she prevents further construction of royal chamber, she passes orders to all the workers who execute work tirelessly. Most acute sense of chemicals exhibited in nature is that of the male Emperor moth *Endia pavonia* which according to experiments conducted in Germany in 1961, can detect the sex attractant of the female as far as 13 kms. This scent has been identified as one of the higher alcohols ($C_{16}H_{21}OH$) of which the female carries less than 0.001 of a milligram. Among many vertebrates the readiness of a female for mating is perceived by male through pheromones produced from vagina therefore, sniffing the genitalia is a common sight in ready-to-mate animals, *e.g.*, pheromone copulin is produced from the vagina of rhesus female the male rhesus would inspect the hindquarters of a female in heat before copulating. Appearance of male dogs from neighbourhood around a pet bitch is the most common example of a pheromone produced from vagina to attract males.

Pheromones of males. There are only few instances of male producing sex attractants. This is true of the male beetle *Harpobittacus.* In this insect, after the male has caught the prey and started to feed, two vesicles are everted from between the posterior abdominal segments. These vesicles are expanded and contracted and the scent is released which excites female for mating. On her arrival male presents her the remains of prey, and while female is busy eating it, the male *Harpobittacus* copulates.

Pheromones of Social Insects

The pheromones of social insects fall roughly into two categories according to their function :

(1) Those concerned with communication between conspecifics and

(2) Those concerned with the maintenance of colony structure or caste system.

1. Communication. Many ant species lay scent trails by which they are able to find their way about. **Edward O. Wilson** (1958) did some experiments with fire ants to study the role of pheromones in communication, he observed that when a worker finds food it returns to the nest laying a trail. On encountering a fellow worker it rushes towards it and may climb on it, apparently bringing the trail substance to its notice. The trail initially consists of a series of scent spots produced by a worker ant touching the ground with its abdomen as it runs along. Subsequently, if the trail is used by many ants the spots which they produce may merge into a continuous streak. Wilson observed that the trail of fire ants consisted of a substance secreted in minute amounts from the edge of the abdomen by dufour's gland (Fig. 4); the substance leaves the ant's body through a pointed thin sting, which is touched to the ground and leaves the pheromone much like a moving pen or it is drawn out just like tooth-paste which has been squeezed from the tube. Wilson extracted pheromone from the dufour's glands of freshly killed workers and performed several experiments, to conclude that fire ants have an elaborate system of communication through chemicals. Wilson developed a colony of fire ants into a glass dish which had one opening and with the help of extracted pheromone he created an artificial trail with a stick. He observed that the workers were attracted from the nest. Workers followed the artificial trail in close formation. Ultimately they gathered in the confusion at its terminus because there was no food. He proposed that the trails can be of different types, one leading to food and other may just be a routine passage or it can be a trail of emergency exits. If an ant is attacked in a colony it secretes alarm pheromone from mandibular or anal gland (Fig. 4) which attracts other members of the colony that quickly reach for the rescue of conspecific. The alarm pheromone among social insects have three main functions (i) to alert the colony (ii) to release aggression and (iii) to mark the target to be attacked. If you are stung by a bee and you reflexly kill that bee the dead stinger might invite hundreds of bees; there are alarm and distress pheromones that are released from stinging or dead bees respectively which triggers a mass attack from the hive. All pheromones are volatile, however, the extent varies. For example, distress pheromones are very highly volatile because if this was not the case then colonies of animals might remain in an almost continually disturbed state. However, pheromones for marking trails of movement or territory are much less volatile.

Worker bees are attracted to each other by a scent from nassanoff's gland [Fig. 3 (E)]. This scent is dispersed by depressing the tip of the abdomen so that the gland is exposed and sometimes the wings are vibrated too, creating an air current for better dispersion. The scent is released in various situations *viz.*, at the time of feeding, during formation of new hive, to mark a source of water, to mark hive for recognition and for maintaining cohesion of swarm during flight.

Some insects use the pheromones to trap the prey. The bola spider tricks male moths that are searching for mates, to attract them, the spider produces a scent like that made by a female moth, as a male moth comes near, spider kills the moth and eats it.

2. Maintenance of colony structure. The queen bee produces pheromones mainly from two glands which play a part in controlling the social structure of her colony. If a queen is removed from a colony her absence is perceived immediately by the workers who become restless, immediately they start building emergency queen cells or royal chambers, by enlarging and reshaping the existing worker cells and larvae within them are fed Royal jelly instead of Bee's bread, these larvae then grow into queens. The queen which comes out first of all locates sister queens with the help of pheromones and sting them to death before they even emerge. In the presence of queen this behaviour of workers of building new royal chambers is kept in check by a pheromone produced by her mandibular gland [Fig. 3 (D)]. Like honey bees, the queen of certain Vespine wasps who are also social but live in smaller colonies, produce pheromones that maintain the stability of the colony. The differentiation and the number of a particular caste in termites is also regulated by a series of pheromones. Replacement of a queen termite is produced within a week from its absence. In termites also, more than one queen is produced and as soon as the first queen comes out, the workers eat away the remaining developing queens.

SCENT MARKING IN VERTEBRATES

Many vertebrates produce odours, scents or pheromones to carry out many important functions. House shrew, striped hyena and black tailed deer produce scent under stress, other mammals mark territories, mates, pups, and their habitat with scent. The scent is released in many ways *viz.*, along with urine, faeces and saliva, they are also produced through special glands.

Use of Urine and Faeces

Urine or faeces of many animals have pheromones or scent through which they can communicate with conspecifics. The most common use of urine and faeces is to identify or scent mark **core area** (an area, used extensively and defended actively), home range (an area around core area, actively used but not defended actively) or **territory** (a bigger area around home range used or exploited but not defended). Some animals use urine and faeces for identifying pathways, resting grounds, feeding grounds and sleeping sites. Some animals urinate or defaecate on rivals, opponents, defeated conspecifics etc.

The most interesting and strange example comes from mammals. The male hippopotamus mark their pathway between aquatic resting place and grassy feeding ground, by the deposition of dung at places along the trail, usually close to some conspicuous objects. As hippopotamus defaecates while walking on the trail it keeps moving its tail rapidly from side to side (Fig. 7), so that the faeces are splashed out and get deposited all over the vegetation above ground level and thus, places it at nose height to make it more noticeable; rhinos mark their pathway by defaecating at prominent land marks and depositing piles of faeces so that it can be both smelt and seen. Tigers select specific places and mark their territories by their droppings. Main land

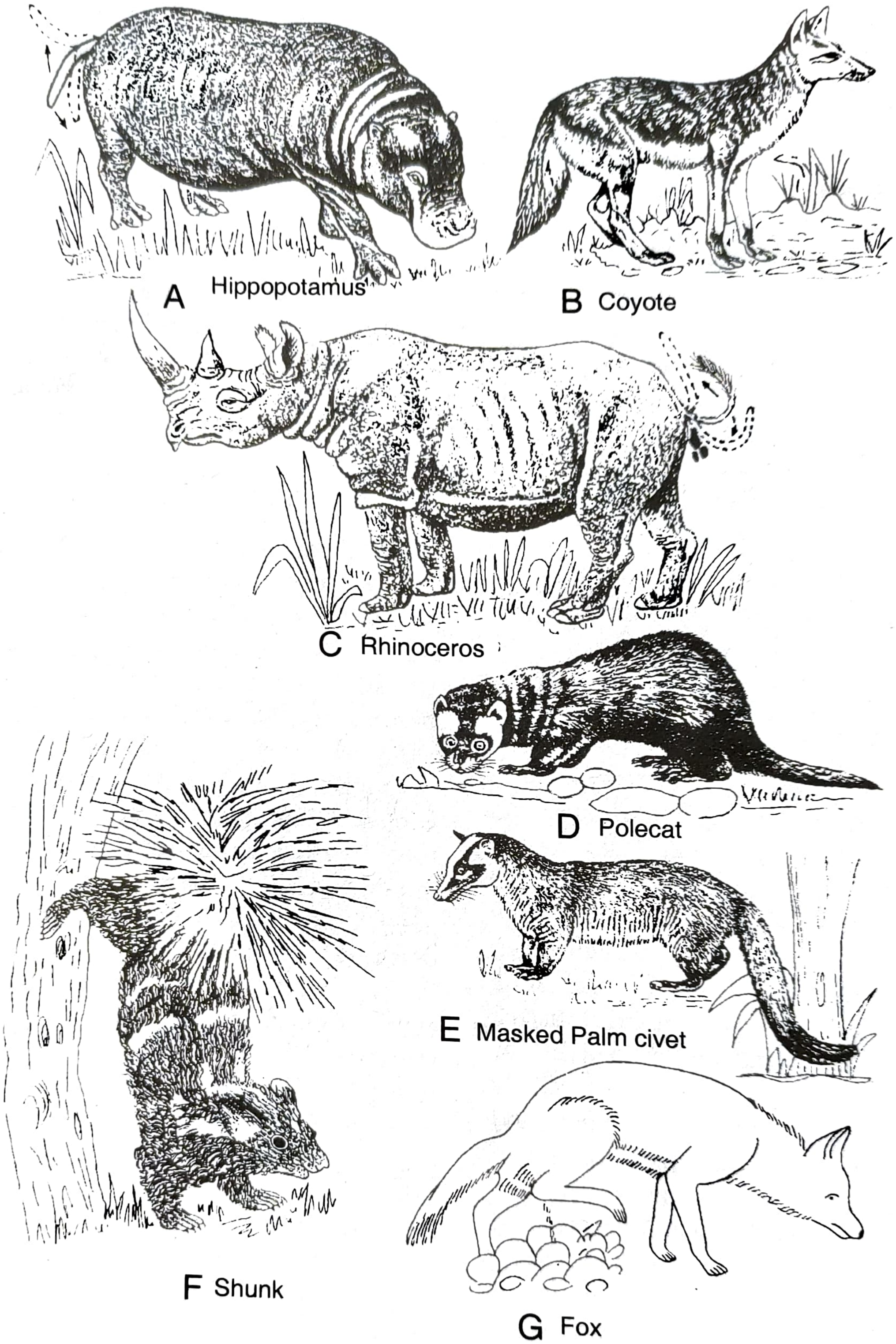

Fig. 7. Animals who use urine and faeces for scent marking.

serow of family Bovidae, found in northern India has fixed pathways of movements, initially these pathways are used visually and later the animal marks traditional spots by depositing its droppings there, so that it can just follow the scent and others are kept away. Polecat (a weasel like animal) and civet (Fig. 7) deposit urine and faeces at particular places along their trail too. The male giant rats and skunks have their own style of marking, they place their droppings above ground

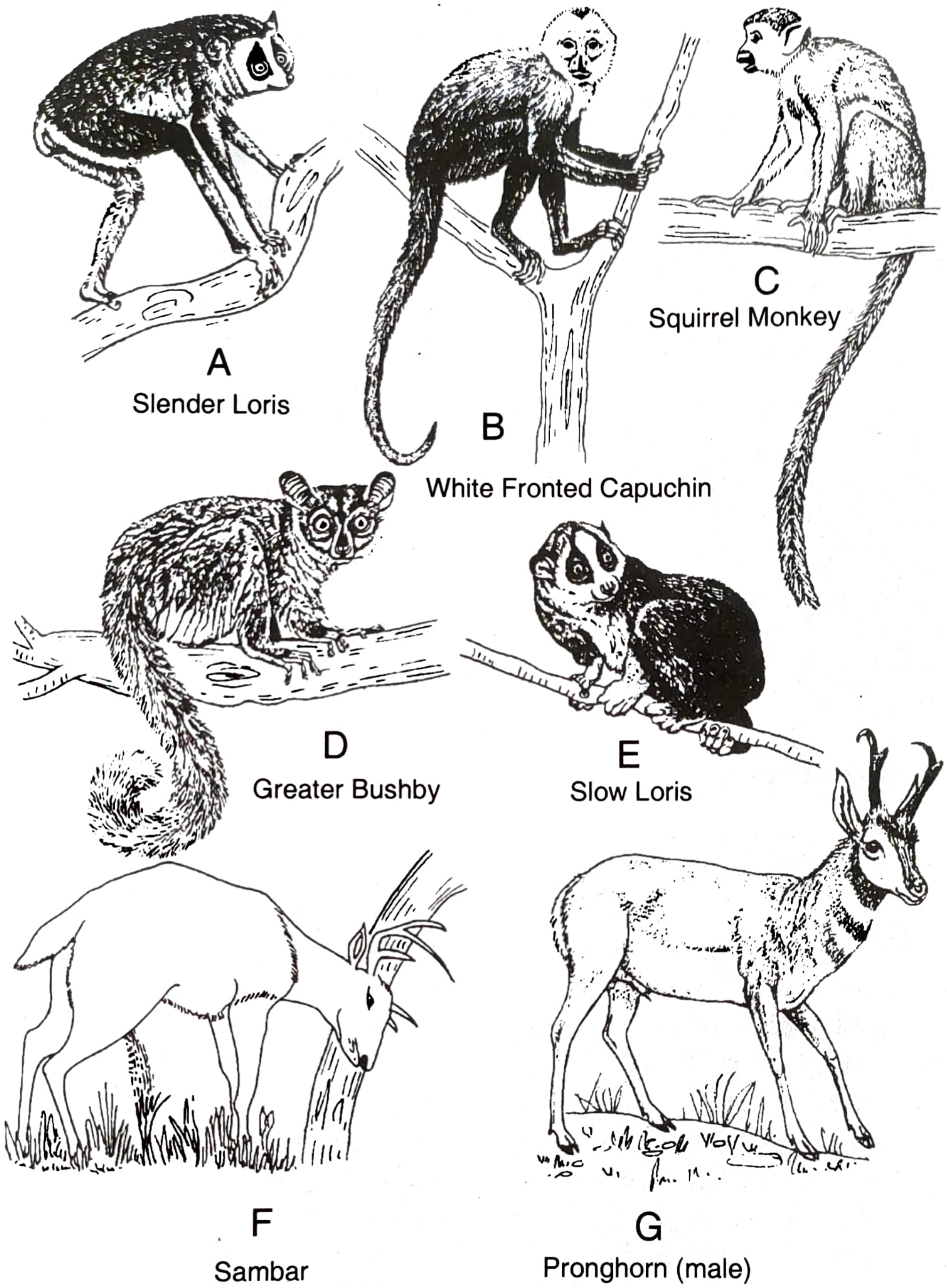

Fig. 8. Animals who use urine and faeces for scent marking.

level by standing on forelimbs and hind limbs supported against some solid object as they defaecate and urinate (Fig. 7), this is done to mark the area at nose level for easy detection. Dogs, coyote and foxes (Fig. 7) use just the urine to mark their territories, the scent left with urine indicates minute details like individual identity, male or female, dominant or subdominant, adult or subadult and also how long ago that area was marked.

Slow loris (Fig. 8) found in south east Asia are small sized primates, they occupy small territories which they mark by their urine. Capuchin (Fig. 8) a new world monkey, found in southern Central America lives in large groups among the dense foliage of forest trees, each group has its own home range in which the members move about. The adult members soak their feet and hands in their urine known as "urine washing" and smear it on the foliage. Urine washing is

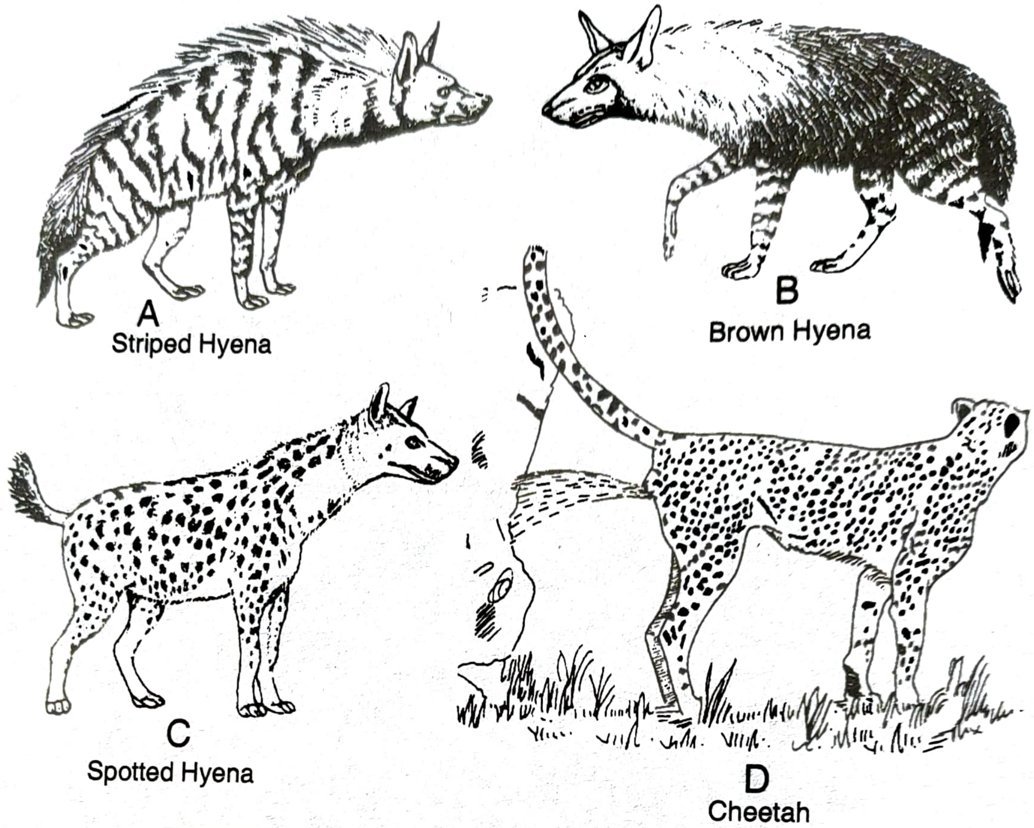

Fig. 9. Animals who use urine and faeces for scent marking.

also seen in slender loris (Fig. 8). It is a small sized animal found in India. They sprinkle urine on tree trunks to mark their territory. Similarly, common squirrel monkey (Fig. 8) of northern South America, for demarcating its own territory, leaves a scent by soaking its body specially, tail in urine. Proghorn (Fig. 8), an antelope found in Canada, USA, Mexico and sambhar (Fig. 8) a common deer in India live in herds, during mating season the adult males become territorial and mark their areas with droppings and urine.

In greater bush baby (Fig. 8) the habit is further peculiar, while urinating one hand is held cupped in front of the urine which is rubbed on tree branches. In both cases the scent marking is done to identify the home or area where they spend maximum time. Some lemurs (non - human primates found in Madagascar) mark their territory by smearing their faeces on branches, quite like painting the house.

Lions, tigers leopards, and all other big and small male cats mark their home range with pheromone which is passed with urine. The cats select some suitable objects, back up to it, extend the back legs, raise the tail, as the urine is passed, the tip of the penis is curved backward so that the urine is given out as a fine jet between the hind legs (Fig. 9). Bears use two different ways, they first mark a tree by scratching and chewing the bark, and in addition, they frequently urinate on such trees to consolidate the marking. All three species of hyena, striped, brown and spotted (Fig. 9) mark the areas of their movement with urine and faeces, they also have special anal glands for the production of pheromones for the same purpose. Use of pheromones through urine and faeces had its own limitations, that the animal has virtually no control over their production and release and this could have been one of the reasons which led to development of special glands to produce pheromones.

Use of Special Glands

Many species are not dependent on urine or faeces but have evolved special glands producing the scent, these have the advantage that their use can be restricted to necessity, that the animals could

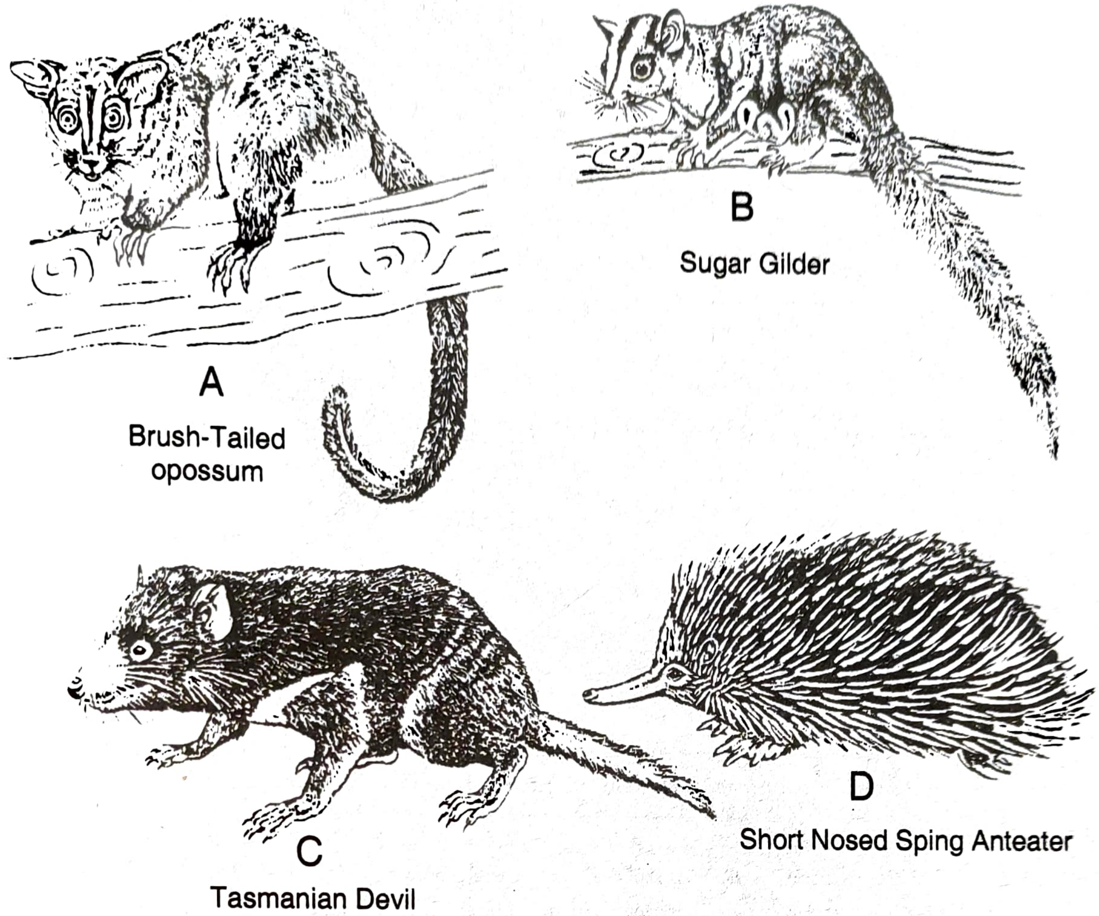

Fig. 10. Animals who use secretions of anal gland for scent marking.

use pheromones as and when needed or production of pheromones remain under control, to prevent its automatic, unwanted release with urine and faeces.

1. Anal gland. The commonest scent producing glands are anal glands. The usual procedure among animals in applying secretions is to evert the anal glands and rub it on the ground or on object to be marked. Marking of this type occurs mainly in Monotremes, Marsupials and in few Placentals.

The male beaver is tenacious about keeping strange beavers out of his neighbourhood, he virtually erects "No Trespassing" signs by pheromones on dams, lodges and feeding trails. He makes mounds by scooping up mud from his pond and on them he squats to deposit a smear from his anal scent gland. Spiny ant eater (Fig. 10) everts the cloaca and rubs it on the ground leaving a smelly mark. The brush tailed opossum and sugar glider (Fig. 10) have two types of cloacal glands with the help of which they mark their nests which is the most precious area for them. In the yellow footed marsupial mouse cloacal secretions are rubbed on twigs and branches around their small territory. The anal gland of black and red tamarin (Fig. 10) produces a strong smelling secretion which keeps others away. Male tasmanian devil (Fig. 10) has scent glands around its anus which it rubs on objects like stones, branches, ground and grass to protect his female and young ones. In most mammals marking the territory is the job of the male but in few selected ones like, ring tailed lemur (Fig. 11) which are small sized, long tailed primates found in Madagascar, both male and female have scent glands in their fore arms and anus, both rub their glands to mark their territory, however, males have additional scent glands, under chin and by the penis which produce pheromones to attract females. Verreaux's sifakas (Fig. 11) also found in Madagascar mark territories with urine and with

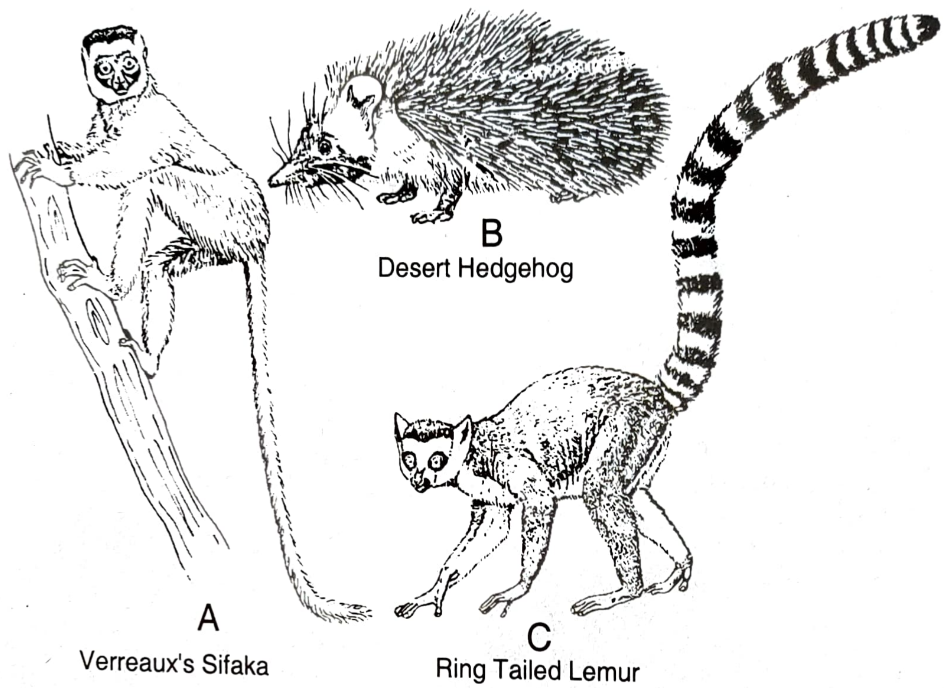

Fig. 11. Animals who use secretions of glands found in forearm, throat and saliva.

secretions of males' throat glands. Brown hare of Europe, normally lives solitary and marks its territory with strong smelling secretions produced from glands situated in its anal region, around its face and inside its cheeks. These secretions are also important in its mating season to attract the mate.

2. Salivary gland. Saliva is a secretion available to all mammals, which has been used as a marking agent by bears, dogs, pigs and a number of other animals. Most marsupials deposit saliva on twigs by chewing them and hence marking the foliage of their territory. Lesser hedgehog (Fig. 11) first salivates on the object to be marked and then scratches it. A female rat licks its nipples to scent mark them so that its blind pups can reach them. A female wildebeest will lick its baby to scent mark it through its saliva for recognition.

3. Miscellaneous. There are many other glands via which the scent marking can be done. Roe deer (Fig. 12) of order Artiodactyla found in Europe and Northern Asia live in small groups, the stag marks its territory with secretions from glands on the forehead, anal and metacarpal glands and urine. Roe deers, black bucks and sambar (Fig. 12) found in India rub facial glands found just below the eyes against trees to mark them. Red brocket, found in Central and South America are small sized solitary deer, during breeding season, males mark territories by strong smelling substance produced from a gland situated at the base of the antlers, the females are attracted to this smell.

Thompson's gazelles found in Africa mark their territory by depositing scent on long twigs and grass (Fig. 12), this scent is a tar like substance which is produced by glands situated just below their eyes. Bulls of elephants have temporal glands which produce a scent to indicate that they are musth *i.e.*, ready to mate and looking for a cow elephant in breeding season. The dominant male reindeer (Fig. 12) have scent glands between their hind toes, which help them to leave scent trails for the remaining members of the herd. Ground squirrel and American porcupine (Fig. 12) mark their mates and territories by rubbing with sides of the head. In marmot, the scent glands occur in the area between eye and ear. The secretions from

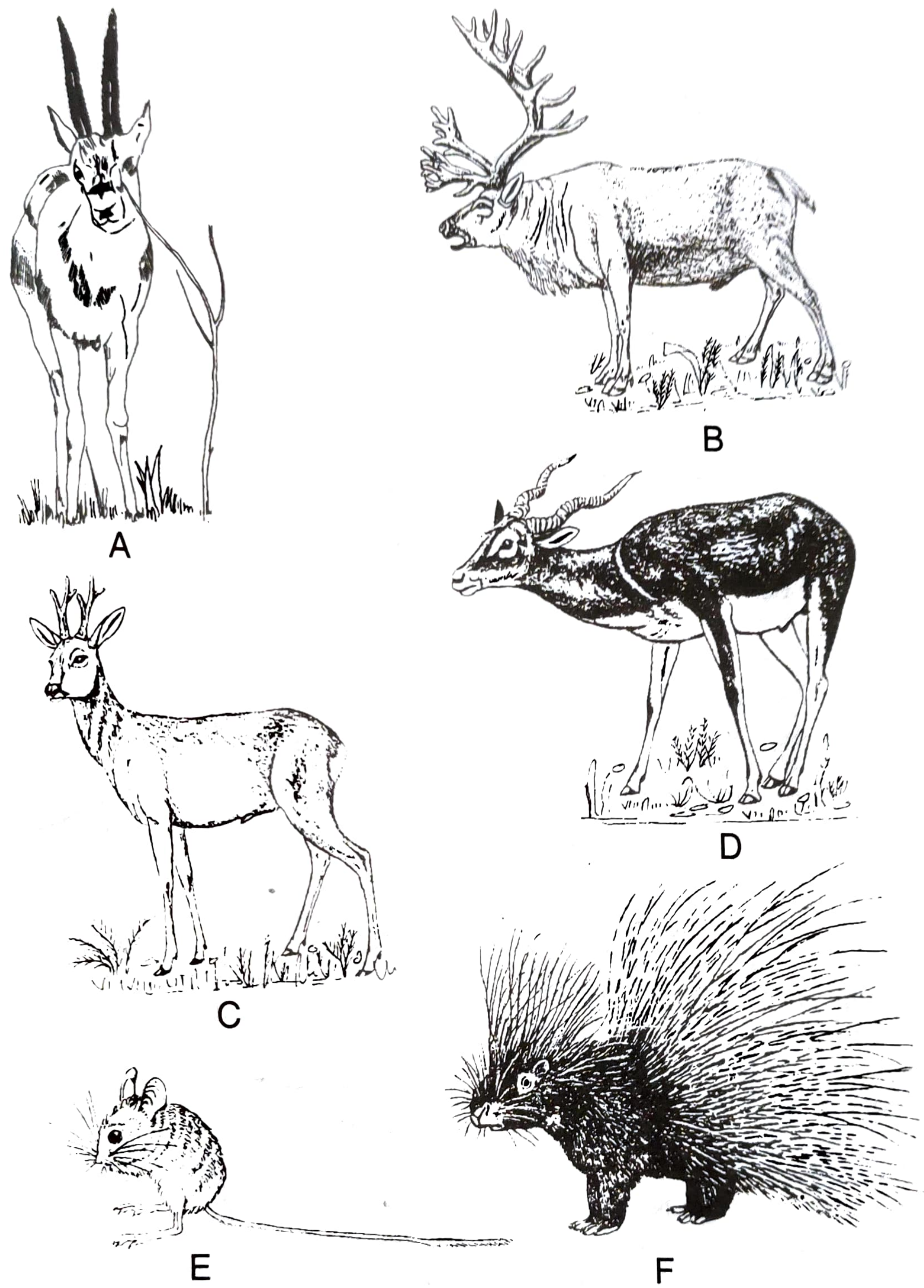

Fig. 12. A. Thompson's gazelle, **B.** Reindeer, **C.** Roedeer, **D.** Black buck, **E.** Hopping mouse and **F.** Porcupine.

these glands are used to mark their territory and mates. In Australian hopping mouse (Fig. 12) the scent glands are found below the chin which it uses to mark pups. In the camel the glands are situated on the neck which are rubbed against the object to be marked and plays an important role in mating. Black tailed deer has 5 different scent producing glands (Fig. 13), located at various places, producing different pheromones to carry out different functions.

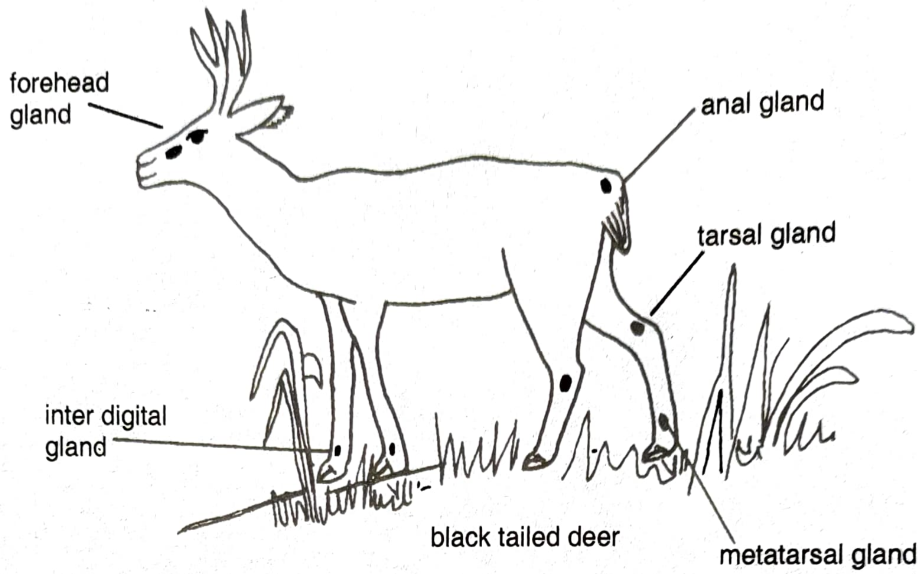

Fig. 13. Locationof different scent glands in black tailed deer.

FUNCTIONS OF SCENT IN VERTEBRATES

Not everything is known about pheromones and their secret functions. Much remains unexplored, decoding of chemical messages has been a difficult task. More than often, the pheromones have been used as marking agents, and for mating purposes in most of the mammals. The knowledge about their utility in other functions remains obscure.

Roth-Kolar observed that for animals, any new object was a source of unease until it had been made safe by marking. It gives them a sense of **belonging**. In one instance, a sleeping box of a fox was removed for cleaning and returned after being thoroughly washed, the animal found it unfamiliar because all its body scent was washed out too. The animal stayed out all night and was found dead in the morning due to cold. The familiar smell gives a feeling of safety and sense of belonging by receiving its own body scent from its dwellings, it gives them a feeling that "this area belongs to me and I am safe here."

The scent increases the **self confidence** of the animal. **Kühme** (1963) recorded that the African elephant, when facing a rival, during the breeding season will sometime turn his trunk round and smell his own temporal gland. This appeared to increase the animal's confidence and make him more likely to attack.

Scent plays an important role in sexual behaviour, the males mark their territories and ward off the rivals which is most commonly seen in deer and antelopes or the rivals do not tresspass marked territory as seen in tigers and other cats. This behaviour can be easily observed among dogs, frequent urination by dogs, on all possible landmarks is a way of marking objects within their territory. Scent brings two sexes together in most of the vertebrates.

Many animals **mark** their **trail** just to leave a record of their comings and goings to be read by themselves and subsequent visitors as in hippo and rhino. These sign posts are regularly visited and inspected by neighbours and thus each animal can keep a check on his fellows without actually seeing them, a newcomer in the area will at once be detected and may be challenged. By marking the pathway animal does not loose path and conserves energy by not finding the way afresh every time it moves.

Scent is used for **marking the territory**, the territory is first acquired by fighting, then the territory is loaded with animal's scent indicating that no more fights are required for this particular territory. Sometimes males also mark their mates with scent *e.g.*, male rabbit marks his female with his chin gland during mating. The male rabbit also marks the youngsters of his own group with his chin gland secretions. In certain animals, marking is often associated with a fight, hamsters mark a defeated rival and the marked animal subsequently retreats. Mice and rats similarly mark a defeated opponent with urine. A wildebeest sniffs her newborn calf to form a permanent olfactory bond with her offspring. The calf also sniffs mother for her odour. Many mammals, such as bighorn sheep, dogs often sniff and smell at each other and, when they do so, they can probably know the sex, the group it belongs to and its **readyness for mating**.

Arthur Hasler studied olfactory imprinting in salmon to understand homing in these migratory fish, as every salmon returns to the same river in which it had bred. Hasler writes that Salmon sniff their way home; according to him each stream contains a particular fragrances to which salmon become imprinted before going to sea and while returning they use this scent as a clue to identify their own tributary.

Important Questions

➤➤ *Long answer type questions*

1. Define pheromone and describe its primer and relaser effect.
2. Write short notes on : (i) Production and perception of pheromones, (ii) Helen-Bruce effect, (iii) Lee-Boot effect, (iv) Whitten effect.
3. Discuss the differences between pheromone and smell and write in details the functions of pheromones in invertebrates.
4. Write an essay on scent marking in vertebrates.
5. Write an essay on role of pheromones in invertebrates.

➤➤ *Short and very short answer type questions*

1. Write briefly on the following :
   (i) Discovery of pheromones, (ii) Names of different pheromones, (iii) Fabre's experiment, (iv) Yomoto's experiment, (v) Primer effect, (vi) Releaser effect, (vii) Lee Boot effect, (viii) Whitten effect, (ix) Helen Bruce effect, (x) Pheromones as sex attractants, (xi) Communication and pheromones, (xii) Use of urine and faeces in vertebrates for marking, (xiii) Names of animals using urine and faeces for marking, (xiv) Names of animals using saliva for marking, (xv) Names of animals using miscellaneous glands for marking.
2. Explain the following :
   (i) Lee Boot effect, (ii) Whitten effect, (iii) Helen Bruce effect, (iv) Primer effect, (v) Releaser effect, (vi) Functions of pheromones in invertebrates, (vii) Functions of pheromones in vertebrates.
3. Draw the diagram :
   (i) Scent producing glands in invertebrates, (ii) Scent receiving gland in invertebrates, (iii) Scent producing glands in ant.
4. Differentiate between the following :
   (i) Smell – Pheromones, (ii) Pheromones - Hormones, (iii) Lee Boot effect – Whitten effect, (iv) Whitten effect- Helen Bruce effect, (v) Primer effect – Releaser effect.

➤➤ *Multiple choice questions*

1. Pheromones were earlier called :
   (a) Kairomones (b) Allmones
   (c) Ectohormones
2. Chemicals used for communication between conspecifics are called :
   (a) Pheromones (b) Kairomones
   (c) Allomones
3. Chemicals used for communication with the members of other species are called :
   (a) Pheromones (b) Kairomones
   (c) Allomones
4. Chemicals used for the benefit of the sender only :
   (a) Pheromones (b) Kairomones
   (c) Allomones
5. Yomomto and coworkers extracted pheromone from :
   (a) Silk moth (b) Ant
   (c) Cockroach
6. Production of immediate effect in receiver by Pheromone is called :
   (a) Primer effect (b) Releaser effect
   (c) Both