CHAPTER - XIV
SANDBATHING BEHAVIOUR OF GERBILS

1. Introduction

"Sandbathing", or "dustbathing", is displayed by heteromyids and gerbils; and by a number of other rodent species like *Peromyscus crinitus*, *Chinchilla lanigera*, *Dipus*, *Eutamias*, *Citellus* and *Glaucommys* species (Eibl-Eibesfeldt, 1958; Kirchshofer, 1958; Eisenberg, 1963). It is integrated with other behaviour components associated with care of body surface (COBS), as 'washing of face', grooming, sand-digging and scratching (Griswold, et al., 1977).

Bathings appear to restore pelage condition when it becomes, e.g. after deprivation or denial of substrate for bathing, matted and greasy (Borchelt, et al., 1976). Species typical patterns of behaviour reflect then the spatial distribution of sebaceous secretions onto pelage (Griswold, et al., 1977). However, the temporal organization of cleaning bouts is readily altered to suit requirements, for example after experimental modifications in pelage condition (Griswold, et al., 1977).

However, it is contended that the behaviour had it's main function in chemical communication; and became only secondarily been involved in dressing of pelage (Eisenberg, 1963). Such inherent complexity has resulted in more variations, between even the closely related forms. Apparently, each species requires separate study.
Sandbathing behaviour of the gerbil, *T. indica*, has not been studied. An account of it is given here.

2. Material and Methods

2.1. The Subjects: The subjects were trapped as adults from fallow lands. They were housed separately in the laboratory in wire-mesh enclosures, 1.32 x 1.00 x 0.32 m. Wooden nest-boxes, 20 x 10 x 9 cm. and paper-sheets, 30 x 30 cm. were given for nesting. The gerbils were fed on cereals (millet, *Pennisetum typhoides* + wheat, *Triticum aestivum*) and cabbage (*Brassica oleracea*). Water was given *ad lib*.

All cages were kept in a rattery (enclosed by wire-mesh on two sides) where L:D cycle varied naturally. Tests were, however, made early in the activity period. Only adults (body-weight > 100 g) were used. (Tab? ^± ?).

The observations, except of gerbils in one group, were completed within 2-3 weeks of capture. Controls were given sand for bathing in their home-cages; but not others.

2.2. Test Arena: Test arena was an all-glass aquarium, 0.90 x 0.45 x 0.35 m. with 10 cm. layer of sand for substrate (Fig. 32). It was situated in a room fitted with 60 watt red bulbs for lighting.
The subjects were carried in a square wire-mesh box with a sliding door for entry and exits (Fig. 33). They were released in the aquarium from a side-door. The observer (E) sat behind a screen of black cloth fitted on iron-frames, at a distance of 2 m. from glass front.

2.3. Experimental Procedure: The bathing actions were counted manually, and timed by stop-watch.

Bathings by all subjects were first studied in 10 min. sessions. After this, they were divided into 9 groups. Subjects belonging to each group were then tested after one of the following pre-treatments; or alternatively, in the social situations described.

2.3.1. "Wetting" of Pelage: In this, the pelage condition was modified by wetting the subject. The gerbil was transferred to carrying-box and showered with water from above the wire-mesh. After wetting, it was released in test arena; and it's bathing actions were counted for 10 min.

2.3.2. Application of Oil to Pelage (Symmetrical Modification): Symmetrical changes in pelage condition were made by applying oil (Lubricating oil, Singer Company Ltd.) to both right and left side of each gerbil.

For this, the gerbil was transferred from carrying-box to a specially-designed holding cage (Fig. 34). The subject was
Figure 32
The aquarium (0.90 x 0.45 x 0.35 m.) which was used as test arena, with a 10 cm. layer of sand substrate.

Figure 33
Square wire-mesh box (21.0 x 21.0 x 8.5 cm.) with a sliding door, used for carrying the gerbils.

Figure 34
'Holding-cage' (32.0 x 11.0 x 7.5 cm.) used for applying oil on the gerbils.
pressed firmly towards the "entry-door", and treated only after it had stopped struggling.

The oil was applied in every case from a syringe with blunted needle coated with wax as further precaution against injury. 1 ml. of oil was used in each application.

The subject was restrained in holding cage for some time to allow penetration of oil to skin, and then released in test arena for observations.

2.3.3. Application of Oil to Pelage (Asymmetrical Modification): The same procedure as described in 2.3.2. was used to alter the pelage condition asymmetrically. Oil was applied to only (a) right side or (b) left side or (c) back or (d) ventrum.

Following the application of oil, the gerbil was released in test arena for observations.

2.3.4. Deprivation Treatment: The subjects were allowed to live in the laboratory for four months, but were not given during this period any access to sand for bathing. They were tested after this.

2.3.5. Presence of 'Conspecifics': In this, both gerbils of a bisexual pair, paired at least a week before the test, were released together in the test arena. Bathing actions of each were counted separately.
Alternatively, the gerbils of the same or opposite sex were trapped from separate cages and released in the aquarium together. Interactions and bathings displayed were recorded.

2.4. Analysis of Results: The results were statistically analysed according to methods described by Bailey (1959) and Lehner (1979).

3. Results

The results are depicted in Figs. 35 to 41).

3.1. Description of Movements: Sandbathing behaviour of T. indica consisted essentially of side-rubs. The two sides were attended alternately. The only other component, identified vide the classification of behaviour patterns given by Eisenberg (1963), was the 'Ventrum-rub. Rubbing of chin often occurred separately from it, but rollings on back were not seen.

Side-rubs included well coordinated movements, or alternate extension and flexion of body. The movements occurred rapidly, but not after application of oil to pelage. The treated side was then pressed hard against the substrate, and each act took more than usual time to complete.

Ventrum-rub involved two main acts (1) lowering the body on the sand and (2) dragging of ventrum on it in the forward direction. However, stereotyped rubbings of ventrum were often displayed by the male gerbils.
3.2. **Frequencies of Components:** The non-deprived subjects released individually in test-arena performed bathing in between bouts of exploratory activity. The number of actions (side-rubs) was, however, limited to at most two. Sand-digging was also rarely observed.

3.3. **Relative Frequencies after Short Periods of Deprivation:** The gerbils denied access to sand for short period (2-3 weeks) displayed relatively more bathing actions than controls. The scores were generally higher for males than females (Fig. 35) and the difference was highly significant ($X^2 = 12.5$, $P < 0.01$).

Side-rubs were only performed; and the number of components directed towards each side was also found to be about equal (Fig. 35). Bathings occurred, however, at irregular intervals. There was much exploration, but very little sand-digging (Fig. 35).

3.4. **Frequencies after Long Period of Deprivation:** In subjects deprived of bathing for as long as four months, the pelage showed no visible signs of deterioration as matting of fur and greasy appearance. Except for one male thus, they displayed very little bathing. The number and sequential patterning of components was found similar to that of non-deprived subjects or controls.

The test-arena was explored for most of the time, but there was relatively more sand digging than that seen after short periods of deprivation.
The gerbils deprived of sand for short periods display side rubs. The number of rubs towards right and left are about equal. The bathing scores are higher for males than females. They show exploration and sand digging also.
Compared to frequencies of bathing patterns in subjects deprived for short periods, there was significant decrease in frequencies after long periods of deprivation (t = 21.3, P < 0.001; Fig. 36).

3.5. **Effect of "Wetting":** After wetting of their pelage, the gerbils bathed intensely by side-rubs; but no action was directed towards ventrum (Fig. 37). In rubbing the sides, the body was often turned on back slightly more than it was done usually.

The same side was often rubbed in a sequence of 2 to 4 actions, before attention was turned to opposite flank. Exploratory activity and sand-digging appeared after the bathing sequences, and not from outset as observed after deprivation (Fig. 37).

There was roughly a four fold increase in relative frequencies from base-line scores of subjects deprived for short periods (Figs. 35 and 37). The increment was obviously very significant (Wilcoxon test, P < 0.05). However, the number of actions on each side was not always equal (Fig. 37), but the differences were not significant either ('t' test, P > 0.1).

3.6. **Effect of Application of Oil to Pelage on Both Sides:** Application of oil to pelage on both right and left sides resulted in a large number of actions that occurred alternately towards either side. The rubbings were performed slowly than after wetting.
The gerbils deprived of sand for long periods display very little bathing. Most of the time the subjects dig the sand and explore in the cage.
After wetting of the pelage, the gerbils show intense sand bathing by right and left rubs. They explore and dig the sand after a few bathing sequences.
However, similar to the observations after the latter treatment, the behaviour was eventually interrupted by exploration. Sand-digging occurred simultaneously (Fig. 38).

There was again significant increase in relative frequencies of bathing patterns, in comparison for example, to number of actions displayed by both non-deprived and deprived subjects (Wilcoxon test, $P<0.05$).

3.7. **Application of Oil to Fur on Back:** This kind of treatment also produced an equal number of side rubs that occurred alternately as described in 3.6 (Fig. 39). The subjects also displayed no attempt to rub the ventrum or chin.

3.8. **Changes in Behaviour Patterns after Application of Oil to Right Side:** The gerbils treated with oil on the right side rubbed this side more than the untreated or left side (Fig. 40). The difference in the number of actions directed towards the two sides was very marked, and also highly significant in terms of Wilcoxon comparisons ($P<0.05$).

3.9. **Changes in Behaviour Patterns after Application of Oil to left side:** The same trend appeared after modifications made in pelage of left side. There was significant increment in relative frequencies ($P<0.05$), but proportionately more components were directed towards the treated, or left side, than untreated, or right side (Wilcoxon test, $P<0.05$; Fig. 40).
Figure 38

Application of oil to pelage on both sides of the gerbils results in a large number of right and left rubs, but gerbils perform slowly than after wetting. Exploration and sand digging also occur simultaneously.
Figure 39

Application of oil to fur on back of the gerbils results an equal number of right and left rubs, occur alternately. Exploration and sand digging did not take place as in other cases.
Figure 40

Treatment of left or right side only with oil results prominent rubs towards the treated side than untreated.
3.10. **Effect of Oiling the Pelage of Ventrum:** The subject treated with oil on ventrum displayed similarly many ventrum-rubs or drags, but some side-rubs were also performed (Fig. 41). The difference in frequencies of two components was significant (Wilcoxon test, \( P < 0.05 \)), but no sequential relationship between them was detected (\( P > 0.01 \)).

Exploration and sand-digging appeared late as after other treatments. There was, however, more sand-digging, which also occurred in a typical manner. The sand was pushed below ventrum by hand, and then kicked backwards by feet.

3.11. **Behaviour Displayed in Presence of Conspecifics:** Strange male gerbils brought together in test arena attacked each other almost continuously. However, the dominant individual 'foot-stomped' and kicked sand repeatedly while approaching the submissive male. Only one of the 15 males tested, showed stereotyped ventrum-rubbing like that described for *Heteromys* (Eisenberg, 1963) or *M. unguiculatu* (Thiessen and Yahr, 1977). It was followed by side-rubs before approaching the opponent again. Apparently, however, there was no bathing as performed by males individually.

Strange females also showed hostility but bathed a few times at separate loci before resuming exploration or agonistic postures.
Figure 41

Application of oil to the pelage of ventrum display intense ventrum rubs. Very few right and left rubs are performed. Sand digging appear after the actions.
Subjects of the opposite sex when released in test-arena evinced, however, much interest in each other. There was much chasing of female by male, grooming of each other, nosing and some attempts at mountings. The females then selected a locus, dug it and bathed by side-rubs, before selecting another. The male dragged the ventrum and rubbed it's side at each locus selected by females. Thus, the bathings by mates occurred in a sequence, or pattern; though it was also subjected to individual variations.

4. Discussion

Most rodents possess an integrated system of behaviour patterns for coat care, or care of body surface (COBS) (Griswold, et al., 1977). This includes 'washing of face', grooming and scratching (Barnett, 1975). It is, however, observed that a number of species bathe in substrates as sand or dust to dress their fur (as referred to in the Introduction). The bathing behaviour, like grooming has, however, other important aspects too; each of which apparently requires separate discussion.

4.1. Development of Behaviour: Bathing by rodents, or stereotyped rubbings of body against the substrate, probably started with the cleaning of fur in an area above and around the "ventral glands" developed to produce sebum for scent-marking (Thiessen and Yahr, 1977). This condition is still found in some species
(Eisenberg, 1963), from which it has been concluded that the primary function of behaviour lies in chemical communication; while its involvement in dressing pelage, even though now extensive, is only secondary (Eisenberg, 1963).

Thus, the behaviour as now displayed consists of three components ventrum-rubs, side-rubs and rollings on back; which involve an equal number of fundamental acts (1) rubbing by an extension and flexion of body (2) rolling on back (3) wriggling from side to side (Eisenberg, 1963). All of these, as also pointed out, are universal motor patterns in vertebrates. Thus, it is by integrating, or acting upon a few basic acts that natural selection has produced functional bathing patterns.

Accordingly, possible changes with specialization have not emerged; there is no distinction between components used for spreading sebum or dressing pelage. It appears then that development of special structures, as combs on toes by ctenodactylidae (George, 1978), are more important adaptations for coat care in rodents than sandbathing.

4.2. Bathing Patterns Found: The bathing patterns in species studied are, however, not similar. They differ widely, and may be regarded even as species-typical (Griswold, et al., 1977). However, variability within the species is found to exist because of the non-integration of acts or lack of components (Eisenberg, 1963).
Thus, ventrum-rub is the only action used in bathing by heteromyinae, but it is integrated with side-rubs in other heteromyids (Eisenberg, 1963). In contrast, Meriones persicus rolls on back, while writhing from side to side (Eibl-Eibesfelder, 1951). The same actions are displayed by Chinchilla (Eisenberg, 1963). However, side-rubs occur to the exclusion of both ventrum-rubs and rolls on back, in bathing behaviour of Gerbillus nanus (Kirchshofer, 1958).

4.3. Patterns of Bathing in T. indica: The bathing pattern of T. indica is apparently similar to that of G. nanus. Thus, side-rubs are mainly performed. The sides are rubbed alternately, and a sequence of actions directed towards the same side, as in heteromyinae (Eisenberg, 1963), is seldom observed. Components as rolls on back and wriggling from side to side, are absent.

However, some differences are also obvious between the two gerbils. Thus, T. indica also display though infrequently, two ventral rubbing components. One of them is no more than a 'drag on ventrum' (Barnett, 1975). However, the other, associated with offensive behaviour of male gerbils is similar to stereotyped ventral rubbing used for scent-marking. It would appear that none of the two bathing behaviour components, have been described for G. nanus. It has, however, not been extensively observed either.
4.4. Functions of Bathing in *T. indica*: The bathings in the substrate by *T. indica* appear to serve, as found in many other species, functions in two different areas.

4.4.1. **Dressing Pelage**: The behaviour is prominently related to cleaning of fur, or dressing pelage in the larger context. That amounts to removal by rubbing in substrate of (1) sebaceous secretions, mostly lipids, coming onto pelage and (2) similarly the materials that get stuck, or are applied, to it. It allowed to accumulate or adhere, the fur is likely to be matted (Borchelt, et al., 1976). Bathings restore pelage condition.

Of actions performed, side-rubs are obviously used to dress the fur on dorsum. Thus, the same actions can be used to dress pelage on back, if attempted for example at fringes of depressions made in substrate. This has actually been seen in natural environment, but only partially in test arena which contained sand.

Possible use of ventrum-rub to dress pelage of the underside, is also compensated by digging of sand. Digging of sand probably cleans the soles and pads on feet and the fur on limbs, while pressing of sand beneath removes the materials adhering to fur on ventrum.

Grooming and scratching are also observed with bathing, but interrelationships, if any, are subject to wide individual variation. Integration of COBS components has been proved in Kangaroo rats, *Dipodomys merriami* (Griswold, et al., 1977).
4.4.2. Chemical Communication: Ventrum-rubs, if not involved in pelage dressing, are perhaps used by gerbils for spreading substitutes to sebum or urine and secretions from perineal glands (Eisenberg, 1963; Barnett, 1975). The pheromones may be of help in demarcating territory. But as ventrum-rubs are always integrated with side-rubs, it appears that the same scent plays a role even in individual identifications. This is also evident from behaviour of mates in test-arena, for male gerbils are observed to drag ventrum and rub the sides at locus of females.

Apparently, the same signals are meant (1) to deter the intruding males (2) while attracting the females.

4.5. Temporal Organization of Bouts: Sandbathing is, however, interrupted to variable degrees by exploration; and wide individual differences are thus noticed in the data. Still, the rubbings and sand-digging appear to be strongly correlated. However, grooming and scratching are only occasionally used for cleaning fur, and have no similar relationship with bathing as sanddigging. Thus, sandbathing with sanddigging, forms the main part of COBS phenomenon in gerbils; while other components are secondary.

Temporal organization of cleaning bouts is also strictly controlled, notwithstanding the variations allowed in number of actions, and their sequential patterning; as found in Kangaroo rats (Griswold, et al., 1977). Thus, side-rubs are main components;
and ventrum-rubs whenever they appear, are integrated with it. Absolute frequencies are normally low.

4.6. **Behaviour Patterns Displayed After Deprivation:** The effects of deprivation, or denial of substrate for bathing, have been studied in Kangaroo rats, (Borchelt, et al., 1976; Griswold, et al., 1977). Their fur becomes matted and greasy due to accumulation of sebaceous secretions. Consequently, significant increments take place in bathing actions on access to substrate again. The actions tend to "cluster" at the beginning of bout, while other COBS components and exploratory activities appear late (Griswold, et al., 1977).

The pelage in gerbils shows the same signs of deterioration within a few days of deprivation. But the results found after short and long periods of deprivation, are not similar to that described for Kangaroo rats. Thus, although short periods of deprivation produce significant shifts in behaviour patterns, relative frequencies of actions for subjects deprived for much longer periods are very low (Figs. 35 and 36).

The differences found are accountable if possible use of paper, given as it was for nesting; as substitute to substrate for cleaning fur is considered. Thus, shredded and used in lining the nest-boxes, the paper may have absorbed sebaceous secretions by contact; or may be when the rubs were attempted directly on it.
This is possible as bathing acts are displayed by gerbils often on wire-mesh floor of cages.

Incidentally, this has some relevance for selection of nesting materials, specially in the natural environment.

4.7. Alterations of Cleaning Bouts: Treatments like (1) "Wetting" (2) application of oil simultaneously both to right and left sides of body (3) and that to fur on back, release intense bathing by side-rubs (Figs. 37 to 39). Relative frequencies are significantly high, as compared to subjects deprived for short periods (Wilcoxon comparisons). The sides are attended alternately, while the actions tend to "Cluster" at beginning of bout. However, the basic organization of cleaning bouts is not affected by these modifications in pelage condition. These can be considered thus as "symmetrical" modifications, which include, it may be emphasized, application of oil on back. Thus, the fur on back is also cleaned by side-rubs, as contended earlier.

In contrast, treatments as application of oil to (1) right side (2) left side and (3) exclusively to ventrum, have different effects. Thus, although relative increase in number of components performed is about the same as with other treatment ($X^2$ test, $P<0.05$), proportionately more actions are directed towards the treated than untreated side (Wilcoxon test, $P<0.05$; Figs. 40 and 41). "Clustering" of actions at beginning of bouts is again observed; but their temporal organization is obviously affected by asymmetrical modifications.
It would appear that bathings are thus directed in response to spatial distribution of materials adhering to pelage. Thus the temporal organization of cleaning bouts is altered to suit requirements, as in Kangaroo rats (Griswold, et al., 1977).

4.8. Responses to Type of Materials Adhering to Pelage: However, significant shifts in relative frequencies occur after treatment of pelage with lanolin, but not water, in Kangaroo rats (Griswold, et al., 1977). This has been attributed to differences between quality of two materials; for water dries up rapidly while in comparison lanolin, or oil, adhere strongly and require cleaning operations for longer periods. These findings are, however, not consistent with present observations on gerbils.

The gerbils show rather quick reflexes after wetting while there is gradual slowing down of pace of motor patterns after application of oil. Evidently, water is easily removed than oil, which requires hard rubbings. However, relative increments in frequencies after treatments with both are about equal, unlike in Kangaroo rats (Figs. 37, 38 and 40).

Probably this difference in response to materials between the two species has some adaptive significance. The gerbils inhabit the regions that also receive regular rainfall, and cleaning of fur. Wet with water may be found necessary during some periods. Unlike them, Kangaroo rats live in an environment where rainfall is scanty, and such exigencies do not arise.
Thus, such responses are influenced by environmental factors.

4.9. Testing of the Substrate: Often the time-lag or interval between release and bathing by subjects in test arena was very small. It may be then conjectured that cues to substrate, particularly about its texture, are transmitted via the soles and pads of feet. Possibly sensations received at the same locations initiate sand digging. It is, however, observed that sand is also lifted and eaten by hands in small amounts. If it has something to do with testing of substrates, then visual cues may also be important. It appears that testing of substrates occurs in many ways. However, further investigations are required to clarify this point.

4.10. Regulation of Sandbathing Behaviour of gerbils, *T. indica*: Sandbathing behaviour of gerbils is highly stereotyped. Its distinctive features are: (1) stable organization (2) one main component, or side-rubs that involve alternate extension and flexion of body, to dress the fur. Ventrum-rub, if it occurs, is integrated with side-rubs. Bathing may be integrated even with other COBS, but this is not evident from present data.

Patterns of bathings displayed by gerbils are also consistent with functions that it seemingly performs, of (1) dressing pelage and (a) spreading pheromones to assist in chemical communication. It is, however, prominently related to dressing pelage in gerbils, as in Kangaroo rats (Griswold, et al., 1977).
It can be deduced from above that patterns of bathing displayed reflect the typical patterns of sebaceous secretions onto their pelage (Griswold, et al., 1977). This is to suggest that more secretions are given out on dorsum than on ventrum of gerbils. Thus, side-rub is the only component required for cleaning fur; though it has been substituted by rollings on back in other species.

However, the temporal organization is readily altered with topographical changes in pelage condition (Figs. 40 and 41). Variations also occur as to the type of components performed. Such ability to adjust the behaviour has also been demonstrated in other species, e.g. Kangaroo rats (Griswold, et al., 1977).

These changes in patterning of behaviour components can be taken as evidence of two things: (1) that peripheral input regulates the behaviour and (2) which is elicited from a central neural mechanism. Conclusions derived from observations of behaviour in Kangaroo rats, are also similar (Griswold, et al., 1977).

Summary

Sandbathing behaviour of gerbil T. indica, consists mainly of side-rubs, but ventrum-rubs are also performed. Frequencies of bathing action are normally low, but significant increments occur with modification in pelage condition. The behaviour is rapidly adjusted to the topographical variations in pelage.
The results suggest that the behaviour is regulated by peripheral inputs. Evidence of the existence of a central neural mechanism coordinating bathing, and integrating it with the COBS components, is also given.