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Observation on life cycle and nesting behavior of dung beetle *Onthophagus Catta* (Fabricius)

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Abstract
The adults of dung beetle *Onthophagus catta* (Fabricius) are powerfully attracted to the fresh cattle dung. These dung beetles are well distributed in South-Western Maharashtra. The life cycle and nesting behavior of this beetle are studied under laboratory conditions. The beetle construct simple nest composed of single unbranched galleries. At the bottom end of each there may be one or two brood balls are lodged. The depth of brood balls constructed ranges from 6 to 22 cm. The length of brood ball ranges from 22 to 34 mm with average of 27.7 mm. The diameter of brood ball ranges between 13-18 mm. It is observed that single pair of this dung beetle has constructed 10 to 35 brood balls in laboratory condition. The female dung beetle deposits single egg in egg chamber of brood ball. The size of egg averaged 2.36 mm in length and 1.39 mm in diameter. Embryological developmental period averaged of 2.38 day. The larval developmental period of three instar stage averaged 31.34 days. While the average pupal stage is of 13.46 days at laboratory temperature condition ranging from 22 ^{O}C to 26^{O}C. The adult longevity ranges between 42 to 85 days.

Keywords: dung beetle, *onthophagus catta*, nesting behavior, brood ball, life cycle

1. Introduction
The dung beetle *Onthophagus catta* is well distributed in South-Western Maharashtra, India [1]. This dung beetle is powerfully attracted to fresh cattle dung. These dung beetles bury dung, which is used as food for both adult and larva, directly below the dung pad. These beetles are definitely beneficial insects to mankind. Due to their activity, they disperses dung, controls the various dung born dipterous flies, bring about improvement in the permeability of soil to water, soil texture, humus content and degree of aeration. Survey of literature on the dung beetle shows that most of the studies are related with taxonomic, ecological and behavior aspects of foraging species of dung beetles. Arrow [1] presented a review on Indian dung beetle species in "Fauna of British India including Ceylon and Burma, Lamellicornia, Part III-Coprinae". Veenakumari and Veeresh [2, 3] and Yadav *et al.*[4] have studied on behavior, taxonomy, Phylogenetic and karyotypic aspects of Indian dung beetles. Gaikwad and Bhawane[5] studied the nidification behavior in three dung beetle species (Scarabaeidae: Scarabaeinae) from South-Western Maharashtra, India. Therefore here we made an attempt to study the life cycle of native dung beetle species Onthophagus *catta* along with its nesting behavior.

2. Material and Methods
2.1 Rearing of dung beetles
2.1.1 Collection of Adults
Adults of *Onthophagus catta* were collected from pasture in and around the town Phaltan, Dist Satara. This dung beetle species is most abundant in study area. As these dung beetles are powerfully attracted towards fresh cattle dung, therefore, they are easily collected from the dung pads. The dung beetles were recovered from the dung pads and brought to the laboratory in perforated plastic containers along with some quantity of dung obtained from the same dung pads. One to three days old pads were selected for the collection purpose. The collection was made in the morning hours between 8 to 10 a.m.

2.1.2 Rearing
Rearing of *O. catta* was done in laboratory. For this purpose large sized earthen pots of 30 cm. depth and 27 cm. upper diameters were used. Rearing method proposed by Blume and Aga [6] and Hunter *et al*. [7, 8] was followed. Rearing medium was the same sand-soil mixture, filled in the earthen pots up to 2/3rd level. The mixture was adequately moistened with water. In each earthen pot, five pairs of (approximately similar size and weight) adults were released. The fresh buffalo dung of about 500gms (half of the litter) obtained from collection site was given as food and for the brood ball constructions to the beetles kept for rearing. After 4-5 days, old dung was replaced by the fresh dung, to ensure the adequate and continuous supply of food and material for construction of brood ball. To maintain adequate moisture, humidity and temperature, rearing pots were covered with similar sized inverted earthen pots and they were kept in plastic troughs containing moist sand. At a time at least 10 such pots were arranged.
After a week time brood ball formation in rearing pots was checked by overall pouring the content from rearing pots. From the preliminary observations the nesting and brood ball construction period in this dung beetle species is 4 –days from the third day of release of adult pair in rearing pots. Thus continuous supply of known age groups of various life cycle stages was obtained by this method. For the observation of nesting behavior same methodology was followed. To assess the development of larvae inside the brood ball, small hole was made with the help of needle to the brood balls. By practice (On basis of diameter of head capsule) the tagging of the larval stages was done. Head capsules of developing larvae were observed under the dissecting binocular microscope, through the hole on the brood ball. After

observation the opening was immediately caped with fresh dung, moreover the larvae have innate capacity to repair the damage of brood ball with the help of own faces.

Under laboratory conditions the temperature of earthen pot retains about 22°C to 26°C and humidity was about 75%. The brood balls after recovering from the rearing pots were maintained in earthen pots by covering with most soil sand mixture the pots were arranged as usual.

3. Observation

a) Adult

The colour is greenish or coppery black with testaceous yellow (Fig.7). It is broadly oval and convex with a thin clothing of yellow setae upon the legs and lower surface. The head is semicircular. The pronotum bears rather sparse granules in its median part. The elytra are finely striate with the intervals flat and unpunctured. The pygidium bears an angulate basal carnia and few scattered punctures.

This dung beetle species also shows sexual dimorphism (Figs.7). In male, vertex a pair of slender horns, curving outward and inclined little backward and not united at base. The front of pronotum is very smooth and shining and having two minute prominences separated by a slight groove. The front tibia in this sex is elongate, slender and curved, it inner extremity produced in to a long spur and its external teeth rather widely separated (Fig.8). In female vertex bears a strongly elevated straight carnia. The front of the pronotum is vertical in the middle and produced on each side, forming a pair of strong slightly divergent, blunt processes (Fig.8).

b) Eggs

The egg in brood ball of, *O. catta* is shown in Fig.1. The eggs are bean shaped and yellowish-white in colour. The length and diameter of eggs in this dung beetle species are shown in Table no. 2.

c) Larvae

The first, second and third instars larvae are shown in Figs. 2, 3 and 4 respectively. The larvae shows sensory area of third antennomere conical, chaetopariae each with 2-5 setae, uncus of lacinia with basal tooth, pronotum lacking shields, legs lacking terminal papillae, third segment of abdomen with a conspicuously setose, dorsomedian prominence. The raster is distinct, tenth sternum with one or two loose fields of short setae. The median prominence of third abdominal tergum is strongly developed. The morphological measurements and developmental periods of three instars of these beetles are shown in Table nos. 1&2.

d) Pupae

The dorsal and ventral view of pupa is shown in Fig.5. The pupa having large, blunt pronotal projection extending over posterior portion of head. The small mesonotal projections are present. Large finger-like tergal projections are callus like. The morphological measurements and developmental period is shown in Table nos. 1&2.

Adult longevity (after emergence from their brood ball) is known only in laboratory reared specimens. It is calculated as follows. The beetles after emergence caged individually in the earthen pots containing most mixture of soil and sand. The fresh dung was regularly provided to them as food till their survival and the survival period was noted for each individual beetle. The adult longevity for the present dung beetle is given in Table.no.1.

e) Nesting Behavior

Under laboratory conditions, nesting behavior studies indicates that the *O. catta* construct simple nest composed of single unbranched vertical or incline galleries. At bottom end of each gallary, brood balls are lodged (Fig.9). The length of *O. catta* brood ball (Table no. 2) ranged between 22 to 34 mm with mean length of 27.7 +/- 3.79 mm. The diameter of brood ball ranges between 13 to 18 mm and mean diameter value is 15.4 +/- 1.49 mm. It was observed that the depth of brood ball constructed ranges between 6 to 22cm and single pair of beetle have constructed 10 to 35 brood balls in laboratory condition.

Plate 1: Life cycle of *Onthophagus catta*

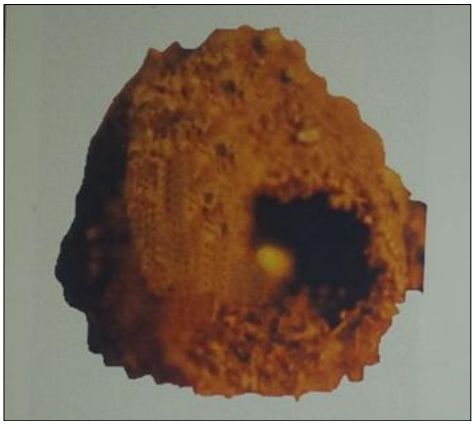

Fig 1: Egg in brood ball

Fig 2: Ist Instar Larva

Fig 3: IInd Instar Larva

Fig 4: III[rd] Instar Larva

Fig 5: Pupae

Fig 6: Brood ball

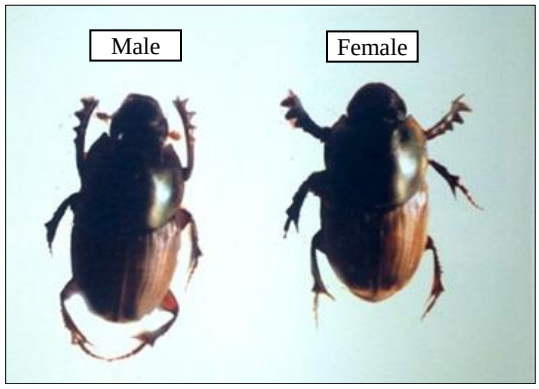

Fig 7: Adult

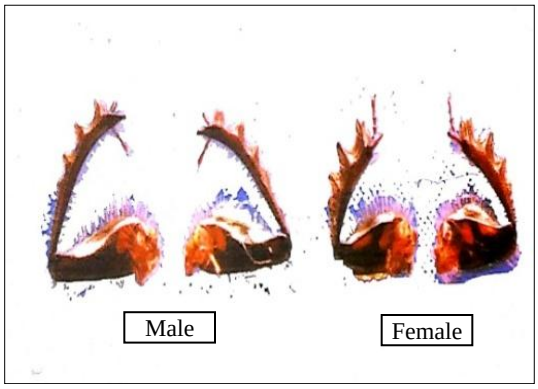

Fig 8: Fore legs showing sexual diamorphism

Table 1: The developmental period for various stages of life cycle of *Onthophagus catta*

S. No.	Stage	No. of Observation	Time (Days)		Mean +/- S.D.
			Minimum	Maximum	
1	Egg	13	2	3	2.38 +/- **0**.835
2	First instar	29	3	5	3.93+/- 1.04
3	Second instar	12	4	6	5.00 +/- 0.81
4	Third instar	36	20	25	22.41 +/- 4.125
5	Pupa	15	12	15	13.46 +/- 0.8
6	Egg to adult in brood ball	6	41	54	48.33 +/- 4.49
7	Adult longevity	20	42	85	66.7 +/- 11.98

Table 2: Measurment of different developmental stages and brood ball of *Onthophagus catta*

S. No.	Stage/ Brood ball	Length in mm		Diameter in mm	
		Range	Mean +/- S.D.	Range	Mean +/- S.D.
1	Egg	2.2-2.5	2.36 +/- 0.08	1.2-1.5	1.39 +/- 0.09
2	First instar	-------	----------	1.3-1.5*	1.36 +/- 0.06
3	Second instar	-------	----------	1.8-2.0*	1.87 +/- 0.7
4	Third instar	16-20	18.0 +/- 1.26	2.3-2.5*	2.38 +/- 0.7
5	Pupa	9--12	10.54 +/- 0.98	6.0-8.0	7.1 +/- 0.83
6	Male	11--12	11.6 +/- 0.48	7.0-8.0	7.5 +/- 0.44
7	Female	9--11	9.9 +/- 0.48	6.0-7.0	6.6 +/- 0.37
8	Brood ball	22--34	27.7 +/- 3.79	13--18	15.4 +/- 1.49

*=Measurement of head capsule at the widest point

4. Discussion

In the present investigation life cycle and nesting behavior of *O. catta* were studied in laboratory conditions by using suitable method. This dung beetle showed three larval instars, which is similar to the other Scarabaeinae beetles. In present insect the life cycle stages passes through the brood balls which were constructed by the parents. This provides the immature stages with an assured food supply and provides other favorable conditions.

The larvae of this dung beetle showed essential features of other Scarabaeinae larvae. These larvae having fully developed month parts with strong mandibles, the eyelessness, the relative immobility and typical Coprinae hump. The legs in Scarabaeinae larvae play no part in

locomotion. These larvae continue to use the dorsum of the anterior part of the abdomen as surface of support and locomotion.

In present investigation larvae of *O. catta* showed character like third antennomere conical, uncus with basal tooth, third segment of abdomen with conspicuously setose, dorsomedian prominence. This description of larva is much more similar to that described in various species of *Onthophagus*. Noteworthy among them are Ritcher [9, 10] in *O. pennsylvanicus*, *O. cyanellus, O. hecate hecate, O. landolti texanus, O. olivius, O. Oklahomensis*; Medvedev [11] in *O. taurus*; Brach [12] in *O. polyphemi, O. tuberculifrons*. Edmonds and Halffter [13] described the morphological character of *Onthophagus* larvae. According to them this larva shows strong affinity towards *Canthochilum*. This larva also shows most resemblance with *Oniticellus* larva. Gardner [14] described strong dorsal hump of *Oniticellus cinctus*. The observation on *O. catta* larvae showed several similarities in characters. These observations match with observations of Edmonds and Halffter [13]. This indicates that the present larvae under study showed several common observations which were drawn by earlier workers.

The life cycle period in this beetle indicates that egg to adult developmental period ranges between 41 to 54 days. The teneral adult periods observed in this beetle under laboratory conditions is 3 to 4 days and adult longevity period is of 42 to 85 days.

The above results show similarity with other Scarabaeinae. Howden and Cartwright [15] studied duration of development in *Onthophagus spp*. in North America, which is 35 to 42 days. The present *O. catta* beetle showed egg to adult developmental period between 41 to 54 days. This duration of development is also similar to that studied in *Onthophagus medorensis* (40.5 to 53 days) and *O. depressus* (36 to 57 days) by Hunter *et al*. [7, 8]. Vision [16] had given the period between 30 to 34 days in *Nesosisyphus spp.* Matthews [17] given the developmental period between 40 to 50 days in *Canthochilum spp*. Prasse [18] has given 36 to 46 days developmental period in *Gymnopleurus geoffroyi* and 41 to 49 days in *Sisyphus schaefferi*. In *Copris remotus* the developmental period is 38 to 39 days [19]. In India similar studies were carried out in two species of *Onthophagus* by Veenakumari and Veeresh [3]. They described the developmental period of 40 to 44 days in *O. gazelle* and 30 to 35 days in *O. reticornustus*. Present result shows that *O. catta* in India much closer developmental period to that described in *O. gazelle* and *O. medorensis* and *O. depressus* which were studied in America. According to Halffter and Mathews [20] larger sized dung beetles have much longer developmental periods.

The teneral adult period is 3 to 4 days in *O. catta*. The teneral adult period are given in different species of *Onthophagus* by Hunter *et al* [7] in *O. medorensis* is 3.5 days ; by Hunter *et al* [8] in *O. depressus* is 3 days by Veenakumari and Veeresh [3] (1996) in *O. gazelle* and *O. rectecornutus* is 3 to 4 days in laboratory conditions. Both Vinson [16] and Matthews [17] observed the continuous presence of teneral adults throughout the year among the forest inhabiting Scarabaeinae of Mauritius and Puerto Rice respectively.

It appears to be general rule in Scarabaeinae that the duration of the immature stages is far shorter than that of adults and shorter than the corresponding immature stages of Pleurosticts. The adult longevity period of present dung beetle is 42 to 85 days under laboratory conditions. We do not actually have much data on adult longevity. Hunter *et al.* [7] has given adult longevity period of 34 to 72 days in *O. medorensis*. Lindquist [19] kept a female *Copris remotus* alive in captivity for over 21 months and Balthasar [21] believes that an adult longevity of 2 to 3 year is normal for the sub- family. The newly emerged beetle has no food reserves to begin reproduction immediately, hence the larva was provided with only just enough food to carry it through metamorphosis.

The observation on nesting behavior of this dung beetle indicates that it may be placed under category I -B which was described by Halffter and Matthews [20]. In such category one egg is laid in relatively small dung mass packed into the end of a burrow. It was observed that this dung beetle dig tunnel just under the dung pad which ends into one or two special cells. Then dung is brought down from the dung pad. When cell is almost filled; a small cavity is molded by the female in end of dung mass and egg in laid in it. The cavity then being covered over with a filtering plug of dung fibers and soil and thus brood balls are constructed. The branch or section of the tunnel leading to the cell is then filled with soil and new cell began higher up. This observation is similar to that given by Burmeister [22] in four European *Onthophagus* spp. The *Onthophagus catta* constructed simple unbranched tunnels with cells lying one above the other. This observation is similar to that in *Onthophagus coenobita* made by Burmeister [22]; *Onthophagus tarus* observed by Fabre [23]; *Onthophagus fucatus* by Main [24]. Some *Onthophagus* spp. shown branched vertical burrows which ends in to brood cells, e.g. in *Onthophagus nuchicornis* and *Onthophagus fracticornis* [22]; in *Onthophagus medoresnsis* [7].

The depth of brood ball construction in present beetle was ranged between 6 to 22 cm. This result is similar to those reported by Ritcher [25] in *Onthophagus hecate* (depth of brood ball ranged from 5 to 22.9 cm); Veenakumari and Veeresh[3]in *Onthophagus gazelle* and *Onthophagus reticornustus* (depth of brood ball at 16.5 ± 3.0 cm). Similarity range of depth also observed by Halffter and Matthews [20] in American *Onthophagus* spp. The brood ball length ranges between 22-34 mm with mean value 27.7 ± 3.79 mm and width ranges between 13-18 mm with mean value 15.4± 1.49 mm. This result is comparable with results given by Hunter *et al.* [7] in *O. medoresnsis* (length ranges from 7.0-13.55mm); in *O. depresssu*s (length range is 19-25 mm and width range is 15-17 mm) and by Veenakumari and Veeresh [3] in *O. gazelle* and average length 40.6 mm and diameter width 16.0 mm. It is observed in present investigation a single pair of *Onthophagus catta* constructed 10 to 35 brood balls on laboratory conditions. According to Howden and Cartwright[15] a single female *O. I. texanus* have constructed 3 to 30 brood balls while female *O. alluvius* have constructed 20-40 brood balls incapativity. According to Lindquist [19] 43-67 brood balls produced by a single female of *Onthophagus* spp. The nesting behavior in the dung beetle increases the survival and growth of the offspring.

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