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DESCRIPTIONS OF LARVAE AND PUPAE OF *BRAUNSAPIS MIXTA* (SMITH) (HYMENOPTERA, APOIDEA, XYLOCOPINAE, ALLODAPINI)

Rajiv K. Gupta
Department of Zoology, Jai Narain Vyas University, Jodhpur 342 005, India.
[e-mail: beesind@gmail.com]

Many nests of *Braunsapis mixta* (Smith) were discovered at Narainpur, Alwar in Eastern Rajasthan (India). The female occupied vacant and open end tubes of *Saccharum munja* (L.) for the purpose of its nesting. Many larvae and pupae were collected from the nests made in the piths of the dried straws which were thatched on roofs of huts. Some nests were occupied by more than one adult female along with the immatures. The parasitic behaviour between females of two species and, division of labour among the females of the same species occupying same nest has been recorded in this species. This paper presents descriptions of second / third instar larva, postdefecating larva and pupae of this minute solitary bee for the first time. *B. mixta* has been so far recorded visiting 28 wild and cultivated crops in northern India. Its distribution range also includes coastal Gujrat where it has been collected in huge number pollinating coconut flowers.

The nests and immature stages of Indian solitary, non-Apis bees are rarely described. Majority of the known species construct their nests individually involving at the most a single pair of adults and in soil [1-2]. Some species construct their independent nests with independent entrance such as bees of family Megachilidae and many pidae[3-5]. Others such as those of family Halictidae construct their nests in huge aggregation but with a single common entrance[6-7]. Many megachilid bees collect leaves, flower petals, plant resins, mud etc. to line their nest chambers[8-9]. Numerous species have been noted building their nests in the pre-excavated tubes left vacated by beetles and other subterranean insects close to farms in Indian countryside[1,9-10] . Michener[11] initially made taxonomic comparisons between earlier separately described larvae of five species of a contemporary genus *Allodape, Lepeletier and Serville* and one species of genus *Exoneura smith*. Later, nests and immature stages of several species of African Allodapini were described[12-14] . Simultaneously a useful character grid applicable for the descriptions of pupae of bees was published[15]. This work insisted upon taxonomic characters of spines and projections found on the body of pupae. These were considered useful in the identification and taxonomy of the pupae of many genera of bees. Michener and Scheiring[16] described pupae of *Australian allodapini*. These works included nest structures and data concerning nesting materials and immatures found in the collected nests. This paper describes the immature stages of a minute Indian allodapine bee for the first time, namely *Braunsapis mixta* (Smith) (Family Apidae, Subfamily Xylocopinae). During past three decades this bee has been collected from almost whole of the northwestern India visiting 28 cultivated and wild crops.

MATERIALS AND METHODS

The nesting site was located at village to laws, under Village Panchayat Narainpur (Alwar district) in north-eastern Rajasthan, India. On 4th May 1991 openings of several dry sticks of *Saccharum munja* (L.), were noticed as the centre of bee activities. These sticks were thatched on a hut, making canopy, at an inclined angle of about 55° - 60°, extending one meter or more beyond the wall of the hut and, were about 1.8 m to 2.4 m high from ground level. Two years old sticks were evenly spread supported with sticks of Bamboos tide together. At 14.00 hours temperature and RH were recorded as 38° C and 40%, respectively, on the date. Nests and immatures of *Pseudoheriades tolawasensis* were also collected from same location[5].

The open ends of many sticks were plugged with dry, sterlized cotton and brought to the laboratory for further investigation. Out of them seven had adults and immatures of *Braunsapis mixta* (Smith). The material found in nests was stored in glass vials containing 70% Alcohol mixed with 0.5% Formaldehyde. A total of 12 first / second / third instar larvae, 02 postdefecating larvae and two pupae were recovered from their nests and studied. The microscopic observations were made directly under an Olympus Stereozoom Binocular Microscope and the measurements were taken with the help of a Micrometer. Permanent preparations were made for the parts to be studied in detail. Figures were drawn by using Camera Lucida. Photographs were taken by Nikon SZBM 1000.

OBSERVATIONS AND DESCRIPTIONS

The nesting site was surrounded by vast cultivated fields with many entomophilous vegetables, fodder crops, wild shrubs and weeds. The names of flora visited by *Braunsapis mixta* for all throughout the previous three decades were identified as: *Calotropis procera* (Ait.) R. Br., *Calotropis gigantean* (L.) W.T. Aiton, *Acacia nilotica* (L.), *Prosopis cineraria* (L.) Druce, *Prosopis juliflora* (Sw.) DC., *Justicia adhatoda* L., *Tephrosia purpuria* (L.) Purs., *Tephrosia hamictonii*, *Chrysanthemum spp.*, *Capparis decidua* (Forsk.) Edgew, *Tecoma stans* (L.) Juss. ex Kunth, *Cassia angustifolia* (Vahl.), *Tradascantia* (L.) spp., *Hibiscus rosa-sinensis* L., *Crotalaria burhia* Buch. Ham., *Aerva tomentosa* Forssk., *Tridax procumbens* L., *Solanum melongenum* L. (Egg plant), *Solanaum lycopersicum* L. (Tomato), *Abelmoschus esculentus* (L.) Moench (Lady's finger), *Ricinus communis* L. (Castor), *Citrullus colocynthis* (L.) Schrad. (Kachra), *Cyamopsis tetragonoloba* (L.) Taub. (Gwar) and *Medicago sativa* L. (Alfalfa). In addition to, huge populations of this bee were observed and collected from the flowerings of Coconut (*Cocos nucifera* L.) in the Coastal area of Gujrat (during months of June and July).

Individuals of both sexes were collected foraging on these flowerings in most of the parts of north, northwestern and central India, throughout the year. Batra [1,17] reported this bee visiting *Luffa cylindrica* (L.) M. Roem, *Daucus carota* L. and *Alyssum sp.* from Ludhiana (Punjab).

Genus Braunsapis is represented by 20 species in Asia[18-19] . Three of the species were recovered from the nests of other Allodapini as social parasites. Their names and collection sites are *B. breviceps* (Cockerell) from Java, *B. kaliago* Reyes and Sakagami from Delhi and *B. bislensis* Michener, Borges, Zaharias & Shenoy from Hassan, Karnataka. Using narrow, dry, hollow sticks for its nesting purpose was known to be a favourable act mostly adopted by species of *Ceratina, Pithitis* and *Braunsapis*[20]. The nests of *Pseudoheriades tolawasensis* and recently described nests of *Megachile (Pseudomegachile)* creusa Smith were also collected from dry and vacant straws of *S. munja* and *Pennisetum glaucum* (L.) R. Br. (Pearl millets), respectively[4].

Batra[20] recorded a few dimension s of the nesting tubes used by *Braunsapis mixta* (Smith) (described as *Braunsapis parvula*). She collected three nests from PAU campus, Ludhiana in 1964 from stalks of *Saccharum spontaneum*. The outer stick dimensions ranged from 7 to 10.5 mm; length of internodal region of stick containing nest from 5 to 11.0 cm and, the inner diameter of the piths of sticks varied between 2.5 to 3.2 mm; the diameters of nest entrances varied between 1.5 to 2.0 mm (?). These nests were without any cells and she noted that the nests were cooperative attempts of one, or more than one female.

Michener[12] also recorded that nests of allodapine bees often have more than one female, usually two or three with a division of labour, among them one female act as queen and rest furnish the responsibilities of workers. Later on, a female of *Braunsapis kaliago* was collected as a social parasite from the nest of *B. mixta*.[21]

The nests collected during present study had similar social status. Almost half of the nest collected had two or three females. The dimensions of our nest containing sticks were more or less similar to those recorded by Batra[20] thus need no repetition here. However, inner dimensions of the nest tubes (pith) collected in this study varied between 3.0 to 6.8 mm that sometimes increased up to 8.5 mm at the open end of the stick (the entrances of nest).

Descriptions of Immature Stages : The diagnostic features of the larval morphology, in general coincided with briefly described African species.[13,14] The pupal morphology has affinities with Australian Allodapini[16] .

Second / Third Instar Larva : Total length 2.0 mm (IInd Instar: Fig 5); Head maximum width and length 1.2 mm and 1.4 mm. Head almost triangular (Fig. 1), slightly elongated with broadly bulging ocular lobes; vertex deeply invaginated in between ocular areas of either sides; ocular area with more than 20 long bristles; antennal papillae quite short, arise from very broad protuberance; frons with a lateral setae and the narrow supraclypeal region with one robust setae near apico-lateral angle; labrum broadly outcurved, its apical margin slightly chitinous and medially very slightly incurved, apico-lateral surface with one prominent setae on short protuberance, lateral lobes not produced however the margin of mandibles are totally concealed beneath it; mandibles (Fig. 3 & 4) short, attenuate, very narrowly bidentate, teeth look acute laterally, inner tooth slightly shorter than outer tooth, teeth margins smooth & sclerotized, not irregular or serrated, transverse base of smooth apical concavity with slight fine serration, two distinct apodemes at dorsal and ventral basal angles among them dorsal apodeme is quite long in comparison to ventral;

labio-maxillary region slightly produced partially concealing the ventral margin of mandibles; palp slightly evident; maxillae elongated, narrowed, not sclerotized, cardo and stipes with few setae (Fig. 2); labium divided into a prementum and postmentum; salivary opening transverse, not sclerotized, dorsal and ventral lips of salivary slit not produced; hypopharynx bilobed and with fewer setae.

Body (Fig. 5 second instar & Fig. 6 third instar; both in Lateral view) moderately robust with distinct bristled fasceae becoming denser on hinder segments; intersegmental lines distinct; dorsal tuberosity broad and slightly markable on second and third thoracic segments; first abdominal segment with a remarkable prominent and projecting dorsal 'conical spine' with quite broad base (marked by an arrow on figure 05 & 06); dorsum of segment 3 to 5 with broad tubercles; ventrolateral tubercles on abdominal segments 3 to 5 feebly markable but not pronounced; spiracle atrium not projecting above body wall; discal setae sparse becoming denser on hinder segments; last abdominal segment quite long, produced and, anus terminal as a broad transverse opened slit.

Post defecating Larva [comparative comments with second/third instar] : Total length 3.6 mm; Head maximum width and length 1.6 mm and 1.8 mm. Head triangular produced (Fig. 7 & 8), margins over-hanged by the prothoracic segment; vertex more deeply invaginated in between ocular areas of either sides; ocular area with more than 50 long bristles, long bristles extending on first two thoracic segments; frons with more lateral setae and the outbursting supraclypeal region with many robust setae all over surface; labral area apical margin more chitinous and becomes transverse, setae denser, lateral lobes produced over the dentate margin of mandibles and latter are completely concealed beneath it; mandibles short, attenuate, very narrowly bidentate but teeth slightly serrated at margin; labio-maxillary region more pronounced; labium quite buldging; salivary opening transverse, dorsal and ventral lips of salivary slit not produced; hypopharynx bilobed and with many setae; all three thoracic segments with ventro-lateral tuberosities but not very much pronounced and cannot be referred as legs for capturing provision in between both ventro-lateral sides.

Body (Fig. 9: Lateral view) much robust with plenty of distinct setae become denser on hinder segments; intersegmental lines distinct and with bristled fasceae; dorsal tuberosity markable on first and second thoracic segments; first abdominal segment dorsally with much produced 'conical spine'; dorsum of segment 3 to 8 with produced tubercles however, in a gradual reducing pattern as move posteriorly; ventrolateral tubercles on 1-3 thoracic segments overhanging ventral surface so as lateralo-abdominal segments 1-7 with pronounced overhanging tuberosities; spiracle atrium depressed below profile of body wall; setae much denser on terga 1-5 with prominent setae and fasceae on apical rims distinct on segments 2 to 5; last abdominal segment quite long and produced.

The larvae distinctly differ from pre-described larvae of African *Braunsapis trochanterata* (Gerstaecker), *B. natalica* Michener, *B. simplicep*s Michener, *B. foveata* (Smith) and *B. leptozoni*a (Vachal) in lacking much pronounced thoracic and or abdominal lateralo-ventral protuberances that act as legs to trap provisioning in between them. These species do not have distinct division of segments into cephalic, thoracic and abdominal annulets. The antennal papillae are inconspicuous in African species however, *B. mixta* has quite broad protuberant base but with very short fibrous papilla; attenuate mandibles that have almost inconspicuous incision between teeth and basal part of dentate margin with fine serration are additional characters of difference.

Pupa (Female) : Two pupae were recovered from two of the nesting sticks. Among them one was a mature female and another was a mature male. The male pupa was almost about to emerge as adult. They are described below in accordance with the character grid of Michener[15]. Length 5.8 mm. Head maximum width and length 1.6 mm and 1.8 mm. Resembles adult in taxonomic characters (Fig. 10: lateral view & 11: ventral view). Yellow pigmentation on clypeus markable resembling adult; vertex with plenty of long bristles more so on ocular area; frons with a fine tubercle, scape without tubercle; paraocular area just close to clypeal base with one fine bristled tubercle; labrum triangular with short protuberance apico-medially; mandible bidentate; rostrum reaching base of abdomen (Fig. 10 & 11).Tegulae with short protuberance; lateral angles of pronotum broadly produced to lobes with broad tubercle; both wings with feebly markable protuberance at base; scutum with few bristles seated on papillae, more so on posterio-lateral surface; scutellum, metanotum and propodeum without tubercle; fore-coxal spine slightly produced;

all tibial apices apicodorsally produced. Apical rims of 2nd tergum onwards with sparse setae becoming denser up to the sixth; from second tergum onwards fine and sparse discal setae appear and become denser upto sixth tergum; hinder tergal fasceae bristles extends ventrally and prominent on lateral sides upto ventral sternal margins; terminal spine (Term. spine in Fig. 10) ventral and oblique.

Pupa (Male) : Resembling female in general characters; with denser bristles; facial pigmentation resembling adult; features of tubercles on frons, paraocular area, labral apico-median surface, tegulae etc resembling female; posterior end with broad buldging genital armature; terminal spine sub apical.

Material examined : 12 first / second / third instar larvae, 02 postdefecating larvae, 02 pupae, 14 adults (02 males & 12 females); Coll. Rajiv K. Gupta; date of Coll. 4 May 1991; Village Tolawas, Narainpur (Latitude 27.33 N, Longitude 76.40 E); 50 km southwest to Alwar, Rajasthan (India). The larvae, pupae and adults (A female in lateral view at figure No. 12) are preserved in the collection of the author and the described larvae, pupae and, a pair of adults will be placed in the National Collection of Zoological Survey of India, Desert Research Centre, Jodhpur.

DISCUSSION

Present study describes the larvae and pupae of an Indian Allodapini bee for the first time. The minute and black *Braunsapis mixta* (Smith) was recorded nesting in pithy stems of *Saccharum munja* in northwestern India. It does not use any nesting material to line its nest tube. Neither has it constructed any chamber or cell in the linear pattern or like an anadolous nest known for other bees of contemporary families such as those of Megachilidae[4,5,9,22,23]. However, the eggs and immatures have been reported sticking to the walls of the nest tubes and female keeps guard at the entrance of the tube. Another significant feature that has been reported in Allodapini ethobiology was the occurrence of more than one female in one nest. Among them one female has the status of queen and remaining female / females help in collection and storage of pollen and nectar for the larvae in the nest. This aspect of sociality has been considered quite primitive and was referred as foundation for the evolution of eusociality in Apidae[12,14,24].

Second and third instar larvae were always found "clinging" with the provision deposits in between their slightly pronounced lateral tuberosities. Quite strong bend of body in 'U' shape is kept to eat the provisioning which is grabbed between thoracic and anterior abdominal segments. Most of the larvae were found with their head burried in their food. Larvae of the African species of this genus are different in possessing the so called- one, two, three or more "legs" which are extensions of their lateral tuberosities with significant prominence[14,25]. A detailed inference concerning identification and taxonomy of the larvae and pupae of Indian species of genus Braunsapis would be possible when immatures of contemporary species will be explored.

The collections made during past three decades have revealed that *B. mixta* utilizes a considerably good amount of floral resource. So far merely 28 angiosperms have been recorded. This number would increase considerably when a thorough and year long collection will be made on all flowerings found within the distribution range of this bee. The importance and role of bees in pollination within tropics encompasses an estimated two-third of angiosperm species.[26] Percentage of solitary or semisocial bees such as *B. mixta* would play a principal role in the cross-pollination[27,28]. In all instances, their habitats and populations need protection in nature so that maximum cross-pollination would take place[29,30].

Studies made elsewhere have proved that maintaining a good population of adults close to crop fields, has remarkably enhanced the crop yields.[31] There are many crops of local economic importance whose yields or quality may be enhanced by good pollinator activity,[32]. This target may be achieved by protecting the broods.[33] Protection and conservation of broods, their transport to other territories as 'seeds' (pupae) and releasing them on other crops help in the even distribution of bee populations and towards those territories which would be in need of more population for more efficient crop pollination by concerned bee species.[34] This study will ultimately help towards artificial domestication and management programme of such important bee which easily occupies the pithy stems of *S. munja* for its nestings.

This author has observed huge populations of *B. mixta,* exclusively foraging on coconut flowers (*Cocos nucifera L.*) in coastal regions of Gujrat (Okha, Dwarika, Veeraval, Porbandar, Gir and Diu, all along the coast of Arabian Sea) during months of June and July. Such gathrings are evidences concerning a bee species to be quite good cross pollinator of many cultivated

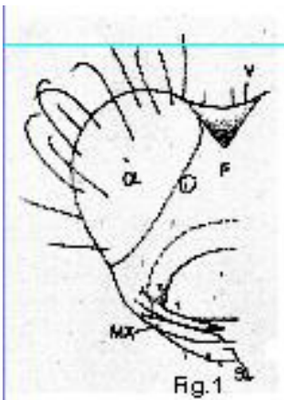

Fig.1

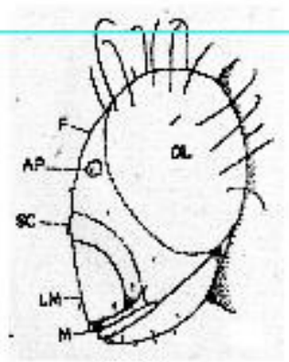

Fig.2

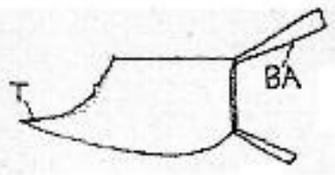

Fig.3

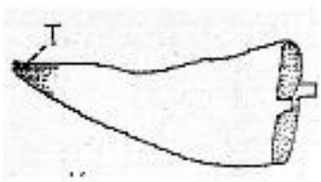

Fig.4

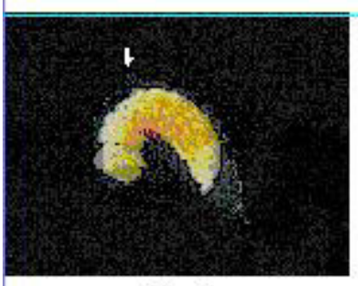

Fig.5

Fig. 6

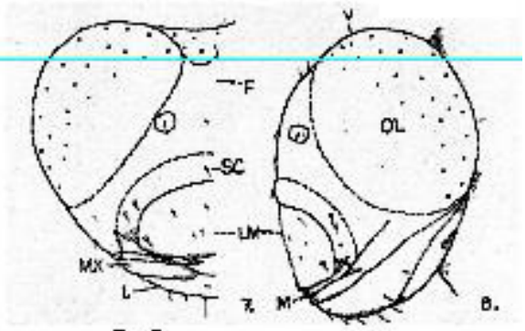

Fig.7

Fig.8

Fig.9

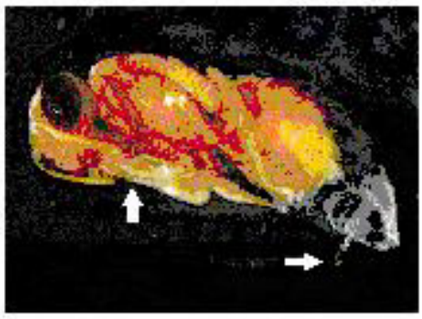

Fig.10

Fig.11

Legendstofigures [02 Plates] (one plate of drawing and another of Photographs)

Braunsapis mixta (Smith): Immature stages and an adult.

Figs. 1- 6: Second / third instarlarva; 7-9: Postdefecating larva;

(Larger dots on ocular lobes on fig. 7 & 8 indicate bristles; length of bristles on fig. 1 & 2 twice than drawn; length of mandible in fig.

3 interrupted to compare the length in fig. 4).

1 & 7: Head, Front View (Right side not drawn), 2 & 8: Head, Lateral View

3: Mandible, Dorsal View , 4: Same in Lateral View 5, 6, 9: Body, lateral view ,

10: Pupa - Female (Lateraloventral View) & 11: Same in ventral view

12: An Adult (Female, Lateral View), [Measurements as per text]

A: Anus, AP: Antennal Papilla, BA: Basal Apodeme, F: Frons, L: Labium

LM: Labrum, M: Mandible, MX: Maxilla, OL: Ocular lobe , SC: Supraclypeal region, SL: Salivary Slit, T: Teeth. V: Vertex

Fig.12

crops. Precisely, the studies concerning nests and immatures become a basic but important tool towards the direction of using the allodapine bees for enhanced cross pollination of crops for better seed yields.

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