A study on scent marking and its olfactory inhibition in the Indian musk shrew, *Suncus murinus viridescens* (Blyth)

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Studies on animal communication systems facilitate a better insight into the biology of social behaviour of animals. The methods of receiving a signal and performing an appropriate behavioural response vary considerably from species to species. Accordingly, our concepts on communication systems of many animals are still fragmentary (Sebeok, 1965; Marler, 1967; Smith, 1969).

Among the diverse modes of communication, the olfactory signals have considerable advantages over others such as visual, acoustic and tactile in their effectiveness over longer distances, their efficacy during dark and in not requiring the presence of a signalling animal (Mykytowycz, 1970; Eisenberg & Kleiman, 1972). Rubbing of specialised glandular regions on objects in the environment and concomitant transfer of the glandular secretion thereon is a common phenomenon observed in many mammals (Mykytowycz, 1965; Thiessen, 1968; 1976). Further, a number of mammalian species employ the secretions of specialised skin glands (Quay, 1976) to mark the environment indirectly, either by using different parts of their body to transfer the secretions (Frank, 1956; Müller-Schwarze, 1967), or in combination with other substances such as saliva, feces or urine which may act as a vehicle for the dissemination of the scent (Mykytowycz, 1968; 1970).

Despite the paucity of literature on the territoriality of shrews (Platt, 1976), the pronounced marking and sniffing of *Suncus murinus* (Balakrishnan, 1975; Balakrishnan & Alexander, 1976) suggest that olfactory communication is important in the social interactions of the species concerned. *Suncus murinus* possesses specialised cutaneous glands at the flank, perineal, throat, postauricular and oral lip and oral angle regions (Dryden & Conaway, 1967; Balakrishnan, 1975; Balakrishnan & Alexander, 1977 a; 1977 b; 1977 c) and the marking patterns of this species revealed the possible deployment of these glandular secretions in communication signals.

Since *Suncus murinus* is a recently acquired laboratory mammal and has an acute sense of smell, a detailed study on their marking patterns and influence of olfactory cues on scent marking would facilitate a better understanding of the ethology of this animal.

Material and method

Animals

Shrews were trapped live from the fields around the University Campus, Kariavattom using small rat traps, brought to the laboratory where sexes were identified. They were kept individually in wire mesh cages (300 x 200 x 150 mm), fed on minced beef sprinkled with shark liver oil with occasional insects (cockroaches). Tap water was given ad libitum. A total of twenty male and twenty female shrews were used for this study.

Procedure

Behavioural observations were made in large cement tanks (600 x 600 x 450 mm) between 19.00 to 22.00 h. Five stones about 50 x 40 x 25 mm in size were kept one at each corner and the fifth in the centre of the tank. A 10 watt bulb kept on, at about 150 mm above the top level of the observation tank was the only source of illumination in the room during the period of observation. The frequency of flank gland rubbing, throat rubbing, perineal rubbing, specialised grooming, urination, defecation, sniffing and the rate of ambulation in the tank were observed for 120 test periods of 15 minutes each, and recorded on a check sheet after every minute (Balakrishnan, 1975). After each session, the stones and tank were washed well with soap water, rinsed with dilute phenol solution and allowed to dry in air for overnight. Only one observation was made in a tank per 24 hours.

To evaluate the olfactory inhibition of diverse marking patterns in shrews, ten adult animals of each sex selected at random were individually caged in large cement tanks, with stones as objects arranged as mentioned earlier, covered over by a wire mesh lid. The shelter box, food and water bowls were also placed in the centre of the tank.

After 24 to 48 hours of occupation by the resident, the marking frequency of intruder was tested in the tank. Individually caged shrews selected at random from the stock pool served as intruders. One of such animals was introduced into the tank immediately after the removal of the resident along with its shelter box, food and water bowls, and the activities of this animal were recorded for 15 minutes. The behaviour of only one intruder was observed in the residential tank of an animal during the 24 hour period. Similarly, the behavioural activities of two males and two females were observed in the residential tank of one animal on consecutive days.

Marking and related behavioural activities were recorded in the following olfactory situations.

1. Marking by male in alien male's enclosure (20 test periods)
2. Marking by male in alien female's enclosure (20 test periods)
3. Marking by female in alien male's enclosure (20 test periods) and
4. Marking by female in alien female's enclosure (20 test periods)

Ten shrews of each sex selected at random, each observed twice in clean tanks, formed the control.

Results

Data on the marking frequencies of shrews in clean and contaminated tanks are given in Table 1.

Table 1 showing olfactory inhibition of marking behaviour; each mean is followed by its standard error

Behaviour	Sex	Type of test cage		
		Clean	Male home cage	Female home cage
Flank rubbing	Male	21.87 ± 3.95	5.33 ± 2.16 ***	3.58 ± 0.93 ***
	Female	20.12 ± 5.73	5.45 ± 3.84 **	2.90 ± 0.93 ***
Perineal rubbing	Male	10.50 ± 2.34	3.41 ± 1.10 **	3.25 ± 0.83 **
	Female	8.87 ± 3.36	3.00 ± 1.09 *	1.45 ± 0.55 **
Throat rubbing	Male	7.88 ± 1.40	7.50 ± 2.33	3.50 ± 0.94 *
	Female	4.00 ± 0.96	2.72 ± 0.90	2.18 ± 1.12
Specialized grooming	Male	30.00 ± 10.10	22.75 ± 7.12	28.50 ± 7.97
	Female	28.75 ± 7.29	0.63 ± 0.41 ***	7.09 ± 5.63 ***
Urination	Male	1.25 ± 0.20	0.25 ± 0.11 ***	0.25 ± 0.12 ***
	Female	1.37 ± 0.29	0.81 ± 0.09	0.63 ± 0.18 *
Defecation	Male	0.81 ± 0.09	0.25 ± 0.11 ***	0.25 ± 0.12 ***
	Female	0.62 ± 0.16	0.81 ± 0.09	0.54 ± 0.15
Movement	Male	15.87 ± 2.93	9.83 ± 3.11 *	9.00 ± 1.89 *
	Female	18.25 ± 3.19	11.18 ± 1.72 *	12.81 ± 1.72 *
Sniffing	Male	464.53 ± 38.09	621.08 ± 47.58 ***	704.25 ± 54.32 *
	Female	526.37 ± 69.49	675.45 ± 64.27 ***	791.45 ± 54.99 *

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Data analysed employing student's t-test. Each treatment mean is compared with the „clean" with d.f = 18.

1. Flank gland rubbing

Shrews of both sexes rub their flanks on sides of the tank and on objects, leaving the oily sebum thereon. Marking was normally performed as the animal moved forward. With all the limbs firmly on the ground, the body

was moved forwards and backwards pressing the gland against the object or the sides of the tank. Sometimes the animal remained still and repeatedly rubbed the region and in such cases each anterior movement of the flank was considered as one mark (Fig. a).

The frequency of rubbing the flank on the sides of the enclosure and on objects placed therein declined significantly if another individual had previously occupied the enclosure.

2. Perineal rubbing

Here a mark consisted of an animal lowering its posterior quarters and rubbing the region on the floor of the tank or on the objects on their way. Each anterior movement of the posterior quarter during such a behavioural act was regarded as one mark (Fig. b).

The perineal rubbing was also considerably reduced in both sexes on exposure to an observation tank previously occupied by other individuals of either sex.

3. Throat rubbing

Shrews rub their throat on the floor of the tank or on objects placed therein. Each anterior movement of the head whereby the shrews bring their throat region into close contact with the object concerned or the floor of the tank, was taken as one mark (Fig. c). A significant decline in the frequency of throat rubbing was discernible only when male shrews were introduced into the area previously contaminated by female shrews.

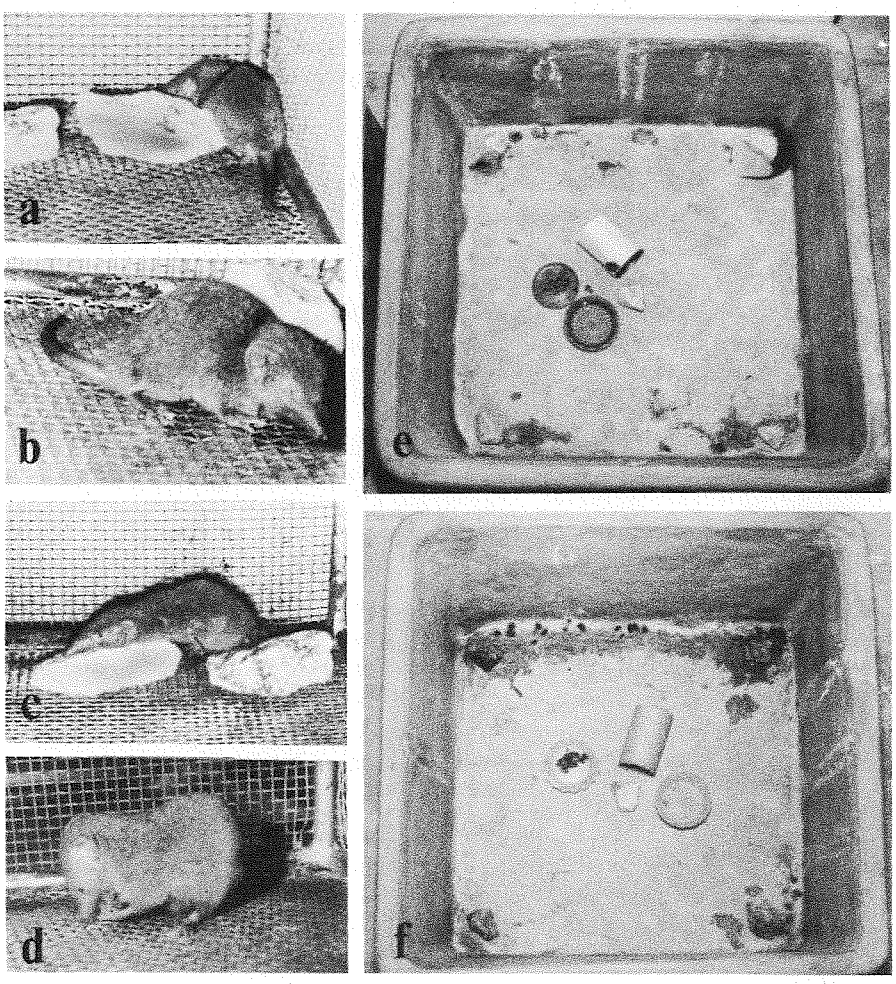
4. Specialized grooming

Specialized grooming employing paws was observed when shrews were introduced into a clean tank. It was noted that shrews groom the oral angle region from cheek anteriorly and move the paws in between the lips while sitting and lifting the head slightly (Fig. d). No direct rubbing with the oral lip zone was observed in this species. A complete passage of paws from the cheek to the anterior tip of the lip was regarded as one specialized grooming.

The frequency of this behaviour was found unchanged in males but significantly decreased in female shrews when they were observed in tanks contaminated by female or male shrews.

5. Urination and defecation

In addition to the earlier mentioned patterns of glandular marking, urination and defecation could possibly have some relevance in olfactory signalling. Shrews of both sexes would urinate and defecate at definite locations in the observation tank soon after they are introduced. Since they



Figs. a–f. Aspects of scent marking.

a. A male shrew rubbing the flank gland on a stone placed in its cage. Note the active marking with close touch of the flank on object.

b. Active marking on the floor of the enclosure by perineal region. Note the close proximity of the perineal zone and cage floor.

c. A male shrew actively marking the object placed in the enclosure with throat. Shrews mark objects placed in the cage as well as in the floor of the enclosure by means of throat rubbing.

d. Showing the 'specialized grooming' whereby the secretions of the oral lip and angle glands could be mixed up with saliva and passed on to the ground through their paws. Observe the typical grooming posture.

e. The observation tank after 24 hours of occupation by a male shrew. Note the urine marks and feces, mainly on the borders of the enclosure.

f. The tank after 7 days of occupation by a male shrew. Fecal pellets could be seen as black spots along the borders and corners. Urine marks could also be seen along the periphery of the enclosure. Note the colour change of the stones (objects) placed in the four corners due to the adhesion of glandular secretions while marking, and also by urine; whereas the one placed in the middle is more or less clear. Oily marks of the flank gland rubbing could be noticed along the side walls of the enclosure at the bottom level.

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urinate while moving and drag the posterior quarters on the ground, the urine mark some times could be seen as a line along the sides of the observation tank (Figs. e, f). Each bladder voiding was considered as one urine mark whereas each fecal dropping was regarded as one defecation.

The frequency of urination was considerably reduced in both cases of contaminated conditions, whereas the frequency of defecation of only male shrews was reduced under these experimental situations.

6. Sniffing and movements

Shrews of both sexes sniffed all around the cage, the objects which they come across and the surrounding air during exploration. The movement of the nostrils was carefully observed and the total sniffing rate per minute was recorded. They normally move along the sides of the observation tank. The frequency of complete trips along the periphery was treated as the unit.

Sniffing was significantly increased in those situations wherein an animal was placed in an area occupied by a conspecific of either sex. The sniffing rates of male shrews were significantly increased when they were observed in tanks contaminated by male and female shrews. The frequency of sniffing of female shrews was comparatively higher and it still increased when observed in the tank contaminated by other members of the same sex or by the opposite sex. In contrast to the sniffing activity, the ambulation on the floor of the observation tank was reduced in both the sexes. The movement of male shrews when observed in tanks previously contaminated by male and female shrews was reduced by 40–45 % whereas that of female shrews in an area contaminated by an alien female or male shrews was reduced to 30–40 %.

Discussion

Olfactory cues have a profound influence on the social behaviour of many mammals. Scent marking often has definite motives and accordingly it conveys specific signals (Marler & Hamilton, 1966; Mykytowycz, 1970). The intruders often try to steer clear of an area contaminated by the resident conspecific.

The ubiquitous occurence of scent glands in mammals indicates the salient role of these in the chemical communication systems of the species. The location of such glands at specific body sites of behavioural relevance facilitate an easy transfer of the secretions on to the objects in their environment. For example, scent marking by flank glands would be easy in the burrowing forms or those species making run ways through vegetation (Ewer, 1968) and the ant-orbital gland secretions of artiodactyles could be transferred onto twigs in the forest at an approximate height of its nostrils, facilitating easy perception for other members of the species (Müller-Schwarze, 1972).

Flank gland rubbing could be observed in shrews of both sexes when they were exposed to a new environment or to that of an alien member of the species. By deploying such a behavioural response, shrews of either sex mark the objects in the enclosure and walls of the observation tank with the secretions of their flank gland.

The post auricular glands which are concerned with the musky scent production in *Suncus murinus* have been reported to extend to the throat region of this species (Dryden & Conaway, 1967). Rubbing of the throat on objects would facilitate the transfer of the scent of these glands to objects in the environment as seen in the chinning and throat rubbing in rabbits and gerbils (Mykytowycz, 1965; Thiessen et al., 1971).

Shrews of both sexes rub their perineal zone on the ground and on objects. Rather infrequently they could be observed to lift up the posterior quarters onto the sides of the corners of the observation tank and mark at specific height. As the ducts of the perineal glands of *Suncus murinus viridescens* drain into the anal cleft (Balakrishnan & Alexander, 1977 a), feces may also be marked with the secretions as reported in rabbits (Mykytowycz, 1966; 1968; Mykytowycz & Gambale, 1969).

During the specialized grooming, the oral lip glands may be pressed and the secretions could be voided. This may probably be mixed with saliva and transferred on to the ground during their movements, thereby marking the runways and the ground by this mixture of glandular secretions and saliva. In fact, the oral lip area and occasionally the ground were observed to be wet after such grooming activity in *Suncus murinus viridescens* (Balakrishnan, 1975). This indicates the possibility of glandular secretions being mixed with the saliva and their subsequent transfer on to the ground. A similar behavioural response was reported in some rodents having specialized glands at the oral lip and angle (Quay, 1965). Deployment of saliva either alone or in combination with the secretions of specialized glands or body odour to convey olfactory signals of various types have been observed in quite a few mammals such as *Petaurus breviceps* (Schulze-Westrum, 1965), *Sminthopsis crassicaudata, Dasycercus*

cristicauda and *Antechinus flaviceps* (Ewer, 1968). They deposit saliva on objects to be marked by mounting or chewing. The tenrec, *Echinops telfairi* salivates on the object and later scratches with one paw alternately in the saliva and on its own body from head to hind quarters for a long time (Eibl-Eibesfeldt, 1965).

Urination and defecation could be observed in *Suncus murinus viridescens* within the first few minutes after exposure of the animal to a clean tank. Some animals urinated and defecated twice or thrice during the 15 minutes observation period. They mark the boundaries of the enclosures by urine and feces while moving and this may possibly help in depositing these along the territorial boundaries. Urination and defecation in novel environments are regarded as a sign of fear or emotionality in animals (Hall, 1934; Broadhurst, 1957; Denenberg, 1969). However, these behavioural responses observed in *Suncus murinus viridescens* do not indicate such a possibility since these markings were performed sometimes upto thrice during the observation period in the tank, and even after orientation to the environment by the prior exposure of the animal to the observation tanks concerned. Defecation may also facilitate olfactory orientation of the animal to its territory – makes it feel more at home. Further, urination and defecation have been reported to be associated with territorial behaviour in many mammals, (Welch, 1953; Mykytowycz, 1964, 1965; Mykytowycz & Gambale, 1969; Ewer, 1968; Thiessen et al., 1969; Mackintosh, 1973) including shrews (Platt, 1976). Captive shrews under laboratory conditions deposit feces and urine at definite places in the cage, particularly at the boundaries and corners in the form of small 'pellet mounds' (Figs. e, f). These marked sites were sniffed at a significantly higher rate by intruders.

The present study on *Suncus murinus viridescens* clearly revealed that the marking frequency of intruders of either sex was significantly reduced in an area established by another member of the species. Shrews of both sexes explored and scent marked at a comparatively lesser level in observation tanks previously occupied and contaminated by conspecifics of either sex, whereas the sniffing frequency was considerably increased (Table 1). Further, the urination and defecation rates of males declined significantly in a territory established by conspecifics.

This could possibly reflect on their behaviour of avoiding an area occupied by a conspecific in the field, probably to reduce conflicts. Since the previous occupant was removed from the experimental enclosure concerned, prior to exposure of the "intruder" the remnant stimuli were mainly the olfactory cues from the diverse marks laid by the earlier occupant, along with the visual signals of urine and feces deposition sites. This observation compares favourably with the earlier report on the Mongolian gerbil, *Meriones unguiculatus* (Thiessen, 1968) in which 88 % of the behavioural responses of male were depressed on entering a field previous-

ly contaminated by another member, whereas female gerbils were comparatively less affected, with depression of activities only about 58 %. The responses included glandular marking, sniffing, general activity, defecation and urination. Subsequent investigations on gerbils (Nyby et al., 1970) revealed that males experimentally introduced to enclosures of residents eventually decreased their marking to about 25 % of control males. Further, it is evident that gerbils can identify odours from conspecifics (Thiessen et al., 1970; Baran, 1973). A multimodel control of ventral marking of the gerbil, *Meriones unguiculatus* was observed with a major contribution from olfactory stimuli, supplemented with visual cues and cutaneous feed back (Baran & Glickman, 1970). However, Nyby et al., (1970) had reported that olfactory cues from residents were responsible for inhibition of marking frequency of Mongolian gerbil *Meriones unguiculatus* whereas visual and auditory signals were ineffective. The present study on shrews indicates that they would also mainly depend on the olfactory signals laid by the residents and the intruders mark at a considerably reduced rate.

In many species of mammals, marking was increased when the odour of a conspecific was encountered, unless the intruder had been defeated in a social encounter with the resident (Johnson, 1973). However, in the present study, the resident animal was removed prior to the introduction of the intruder, thus permitting only the olfactory interaction between the two. The intruder marked less frequently, showing its response against the olfactory signals laid by the resident.

In consensus, the flank, oral lip and angle, post-auricular and the perineal glands are involved in the scent marking of the musk shrew, *Suncus murinus viridescens.* The secretions of flank, throat and perineal glands are actively transferred on to the environmental objects whereas those of the oral lip and angle glands are passively transferred after mixing with saliva. These glandular secretions as well as the urine and feces are having a significant role in the social behaviour of this species. However, a more detailed investigation employing the various fractions of each of the secretory products, and bioassay of these on animals are warranted for an elucidation of the specific functional relevance of the secretions of specialized skin glands and urine and feces of the shrew.

Summary

The Indian musk shrew, *Suncus murinus viridescens* marks the objects in its environment by glandular rubbing, urination and defecation. The flank, throat and perineal regions were actively rubbed against objects whereas the secretions of oral lip and angle glands were mixed with saliva and passively transferred on to the environment. Urination and defecation were confined to specific sites, mostly at the corners of the enclosure. The frequency of flank, perineal and throat rubbing declined significantly in both sexes when they were observed in tanks contaminated by conspecifics of either sex. The specialized grooming was inhibited

in female shrews introduced into a tank previously occupied by other members of the species. The frequency of urination and defecation were also affected by the presence of olfactory cues left by the resident. The ambulatory score of the intruder is much lower in the tank of a resident, with an increased rate of sniffing.

Zusammenfassung

Die Indische Moschusspitzmaus *Suncus murinus viridescens* markiert Objekte ihrer Umgebung durch Drüsenreiben und Absetzen von Kot und Urin. Die Flanken-, Kehl- und Perinealregionen werden aktiv an Objekten gerieben, während Sekrete der Lippen- und Mundwinkeldrüsen mit Speichel vermischt passiv über die Handflächen in der Umgebung verteilt werden. Die Abgabe von Kot und Urin ist auf bestimmte Plätze, meist die Ecken des Käfigs, beschränkt. Die Häufigkeit des Flanken-, Kehl- und Perinealmarkierens sank bei beiden Geschlechtern in signifikanter Weise, wenn der Versuchskäfig mit dem Geruch eines Artgenossen, gleich welchen Geschlechts, behaftet war. Das Schnauzenwaschen (specialized grooming) wurde bei weiblichen Spitzmäusen gehemmt, wenn sie in einen Käfig gesetzt wurden, in dem zuvor ein Artgenosse gewohnt hatte; in ähnlicher Weise wurde die Häufigkeit der Abgabe von Kot und Urin beeinflußt Der Bewegungsdrang der Versuchstiere war in einem mit Fremdduft behafteten Käfig stark herabgesetzt, die Häufigkeit von Schnüffelbewegungen jedoch überdurchschnittlich hoch.

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