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Behavioural analysis of feeding and breeding in Lamellicorn beetles

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Abstract. Social behaviour is recognised in nine families of Coleoptera. The Lamellicorn beetles, in the families Passalidae and Scarabaeidae exhibit varying types of social behaviour.

Sound production by stridulation in both the larvae and adult passalids is attributed as a social behaviour to hold the families together.

Some South American scarabs live very close to the anus of sloths and monkeys in order to oviposit on their dung. Many have association with ant nests either for food, shelter or breeding.

The dung beetles present a whole sequence of bisexual cooperation in the nesting behaviour, excavation and ball-rolling. Parental care is exhibited to a varying degree.

An attempt has been made to review the feeding and breeding behaviour of Lamellicorn beetles in the light of available Indian literature including studies made by the authors.

Keywords. Behavioural analysis; Lamellicorn beetles; feeding and breeding behaviour.

Feeding and breeding habits seen in many Lamellicorn beetles are fundamental features of their biology which determines the characteristics of their behaviour, distribution, morphology and development. Their food habits are varied but most of the free living scarab adults and larvae are saprophagous or phytophagous. In addition many members belonging to the six subfamilies, the Scarabaeinae, Aphodiinae, Ceratocanthinae, Melolonthinae, Dynastinae and Cetoniinae are found in the nests of ants, termites, honey-bees, wasps etc.

Although "Truly Social" or "Eusocial" species which meet three criteria like living in groups as adults of different generations, with co-operative activity and different individuals performing different roles for the success of the colony, are not found in scarabs, yet varying types of social behaviour are encountered especially in Passalidae and Scarabaeinae.

The hind legs of larvae of the scarabaeoid families Lucanidae and Passalidae and the subfamily Geotrupinae often have stridulatory organs on the coxae working against those of the middle legs. In Passalidae the great reduction and modification of the hind legs has little effect on locomotion but are believed to be of great help in communication by stridulation to hold the family together which is attributed as a social behaviour.

The Passalids are considered to have a primitive society. They are gregarious living in the same tunnel system but during reproduction, each beetle maintains its own tunnel, lays eggs. The developing young feed on the material prepared by the adults. The wood consuming species lack digestive symbionts and mix fecal pellets and frass which act as a substrate for bacterial and fungal development, as was found by Matthews and Matthews (1978) in *Odontotaenius disjunctus* whose larvae cooperate with the adults in the construction of the pupal chamber. Parental care is also exhibited in passalids.

Two species of passalids are commonly found in the decaying, wet logs in the evergreen forests of the Western ghats in Karnataka. These two species *Episphenus indicus* (Stol.) and *Plaurarius brachuphyllus* Stol. are often in the same log, side by side

but will have distinct tunnels in which their own larvae are lodged separately, thus exhibiting a niche behaviour. The larvae, like adults, are gregarious, 3 cm long, with well developed first two pairs of legs, the hind legs being greatly reduced and stubby. These larvae live very close to each other in the tunnel and move quickly to come together when separated.

In Cetoniinae, the adults are usually phytophagous and the larvae feed on dung, humus or decaying wood. However some species become adapted to the nests of ants and termites. *Potosida cuprea* spends the larval and pupal stage in the nests of *Formica rufa* in Europe (Wheeler 1910). Larval cases are generally ignored by the ants as they look like lumps of earth. Other cetoniids like *Potosia cuprea* (Fab.) and *P. lumgarica* Herbst feed as adults upon honey in bee hives while the larvae feed on decaying organic matter (Caron 1978).

In South Africa the larvae of the green protea beetle (*Trichostetha fascicularis*) live on termite droppings for two years in the mound of the termite *Amitermes hastatus*, whereas the adults are flower feeders (Skaife 1955).

A cetoniid beetle *Coenochilus taprobanicus* Westwood and a valgine scarab *Oreoderus argillaceus* (Hope) are commonly found in the nest of *Odontotermes wallonensis* in South India. They feed on the fungus reared by the termites (Rajagopal and Veeresh 1981). According to Kistner (1982) the principle adaptation here seems to be the conditioning of the wood by the termites rather than social interactions with similar eating habits.

The Cetoniiae beetles having predaceous food habit is reported from North America and India. Adult *Cremastocheilus stathamae* Cazier (Cetoniinae) are obligate predators of the ant larvae in the nests (Cazier and Mortenson 1965). Another interesting feeding behaviour of a cetoniid beetle *Spilophorus maculatus* (Gory and Percheron) has been reported by Ghorpade (1975) from Southern India. These beetles feed on the nymphs of the treehopper *Oxyrhachis tarandus* Fab. occurring on *Acacia concinna*. Cremastocheilini feed on a variety of insects but it is not known whether they became predaceous before or after their invasion of ant nests.

The two genera *Chaetopisthes* and *Corythoderus* of Aphodiinae, are found with *Odontotermes* sp. in India. *Chaetopisthes assmuthi* Wasmann is quite common in the nests of *Odontotermes obesus* (Rambur) (Wasmann 1903). Although these beetles are normally found in the fungus gardens, they may also occur in the royal cells. The termite workers find the trichomes attractive and carry the beetles from place to place and the beetles feed on the fungus (Kistner 1982) but how this help the termites is not known.

Melolonthines are rarely reported from ant and termite nests. A species of *Diplotaxis* is reported from the nest of *Pogonomyrmex occidentalis* (Idaho, USA) and a species of *Maechidias* in ants and termites nest is reported from Australia (Lea 1910).

The Dynastid, *Coelosis bilobata* Linn. found with *Atta sexdens* in Brazil is supposed to be the largest of all the myrmecophilous arthropods (Eidmann 1931). The adult beetles lay eggs in the leaf mulch which are carried to the fungus gardens where they live in oval earthen holes and feed on fungus.

Nest making reaches its epitome among dung and carrion feeding Scarabaeinae (Eickwort 1981). Since the food source, dung or carrion, is ephemeral and randomly scattered it should be removed and protected from desiccation and has to be buried before egg laying. Both sexes frequently participate in food provisioning, defence and prevention of fungus contamination resulting in parental care and true subsocial behaviour.

The peak of subsocial behaviour is seen in *Cephalodesmius* and *Necrophorus* in which larvae are provided food by regurgitation (Wilson 1971). In *Cephalodesmius* the male is responsible for foraging and the female molds the food into 'cake' and allow it to ferment for two weeks adding adult feces to it. This "home made dung" is thus partitioned by the female into six to ten brood balls. The male and female remain in the nest till their offspring emerge as adults (Halffter 1977).

According to Halffter and Matthews (1966). "Scarabaeine beetles live in a world of smell and touch almost exclusively and that a suitable ambient temperature is the first requisite for activity". Olfaction seems to be the dominant sense of scarabaeines, image perception not being that dominant due to poor vision. Light is used perhaps only for orientation. Sound production although exists in most scarabaeinae, auditory stimuli is very less. Tactile perception seems to be highly developed particularly in ball-rolling beetles.

Considering the Scarabaeinae as a whole, the food used by the majority of the species both for the larvae and for adult is the excrement of large animals, particularly of mammals and man, suggesting that these beetles are coprophagous. However other types of food habits, among the scarabaeines are not very rare.

Necrophagy is found in one genus *Onthophagus* in South America and India. A number of species of *Onthophagus* are known to be carrion feeders in India. *Onthophagus igneus*, *O. unifasciatus*, *O. pygmaeus* and *O. kchatriya* were found in the carcasses of crows and frogs in Bangalore (Veena Kumari 1984).

Saprophagous scarabaeids are not uncommon. There are different types of saprophagous Scarabaeinae feeding on leaf litter, vegetable debris, decaying fruits, fungi etc.

Predatory habits among the scarabaeines are rare except a Brazilian species of *Canthon* which attacks ants of the genus *Atta* (Navajas 1950).

In addition, there are several special ecological niches where the scarabaeines are found, although their food habits are not well defined.

There are reports of scarabaeines on ectocommensals of mammals like monkeys in Brazil, sloths in America, kangaroos and wallabies in Australia.

As endoparasites of mammals there are reports of scarabs causing 'Scarabiasis' in India among human beings resulting in recurrent intestinal illness accompanied by bloody diarrhoea due to *Onthophagus bifasciatus* (Fab.) and *Caccobius vulcanus* (Fab.) (Senior-white 1920; Iyengar 1923).

In recent years there are reports of Scarabaeinae, mainly *Onthophagus*, occurring in nests and burrows of vertebrates, particularly in rat burrows.

Examples of termitophily and myrmecophily in Scarabaeinae are many. Arrow (1931) has reported presence of *Sisyphus longipes* in the nest of *Pheidole rhombinoda* in Madras.

Largest number of Scarabeinae are known from Grassland biomes and Forest ecosystems. High mountain colonization of these beetles is known from the Himalayas. Various species of *Copris* are known to climb high mountains between 2000 and 2500 m. *Caccobius himalayanus* Jekel has been collected frequently at 3000 m and *Onthophagus tibetanus* Arrow lives between 3000–4200 m in Sikkim and Tibet. The highest locality known for any scarabaeid is that of *O. cupreiceps* which is found at 5200 m and the same has not yet been collected below 4000 m (Arrow 1931; Balthasar 1963). Feeding and breeding behaviour of these high altitude scarabs are not known clearly.

Fossilized scarab brood balls have been described from various tertiary deposits in South America, which demonstrate nidification behaviour at a fairly advanced level in Scarabaeinae, as early as in the lower Oligocene (Balthasar 1963).

Detection of food and approach behaviour like search flight, altitude of flight, distance at which the smell of food is first perceived in the Scarabaeinae are not fully understood. These behaviours differ from species to species and place to place depending on the source of food.

Most of the dung beetles land a little away from the pat and crawl towards the food. Some, like most Coprini come to semiliquid cow dung immediately after deposition, and utilise it in that state. In the case of human excrement many species come a few minutes after deposition of the feces. The Eucraniina dung beetles habitually go to dry excrement under semi desert conditions. *O. tritinctus* is found attracted to dry dung in Bangalore (Veena Kumari 1984).

Feeding behaviour differ from group to group. Adult Scarabaeinae and Geotrupinae nearly always bury the food both for themselves and for their larvae directly beneath or beside the food source. In the genus *Gymnopleurus* most of the species feed at the surface. *G. miliaris* and *G. spilotus* recorded from Bangalore fall under this category.

Overland transportation of food without formation of ball, is done in three ways: (i) carry food with forelegs and walk backward towards the burrow e.g. *Copris* spp. and *Onthophagus* spp. (ii) pieces of food rolled away from the source without making balls and walking forward and pushing with its head and forelegs. This "butting" technique is seen in *Onthophagus tritinctus* (iii) the beetle grasps the food with the forelegs and head, and elevating the fore body it runs rapidly forward on the remaining four legs as found in Argentine subtribe Eucraniina (Kolbe 1905).

Overland transportation with formation of ball is common to the tribe Scarabaeini with a few exceptions. Ball rolling behaviour of dung beetles has been studied in detail in various parts of the world (*Scarabaeus* spp., *Gymnopleurus* spp., *Sisyphus* spp. and *Canthon* spp.)

The biological advantage of ball rolling is that the ephemeral food source, scattered randomly has to be protected from competition from other insects and desiccation.

The ball rolling behaviour seems to have originated with the habit of carrying more or less spherical pellets such as those of rodents, lagomorphs and caprines and later they might have developed other techniques for rolling (Halffter and Matthews 1966).

Ball making behaviour, initiation of ball rolling, the role of sexes in ball rolling, the direction in which balls are rolled, distance rolled and burial of the ball have all been well documented for several species from many parts of the world and the same is beautifully summarised by Halffter and Matthews (1966). The above behaviours are well exhibited in *Gymnopleurus miliaris*, and *Gymnopleurus geoffroyi.*

Nidification behaviour in Scarabaeinae may be classified into four groups:

(i) Egg laid directly in the food mass packed into the blind end or branch or a burrow dug near or under food source e.g. *Onthophagus* spp., *Onitis* spp.

(ii) Egg laid in a pear shaped shell covered with soil, constructed under the food source e.g. *Catharsius* spp.

(iii) Spacious underground chambers are constructed near or under the food source, a large mass of dung is compacted and then divided into several brood ovoids containing one egg each not enveloped in a clay shell. Male and female remain in the nest till the larvae develop. e.g. *Copris, Synapsis, Catharsius* spp.

(iv) Formation of ball of food on the surface and rolling away on the surface and

laying an egg in it. e.g. *Gymnopleurus, Scarabaeus, Sisyphus* etc.

Male and female cooperation in ball formation and burying the dung, combat and parental care have been reported from a number of species like *Copris hispanus, Copris lunaris, Heliocopris dilloni* etc.

The larval behaviour of some of the Scarabaeinae are interesting. In *Copris repertus* the larva repairs the breech in the brood ball if it is damaged. Also the larvae make a scratching noise when the ball is touched. This noise is a result of scratching the inner wall of the ball with its mandible. Melolonthine beetles emerge at a particular intensity of light (foot candle) in the evening after the first summer rains and get back to the soil early morning at the same intensity of light. Although rain is a must for adult emergence yet unless the gonads are well developed, the young ones will not emerge inspite of the rains. *Holotrichia serrata* needs a minimum of 23°C soil temperature for its gonads to mature (Veeresh 1983).

Among the phytophagous lamellicorn beetles some species show strong tendencies towards a particular host plant, the presence of which decides the distribution of the pest. Adults of *Holotrichia serrata* F. goes only to neem plants *Azadirecta indica* in the midst of several of its host plants. Likewise adults of *Holotrichia nilgiria* Arrow has decided preference to *Ficus racemose* and the pest distribution is confined around the adult beetle's, host plants, in coffee plantations. Similarly *Holotrichia reynondi* Bl. concentrates around *Moringa oleifera* to which it is highly attracted.

Concentration of *Holotrichia* to a particular patch of field seems to be guided by the adults egg laying behaviour, which in turn is influenced by the first few adults going to a particular side of a host tree or a particular patch of a field for egg laying. There is a strong tendency of the beetles following a pheromone trial (Veeresh 1983).

The *Leucopholis* spp. have no attractive adult host plants. *Leucopholis coneophora* female attracts the male while it is still in the process of emergence and more often it gets back into the soil from where it has emerged, for egg-laying.

These are but a few scattered reports of behavioural analysis of feeding and breeding in this vast and widely distributed group of Lamellicorn beetles. Except for a few reports, nothing is available from India on the behaviour of Lamellicorn beetles. Many more fascinating accounts of behaviour particularly of Scarabaeinae will come to light if more and more attempts are made on these abundantly available beetles.

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