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Diversity, host association, and cocoon variability of reared Indian Microgastrinae (Hymenoptera: Braconidae)

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Abstract

Nearly 3,500 specimens of microgastrine wasps (Hymenoptera: Braconidae) were reared during caterpillar surveys undertaken in 2010–2013 across India, covering 16 States and one Union Territory (Andaman & Nicobar islands), and deposited in the National Bureau of Agriculturally Important Insects, Bangalore, India. The caterpillar inventory recovered over two hundred morpho-species within 22 families of Lepidoptera and yielded 90+ morpho-species of microgastrine wasps distributed among 13 genera: *Apanteles* Förster, *Buluka* de Saeger, *Cotesia* Cameron, *Diolcogaster* Ashmead, *Distatrix* Mason, *Dolichogenidea* Viereck, *Fornicia* Brulle, *Glyptapanteles* Ashmead, *Microgaster* Latreille, *Microplitis* Förster, *Neoclarkinella* Rema & Narendran, *Parapanteles* Ashmead, and *Protapanteles* Ashmead. Records of hyperparasitoids are also included: *Mokrzeckia menzeli* Subba Rao (Pteromalidae), *Pachyneuron groenlandicum* (Holmgren) (Pteromalidae), *Pediobius foveolatus* (Crawford) (Eulophidae), *Trichomalopsis thekkadiensis* Sureshan & Narendran (Pteromalidae), *Eurytoma* sp., and *Pediobius* sp. (Eurytomidae). The present study adds eight new host records and provides illustrations of 40 species of wasps (including types). A comprehensive list of microgastrine genera, host caterpillar species, host plants, cocoon colour, structure and spinning pattern, and hyperparasitoids is provided. Numerous photographs of parasitized caterpillars, cocoons (number/arrangement), associated host plants, and adult wasps are also provided. The Indian species *Deuterixys ruidus* (Wilkinson, 1928) is transferred to the genus *Cotesia* based on the shape and sculpture of the first and second mediotergites: *Cotesia ruidus* (Wilkinson) **comb. nov.** *Microgaster carinicornis* Cameron is transferred to *Microplitis*, based on examination of first and second mediotergites, length of metatibia spurs, and size of metaxocoxa: *Microplitis carinicornis* (Cameron) **stat. rev.**

Key words: Hymenoptera, Braconidae, India

Introduction

Microgastrinae (Hymenoptera: Braconidae) is one of the most important groups of Lepidoptera parasitoids. It is also one of the most diverse –Rodriguez et al. (2012) estimated the species richness of the group ranging from 17,000 to 46,000+ species.

Microgastrinae wasps are endoparasitoids of caterpillars, and species are usually gregarious or solitary (although, occasionally, one wasp species can be solitary or gregarious depending on the size and species of the host caterpillar). Generally, each microgastrine wasp species has a fixed cocoon spinning pattern, structure and colour, which is quite distinctive and helps in ascertaining its identity.

In spite of their enormous species richness and economic importance in biological control programs, the Indian microgastrines still remain a taxonomically challenging group due to inadequate taxonomic expertise in India, missing type specimens (not to be located in repositories mentioned in literature) and erroneous identifications. The Microgastrinae fauna from India encompass 231 species within 21 genera: *Apanteles* Förster, *Buluka* de Saeger, *Cotesia* Cameron, *Distatrix* Mason, *Dolichogenidea* Viereck, *Diolcogaster* Ashmead, *Fornicia* Brulle, *Glyptapanteles* Ashmead, *Hypomicrogaster* Ashmead, *Microgaster* Latreille, *Microplitis* Förster, *Neoclarkinella* Rema & Narendran, *Parapanteles* Ashmead, *Parenion* Nixon, *Philoplitis* Nixon, *Pholetesor* Mason, *Protapanteles* Ashmead, *Promicrogaster* Brues & Richardson, *Protomicroplitis* Ashmead, *Snellenius* Westwood, and *Wilkinsonellus* Mason. Four species have been introduced as biological control agents: *Apanteles subandinus* Blanchard, which has been recovered from field hosts, while the rest—*Apanteles malevolus* Wilkinson, *Apanteles scutellaris* Muesebeck, and *Cotesia sesamiae* (Cameron)—appear not to have been established, or else their present status is not known (Rao et al. 1971; Sankaran 1974).

With the aim of improving existing information on the Indian fauna of Microgastrinae, this paper presents an account of reared wasps, their diversity, life history/host association and cocoon variability.

Materials and Methods

Caterpillar rearings were undertaken under the ICAR project “Biodiversity of economically important Indian Microgastrinae (Braconidae)” by the senior author, staff of the Insect Systematics Division of the National Bureau of Agriculturally Important Insects (NBAIL), Bangalore-India, and various collaborators during the period 2010-2013. Also, the past collection of Commonwealth Institute of Biological Control (CIBC)-Indian Station-Bangalore, and types at the National Pusa Collection, Indian Agricultural Research Institute, New Delhi, were examined. Additionally, specimens (mostly types) from the Natural History Museum, London, UK (BMNH) housing microgastrines of South East Asia and Great Britain were studied.

The collection localities covered 16 States of India and one Union Territory: Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Uttarakhand, North-Eastern Region (Meghalaya, Assam), West Bengal, Rajasthan, Orissa, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Kerala, Tamil Nadu, Andaman & Nicobar islands. Reared species housed in NBAIL and those from CIBC collections, collected before 2010 were also examined and included in the study.

The caterpillars/cocoons were coded based on the date of collection, host plant and locality. For example, 61212CN-K—means a caterpillar collected on December 6th, 2012 on *Cocus nucifera* from Kerala. If two species of caterpillars are collected on the same host plant on the same date then they are maintained along with an additional supporting numeral (e.g., 61212CN-K-1 and 61212CN-K-2). For every wasp species reared, a code was designated based on the collection date of the associated host caterpillar (e.g., *Apanteles folia* Nixon—Code: 28512 explains the collection date of host caterpillar *Spindasis vulcanus* (Fabricius) as May 28th, 2012). Occasionally, when multiple species (as in case of hyperparasitoids) emerged on the same date from the same host caterpillar, the collection date is supported with alphabets either as prefix or suffix to avoid confusion (e.g. *Glyptapanteles clanisae* Gupta—Code: 2211CLP for the primary parasitoid and Code: 2211 for the associated hyperparasitoid *Eurytoma* sp.). For examined museum specimens, which were collected in the past and not as part of this study, the code mentioned is that available on the original label(s).

Wasp specimens were reared from field collected caterpillars, as well as recovered from field collected cocoons (Figures 1A & 1B). Caterpillars were hand picked from various crop fields, forest trees, and wild plantation throughout the year. Caterpillars from the same host plant were kept separately in individual plastic containers with fine meshed lids carrying specific code numbers in the laboratory. Unparasitized caterpillars from the same brood were reared to adult for host confirmation. Caterpillar rearings were conducted at 25±2°C and 50±10% relative humidity and were fed with the natural host plant from which the respective caterpillar was collected. More than 2,500 caterpillars were reared individually, and 3,500 microgastrine specimens under 13 genera were recovered. The wasps were later curated, mounted and taxonomically examined.

Identification was undertaken consulting many references (Ayyar 1927, 1928; Wilkinson 1927, 1928, 1929; Bhatnagar 1948; Rao 1961; Nixon 1965, 1967, 1968; Rao et al. 1969; Sharma 1972, 1984; Mason 1981; Sumodan & Narendran 1990; Austin & Dangerfield 1992; Rema & Narendran 1996; Sharkey & Wharton 1997; Whitfield 1997; Whitfield et al. 2002, 2009; Rema & Sheeba 2004; Valerio et al. 2009; Ahmad et al. 2009; Gupta et al.

2011a; Gupta et al. 2011b; Gupta & Kalesh 2012; Gupta & Pereira 2012; Gupta 2013a, Gupta 2013b, Gupta & Lokhande 2013c, Gupta et al. 2013d and Gupta et al. 2013e). Yu et al. 2012 was consulted for host associations.

Photographs

For each genus of Microgastrinae, host caterpillar species, cocoons formed, and host relationships are provided. Most of the wasps were reared and photographed in NBAII Insect Systematics laboratory, with few exceptions where the collaborators reared host caterpillars and supplied specimens along with images. The wasp images were taken using Leica M 205 A Stereozoom microscope with Leica DC 420 inbuilt camera using automontage software (version 3.8). All specimens of the present study are provided with code numbers and housed in the National Bureau of Agriculturally Important Insects (NBAII), Bangalore, India.

Results and Discussion

A total of 90+ morphospecies of reared microgastrine wasps were obtained. Forty two species under 13 genera were identified. For some species, correct identity could not be confirmed as revisionary studies along with molecular characterization will be needed. Hence they are placed as close to the nearest known species as possible. The genera reared from various species of caterpillars include *Apanteles*, *Buluka*, *Cotesia*, *Distatrix*, *Dolichogenidea*, *Diolcogaster*, *Fornicia*, *Glyptapanteles*, *Microgaster*, *Microplitis*, *Neoclarkinella*, *Parapanteles*, and *Protapanteles*.

Microgastrinae wasps were reared from 64 species of identified host caterpillars, with an additional hundred or so field collected cocoons/cocoon masses where the host caterpillar species are not known. Altogether, 22 host families of Lepidoptera are here documented as hosts for Indian microgastrines: Brachodidae, Blastobasidae, Bombycidae, Crambidae, Erebiidae (Arctiinae, Lymantriinae), Gelechiidae, Geometridae, Gracillariidae, Hesperidae, Lasiocampidae, Limacodidae, Lycaenidae, Noctuidae, Nymphalidae, Oecophoridae, Papilionidae, Pieridae, Plutellidae, Pyralidae, Riodinidae, Sphingidae, and Tortricidae. The majority of those records are associated with moths.

Of the reared Microgastrinae, 53 morphospecies were found to be gregarious: *Apanteles inquisitor* Wilkinson, *A. javensis* Rohwer, *A. machaeralis* Wilkinson, *A. phycodis* Viereck, *A. platydrae* Wilkinson, *Apanteles* nr. *bambusae*, *Apanteles* nr. *calycinae*, *Apanteles* nr. *phycodis*, *Cotesia erionotae* (Wilkinson), *C. flavipes* Cameron, *C. glomerata* (Linnaeus), *C. ruficrus* (Haliday), *C. ruidus* (Wilkinson), *C. tiracolae* (Ashmead), *Cotesia* nr. *ruidus* (code: 20911), *Cotesia* spp. (numbered as 01–07, 09, 10), *Diolcogaster* sp. 02, *Distatrix papilionis* (Viereck), *Dolichogenidea cinnarae* Gupta, Lokhande & Soman, *D. kunhi* Gupta & Kalesh, *D. stantoni* (Ashmead), *Dolichogenidea* spp. (numbered as 02, 05, 06), *Glyptapanteles aristolochiae* (Wilkinson), *G. clanisae* Gupta, *G. creatonoti* Viereck, *G. hypermnestrae* Gupta & Pereira, *G. obliquae* (Wilkinson), *Glyptapanteles* spp. (numbered as 04, 06–11, 13), *Parapanteles echeriae* Gupta, Pereira & Churi, *Parapanteles* spp. (numbered as 03, 04, 06), and *Protapanteles* spp. (numbered as 01, 02, 03, 04).

Another 39 morphospecies were found to be solitary: *Apanteles diparopsidis* Lyle, *A. folia* Nixon, *A. galleriae* Wilkinson, *A. mamitus* Nixon, *A. mohandasi* Sumodan & Narendran, *A. tachardiae* Cameron, *A. taragamae* Viereck, *Apanteles* nr. *agilis*, *Apanteles* nr. *bisulcatus*, *Apanteles* spp. (numbered as 01–03), *Buluka horni* Gupta, *Buluka* nr. *noyesi*, *Cotesia vestalis* (Haliday), *Cotesia* nr. *rufiventris*, *Cotesia* nr. *ruidus* (Linnaeus) (code: 3812), *Cotesia* sp. 08, *Dolichogenidea* spp. (numbered as 01, 04), *Fornicia ceylonica* Wilkinson, *Glyptapanteles trilochae* Gupta, *Glyptapanteles* spp. (numbered as 02, 05, 12), *Microplitis carinicolis* (Cameron), *Microgaster* spp. (numbered as 01, 02), *Microplitis prodeniae* Rao & Kurian, *M. demolitor* Wilkinson, *M. indicus* Marsh, *M. manilae* Ashmead, *M. maculipennis* (Szepligeti), *M. spodopterae* Rao & Kurian, *Parapanteles* spp. (numbered as 02, 05), *Protapanteles africanus* (Cameron), *Protapanteles beneficus* (Viereck), and *Protapanteles* nr. *beneficus* (Viereck).

A comprehensive list of host-parasitoid association for the species of microgastrine wasps documented during 2010–2013 is provided in Table 1. Parasitoid wasps could not be recovered from four species of caterpillars, *Troides minos* Cramer, *Matapa aria* (Moore), *Pieris canidia* (L.), and *Amblypodia anita* Moore. However, as the images of the parasitoid cocoons were captured, they are included below.

Genus *Apanteles* Förster (Figures 1C–22, 27–30, 107–120)

Types examined: Repository BMNH

Apanteles javensis Rohwer (Fig. 109)

Apanteles javensis Rohw.; female Paratype; Paratype No. 21506 USNM; Dammerm K. W. Colr.; Buitenzarg JAVA; x.1911; 2531 Panvon; *Hesperia conjuncta*.

Apanteles machaeralis Wilkinson (Figs 110, 111)

Apanteles machaeralis Wilk.; Paratype; Rahatgoan, Hoshangabad, CP; S. N. Chatterjee 26.ix.1926; parasitic on *Pyrausta machaeralis* Walk. larva; defoliate *Tectona grandis*. [The original label mentions this specimen as “cotype”].

Apanteles machaeralis Wilk.; Paratype; Nilambur, Madras; S. N. Chatterjee; 26.v.1927; parasitic on *Hapalia macaeralis* larva; defoliate *Tectona grandis*. [The original label mentions this specimen as “cotype”].

Apanteles phycodis Viereck (Figs 114–116)

Apanteles phycodis Vier.; L. C. Coleman coll.; female Paratype; Paratype No. 15279; USNM.

Apanteles tachardiae Cameron (Figs 117, 118)

Apanteles tachardiae Cam.; female; Lyallpur, Punjab; Lac 6331; det. D. S. Wilkinson 1931.

Apanteles tachardiae; male; Mathurpur, Bengal; 1926; Lac R. I. Namkum; don. Kartiki Ber lac; 613; det. D. S. Wilkinson 1928.

Apanteles taragamae Viereck (Figs 119, 120)

Apantele taragamae Wilk.; G. E. J. Nixon det. 196?; S. India Coimbatore; 27.vii.1934; P. S. Nathan; BM 1938-102; ex. pyralid larva.

Rearing Data: The genus *Apanteles* Förster was reared from 22 species and 473 specimens of Lepidoptera, and was found to be associated with the families Brachodidae, Blastobasidae, Crambidae, Erebidae (Arctiinae), Gelechiidae, HesperIIDae, Lycaenidae, Noctuidae, Oecophoridae, Pyralidae, and Tortricidae.

Life history comments: *Apanteles diparopsidis* Lyle was reared only once from caterpillars of *Syllepte derogata* (Fabricius) on the host plant *Gossypium arboreum* L.

Apanteles folia Nixon (Fig. 107), a solitary parasitoid, was predominantly associated with only lycaenid hosts—*Arhopala amantes* (Hewitson) (Fig. 5), *Tajuria cippus* (Fabricius) (Figs 6, 7) and *Spindasis vulcanus* (Fabricius) (Fig. 8). For all the three lycaenid species, the solitary cocoon was spun beneath the host caterpillar.

Apanteles javensis Rohwer (Fig. 109), a gregarious wasp, was associated with hesperiid hosts—*Pelopidas conjuncta* (Herrich-Schaffer) (Figs 12, 13) and *Pelopidas mathias* (Fabricius) (Fig. 14).

Apanteles mamitus Nixon was reared from crambids: *Spoladea recurvalis* (Fabricius), on the host plant *Amaranthus* sp.; and from *Maruca vitrata* (Fabricius) on the host plant *Cajanus cajan* (L.). On *Maruca vitrata*, the solitary cocoon formed was light yellowish in colour, compared to the white coloured cocoon formed on the host *Spoladea recurvalis*.

Apanteles mohandasi Sumodan & Narendran (Fig. 112), a solitary endoparasitoid of *Pammene critica* Meyrick (Figs 15, 16), a major pest on *Cajanus cajan* (L.) can be easily confused with *Apanteles taragamae* Viereck—which is also associated with pests on *C. cajan* (namely *Maruca vitrata* and *Diaphania indica* Saunders). Both species were molecularly characterized for correct identification (Gupta et al. 2011a).

Apanteles phycodis Viereck (Figs 114–116) was reared from *Phycodes radiata* Ochseneheimer (Brachodidae). The parasitized caterpillar with the cocoon mass remained confined inside the silken web of the leaves (Figs 18–20). The infested leaves could be easily recognized by its yellow colouration, curled and dry appearance, and the presence of silken webs. *Apanteles phycodis* was also reared from an arctiid species, *Argina syringa* Cramer (Fig. 17).

Apanteles tachardiae Cameron (Figs 117, 118) was recovered as a solitary endoparasitoid on *Holcocera pulvereana* (Meyrick) (Blastobasidae) from Orissa.

Profuse solitary parasitism by *Apanteles taragamae* Viereck (Figs 119, 120) was noticed for an economically important and notorious pest, *Opisina arenosella* Walker, commonly known as coconut black headed caterpillar. It was also recovered from Port Blair, Andamans parasitizing an undeterminate leaf webber (Fig. 27). Additionally, *Apanteles taragamae* was found to be gregarious on caterpillars of *Diaphania indica* Saunders (Fig. 28) on the host plant *Cajanus cajan* L.; whereas it was solitary on early instars of *Opisina arenosella* Walker. The wasp thus shows remarkable behavior on account of host association.

Species of *Apanteles* reared from mulberry leaf roller, *Glyphodes pulverulentalis* Hampson, cashew leaf roller *Pleuroptya balteata* (Fabricius), *Acria* sp. on oil palm, and *Acontia marmoralis* Fab. (Figs. 29, 30) will need further taxonomic studies for identification of the species.

Genus *Buluka* de Saeger (Figures 31, 32, 121, 122)

Types examined: Repository NBAIL

Buluka horni Gupta (Figs 121, 122)

Buluka horni Gupta; Holotype; female; India, Karnataka, Bangalore, Ganganhalli; 22.xiii.2011; emerged from solitary cocoon on leaf of *Mangifera indica* L.; Coll. Mallesh; Code NBAIL/Micro/Buluka/22811.

Rearing Data: The genus *Buluka* de Saeger is known from the Afrotropical, Australasian, and Oriental regions. It is one of the rarest collected genera in India and elsewhere. Austin (1989) provided the first and so far only known host record for the genus: *Imma thyriditis* Meyrick (Lepidoptera: Immidae), from Solomon Island. Here we provide the second host record for *Buluka*, which also represents a new host family for the genus.

Life History Comments: *Buluka horni* Gupta (Figs 121, 122) was reared from an undeterminate caterpillar feeding on leaves of *Mangifera indica* L. (Fig. 31). *Buluka* nr. *noyesi* was reared as a solitary parasitoid of *Psimada quadripennis* Walker (Noctuidae) on *Ficus benghalensis* L. (Fig. 32). The solitary white cocoon of *Buluka* is uniquely distinctive in appearance when compared to the microgastrine cocoons belonging to other genera. The cocoon is oval and flat with a faint black spot in the center and light black oval lining surrounding the black spot. It remains attached to the leaf surface with white cottony fibers arising from the edges.

Genus *Cotesia* Cameron (Figures 33–53, 123–135)

Types examined: Repository BMNH

Cotesia erionotae (Wilkinson) (Figs 123, 124)

Apanteles erionotae Wilk.; Paratype; Sumatra, East coast, Deli; 26.i.1926; ex. *Erionota thrax*. [The original label mentions this specimen as “cotype”].

Cotesia flavipes Cameron (Figs 125, 126)

Cotesia flavipes Cameron; det. A. K. Walker 1994; *Apanteles flavipes*; Bhubaneswar; 21.vi.1955; State Entomologist; Coll. No. 14383; ex. *Chilotrea*.

Apanteles flavipes Cam.; G. E. Nixon det 1967; India, Padegaon; 7.vii.66; 110N; ex. larva of *S. inferens*; cie A1474.

Cotesia ruidus **comb. nov.** (Figs 129, 130)

Apanteles ruidus Wilk.; Paratype; Rahatgaon, Hoshangabad CP; S. N. Chatterjee; 3.xii.1926; parasitic on *Pyrausta machaeralis* larva; defol. *Tectona grandis*; 235. [The original label mentions this specimen as “cotype”].

Apanteles ruidus Wilk.; Paratype; Rahatgaon, Hoshangabad CP; S. N. Chatterjee; 3.x.1926; parasitic on *Pyrausta machaeralis* larva; defol. *Tectona grandis*; 24. [The original label mentions this specimen as “cotype”].

The species *Deuterixys ruidus* (Wilkinson 1928), which had been recently placed in that genus (e.g. Yu et al. 2012) is here transferred to the genus *Cotesia*, based on the shape and sculpture of first and second mediotergites: *Cotesia ruidus* (Wilkinson 1928) **comb. nov.**

Cotesia tiracolae (Ashmead) (Figs 131–133)

Apanteles tiracholae Ashm.; G. E. J. Nixon det. 1966; Tista village—W. Bengal; 18. x. 65; ex larva *Tiracola plagiata*; CIBC IS-4.

Cotesia vestalis (Haliday) (Figs 134, 135)

Cotesia plutellae (Kurdjumov); det. A. K. Walker 1998; India; Charboll B. K.; Pune; 7.ix.1994; A. G. Chande; ex. Cabbage; Coll. 5; IIE 23182; Pres. by Int. Inst. Ent.; BM 1992.

Rearing Data: *Cotesia* Cameron is the second largest genus in the Indian region after *Apanteles*. An estimated of 1269 specimens and around 20 species were reared from the following families of moths and butterflies: Crambidae, Erebidae (Arctiinae), Geometridae, Hesperidae, Lasiocampidae, Noctuidae, Nymphalidae, Pieridae, and Plutellidae.

Life History Comments: Most of the reared species were gregarious, except for a few solitary, such as *Cotesia vestalis* (Haliday) from *Plutella xylostella* (L.) on cabbage (Fig. 37). The gregarious species reared include: *Cotesia flavipes* Cameron from *Chilo partellus* (Swinhoe) on maize (Fig. 34), *Cotesia glomerata* (L.) from *Pieris brassicae* L. on cabbage (Fig. 36), *Cotesia ruficrus* (Haliday) from *Spodoptera* sp. from Indian mainland and from Andaman & Nicobar islands (Fig. 41), *Cotesia ruidus* Wilkinson from *Eutectona machaeralis* (Walker) on *Tectona grandis* L. (Fig. 38), and *Cotesia tiracolae* (Ashmead) from *Phaedyra columella* (Cramer) on the host plant *Grewia tiliifolia* Vahl (Figs 39, 40).

Cocoons of *C. glomerata* are distinct in colouration and arrangement, being yellow and arranged in irregular clusters with around 8 cocoons/cluster. Also cocoons of *C. tiracolae* are brilliant yellow in colouration. In addition to the identified species of *Cotesia* recorded here, another 12 species were recovered from varied hosts, which will need further taxonomic studies before concluding on their identity.

Genus *Diolcogaster* Ashmead (Figures 54, 136)

Rearing Data: The genus *Diolcogaster* Ashmead was considered by Mason (1981) to include many species grouped by Nixon (1965) under *Protomicroplitis*. The genus was recently revised for the Australasian region, including comments on its biology and host relationships (Saeed et al. 1999). Those authors expanded the *connexus*-group *sensu* Nixon into non-Australasian groups (*D. ippis* Nixon and *D. reales* Nixon), while the *spretus*-group *sensu* Nixon was expanded to include *D. coenonymphae* (Watanabe) from Japan. The present understanding of the genus from India is very poor with only four species reported so far. Nearly 52 specimens were bred from three regions.

Life History Comments: Only one gregarious species could be reared from an undetermined caterpillar feeding on *Terminalia* sp. (Fig. 54). Another species was collected from Malaise traps in the Andaman islands.

Genus *Distatrix* Mason (Figs 55–56, 137)

Rearing Data: The genus *Distatrix* is mainly reported from pantropical regions with very few records from temperate areas. The genus is equivalent to Nixon's *formosus* group (Mason 1981). Cocoons that are gregarious in nature mimic flower heads, while the solitary ones make single stalked cocoons (Whitfield 1997). Almost 758 specimens were bred from caterpillars collected all over India.

Life History Comments: Only one species, *Distatrix papilionis* (Viereck) (Fig. 137) is recorded from India,

attacking *Papilio demoleus* Linnaeus. Gregarious white cocoon masses ranging from 15-158 cocoons/leaf were observed (Figs 1A, 55, 56). Number of cocoons/caterpillar/leaf varied with the stage of larval instar. The early instars (2nd instar) of lime butterfly, having the appearance of bird droppings, yielded 15-26 cocoons/caterpillar/leaf. Third instar parasitism yielded 49, 58, 96 cocoons/caterpillar/leaf, respectively. From late instars 112, 131, 148, and 158 cocoons/caterpillar/leaf were collected. This shows positive correlation between the number of cocoons/caterpillar/leaf and the larval stage (and possibly with the size of the host).

Genus *Dolichogenidea* Viereck (Figures 23–26, 57–63, 138–144)

Types examined: Repository BMNH and NBAII

Dolichogenidea cinnarae Gupta, Lokhande & Soman (Fig. 138)

Dolichogenidea cinnarae Gupta, Lokhande & Soman 2013; Holotype; female; India, Mumbai, Powai; 5.ix.2012; ex. parasitized larvae of *Borbo cinnara* on indet. Gramineae plant; coll. Swapnil Lokhande & Abhay Soman; Code NBAII/Brac/Micro/Dolicho/50912.

Dolichogenidea hyposidrae (Wilkinson) (Figs 139, 140)

Apanteles hyposidrae Wilk.; Paratype; Java: Midden; 1924; R. Menzel; ex. *Hyposidra* sp. on *Mimosa*; BMNH. [The original label mentions this specimen as “cotype”].

Dolichogenidea kunhi Gupta & Kalesh (Figs 141, 142)

Dolichogenidea kunhi Gupta & Kalesh 2012; Holotype; female; India, Kerala, Thiruvananthapuram; January 2011; ex. parasitized larvae of *Thoressa evershedi* on host plant *Ochlandra* sp.; leg. Kalesh, S.; Paratype, male, with same data as holotype; Code. NBAII/Bra/Mic/Dol/111 (Holotype), NBAII/Bra/Mic/Dol/112 (Paratype).

Dolichogenidea stantoni (Ashmead) (Figs 143, 144)

Apanteles stantoni Ashm.; det. D. S. Wilkinson 1930; 5477 Malaya Kuala Lumpur; ex. dead larva of *Sylepta derogata* on *Hibiscus esculentus*; G. H. Corbett; BMNH.

Apanteles fistulae Wilk.; Paratype; Nilambur, Madras; S. N. Chatterjee; 2.vii.1925; BMNH. [The original label mentions this specimen as “cotype”].

Rearing Data: Eight species and 180 specimens of *Dolichogenidea* were reared from six Lepidoptera families: Crambidae, Erebiidae (Lymantriinae), Geometridae, Gracillariidae, Hesperiidae, and Lycaenidae.

Life History Comments: *Dolichogenidea cinnarae* Gupta, Lokhande & Soman (Fig. 138) was reared from *Borbo cinnara* (Wallace).

Dolichogenidea kunhi Gupta & Kalesh, 2012 (Figs 141, 142) was reared from *Thoressa evershedi* (Evans) (Fig. 57), a rare skipper endemic to southern Western Ghats, Kerala.

The often encountered, *Dolichogenidea stantoni* (Ashmead) (Figs 143, 144) was found to be gregarious on caterpillars of *Parotis marginata* (Hampson) on host plant *Gardenia jasminoides* J. Ellis (Figs 23–25), and also from an undetermined species of Lymantriidae.

Additional specimens of *Dolichogenidea* were reared from hosts -*Artaxa guttata* Walker, *Perina nuda* (Fabricius) and an undetermined gracillarid on Amla, but its specific identity remains to be determined.

Genus *Fornicia* Brulle (Figures 64, 145)

Rearing Data: The genus *Fornicia* is pantropical and is prevalent in southern parts of India. Only two species are known from India. *Fornicia andamanensis* Sharma from Andaman Islands, and *Fornicia ceylonica* Wilkinson (Fig. 145) from Indian mainland. One species, *F. ceylonica* with 26 specimens was reared from southern India.

Life History Comments: It has been reported from Tamil Nadu, Kerala and from Karnataka where *Fornicia ceylonica* Wilkinson, a solitary parasitoid, was found parasitizing larvae of *Spatulifimbria castaneiceps* Hampson (Lepidoptera: Limacodidae) on castor (Fig. 64).

Genus *Glyptapanteles* Ashmead (Figures 65–82, 146–156)

Types examined: Repository BMNH and NBAII

Glyptapanteles aristolochiae (Wilkinson) (Figs 146, 147)

Apanteles aristolochiae Wilk.; Paratype, female; Ceylon, Peradeniya; 24.11.19; bred from the larva of *Papilio aristolochiae*; J. C. Hutson; BMNH. [The original label mentions this specimen as “cotype”].

Apanteles aristolochiae; det. A. K. Walker 1998; Indonesia Sumba Is.; Nr Lewapaku remnant; forest 500 m; v.1999; J. Weintraub; ex. larva of *Pachliopta oreon* on *Aristolochia tagala*; gregarious; CIE A20936; BMNH.

Glyptapanteles clanisae Gupta (Fig. 148)

Glyptapanteles clanisae Gupta 2013; Holotype; female; India, Karnataka, Bangalore; 22.xi.2011; ex. cottony cocoon mass from parasitized caterpillar of *Clanis phalaris* on *Pongamia pinnata*; leg. Venkatesh; Code NBAII/Micro/Gly/clan/2211. Paratypes six females and two males on card and two females, dissected, on slide, with same data as holotype.

Glyptapanteles creatonoti (Viereck) (Figs 149, 150)

Apanteles creatonoti Vier.; G. Nixon det.1950; 04724 Malaya Kuala Lumpur; 18.12.1943; Entom. Div., Agric. Dept.; ex. 04723 Larva; COM. DIST. EST.; CoLL No. 11490; BMNH.

Apanteles creatonoti Vier.; G. E. J. Nixon det. 1959; *Deiopera pulchella*; Phillippines, Laguna, Los Banos, 150 ft alt; 186; 20.vi.1934; Feng Yung Tsan; per LB Uichaneo; BMNH.

Glyptapanteles hypermnestrae Gupta & Pereira (Fig. 151)

Glyptapanteles hypermnestrae Gupta & Pereira 2012; Holotype; female; India, Maharashtra, Mumbai, Borivli; 11.x.2011; emerged from caterpillar of *Elymnias hypermnestra* on coconut; leg. Blaise Pereira; Paratypes: two females and six males on card and two females and males, dissected, on slide, with same data as holotype; NBAII-Code 111011.

Glyptapanteles obliquae (Wilkinson) (Figs 152–154)

Apanteles obliquae Wilk.; Paratype; Nilambur, Madras; S. N. Chaterjee; 12.ix.1925; parasitic on *Diacrisia obliqua confusa*; BMNH. [The original label mentions this specimen as “cotype”].

Apanteles obliquae; det. D. S. Wilkinson 1934; Punjab, Hoshiarpur; male, 21.xii.1932; S. A. Shah; ex. larva of *Amsacta* sp.; BMNH.

Glyptapanteles trilochae Gupta (Fig. 156)

Glyptapanteles trilochae Gupta 2013; Holotype, female; India, Karnataka, Bangalore; 18.x.2012, ex. solitary cocoon from parasitized caterpillar of *Trilocha varians* on *Ficus racemosa*; leg. Rajesh; Code NBAII/Micro/Gly/tril/181012-A. Paratype, one female on card, with same data as holotype.

Rearing Data: The genus *Glyptapanteles* is highly speciose, shows remarkable diversity of host associations, and is prominently prevalent in tropical countries. A total of 1100 specimens could be reared from various hosts.

Life History Comments: Gupta and Pereira (2012) provided a list of Indian species for the genus *Glyptapanteles* and their associated hosts. The genus was reared from following Lepidoptera families: Bombycidae, Erebidae (Arctiinae, Lymantriinae), Geometridae, Noctuidae, Nymphalidae, Papilionidae, and Sphingidae. The reared species include *Glyptapanteles aristolochiae* (Wilkinson) (Figs 146, 147) from *Pachliopta hector* (Linnaeus) (Fig. 65), *G. clanisae* Gupta (Fig. 148) from *Clanis phalaris* Cramer, *G. creatonoti* Viereck (Figs 149, 150) from

Amsacta albistriga (Walker) on groundnut, *G. hypermnestrae* Gupta and Pereira (Fig. 151) from *Elymnias hypermnestra* (Linnaeus) (Figs 66, 67), *G. obliquae* (Wilkinson) (Figs 152–154) from *Spilosoma obliqua* Walker (Fig. 68), *G. spodopterae* Ahmad (Fig. 155) from *Spodoptera litura* Fab., and *G. trilochoe* Gupta (Fig. 156) from *Trilocha* (= *Ocinara*) *varians* (Walker) (Fig. 70).

Other undetermined species were reared from *Orgyia postica* Walker (Figs 72, 73), *Argina astrea* (Drury) (Fig. 76), and *Ascotis imparata* (Walker) (Fig. 77). One species was reared from ?*Melanephia mosara* Swinhoe from Andaman & Nicobar islands on *Ipomoea pes-caprae* (L.) R. Br (Figs 74, 75). The host caterpillar could not be reared to adulthood as all were parasitized, hence the host identity should be considered as provisional.

Genus *Microgaster* Latreille

Rearing Data: The genus *Microgaster* Latreille was rarely encountered during the caterpillar inventories carried out in India. Six specimens were reared from solitary cocoons but its specific identity remains unknown.

Genus *Microplitis* Förster (Figures 83–86, 157–164)

Microgaster carinicornis Cameron is transferred to *Microplitis*, based on examination of first and second mediotergites, length of metatibia spurs, and size of metaxocoxa: *Microplitis carinicornis* (Cameron) **stat. rev.**

Rearing Data: Indian species of *Microplitis* were recently revised by Gupta (2013), including diagnostic details, illustrations and key to all Indian species. Seventy nine specimens were reared.

Life History Comments: The species *Microplitis carinicornis* Cameron (Figs 157, 158) was reared from *Psalis pennatula* (Fab.) (Erebidae: Lymantriinae). The cocoon was solitary and brown (Fig. 83).

Microplitis demolitor Wilkinson (Fig. 159) is reported as a larval parasitoid of several noctuid moths, *Helicoverpa armigera* (Hubner), *Helicoverpa* spp., and *Spodoptera* spp.

Spodoptera litura (Fabricius) is recorded as host for *M. demolitor* Wilkinson, *M. manilae* Ashmead (Fig. 162) and *Microplitis prodeniae* Rao & Kurian (Fig. 163).

Microplitis maculipennis (Szepligeti) (Fig. 161) is a natural biological control agent of the castor semilooper *Acanthodelta janata* (L.) (Fig. 84). This parasitoid wasp has a life cycle of nearly 15 days in India. The brown coloured cocoon remains clasped by the last pair of legs at the anal end of the host caterpillar and remains attached firmly to the leaf surface. The parasitoid is most active from August to October and 80–90% of parasitism has been observed in the field.

Microplitis spodopterae Rao & Kurian (Fig. 164) was reared from *Spodoptera* sp. feeding on *Trigonella foenum-graecum* L. The cocoon is solitary and brown (Fig. 86).

Genus *Neoclarkinella* Rema & Narendran (Figure 165)

Rearing Data: The Genus *Neoclarkinella* Rema & Narendran is represented in the Old World tropics, particularly India, Thailand, Malaysia, Philippines and China. Six specimens were reared from southern India.

Life History Comments: *Neoclarkinella vitellinipes* (You & Zhou) (Fig. 165) was reared from an undetermined caterpillar from a forest plantation in Karnataka. Unfortunately, the identity of host species for this genus of Microgastrinae, in India and elsewhere, remains unknown.

Genus *Parapanteles* Ashmead (Figures 87–92, 105–106, 166–167)

Types examined: Repository NBII

Parapanteles echeriae Gupta, Pereira & Churi (Figs 166, 167)

Parapanteles echeriae Gupta *et al.* 2013e; Holotype, female; India, Maharashtra, Mumbai; August 2012; ex. larvae of *Abisara echeria*; leg. Blaise Pereira & Paresh V. Churi; NBAIL/Bra/Mic/Para/0812—A. Paratypes, two females and two males on card, with same data as holotype.

Rearing Data: The genus *Parapanteles* Ashmead is known from three species in the Oriental region. In total, 397 specimens were reared from caterpillars belonging to the families Erebiidae (Arctiinae, Lymantriinae), Lycaenidae, Noctuidae and Riodinidae.

Life History Comments: *Parapanteles echeriae* Gupta, Pereira & Churi (Figs 166, 167) was reared from *Abisara echeria* Stoll (Lepidoptera: Riodinidae) on the host plant *Embelia* sp. (Myrsinaceae) (Figs 105, 106).

Parapanteles shivranginii Sathe & Ingawale (1989) was reared from an undetermined caterpillar on the host plant *Amaranthus spinosus* L.

Parapanteles sireeshae Ahmad & Akhtar (2010), was found parasitizing larvae of *Hyposidra successaria* (Lepidoptera: Geometridae) on the host plant *Tinospora cordifolia* (Ranunculales: Menispermaceae).

Parapanteles spp., reared from *Asota caricae* Fab. (Fig. 87) on an undeterminate weed from Andaman island, from *Orgyia* sp. (Fig. 90), and from *Chilades pandava* Horsfield on *Cycas revolute* Thunb (Fig. 91), are yet to be identified.

Solitary parasitism was observed in host caterpillars of *A. caricae* and *C. pandava*, while for all other caterpillar species it was recovered as gregarious.

Genus *Protapanteles* Ashmead (Figures 93, 95–100)

Rearing Data: The genus *Protapanteles* Ashmead equates to Nixon (1965)'s *popularis* group of *Apanteles*. Nearly 50 specimens were reared from the families Erebiidae (Arctiinae) and Noctuidae.

Life History Comments:

The wasps were reared from the host caterpillars *Utetheisa pulchella* (L.) (Fig. 95), *Anomis sabulifera* Guenée and three undeterminate species on the host plants *Glycine max* (L.), *Abelmoschus esculentus* (L.) Moench (Fig. 99), and *Hibiscus vitifolius*.

Conclusions

This paper includes rearing records of parasitic wasps and their host relationships, many of them illustrated for the first time. More than 90 species of microgastrine wasps in 13 genera are documented from across India. Lepidopteran hosts of 22 families are documented as hosts. More than 250 morpho-species of host caterpillars were reared, and 64 species of caterpillars could be identified to genus/species level. Gregariousness was recorded for 53 species of wasps (57.6 %), while 39 species (42.3 %) were solitary.

The most common species during our survey of the Indian fauna was *Distatrix papilionis*, a gregarious endoparasitoid of *Papilio demoleus* Linnaeus on *Citrus* spp.; the parasitized caterpillars are usually noticed in great numbers during June–September. Other commonly occurring species included: *Apanteles taragamae* Viereck from *Opisina arenosella* Walker (a major pest of coconut in southern India), from *Diaphania indica* Saunders, and from *Pammene critica* Meyrick (earlier known as *Grapholita* (*Cydia*) *critica*, a major pest on *Cajanus cajan* (Linnaeus); *Cotesia flavipes* Cameron from *Chilo partellus* Swinhoe on maize and sorghum, *Chilo auricilius* Dudgeon, *C. infuscatellus* Snellen, and *C. tumidicostalis* Hampson on sugarcane, *Sesamia inferens* (Walker) on wheat and rice, *Syllepte derogata* Fabricius on cotton, and *Spilarctia obliqua* Walker on many crops; *Cotesia glomerata* (Linnaeus) from *Pieris brassicae* (Linnaeus) and *P. rapae* (Linnaeus) on cabbage, and *Cnaphalocrocis medinalis* (Guenée) on rice; *Cotesia ruficrus* (Haliday) from *Pelopidas mathias* (Fabricius) on rice, *Pieris brassicae* (Linnaeus) and *P. rapae* (Linnaeus) on cabbage, *Chilo* spp., *Pectinophora gossypiella* (Saunders) on cotton, *Plutella xylostella* (Linnaeus) on cabbage, and *Heliothis armigera* (Hubner) on many crops; *Cotesia vestalis* (Haliday) from *Plutella*

xylostella (Linnaeus) on cabbage; and *Glyptapanteles obliquae* from *Spilarctia obliqua* Walker on mulberry and many other crops. All of those microgastrine species are cosmopolitan in habitat. Also, *Microplitis maculipennis*, a parasitoid of *Acanthodelta janata* (Linnaeus), a common pest of castor, and *Apanteles machaeralis*, a parasitoid of *Eutectona machaeralis* (Walker) a pest of the Teak tree *Tectona grandis* are well distributed throughout India.

Many species were restricted to particular regions, e.g., *Fornicia ceylonica*, a solitary parasitoid of *Spatulifimbria castaneiceps* Hampson on castor, was confined to southern parts of India. Similarly, *Dolichogenidea stantoni* was frequently documented from larvae of *Parotis marginata* (Hampson) on the host plant *Gardenia jasminoides* from southern India.

Our results show a rather strong specialization on lepidopteran families for microgastrine wasps. For example, *Apanteles* was a predominant parasitoid on crambid, hesperiid and lycaenid hosts, while the families Plutellidae, Pieridae and Lasiocampidae were mostly parasitized by *Cotesia*. Few families (Brachodidae, Blastobasidae, Gelechiidae, Oecophoridae, Pyralidae and Tortricidae) were exclusively attacked by *Apanteles*.

Crambidae was mostly parasitized by *Apanteles*, followed by *Cotesia*. Caterpillars of the family Erebiidae (Lymantriinae) were attacked by a wide range of microgastrine genera in India: *Apanteles*, *Dolichogenidea*, *Glyptapanteles*, and *Parapanteles*. For Erebiidae (Arctiinae), the majority of records were associated with *Glyptapanteles* followed by *Apanteles*, *Cotesia*, *Parapanteles*, and *Protapanteles*. Some associations observed include: family Geometridae—*Cotesia*, *Dolichogenidea* and *Glyptapanteles*; family Lycaenidae—*Apanteles*, *Dolichogenidea* and *Parapanteles*; family Hesperidae—*Apanteles*, *Cotesia* and *Dolichogenidea*; family Nymphalidae—*Cotesia* and *Glyptapanteles*; family Papilionidae—*Distatrix* and *Glyptapanteles*.

Some exclusive relationships found included the family Limacodidae only parasitized by *Fornicia*; family Bombycidae by *Glyptapanteles*; family Gracillariidae by *Dolichogenidea*, and family Sphingidae by *Glyptapanteles*. *Microplitis* was attacked only by members of family Noctuidae. Interestingly, the family Noctuidae is a new host record for *Buluka*. Further studies on Microgastrinae hosts (both in India and elsewhere) may reveal different patterns than the ones reported here.

This paper presented the information on host-parasitoid interactions based on surveys initiated in 2010, which are still continuing. Many species await identification and more are expected to be reared as the survey continues. Microgastrinae in India needs more exploratory surveys, systematic host rearings, and molecular characterization to deal with ambiguous taxa. Post collection, transportation of caterpillars from different geographical locations of the country to NBAII caused considerable in-transit mortality of many caterpillar species. It is worth mentioning that since the sampling involves individuals there are many chances of inherent sampling biases and recurrent sampling in some parts of the country as compared to others.

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Photo credit

Majority of the images are taken by AG except for the ones with mentioned photo credit. Dr. Kalesh Sadasivan, GMC, Thiruvananthapuram, Kerala—*Thoressa evershedi* and *Pelopidas mathias*; Mr. Blaise Pereira,

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TABLE 1. Host—parasitoid association documented for reared microgastrine wasps in India during 2010-2013. For an explanation of code numbers (for microgastrine wasps) see Methods above. (*)—New host record or new host family. (?)—Uncertain host genus and/or species (because the host identity could only be established from caterpillars but not from adults). When a hyperparasitoid was reared, the record is indicated between brackets after the name of the corresponding microgastrine wasp.

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Apanteles diparopsidis</i> Lyle Code: 24610	<i>Syllepte derogata</i> (F.)	Crambidae	<i>Gossypium arboreum</i> L.	Karnataka	Solitary, white
<i>Apanteles folia</i> Nixon Code: 12811	<i>Arhopala amantes</i> (Hewitson)	Lycanidae	<i>Lagerstroemia speciosa</i> L.	Karnataka	Solitary, white, laid beneath the host caterpillar
<i>Apanteles folia</i> Nixon Code: 6912	<i>Tajuria cippus</i> (Fabricius) (*)	Lycanidae	<i>Loranthus</i> sp.	Karnataka	Solitary, white, laid beneath the host caterpillar
<i>Apanteles folia</i> Nixon Code: 28512	<i>Spindasis vulcanus</i> (Fabricius)	Lycanidae	<i>Ziziphus mauritiana</i> Lam.	Maharashtra	Solitary, white, laid beneath the host caterpillar
<i>Apanteles galleriae</i> Wilkinson Codes: 31510JK, 30711K	<i>Galleria mellonella</i> L.	Pyrilidae	-	Jammu & Kashmir, Karnataka	Solitary, white
<i>Apanteles inquisitor</i> Wilkinson Code: 41111	-	-	-	Karnataka	Gregarious, white
<i>Apanteles javensis</i> Rohwer Code: 4212	<i>Pelopidas conjuncta</i> (Herrich-Schaffer)	Hesperiidae	<i>Sorghum</i> sp.	Maharashtra	Gregarious, white, covered with white cottony web
<i>Apanteles javensis</i> Rohwer Code: 1110	<i>Pelopidas mathias</i> (Fabricius)	Hesperiidae	<i>Brachiaria mutica</i> (Forssk.) Stapf	Kerala	Gregarious, white
<i>Apanteles machaeralis</i> Wilkinson Code: 16510	<i>Eutectona machaeralis</i> (Walker)	Crambidae	<i>Tectona grandis</i> L.	Gujarat	Gregarious, white
<i>Apanteles mamitus</i> Nixon Code: 2012AM	<i>Spoladea recurvalis</i> (Fabricius)	Crambidae	<i>Amaranthus</i> sp.	Karnataka	Solitary, white
<i>Apanteles mamitus</i> Nixon Code: 2012MV	<i>Maruca vitrata</i> (Fabricius) (*)	Crambidae	<i>Cajanus cajan</i> (L.).	Karnataka	Solitary, yellow
<i>Apanteles mohandasi</i> Sumodan & Narendran Code: BR511	<i>Pammene critica</i> Meyrick	Tortricidae	<i>Cajanus cajan</i> (L.)	Uttar Pradesh	Solitary, white
<i>Apanteles phycodis</i> Viereck Code: 30312	<i>Argina syringa</i> Cramer (*)	Erebidae: Arctiinae (*)	undetermined weed	Karnataka and Tamil Nadu	Gregarious, white
<i>Apanteles phycodis</i> Viereck Codes: 8512, 12152	<i>Phycodes radiata</i> Ochsenheimer	Brachodidae	<i>Ficus benjamina</i> L.	Karnataka	Gregarious, white, cocoons inside white silken cottony web
<i>Apanteles platyedrae</i> Wilkinson Code: 171012	-	-	weed	Karnataka	Gregarious, white
<i>Apanteles tachardiae</i> Cameron Code: 16112	<i>Holcocera pulvereana</i> (Meyrick)	Blastobasidae	<i>Kerria lacca</i> (Kerr)	Orissa	Solitary, white

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TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Apanteles</i> Viereck Code: 161109	<i>taragamae</i> <i>Diaphania</i> Saunders	<i>indica</i> Crambidae	<i>Cajanus cajan</i> (L.)	Cosmopolitan	Gregarious, white
<i>Apanteles</i> Viereck Code: 8312AT	<i>taragamae</i> Undetermined webber	leaf -	undetermined host plant	Port Blair, Andamans	Solitary, white
<i>Apanteles</i> Viereck Codes: 101212, 1012OA	<i>taragamae</i> <i>Opisina</i> Walker	<i>arenosella</i> Oecophoridae	<i>Cocos nucifera</i> L.	Kerala	Solitary, white
<i>Apanteles</i> Cameron Code: 0411	nr. <i>agilis</i> <i>Glyphodes</i> (<i>Diaphania</i>) <i>pulverulentalis</i> Hampson	(= Crambidae	<i>Morus alba</i> L.	Karnataka	Solitary, white
<i>Apanteles</i> Wilkinson Code: 211211	nr. <i>bambusae</i> <i>Pleuroptya balteata</i> (Fabricius)	Crambidae	<i>Anacardium occidentale</i> L.	Karnataka	Gregarious, white
<i>Apanteles</i> Wilkinson Code: 2012AP	nr. <i>bisulcatus</i> <i>Acrida</i> sp.	Oecophoridae	<i>Elaeis guineensis</i> Jacq.	Andhra Pradesh	Solitary, white
<i>Apanteles</i> Wilkinson Code: 2011CT	nr. <i>calycinae</i> -	-	<i>Carthamus tinctorius</i> L.	Karnataka	Gregarious, white
<i>Apanteles</i> Code: 2911	nr. <i>phycodis</i> -	-	<i>Ficus</i> sp.	Karnataka	Gregarious, white, 5 cocoons/caterpillar
<i>Apanteles</i> sp. 01 Code: 10610	<i>Acontia marmoralis</i> Fab.	Noctuidae	undetermined weed	Southern India	Solitary, light yellow
<i>Apanteles</i> sp. 02 Code: 1412	-	-	<i>Coffea arabica</i> L. fruit	Tamil Nadu	Solitary, white
<i>Apanteles</i> sp. 03 Code: 8312	-	Pyralidae	<i>Hyptis capitata</i> Jacq.	Middle Andamans	Solitary, white
<i>Apanteles</i> sp. 04 Code: 11205	<i>Pectinophora gossypiella</i> (Saunders)	Gelechiidae	-	Karnataka	-
<i>Apanteles</i> sp. 05 Code: 4483	<i>Chilo infuscatellus</i> Snellen	Crambidae	<i>Saccharum officinarum</i> L.	Karnataka	-
<i>Buluka horni</i> Gupta Code: 22811	-	-	<i>Mangifera indica</i> L.	Karnataka	Solitary, white, laid under the surface of leaf, near the mid rib
<i>Buluka</i> nr. <i>noyesi</i> Code: 29613	<i>Psimada quadripennis</i> Walker (*)	Noctuidae (*)	<i>Ficus benghalensis</i> L.	Karnataka	Solitary, white
<i>Cotesia</i> (Wilkinson) Code: 1110B	<i>erionotae</i> <i>Udaspes</i> (Cramer)	<i>folus</i> Hesperidae	<i>Zingiber zerumbet</i> (L.) Smith	Kerala	Gregarious, off- white
<i>Cotesia</i> (Wilkinson) Code: 11912	<i>erionotae</i> <i>Udaspes</i> (Cramer)	<i>folus</i> Hesperidae	-	Karnataka, Maharashtra	Gregarious, off-white, laid in two rows, 22-25 cocoons/caterpillar
<i>Cotesia flavipes</i> Cameron Code: 15906	<i>Chilo partellus</i> (Swinhoe) on maize	Crambidae	<i>Zea mays</i> L.	Cosmopolitan	Gregarious, white, in cottony mesh

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TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Cotesia</i> (Linnaeus) Code: 1713	<i>glomerata</i> <i>Pieris brassicae</i> L.	Pieridae	<i>Brassica oleracea</i> L.	Meghalaya, Khasi hills and Punjab	East and Gregarious, yellow, white (gregarious associated with Cotyph from Great Britain) in irregular clusters, around 8 cocoons/ cluster
<i>Cotesia ruficrus</i> (Haliday) Codes: 141112K, 27212 AN	<i>Spodoptera</i> sp.	Noctuidae	Undetermined weed	Karnataka Andamans & Nicobar islands	& Gregarious, white &
<i>Cotesia ruidus</i> Wilkinson Code: 28711	<i>Eutectona machaeralis</i> (Walker)	Crambidae	<i>Tectona grandis</i> L.	Karnataka	Gregarious, white, laid loose giving appearance of solitary cocoon, covered with thin, cottony transparent web, around 7 cocoons/ caterpillar
<i>Cotesia</i> (Ashmead) Code: 29612	<i>tiracolae</i> <i>Phaedyra (=Neptis) columella</i> (Cramer)	Nymphalidae	<i>Grewia tiliifolia</i> Vahl	Maharashtra	Gregarious, mustard yellow in colour, 8 cocoons/caterpillar
<i>Cotesia vestalis</i> (Haliday) Code: 0812	<i>Plutella xylostella</i> (L.)	Plutellidae	<i>Brassica oleracea</i> L.	Cosmopolitan	Solitary, white
<i>Cotesia</i> nr. (Linnaeus) Code: 3812	<i>ruidus</i> <i>Olepa (=Pericallia) ricini</i> Fabricius	Erebidae: Arctiinae	<i>Ricinus communis</i> L.	Karnataka	Solitary, white
<i>Cotesia</i> nr. (Linnaeus) Code: 20911 [Hyperparasitoid: <i>Eurytoma</i> sp.]	<i>ruidus</i> Undetermined caterpillar	-	<i>Psidium guajava</i> Mill.	Karnataka	Gregarious, cocoons heaped together in inverted 'U' shaped hard cocoon mass covered with cotton fibers along with a long tail. Tail is fibrous and devoid of cocoons.
<i>Cotesia</i> nr. <i>rufiventris</i> Code: 1012CP	<i>Catopsilia pyranthe</i> L.	Pieridae	<i>Cassia</i> sp.	Gujarat	Solitary, white
<i>Cotesia</i> sp. 01 Code: 61212	<i>Trabala vishnou</i> Lefèbvre	Lasiocampidae	-	Kerala	Gregarious, off-white, laid erect on the dorsal surface of the caterpillar, 65-70/ caterpillar
<i>Cotesia</i> sp. 02 Code: 31112	<i>Euthalia lubentina</i> Cramer	Nymphalidae	<i>Loranthus</i> sp.	Karnataka	Gregarious, white
<i>Cotesia</i> sp. 03 Code: 11613	-	Erebidae: Arctiinae	<i>Thelypteris</i> sp.	Meghalaya	Gregarious, white, scattered lose around the caterpillar
<i>Cotesia</i> sp. 04 Code: 92003	<i>Amsacta</i> sp.	-	-	Karnataka	Gregarious, white
<i>Cotesia</i> sp. 05 Code: 201106	-	-	<i>Vicia faba</i> L.	Karnataka	Gregarious, white
<i>Cotesia</i> sp. 06 Code: 5810	-	-	<i>Mangifera indica</i> L.	Karnataka	Gregarious, white

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TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Cotesia</i> sp. 07 Code: 8811	-	-	<i>Ziziphus</i> sp.	Karnataka	Gregarious, white
<i>Cotesia</i> sp. 08 Code: 2811Y			<i>Cajanus cajan</i> (L.) Millsp.	Karnataka	Solitary, yellow
<i>Cotesia</i> sp. 09 Code: 12912	? <i>Idioclora</i> sp.	Geometridae	<i>Helianthus annuus</i> L.	Andhra Pradesh	Gregarious white
<i>Cotesia</i> sp. 10 Code: 27610		-	<i>Syzygium cumini</i> (L.) Skeels.	Karnataka	Gregarious, white
<i>Diolcogaster</i> sp. 01 Code: 8312D	-	-	-	Andaman Islands	-
<i>Diolcogaster</i> sp. 02 Code: 20512	-	-	<i>Terminalia</i> sp.	Tamil Nadu, Karnataka	Gregarious, white
<i>Distatrix papilionis</i> (Viereck) Codes: 9810, 0710, PD12011	<i>Papilio demoleus</i> L.	Papilionidae	<i>Citrus aurantiifolia</i> (Christm.) Swingle	Karnataka, Assam, Andhra Pradesh and Tamil Nadu	Gregarious, white, cocoon mass ranging from 15-158 cocoons/ mass depending on the larval instar
<i>Dolichogenidea cinnarae</i> Gupta, Lokhande & Soman Code: 50912 [Hyperparasitoid: <i>Pediobius foveolatus</i> (Crawford) (Eulophidae)]	<i>Borbo cinnara</i> (Wallace)	Hesperiidae	undetermined graminaceous weed	Tamil Nadu & Maharashtra Kerala	Gregarious, white
<i>Dolichogenidea kunhi</i> Gupta & Kalesh Code: DOL111	<i>Thoressa evershedii</i> (Evans)	Hesperiidae	<i>Ochlandra</i> sp.	Kerala	Gregarious, white
<i>Dolichogenidea stantoni</i> (Ashmead) Codes: 27911, 71011, 5511, 11111, 171112	<i>Parotis marginata</i> (Hampson)	Crambidae	<i>Gardenia jasminoides</i> J. Ellis	Karnataka	Gregarious, white
<i>Dolichogenidea stantoni</i> (Ashmead) Code: 20130	<i>Olene Hubner</i>	Erebidae: Lymantiriinae (*)	-	Tamil Nadu	Gregarious, white
<i>Dolichogenidea</i> sp. 01 Code: 14512	?	Gracillariidae	<i>Phyllanthus emblica</i> (= <i>Emblica officinalis</i>) L.	Tamil Nadu	Solitary, white
<i>Dolichogenidea</i> sp. 02 Code: 2710	<i>Artaxa guttata</i> Walker	Erebidae: Lymantiriinae	<i>Rosa</i> sp.	Karnataka	Gregarious, off white, covered with fuss
<i>Dolichogenidea</i> sp. 04 Code: 291211	<i>Perina (Fabricius)</i>	Erebidae: Lymantiriinae	?	Karnataka	Solitary, white
<i>Dolichogenidea</i> sp. 05 Code: 2011AS [Hyperparasitoid: <i>Pachyneuron groenlandicum</i> (Holmgren)]	-	Lycaenidae	-	Assam	Gregarious

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TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Dolichogenidea</i> sp. 06 Code: 26613		Geometridae	<i>Acacia</i> sp.	Karnataka	Gregarious, white
<i>Fornicia</i> <i>ceylonica</i> Wilkinson Code: 41111	<i>Spatulifimbria</i> <i>castaneiceps</i> Hampson (*)	Limacodidae	<i>Ricinus</i> <i>communis</i> L.	Karnataka	Solitary, white, beneath the host caterpillar
<i>Glyptapanteles</i> <i>aristolochiae</i> (Wilkinson) Code: 0710	<i>Pachliopta</i> <i>hector</i> (Linnaeus)	Papilionidae		Karnataka	Gregarious, white, congregated together
<i>Glyptapanteles</i> <i>clanisae</i> Gupta Code: 2211CLP [Hyperparasitoid: <i>Eurytoma</i> sp.]	<i>Clanis</i> <i>phalaris</i> Cramer	Sphingidae	<i>Pongamia</i> <i>pinnata</i> (L.)	Karnataka	Gregarious, white, cottony mass appearance
<i>Glyptapanteles</i> <i>creatonoti</i> Viereck Code: 2005AA	<i>Amsacta albistriga</i> (Walker)	Erebidae: Arctiinae	<i>Arachis</i> <i>hypogaea</i> L.	Karnataka	Gregarious, white
<i>Glyptapanteles</i> <i>hypermnestrae</i> Gupta & Pereira Code: 111011	<i>Elymnias</i> <i>hypermnestra</i> (Linnaeus)	Nymphalidae	<i>Cocos nucifera</i> L.	Maharashtra	Gregarious, yellow, laid in clusters in a row on lateral sides of caterpillar
<i>Glyptapanteles</i> <i>obliquae</i> (Wilkinson) Code: 812SO	<i>Spilosoma</i> <i>obliqua</i> Walker	Erebidae: Arctiinae	-	Karnataka	Gregarious, white
<i>Glyptapanteles</i> <i>obliquae</i> (Wilkinson) Code: 812CP	-	Erebidae: Arctiinae	<i>Coccinia</i> sp.	Karnataka	Gregarious, white
<i>Glyptapanteles</i> <i>spodopterae</i> Ahmad Code: 22713SL	<i>Spodoptera litura</i> Fab.	Noctuidae		Karnataka	Gregarious, white
<i>Glyptapanteles</i> <i>trilochae</i> Gupta Code: 181012	<i>Trilocha</i> <i>varians</i> (Walker)	Bombycidae	<i>Ficus</i> <i>racemosa</i> L.	Karnataka	Solitary, white
<i>Glyptapanteles</i> sp. 02 Code: 14912	Undetermined caterpillar	-	<i>Artemisia</i> <i>vulgaris</i> L.	Uttarakhand (Almora)	Solitary, white
<i>Glyptapanteles</i> sp. 04 Code: 51112 [Hyperparasitoid: <i>Pediobius</i> sp.]	<i>Orgygia</i> <i>postica</i> Walker	Erebidae: Lymantriinae	<i>Cajanus cajan</i> (L.) Millsp.	Karnataka	Gregarious, white
<i>Glyptapanteles</i> sp. 05 Code: 10312	? <i>Melanephia mosara</i> Swinhoe	Noctuidae	<i>Ipomoea pes-</i> <i>caprae</i> (L.) R. Br.	Wandoor (Andaman Islands)	Solitary, white
<i>Glyptapanteles</i> sp. 06 Code: 1211	<i>Argina astrea</i> (Drury)	Erebidae: Arctiinae	<i>Crotalaria</i> <i>juncea</i> L.	Andhra Pradesh	Gregarious, white
<i>Glyptapanteles</i> sp. 07 Code: 14912	<i>Ascotis</i> <i>imparata</i> (Walker)	Geometridae	<i>Melia</i> <i>azedarach</i> L.	Andhra Pradesh	Gregarious, white, spinned together in a round ball

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TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Glyptapanteles</i> sp. 08 Code: 16810SA	-	-	<i>Melia azedarach</i> L.	Karnataka	Gregarious, compact rectangular elongated cocoon mass, cocoons heaped together on top of each other sided by side.
<i>Glyptapanteles</i> sp. 09 Code: 14810SA	-	-	<i>Melia azedarach</i> L.	Karnataka	Gregarious, compact round cocoon mass, cocoons heaped together on top of each other in the shape of a ball
<i>Glyptapanteles</i> sp. 10 Code: 221011	-	Erebidae: Arctiinae	<i>Pongamia</i> sp.	Karnataka	Gregarious, white
<i>Glyptapanteles</i> sp. 11 Code: 2810	-	Erebidae: Arctiinae	-	Karnataka	Gregarious, white
<i>Glyptapanteles</i> sp. 12 Code: 27613	-	Geometridae	<i>Acacia</i> sp.	Karnataka	Solitary, off white
<i>Glyptapanteles</i> sp. 13 Code: CA2711	-	-	<i>Ricinus communis</i> L.	Karnataka (Savandurga forests)	Gregarious, white
<i>Microgaster</i> sp. 01 Code: 24812K	-	-	undetermined weed	Kashmir	Solitary, light brown
<i>Microgaster</i> sp. 02 Code: 10712	-	-	undetermined weed	Western Ghats, Karnataka	Solitary, light brown
<i>Microplitis carinicollis</i> (Cameron)	<i>Psalis pennatula</i> (Fab.)	Erebidae: Lymantriinae	-	Karnataka	Solitary, brown
<i>Microplitis demolitor</i> Wilkinson Code: 1311	<i>Helicoverpa armigera</i> (Hubner)	Noctuidae	-	Karnataka	Solitary, light brown
<i>Microplitis indicus</i> Marsh Code: CIBC-0764	<i>Helicoverpa</i> sp. <i>Helicoverpa assulta</i> (Guenee)	Noctuidae	-	Himachal Pradesh - (Kulu)	-
<i>Microplitis maculipennis</i> (Szepligeti) Code: 27121	<i>Acanthodelta janata</i> L.	Erebidae	<i>Ricinus communis</i> L.	Karnataka, Andhra Pradesh, Orissa, Maharashtra and Tamil Nadu	Solitary, brown, clasped by the last pair of legs at the anal end of the caterpillar
<i>Microplitis manilae</i> Ashmead Codes: 23812J, CIBCIS3	<i>Spodoptera</i> sp.	Noctuidae	-	Jammu & Kashmir and Uttar Pradesh	-
<i>Microplitis prodeniae</i> Rao & Kurian Code: 25121	<i>Spodoptera litura</i> (Fabricius)	Noctuidae	<i>Amaranthus</i> sp.	Karnataka	Solitary, light brown
<i>Microplitis spodopterae</i> Rao & Kurian Code: 28811	<i>Spodoptera mauritia</i> (Boisduval)	Noctuidae	<i>Trigonella foenum- graecum</i> L.	Karnataka and Bihar	Solitary, brown
<i>Neoclarkinella vitellinipes</i> (You & Zhou) Code: 8812	Undetermined caterpillar	-	Forest ecosystem	Karnataka	-
<i>Parapanteles echeriae</i> Gupta, Pereira & Churi Code: 0812	<i>Abisara echeria</i> Stoll	Riodinidae	<i>Embelia</i> sp.	Maharashtra	Gregarious, white, 5-6 cocoons laid on each side of caterpillar

.....Continued on the next page

TABLE 1. (Continued)

Species with code #	Host	Host family	Host Plant	Collection (States/ Union Territory)	Cocoon variations
<i>Parapanteles</i> sp. 02 Codes: 7312, 6312	<i>Asota caricae</i> Fab.	Noctuidae	Dabra weed	Havelock island, Andamans	Solitary, white
<i>Parapanteles</i> sp. 03 Code: 25711	-	Erebidae: Arctiinae	<i>Achras zapota</i> L.		Gregarious, white
<i>Parapanteles</i> sp. 04 Code: 71212	<i>Orgyia</i> sp. (*)	Erebidae: Lymantriinae (*)	<i>Ricinus communis</i> L.	Southern India	Gregarious, off-white, laid erect on the dorsal surface of caterpillar in two rows, each placed laterally
<i>Parapanteles</i> sp. 05 Code: 6613	<i>Chilades pandava</i> Horsfield (*)	Lycaenidae (*)	<i>Cycas revolute</i> Thunb.	Karnataka	Solitary, white, laid beneath the host caterpillar
<i>Parapanteles</i> sp. 06 Code: 3112	-	-	<i>Parthenium hysterophorus</i> L.	Karnataka	Gregarious, white, covered by cottony fibres
<i>Protapanteles africanus</i> (Cameron) Code: 0911	? <i>Gessonia gemma</i> Swinhoe (*)	Noctuidae	<i>Glycine max</i> (L.)	Rajasthan	Solitary, white
<i>Protapanteles</i> <i>beneficus</i> (Viereck) Code: 14711	nr. <i>Utetheisa pulchella</i> (L.)	Erebidae: Arctiinae	<i>Crotalaria juncea</i> L.	Andhra Pradesh	Solitary, white
<i>Protapanteles</i> sp. 01 Code: 1012	<i>Anomis sabulifera</i> Guenée	Noctuidae	<i>Corchorus</i> sp.	Kolkata (Barrackpore)	-
<i>Protapanteles</i> sp. 02 Code: 29610 Eulophids		Noctuidae	<i>Hibiscus vitifolius</i> L.	Karnataka	Gregarious, white
<i>Protapanteles</i> sp. 03 Code: 6810			<i>Abelmoschus esculentus</i> (L.) Moench	Karnataka	Gregarious, white
<i>Protapanteles</i> sp. 04 Code: 91212	-	-	-	Kerala	Gregarious, white
Unidentified Genera and species of Microgastrinae	Groundnut leaf miner		<i>Arachis hypogaea</i> L.	Andhra Pradesh	Solitary
Unidentified Genera and species of Microgastrinae	<i>Troides minos</i> Cramer	Papilionidae	-	Maharashtra	Gregarious, white
Unidentified Genera and species of Microgastrinae	<i>Matapa aria</i> (Moore)	Hesperiidae	-	Maharashtra	Gregarious, white
Unidentified Genera and species of Microgastrinae	<i>Pieris canidia</i> (L.)	Pieridae	-	West Bengal (Mirik)	Gregarious, yellow
Unidentified Genera and species of Microgastrinae	<i>Amblypodia anita</i> Moore	Lycaenidae	-	Maharashtra	Gregarious, white

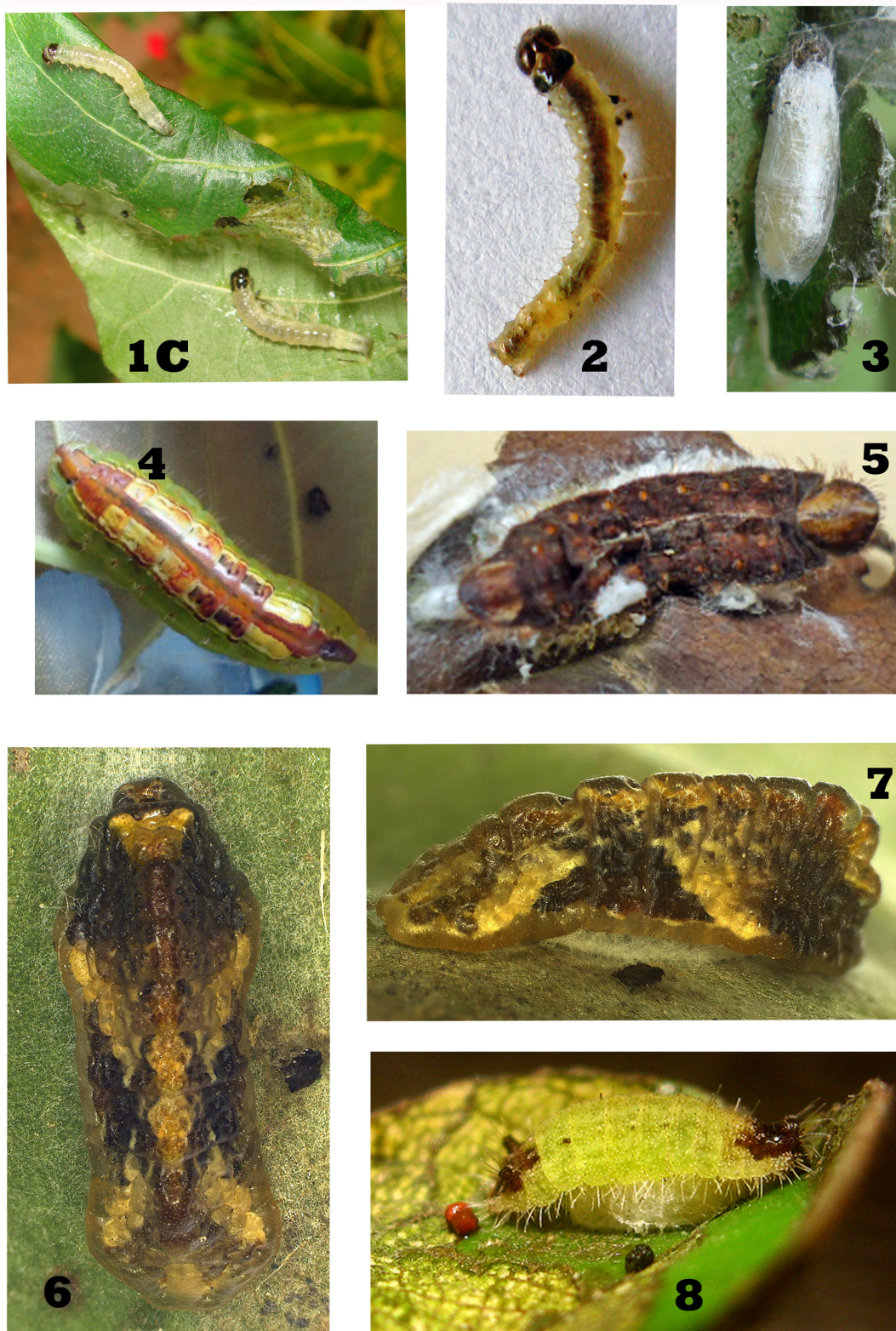


1A

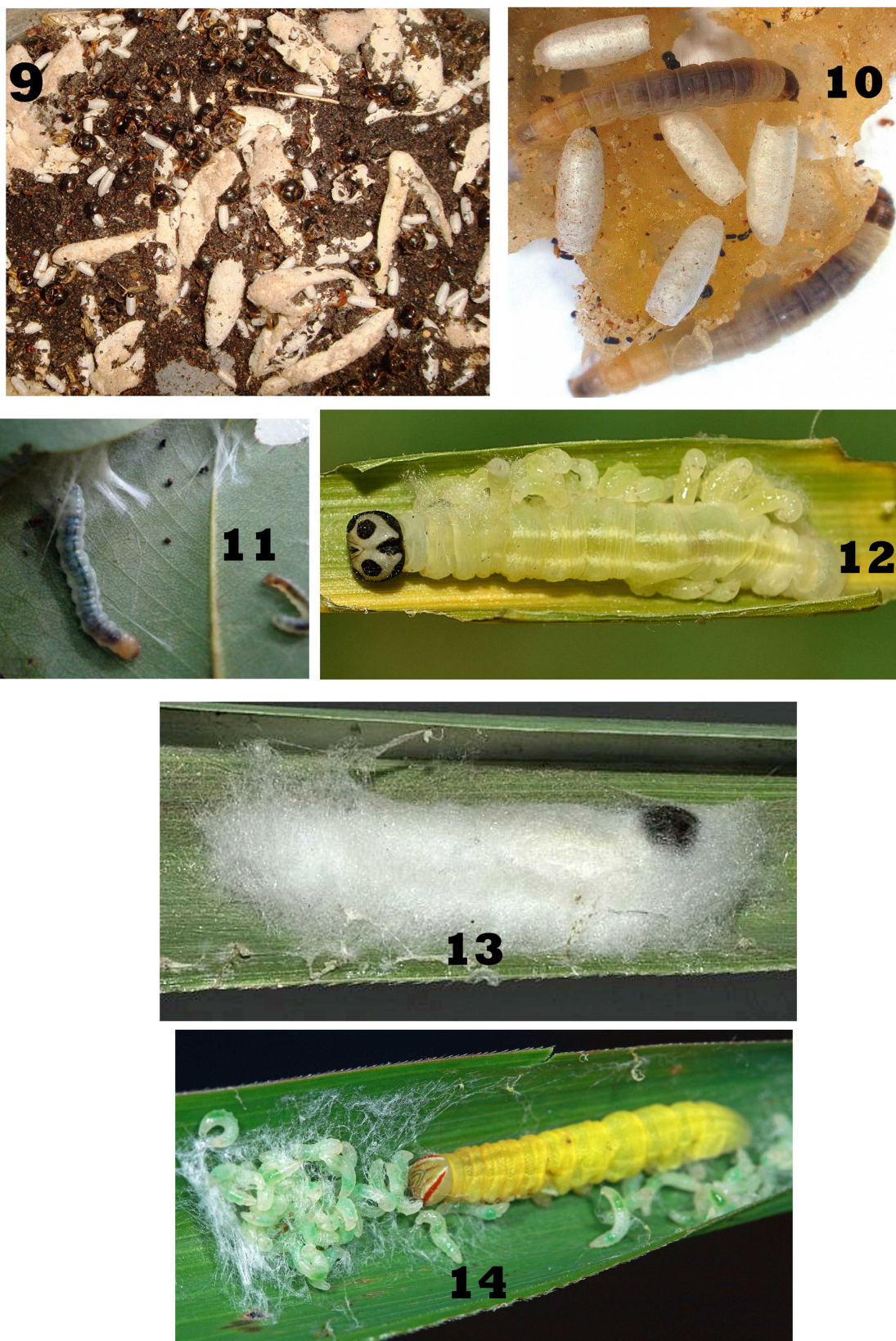


1B

FIGURE 1. 1A. Leaves with cocoons; 1B. Test tubes with single cocoon mass for emergence.



FIGURES 1C–8. 1C. Healthy caterpillars of *Syllepte derogata* (Fab.) on cotton; 2. Parasitized caterpillar of *Syllepte derogata*; 3. Cocoon of *Apanteles diparopsidis* Lyle; 4. Healthy caterpillar of *Arhopala amantes* (Hewitson); 5. Parasitized caterpillar of *Arhopala amantes* with cocoons of *Apanteles folia* Nixon; 6. *Tajuria cippus* (Fab.) caterpillar; 7. Parasitized caterpillar of *Tajuria cippus* with cocoon of *Apanteles folia*; 8. *Spindasis vulcanus* (Fab.) caterpillar with cocoon of *Apanteles folia*.



FIGURES 9–14. 9. Cocoons of *Apanteles galleriae* Wilkinson in debris of *Galleria mellonella* L.; 10. Enlarged view of *Apanteles galleriae* cocoons with caterpillars of *Galleria mellonella*; 11. Host caterpillar of *Apanteles inquisitor* Wilkinson; 12. Parasitized caterpillar of *Pelopidas conjuncta* (Herrich-Schaffer); 13. Parasitized caterpillar of *Pelopidas conjuncta* inside cottony mesh; 14. Parasitized caterpillar of *Pelopidas mathias* (Fab.) with *Apanteles javensis* Rohwer larvae spinning cocoons.



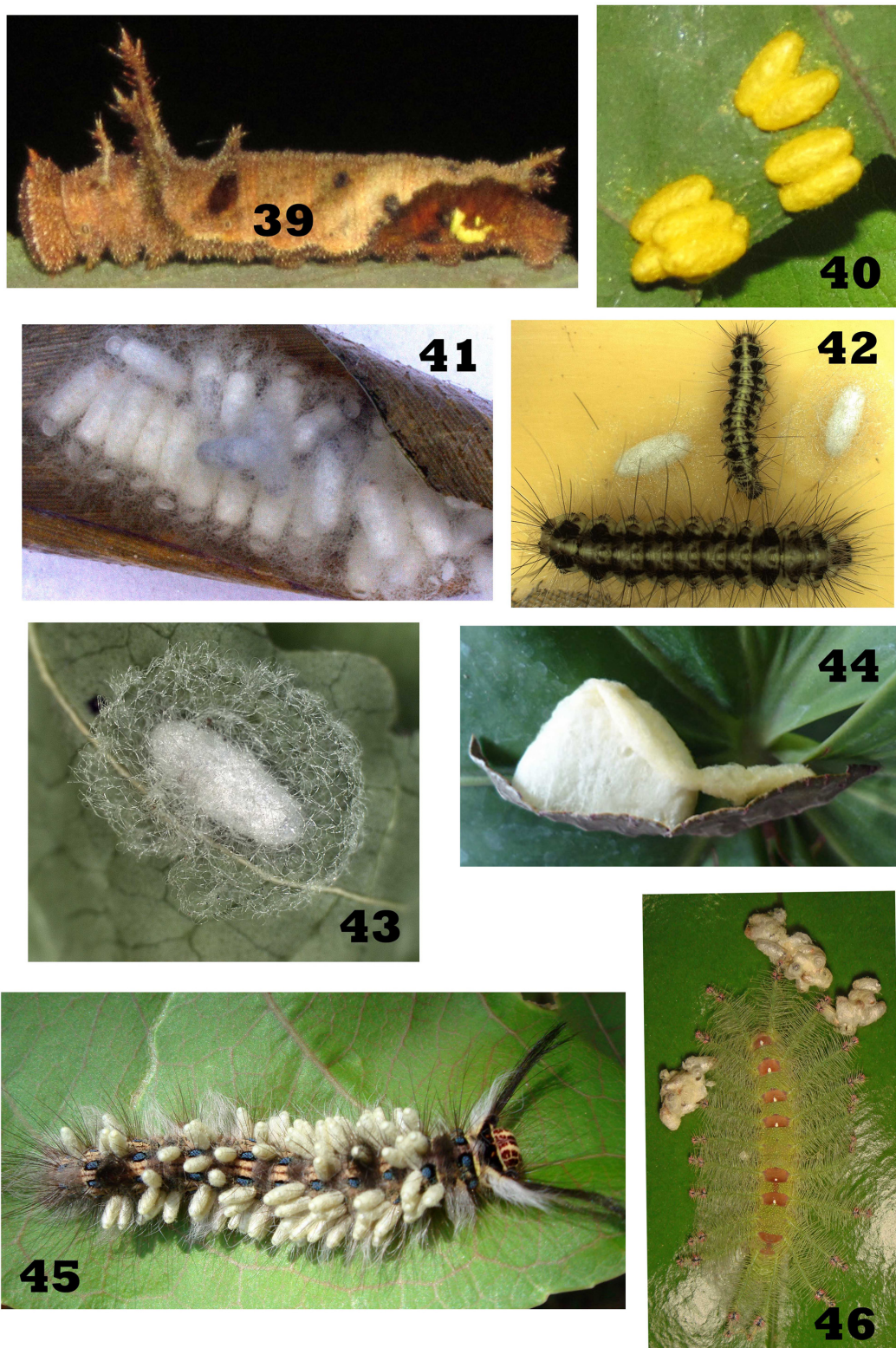
FIGURES 15–22. 15. Caterpillar of *Pammene critica* Meyrick; 16. *Apanteles mohandasi* Sumodan & Narendran cocoon with parasitized caterpillar of *Pammene critica*; 17. Gregarious cocoons of *Apanteles phycodis* Viereck from host caterpillar *Argina syringa* Cramer; 18. *Apanteles phycodis* emerged from cocoons of *Phycodes radiata* Ochsenheimer; 19. *Ficus* sp. leaves with cocoon mass of *Apanteles phycodis* inside cottony mesh; 20. Parasitized caterpillar with cocoons of *Apanteles phycodis* (after removing cottony mesh); 21. Host caterpillar of *Apanteles platydrae* Wilkinson; 22. Parasitized caterpillar with cocoons of *Apanteles platydrae*.



FIGURES 23–30. 23. Healthy caterpillar of *Parotis marginata* (Hampson); 24. Parasitized caterpillar of *Parotis marginata*; 25. Parasitized caterpillar of *Parotis marginata* with *Dolichogenidea stantoni* (Ashmead) cocoons; 26. *Dolichogenidea stantoni* cocoons along with healthy caterpillar of *Olene ?mendoza* Hubner undergoing pupation; 27. Solitary cocoon of *Apanteles taragamae* Viereck with undetermined leaf webber; 28. Cocoons of *Apanteles taragamae* with caterpillar of *Diaphania indica* Saunders; 29. Healthy caterpillar of *Acontia marmoralis* Fab.; 30. Parasitized caterpillar of *Acontia marmoralis* with *Apanteles* sp. 01 cocoon.



FIGURES 31–38. 31. Cocoon of *Buluka horni* Gupta on *Mangifera indica* L.; 32. Cocoon of *Buluka* nr. *noyesi* from parasitized caterpillar of *?Psimada quadripennis* Walker; 33. Parasitized caterpillar of *Udaspes folus* (Cramer) with cocoons of *Cotesia erionotae* (Wilkinson); 34. Cocoons of *Cotesia flavipes* Cameron with caterpillar of *Chilo partellus* (Swinhoe) on maize; 35. Healthy caterpillar of *Pieris brassicae* L.; 36. Gregarious yellow cocoons of *Cotesia glomerata* (Linnaeus) with parasitized caterpillar of *Pieris brassicae*; 37. Solitary cocoon of *Cotesia vestalis* (Haliday) with caterpillars of *Plutella xylostella* (L.); 38. Cocoons of *Cotesia ruidus* Wilkinson with parasitized caterpillar of *Eutectona machaeralis* (Walker).



FIGURES 39–46. 39. Parasitized caterpillar of *Phaedyra columella* (Cramer); 40. Cocoons of *Cotesia tiracolae* (Ashmead); 41. Cocoons of *Cotesia ruficrus* (Haliday); 42. Cocoons of *Cotesia* nr. *ruidus* with parasitized caterpillar of *Olepa* (= *Pericallia*) *ricini* Fab.; 43. Solitary cocoon of *Cotesia* nr. *ruidus*; 44. Cocoon mass of *Cotesia* nr. *ruidus* (Linnaeus); 45. Cocoons of *Cotesia* sp. 01 on *Trabala vishnou* Lefèbvre; 46. Cocoons of *Cotesia* sp. 02 on *Euthalia lubentina* Cramer.



FIGURES 47–54. 47. Cocoons of *Cotesia* sp. 03 on undetermined. arctiid caterpillar on *Thelypteris* sp.; 48. Cocoons of *Cotesia* sp. 05 on host plant *Vicia faba* L.; 49. Cocoons of *Cotesia* sp. 06 on host plant *Mangifera indica* L.; 50. Cocoons of *Cotesia* sp. 08 on host plant *Cajanus cajan* (L.) Millsp.; 51. Host caterpillar of *Cotesia* sp. 09 on *Helianthus annuus* L.; 52. Parasitized host caterpillar of *Cotesia* sp. 10 on *Syzygium cumini* (L.) Skeels.; 53. Cocoons of *Cotesia* sp. 10; 54. *Diolcogaster* sp. 02 on *Terminalia* sp..



FIGURES 55–56. 55. Parasitized caterpillar of *Papilio demoleus* L. with cocoons of *Distatrix papilionis* (Viereck); 56. Cocoon mass of *Distatrix papilionis* (Viereck).



57



58



59 A



59 B



60



61



62



63

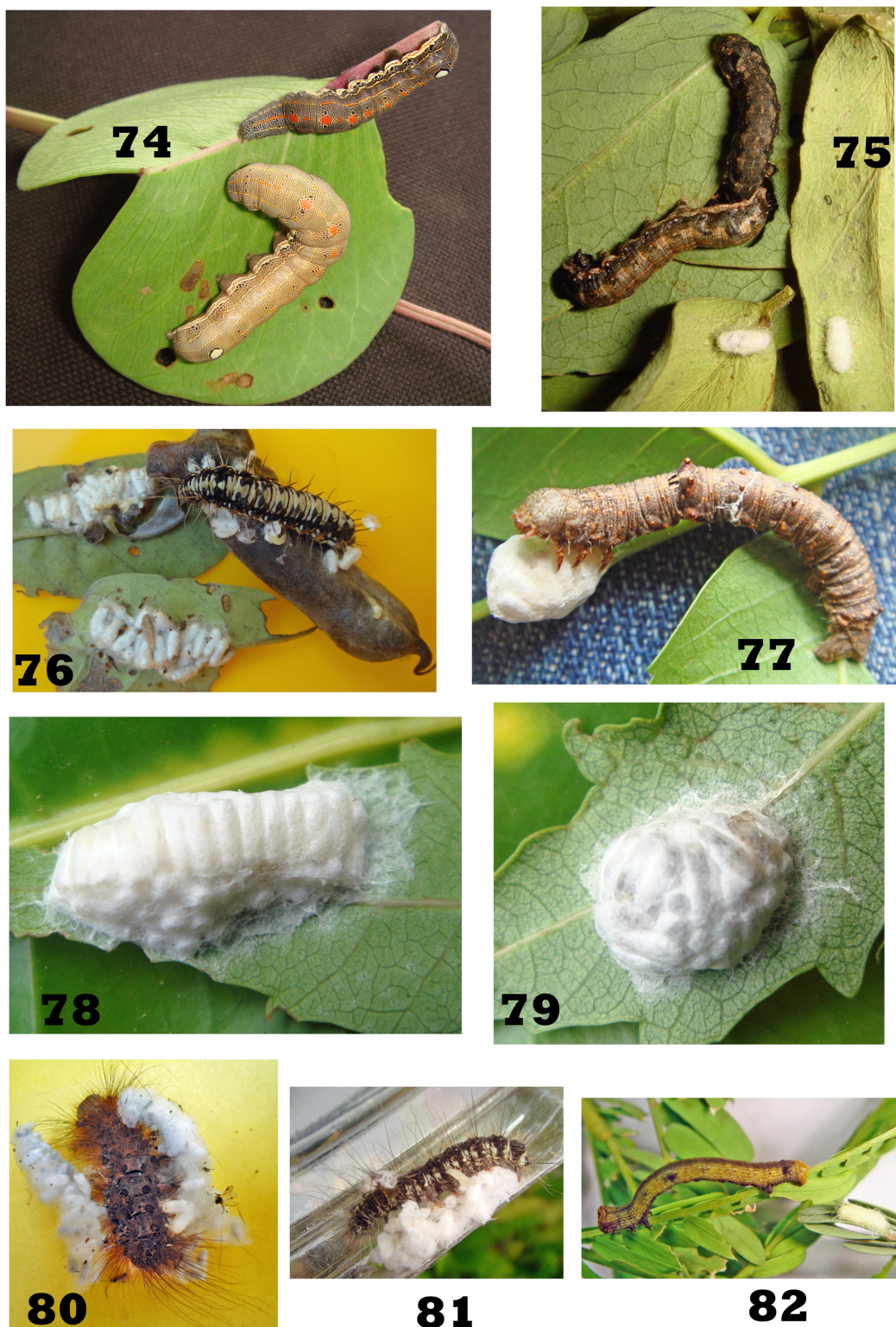


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FIGURES 57–64. 57. Parasitized caterpillar of *Thoressa evershedii* (Evans) with cocoons of *Dolichogenidea kunhi* Gupta & Kalesh; 58. Parasitized caterpillar of *Borbo cinnara* (Wallace) with cocoons of *Dolichogenidea cinnarae* Gupta, Lokhande & Soman; 59. A & B-Host of *Dolichogenidea* sp. 01; 60. Cocoons of *Dolichogenidea* sp. 02 with parasitized caterpillar of *Artaxa guttata* Walker; 61. Caterpillar of *Perina nuda* (Fab.) (host of *Dolichogenidea* sp. 04); 62. Solitary cocoon of *Dolichogenidea* sp. 04; 63. Cocoons of *Dolichogenidea* sp. 06 on *Acacia* sp.; 64. Caterpillar of *Spatulifimbria castaneiceps* Hampson (Host of *Fornicia ceylonica* Wilkinson).



FIGURES 65–73. 65. Parasitized caterpillar of *Pachliopta hector* (Linnaeus) with cocoons of *Glyptapanteles aristolochiae* (Wilkinson); 66. Healthy caterpillar of *Elymnias hypermnestra* (L.); 67. Cocoons of *Glyptapanteles hypermnestrae* Gupta & Pereira with parasitized caterpillar of *Elymnias hypermnestra*; 68. *Glyptapanteles obliquae* (Wilkinson) cocoons with parasitized caterpillar of *Spilosoma obliqua* Walker; 69. *Glyptapanteles obliquae* cocoons with parasitized caterpillar of undetermined arctiid on *Coccinia* sp.; 70. *Glyptapanteles trilochoe* Gupta cocoon with parasitized caterpillar of *Trilocha varians* (Walker); 71. Cocoon mass of *Glyptapanteles clanisae* Gupta with parasitized caterpillars of *Clanis phalaris* Cramer; 72. Cocoons of *Glyptapanteles* sp. 04 with parasitized caterpillar of *Orgygia postica* Walker; 73. Healthy caterpillar of *Orgygia postica* Walker.



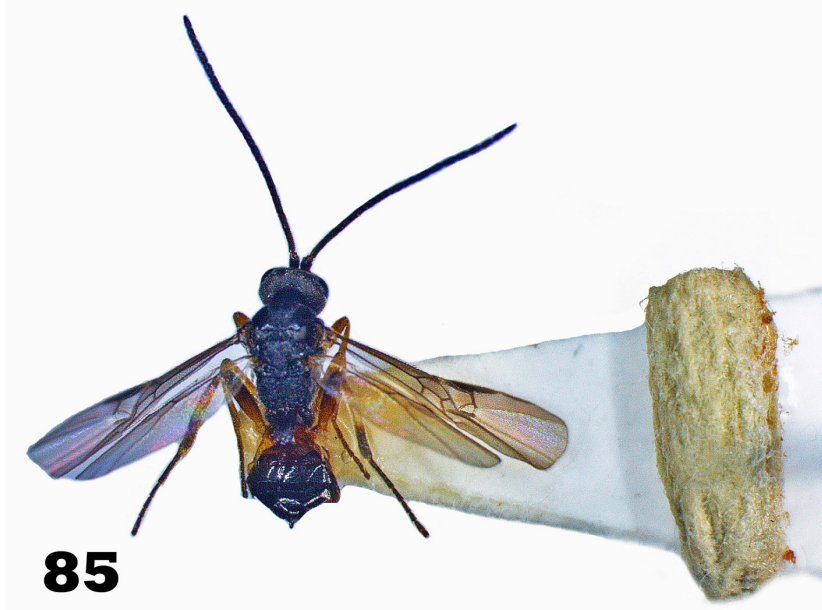
FIGURES 74–82. 74. Host caterpillars (?*Melanephia mosara* Swinhoe) of *Glyptapanteles* sp. 05; 75. Parasitized caterpillar of ?*Melanephia mosara* with cocoons of *Glyptapanteles* sp. 05; 76. Parasitized caterpillar of *Argina astrea* (Drury) with cocoons of *Glyptapanteles* sp. 06; 77. Parasitized caterpillar of *Ascotis imparata* (Walker) with cocoon mass of *Glyptapanteles* sp. 07; 78. Elongate cocoon mass of *Glyptapanteles* sp. 08; 79. Round cocoon mass of *Glyptapanteles* sp. 09; 80. Parasitized undetermined arctiid caterpillar on *Pongamia* sp. with cocoons of *Glyptapanteles* sp. 10; 81. Cocoons of *Glyptapanteles* sp. 11; 82. Solitary cocoon of *Glyptapanteles* sp. 12 with undetermined parasitized geometrid caterpillar on *Acacia* sp..



83



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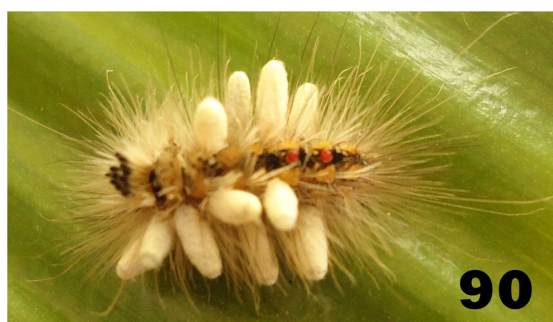


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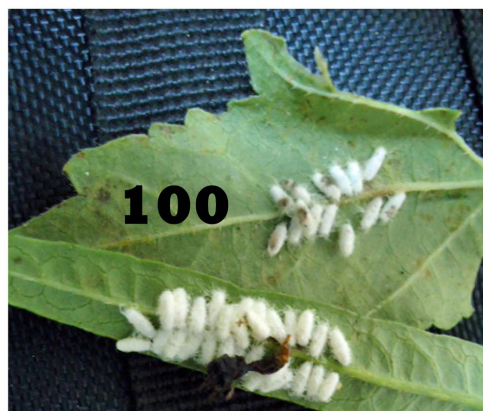


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FIGURES 83–86. **83.** *Microplitis carinicornis* (Cameron) wasp on brown cocoon from host caterpillar *Psalis pennatula* (Fab.); **84.** Parasitized caterpillar of *Acanthodelta janata* L. with cocoon of *Microplitis maculipennis* (Szepligeti); **85.** *Microplitis prodeniae* Rao & Kurian with grey brown cocoon from host caterpillar *Spodoptera litura* (Fab.); **86.** Cocoon of *Microplitis spodopterae* Rao & Kurian.



FIGURES 87–92. 87. Parasitized caterpillar of *Asota caricae* Fab. with cocoon of *Parapanteles* sp. 02; 88. Parasitized undetermined caterpillar with cocoons of *Parapanteles* sp. 02; 89. Parasitized arctiid caterpillar on *Achras zapota* L. with cocoons of *Parapanteles* sp. 03; 90. Parasitized *Orgyia* sp. caterpillar on *Ricinus communis* L. with cocoons of *Parapanteles* sp. 04; 91. Parasitized caterpillar of *Chilades pandava* Horsfield with cocoon of *Parapanteles* sp. 05; 92. Cocoon masses of *Parapanteles* sp. 06 on *Parthenium hysterophorus* L..



FIGURES 93–100. **93.** Solitary cocoon of *Protapanteles beneficus* (Viereck); **94.** Parasitized caterpillar of *Amsacta albistriga* (Walker) with cocoons of *Glyptapanteles creatonoti* Viereck; **95.** *Utetheisa pulchella* (L.) caterpillar (host of *Protapanteles* nr. *beneficus* (Viereck)); **96.** Parasitized undetermined caterpillar with cocoons of *Protapanteles* sp. 04; **97.** Host plant of noctuid caterpillar with cocoons of *Protapanteles* sp. 02; **98.** Host caterpillar with cocoons of *Protapanteles* sp. 02; **99.** Host caterpillar on *Abelmoschus esculentus* (L.) Moench with cocoons of *Protapanteles* sp. 03; **100.** Cocoons of *Protapanteles* sp. 03.



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104



FIGURES 101–104. **101.** Parasitized caterpillar of *Troides minos* Cramer; **102.** Parasitized caterpillar of *Matapa aria* (Moore); **103.** Parasitized caterpillar of *Pieris canidia* (L.); **104.** Parasitized caterpillar of *Amblypodia anita* Moore.



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FIGURES 105–106. **105.** Unparasitized caterpillar of *Abisara echeria* Stoll; **106.** Parasitized caterpillar of *A.echeria* with cocoons of *Parapanteles echeriae* Gupta, Pereira & Churi.



A



B



C

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FIGURE 107. *Apanteles folia* Nixon (female)—A. Profile view B. Mesosoma C. Propodeum with first two tergites.

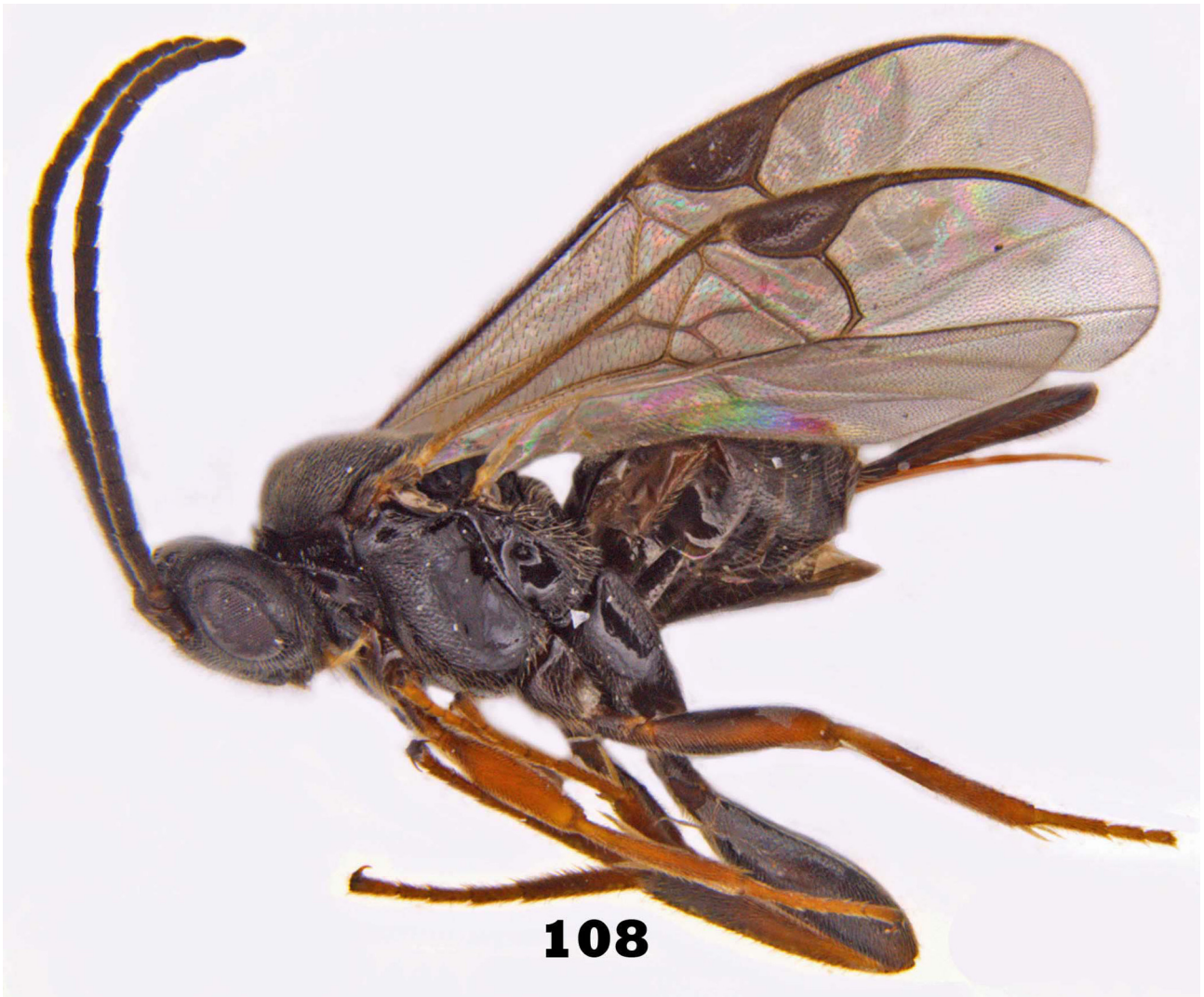


FIGURE 108. *Apanteles galleriae* Wilkinson (female)—Profile view.



A



B



C



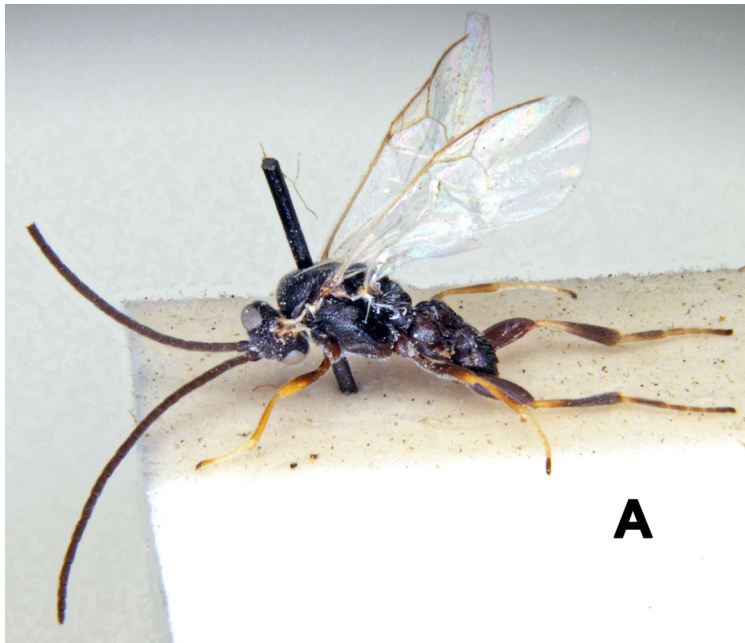
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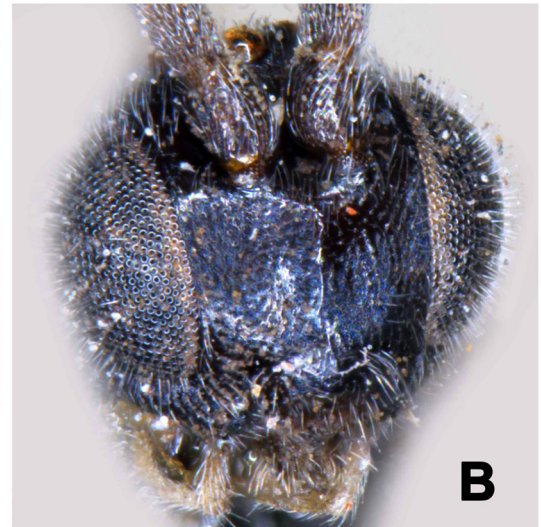
E

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FIGURE 109. *Apanteles javensis* Rohwer (female)—A. Mesosoma B. Profile view C. Propodeum (KOH treated) D. Propodeum with metasoma E. Metasoma (KOH treated).



A



B



C



D

110

FIGURE 110. *Apanteles machaeralis* Wilkinson (Paratype, female, Hoshangabad)—A. Profile view B. Head C. Mesosoma D. Metasoma.



FIGURE 111. *Apanteles machaeralis*—(Paratype, female, Hoshangabad)—E. Wings F. Body in lateral view G. Specimen on card along with cocoon.

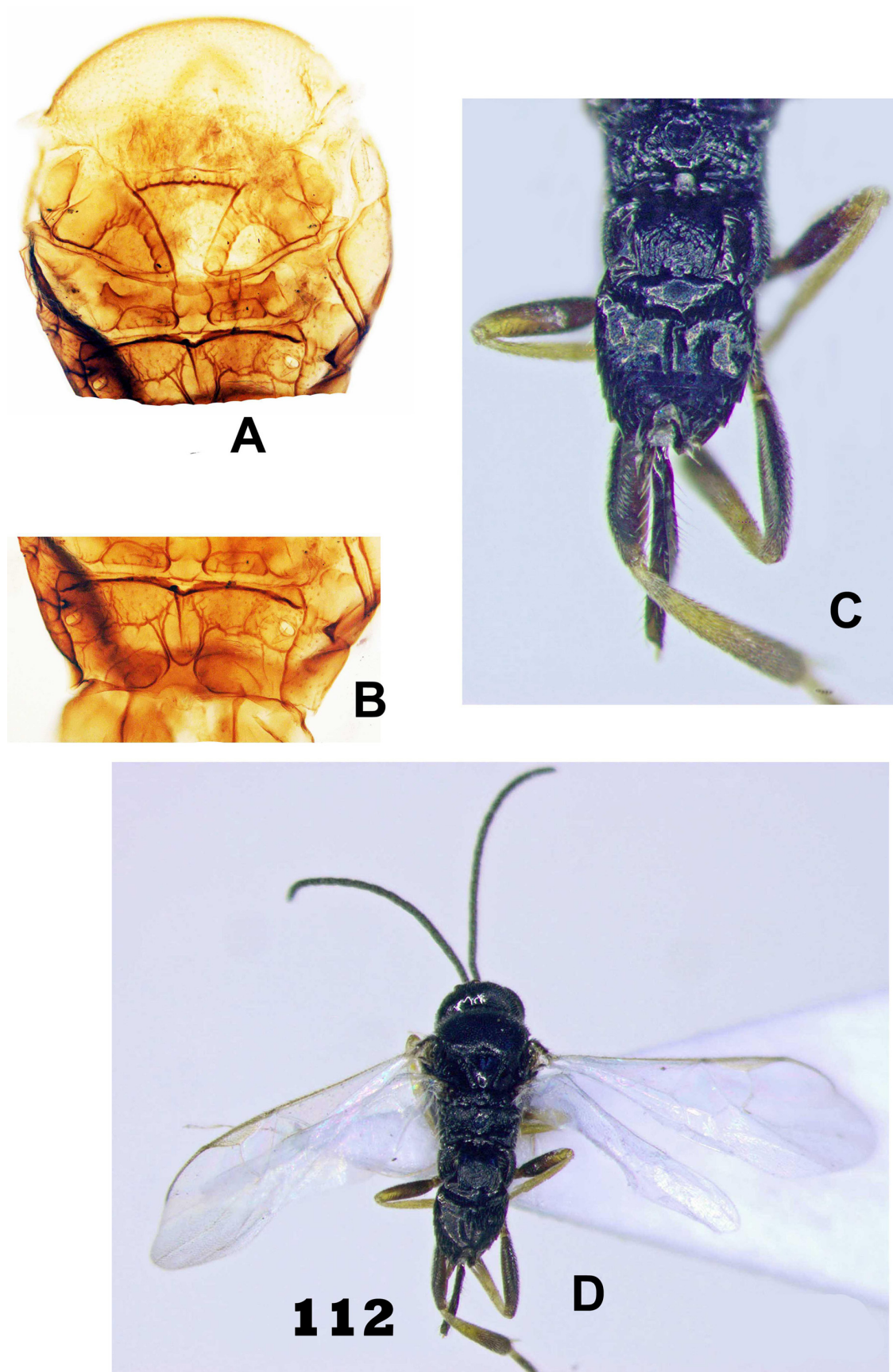


FIGURE 112. *Apanteles mohandasi* Sumodan & Narendran (female)—A. Mesosoma (KOH treated) B. Propodeum (KOH treated) C. Metasoma D. Body in dorsal view.

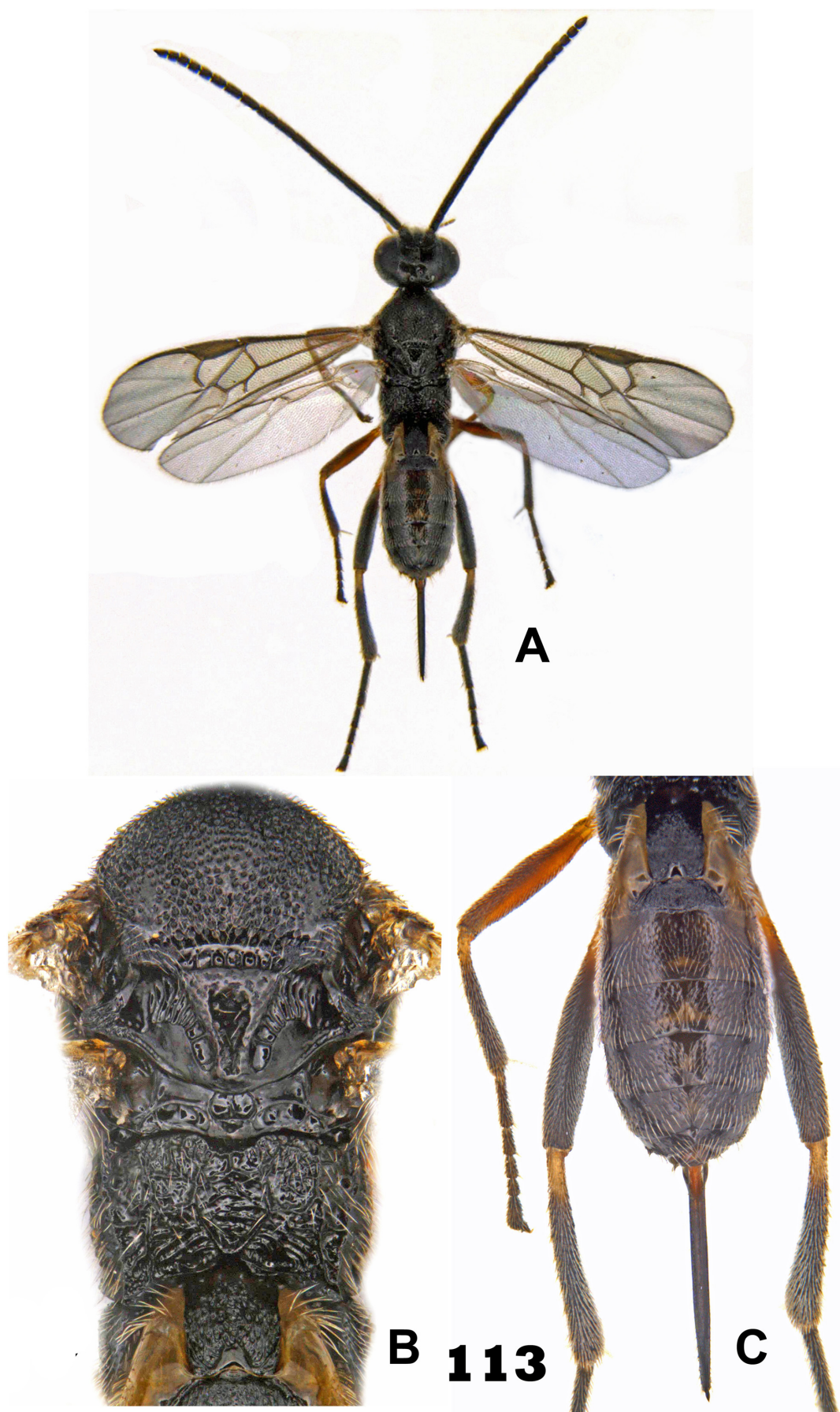
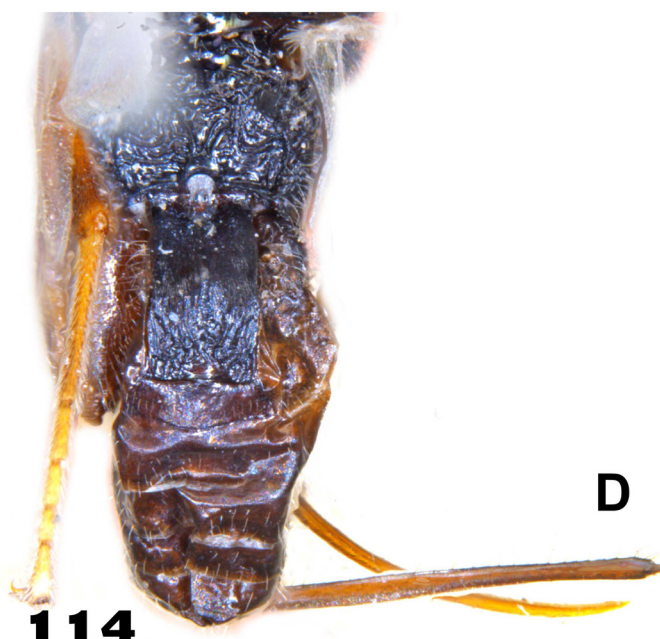
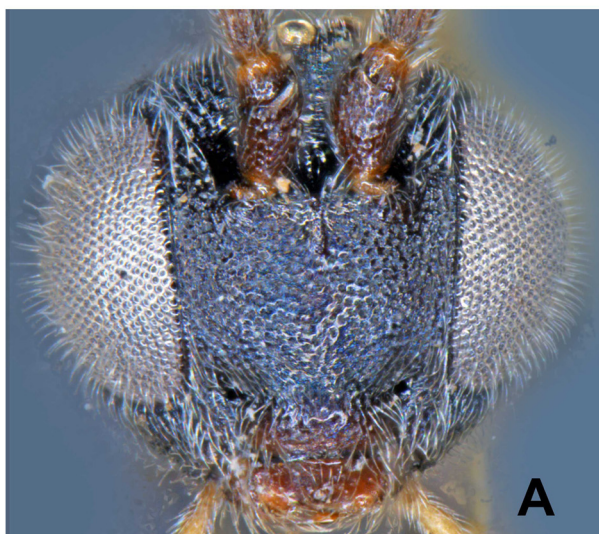


FIGURE 113. *Apanteles opacus* (Ashmead) (female)—A. Dorsal view B. Mesosoma with part of metasoma C. Metasoma.



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FIGURE 114. *Apanteles phycodis* Viereck (Paratype No. 15279, female, Coleman coll.)—A. Head B. Profile view C. Mesosoma with part of metasoma D. Metasoma .

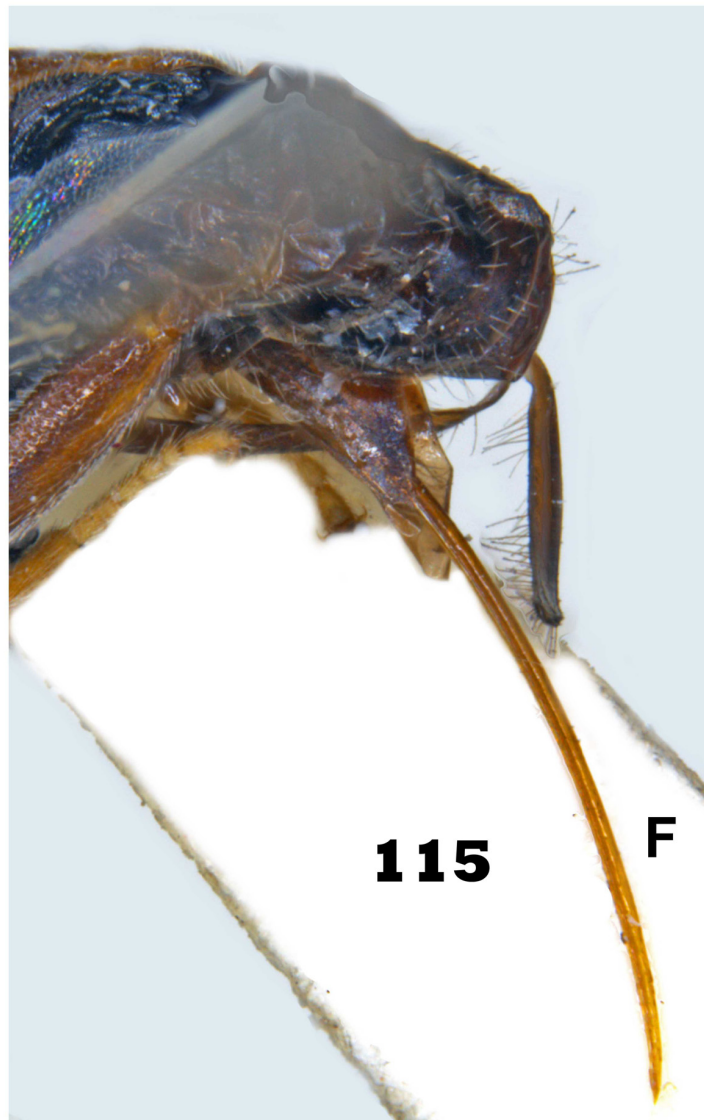
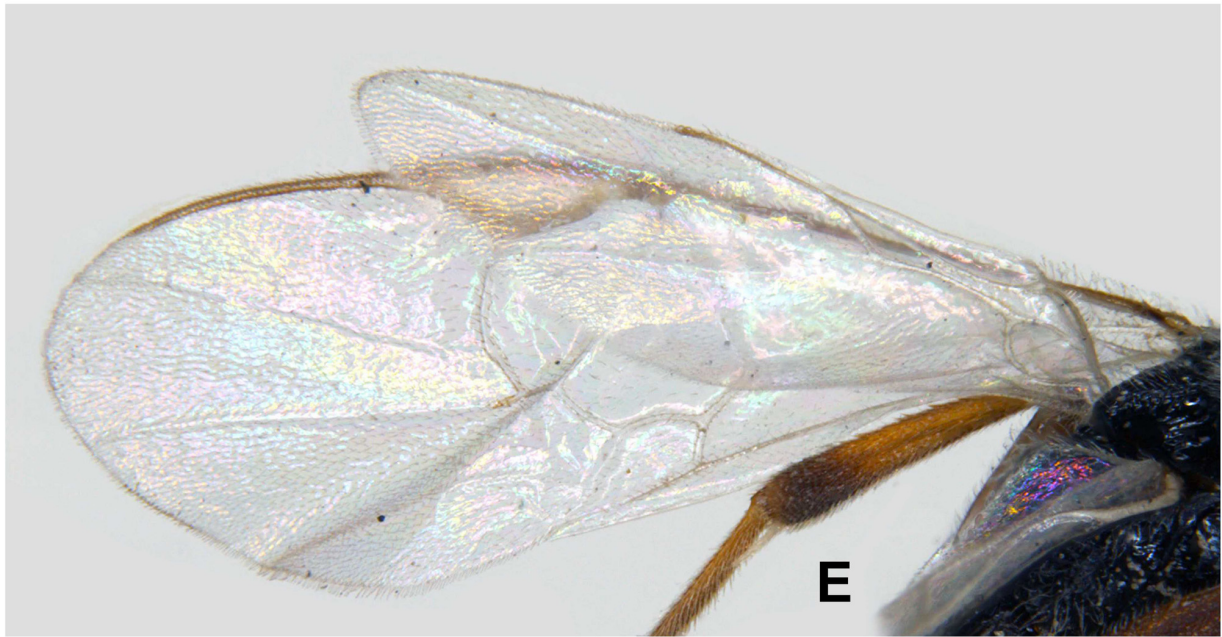


FIGURE 115. *Apanteles phycodis* Viereck (Paratype No. 15279, female, Coleman coll.)—E. Wings F. Ovipositor

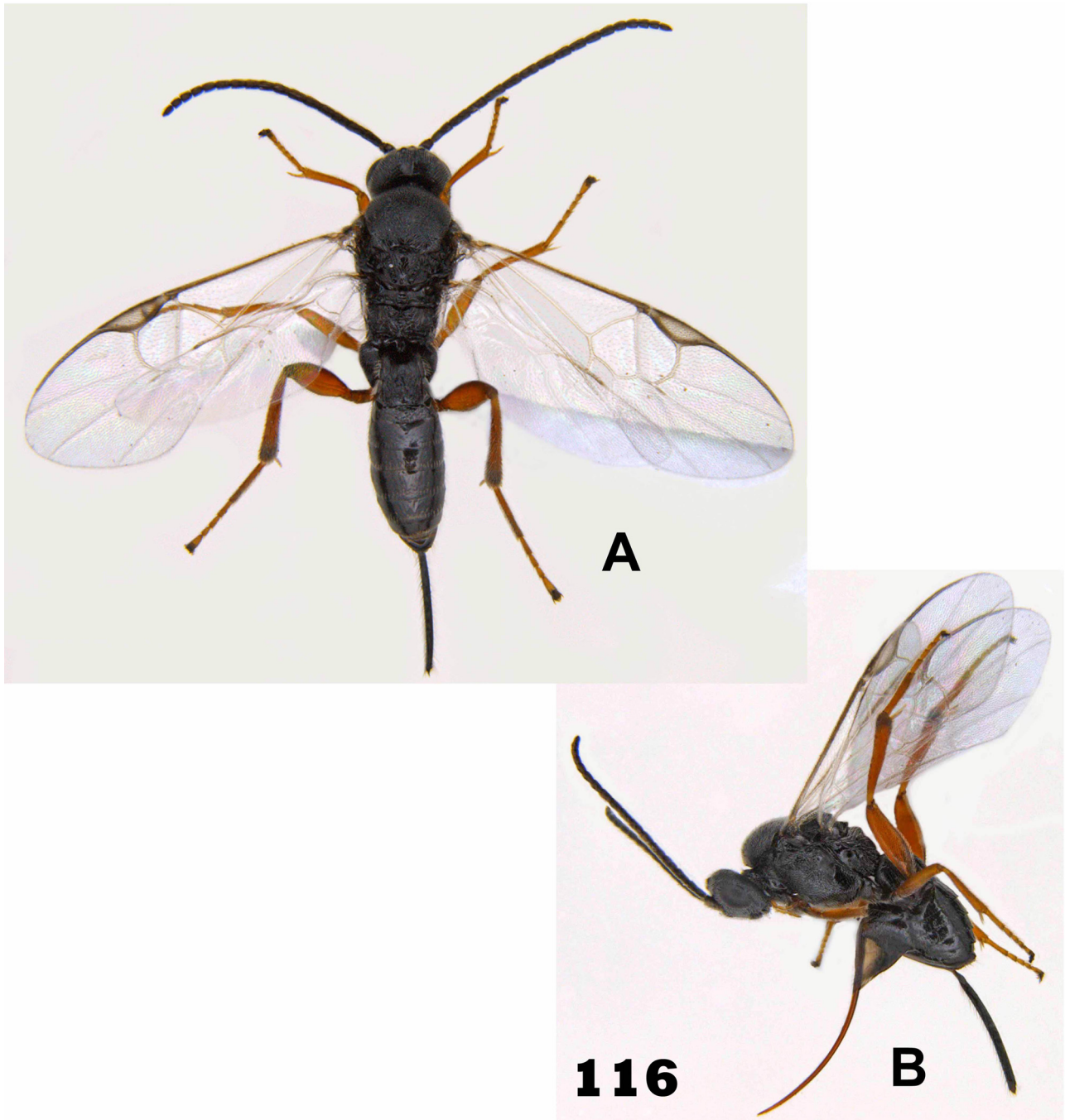
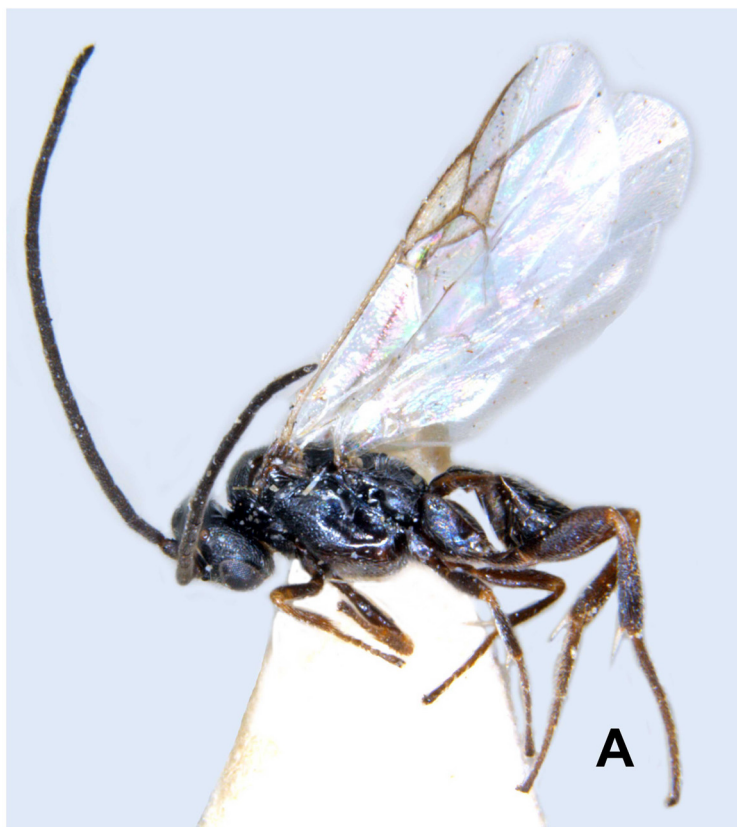


FIGURE 116. *Apanteles phycodis* (female, ex. *Phycodes radiata*)—A. Dorsal view B. Profile view.



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FIGURE 117. *Apanteles tachardiae* Cameron (Male, Mathurpur—Bengal)—A. Profile view B. Head C. Mesosoma D. Propodeum with metasoma

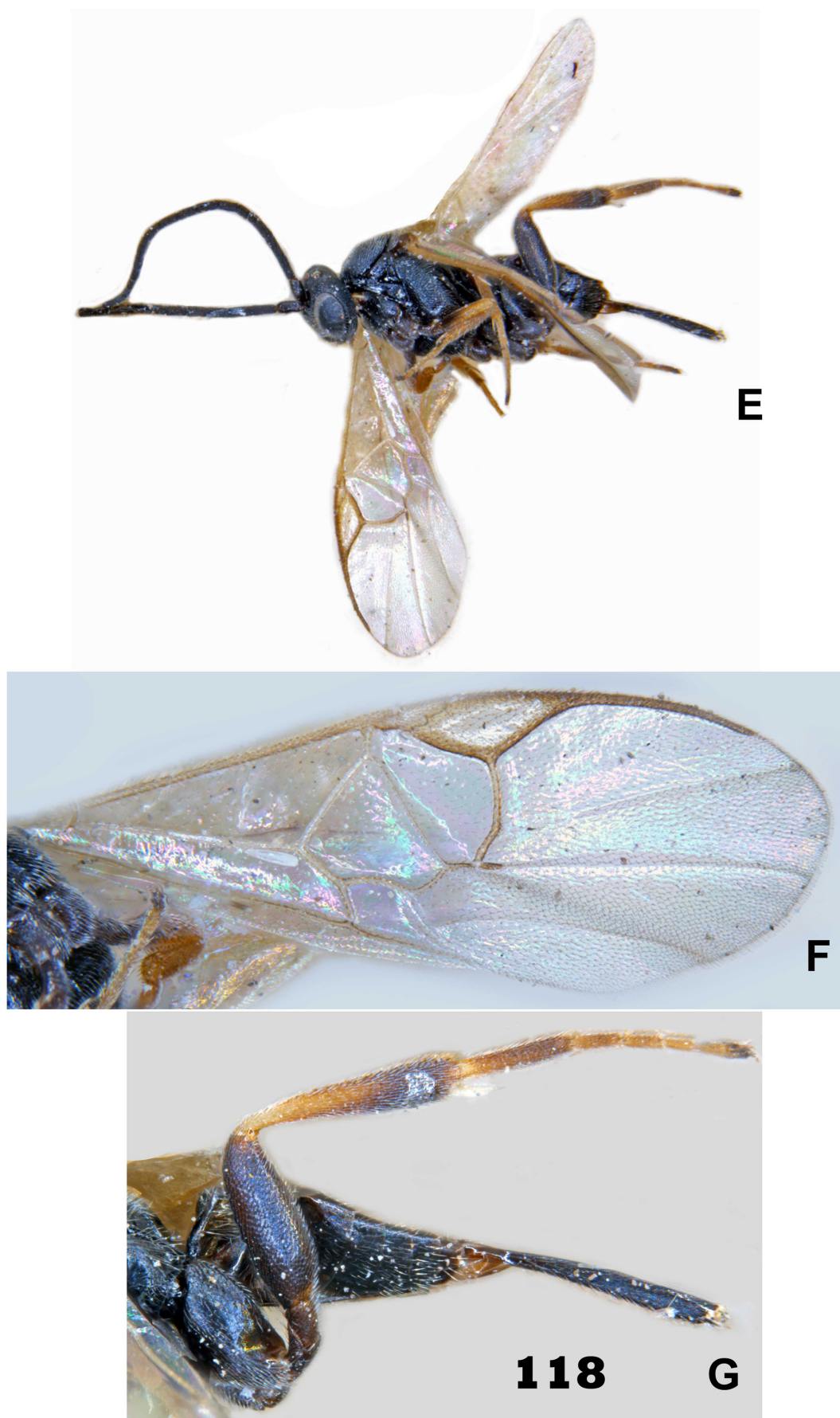


FIGURE 118. *Apanteles tachardiae* (female, Punjab)—E. Profile view F. Fore wing G. Metasoma in lateral view.



FIGURE 119. *Apanteles taragamae* Viereck (female, Coimbatore)—A. Profile view B. Head C. Mesosoma with metasoma in part D. Propodeum with part of metasoma.

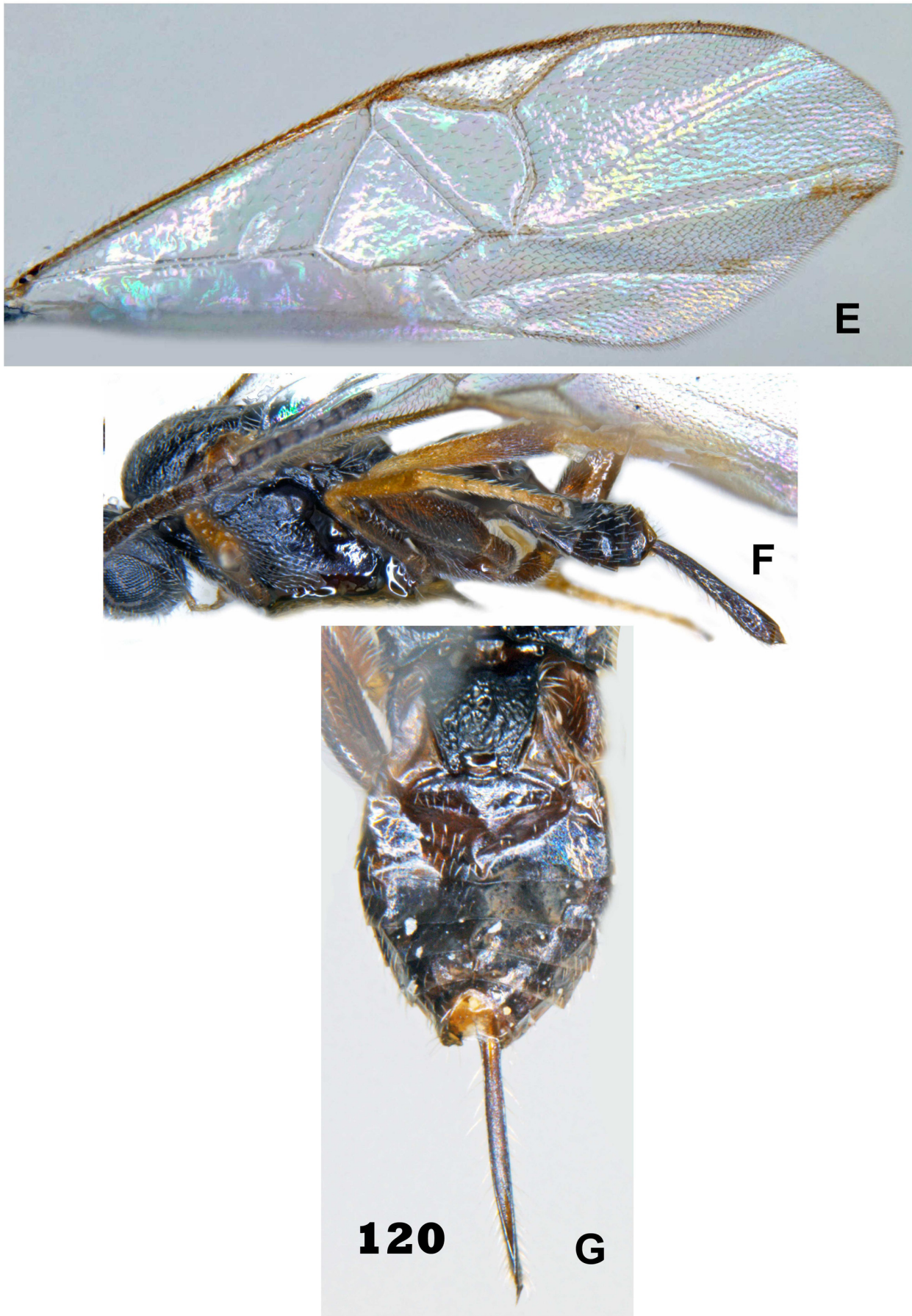


FIGURE 120. *Apanteles taragamae* (female, Coimbatore)—E. Fore wing F. Body in lateral view G. Metasoma.

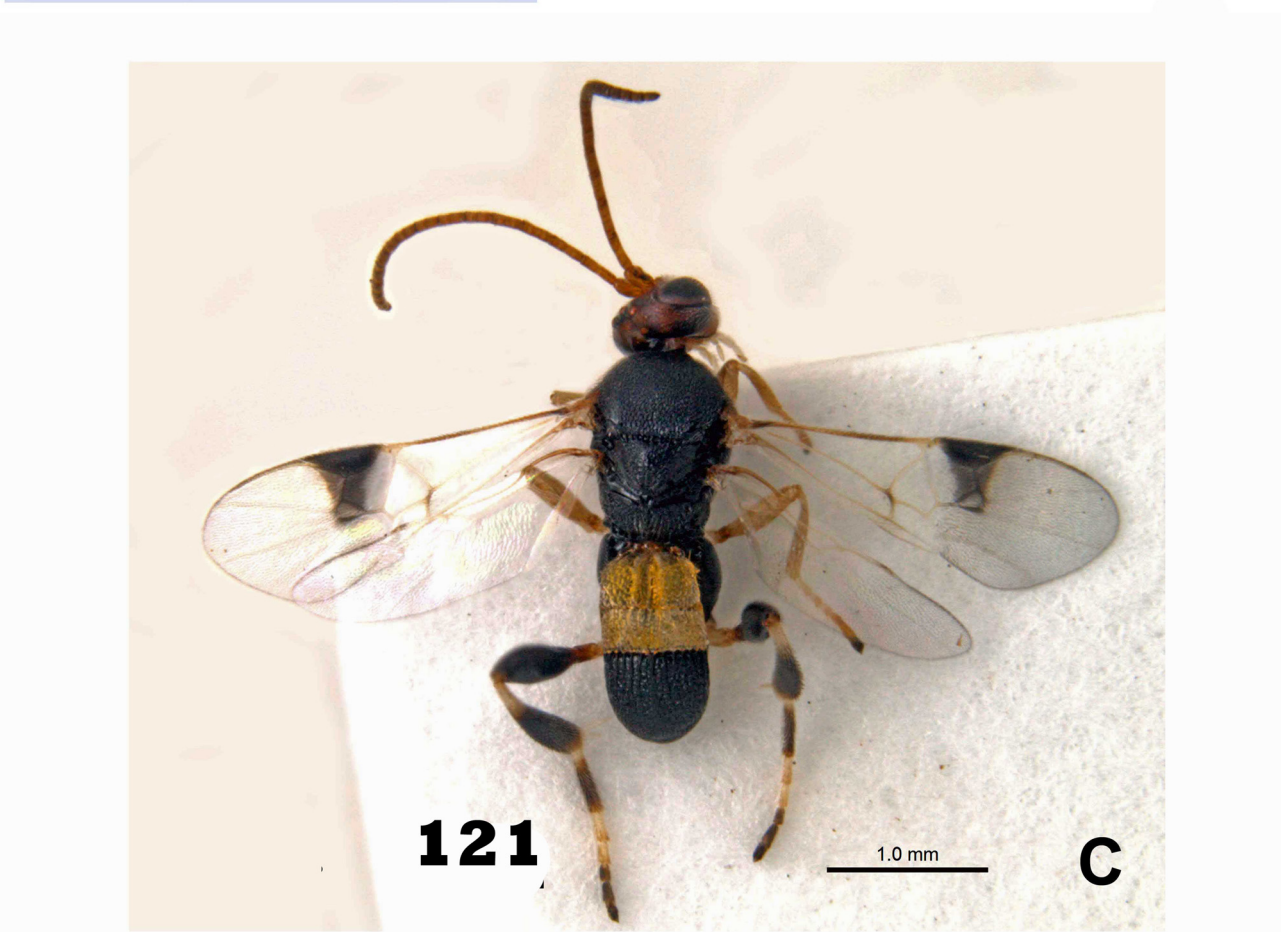
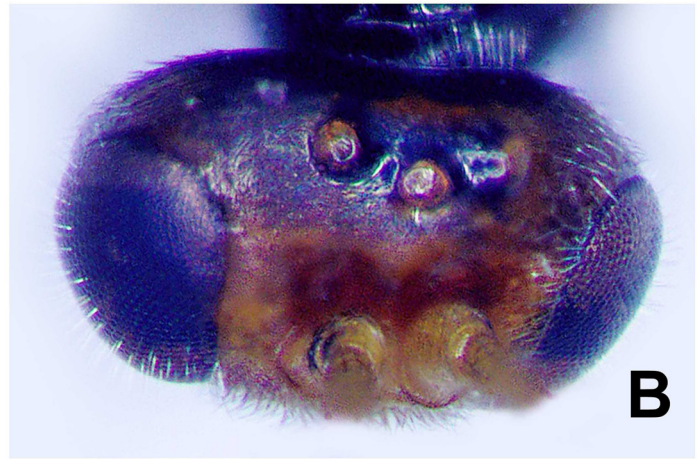
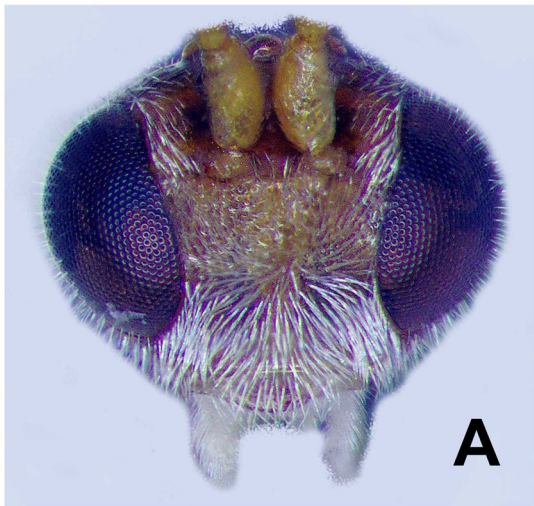


FIGURE 121. *Buluka horni* Gupta (Holotype, female, Bangalore)—A. Head B. Vertex C. Body in dorsal view.



D



E

122



F

FIGURE 122. *Buluka horni* (Holotype, Female, Bangalore)—D. Wings E. Mesosoma F. Metasoma.

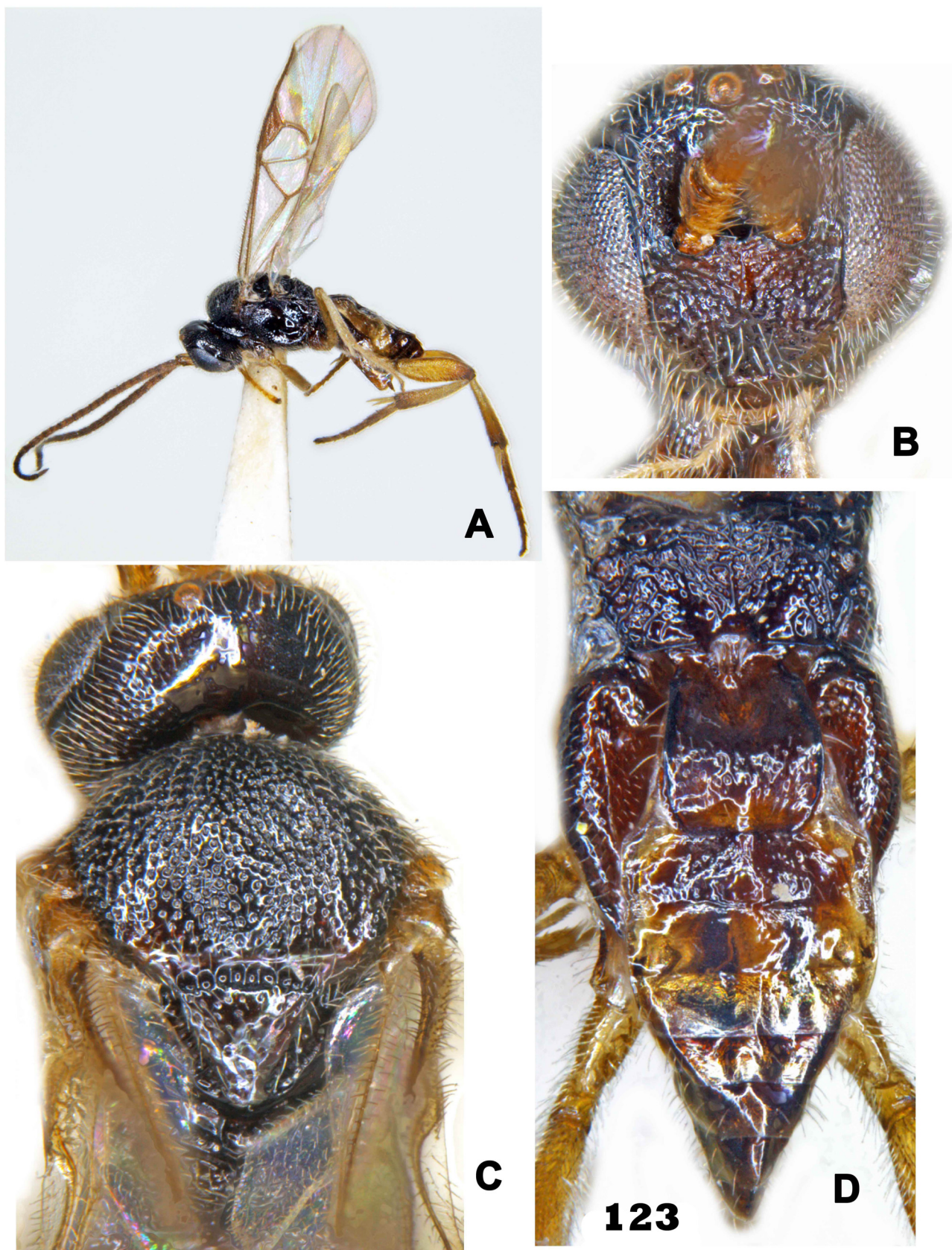


FIGURE 123. *Cotesia erionotae* (Wilkinson) (Paratype, Sumatra)—A. Profile view B. Head C. Mesosoma D. Metasoma.



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FIGURE 124. *Cotesia erionotae* (Paratype, Sumatra)—E. Mesopleuron and metasoma F. Wings.

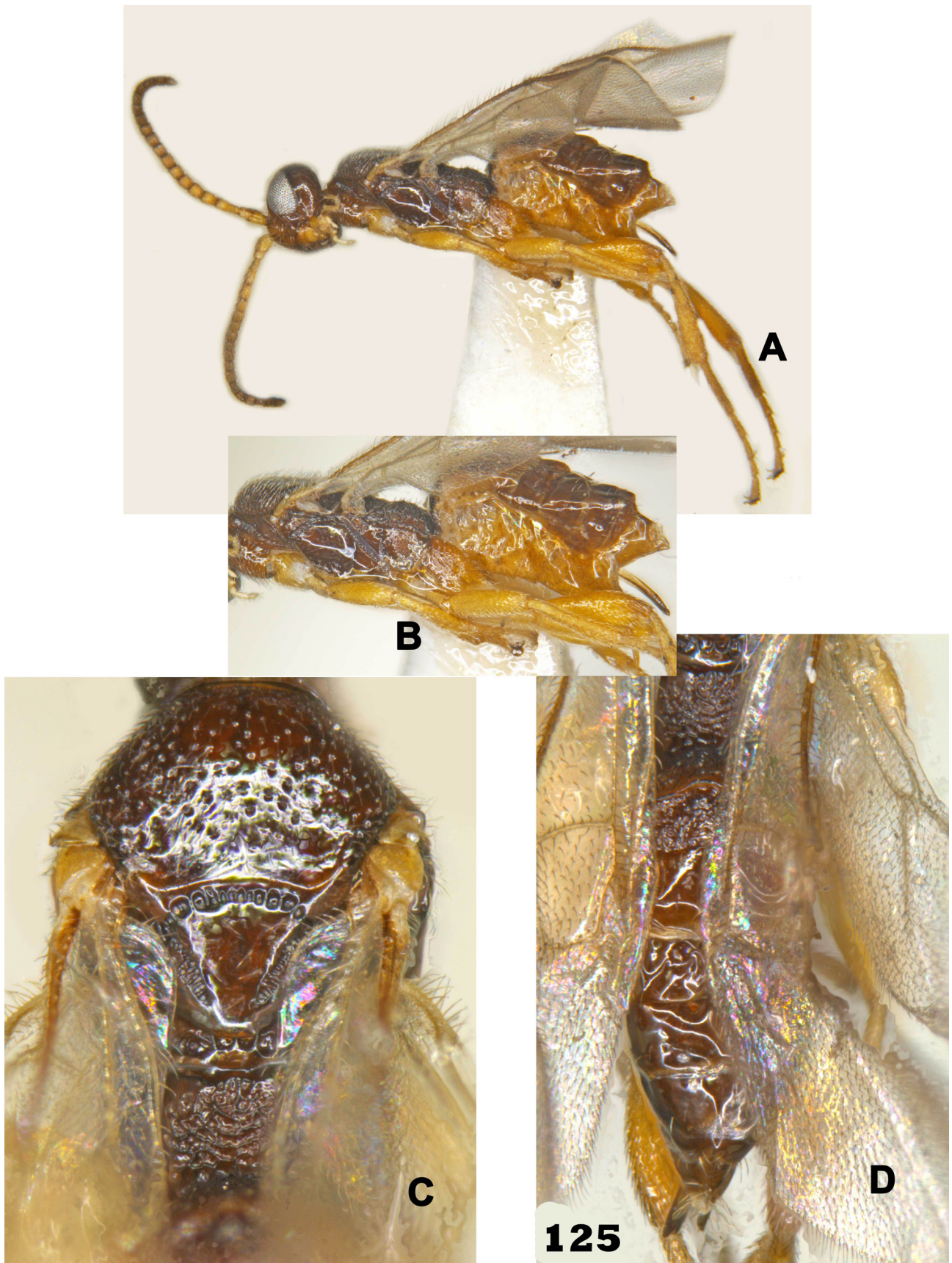


FIGURE 125. *Cotesia flavipes* Cameron (female, Padegaon)—A. Profile view B. Body in lateral view C. Mesosoma D. Metasoma.

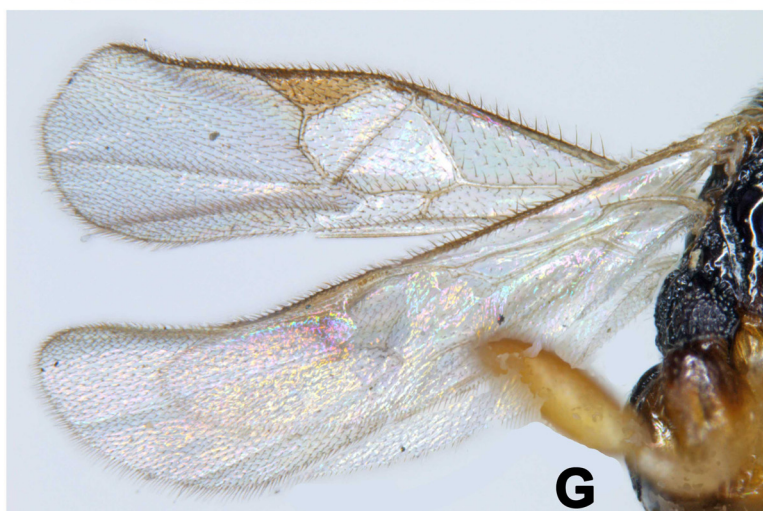
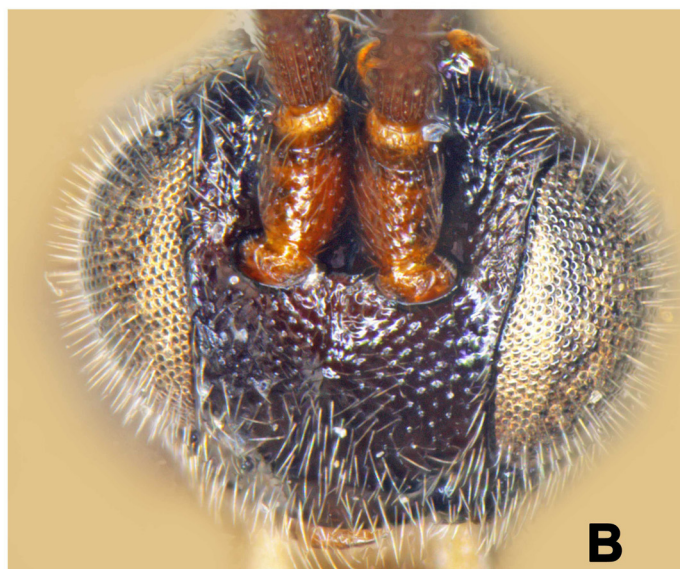
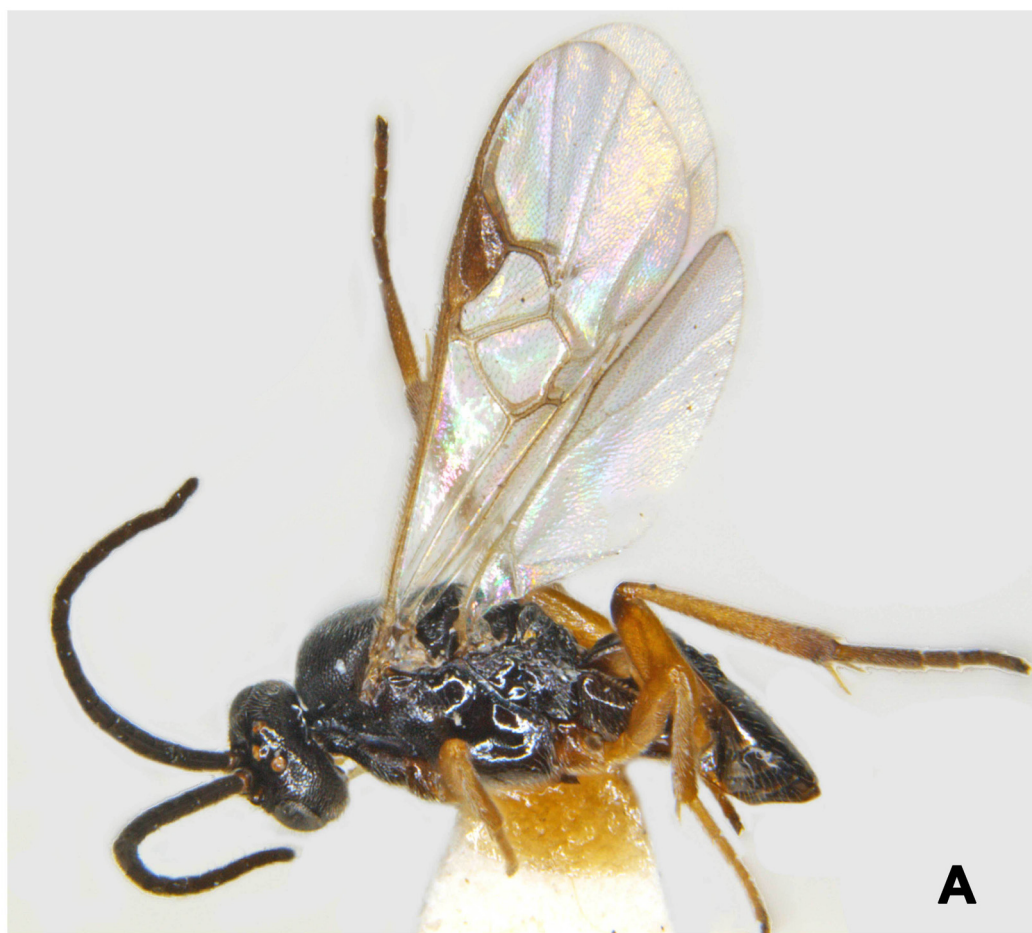
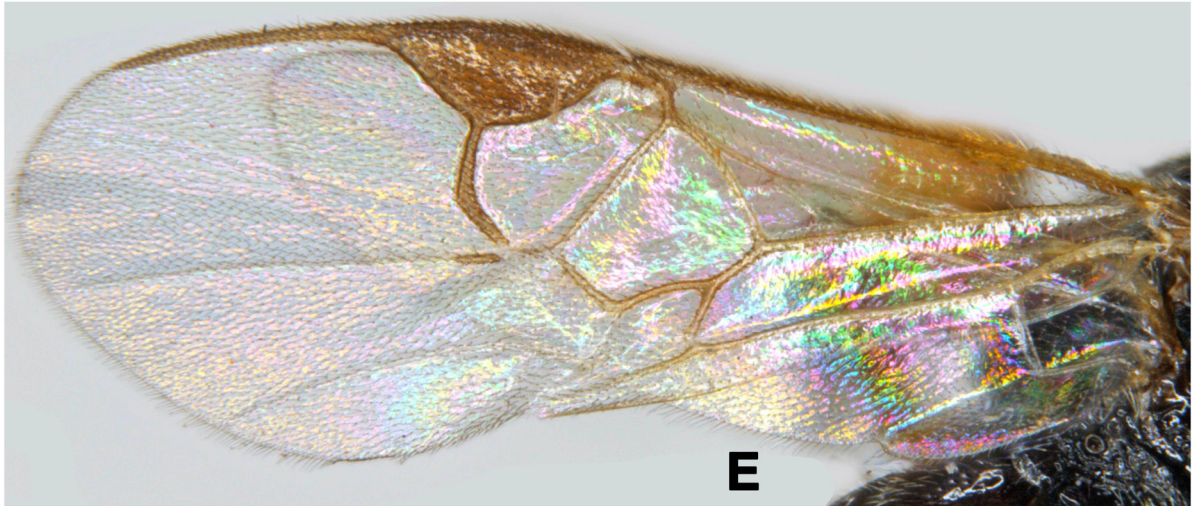


FIGURE 126. *Cotesia flavipes* (female, Bhubaneswar)—E. Body in lateral view F. Head G. Wings H. Metasoma with propodeum.



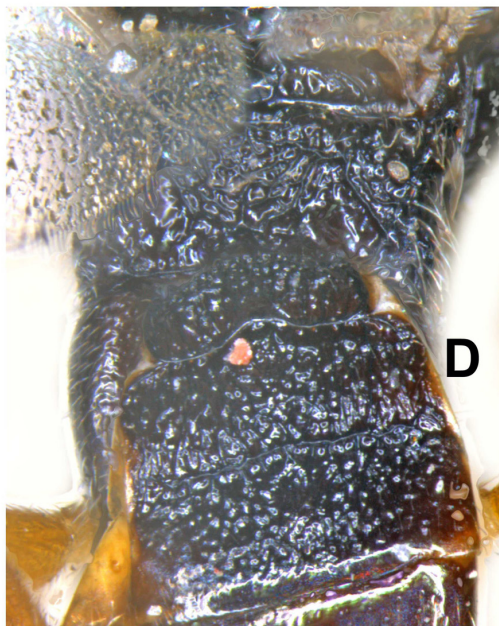
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FIGURE 127. *Cotesia glomerata* (Linnaeus) (female, England-Kent, ex. *Pieris brassicae*)—A. Profile view B. Head C. Mesosoma.



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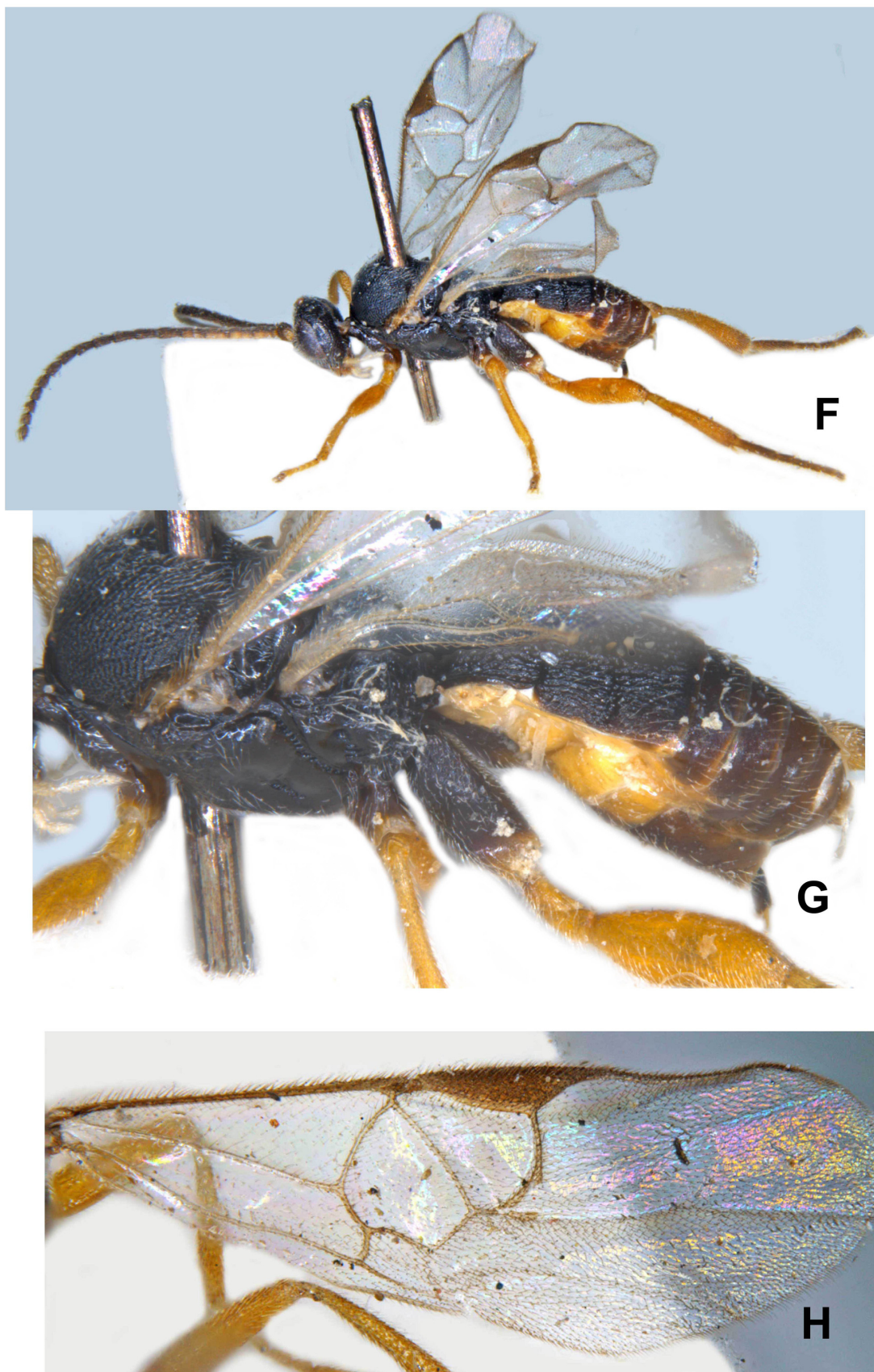
FIGURE 128. *Cotesia glomerata* (Linnaeus) (female, England-Kent, ex. *Pieris brassicae*)—E. Wings F. Mesopleuron G. Metasoma H. Cocoon mass.



129

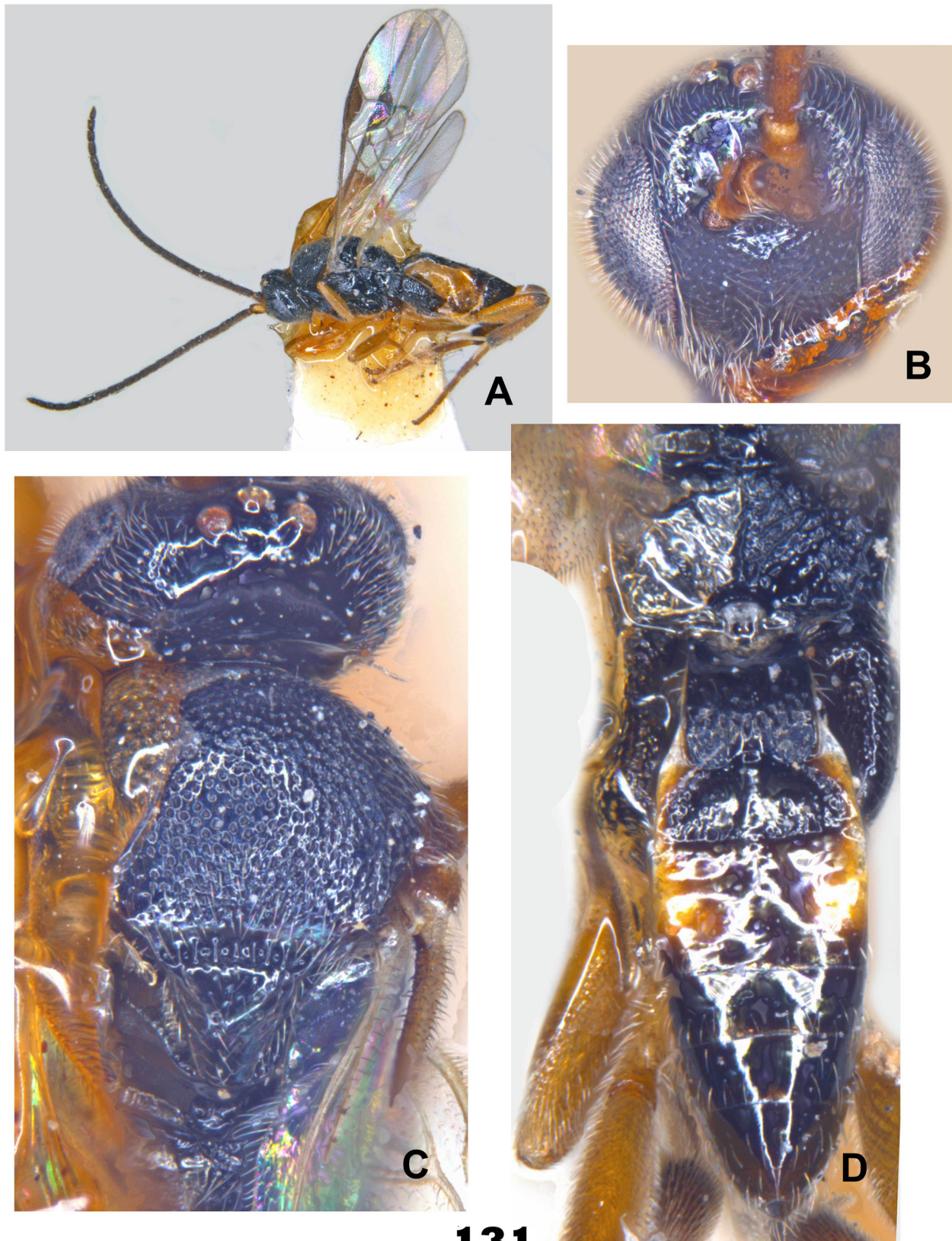
E

FIGURE 129. *Cotesia ruidus* (Wilkinson) **comb. nov.** (female, Paratype, Hoshangabad)—A. Profile view B. Mesosoma C. Head D. Propodeum with first 3 tergites E. Metasoma.



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FIGURE 130. *Cotesia ruidus* **comb. nov.** (specimen details—female, 30.x.1926; 214)—F. Profile view G. Mesopleuron and metasoma H. Fore wing.



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FIGURE 131. *Cotesia tiracolae* (Ashmead) (female, Bengal, ex. *Tiracola plagiata*)—A. Profile view B. Head C. Mesosoma D. Metasoma.

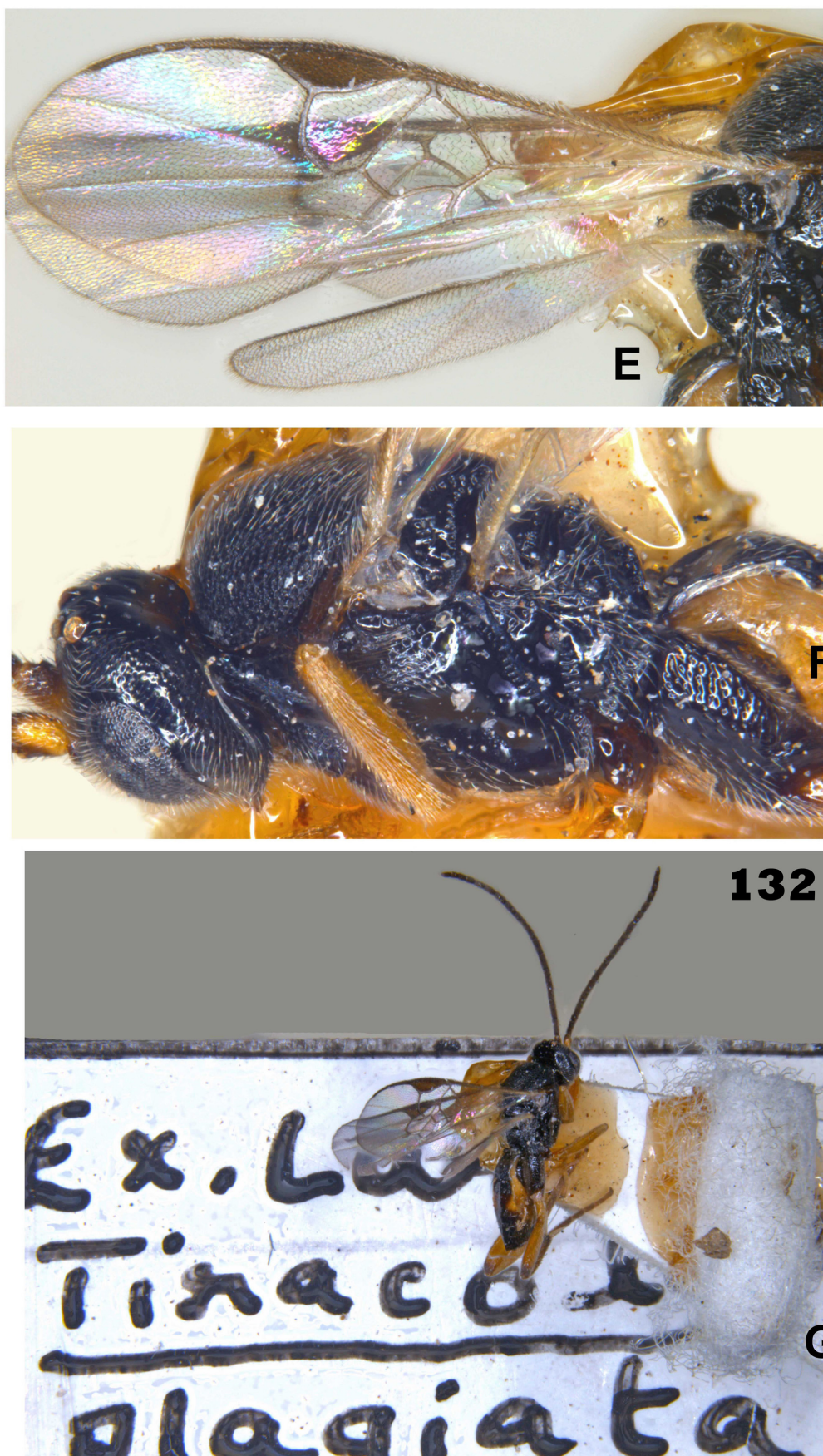


FIGURE 132. *Cotesia tiracolae* (female, Bengal, ex. *Tiracola plagiata*)—E. Wings F. Mesopleuron E. Cocoon along with the specimen.

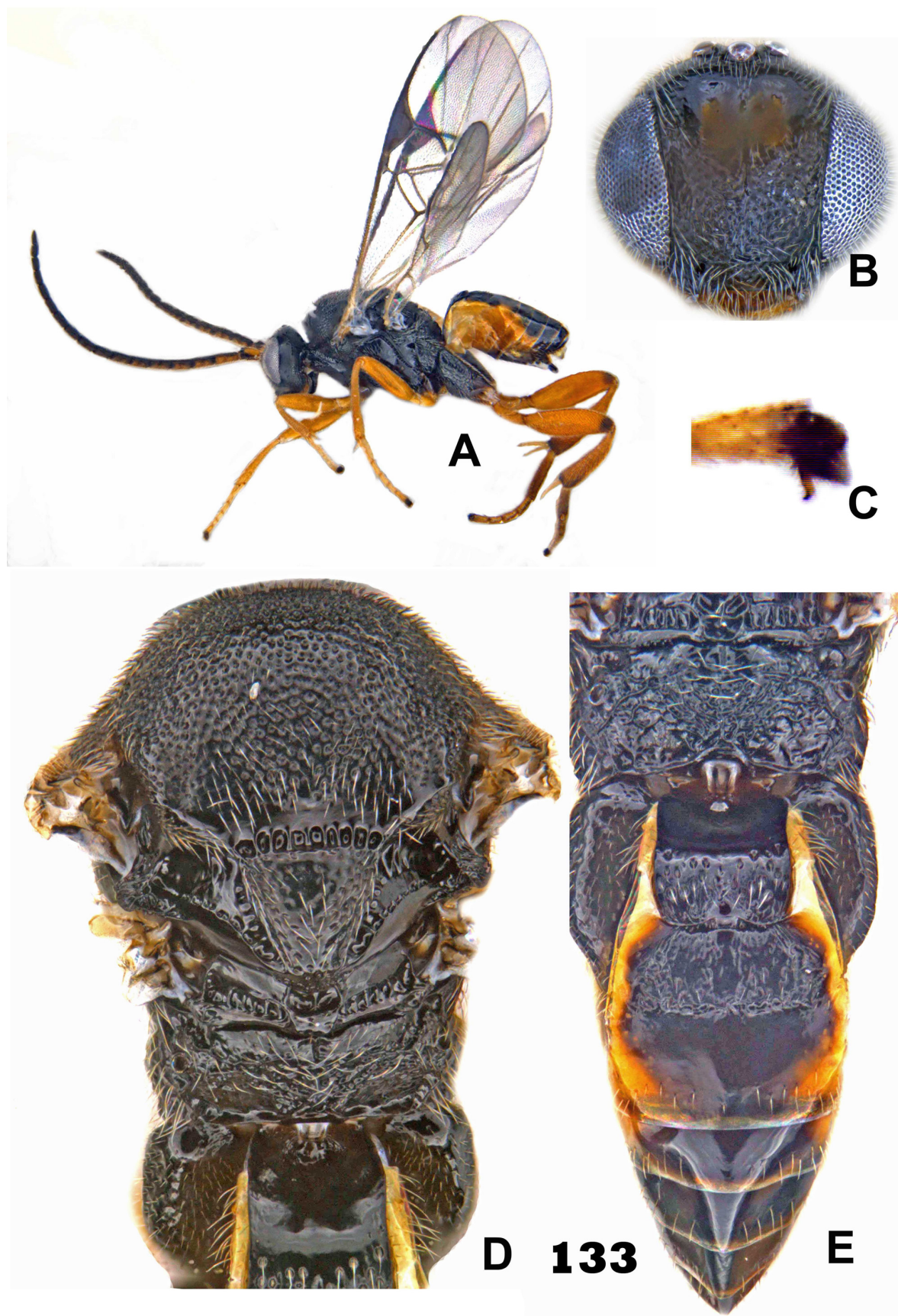
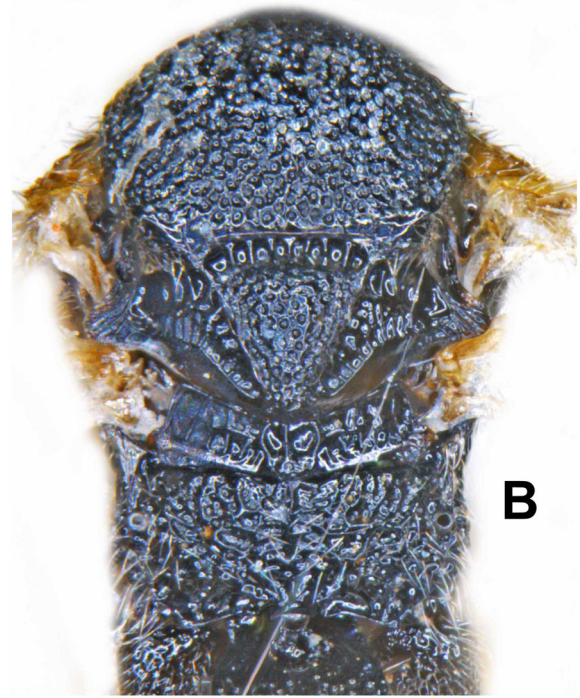
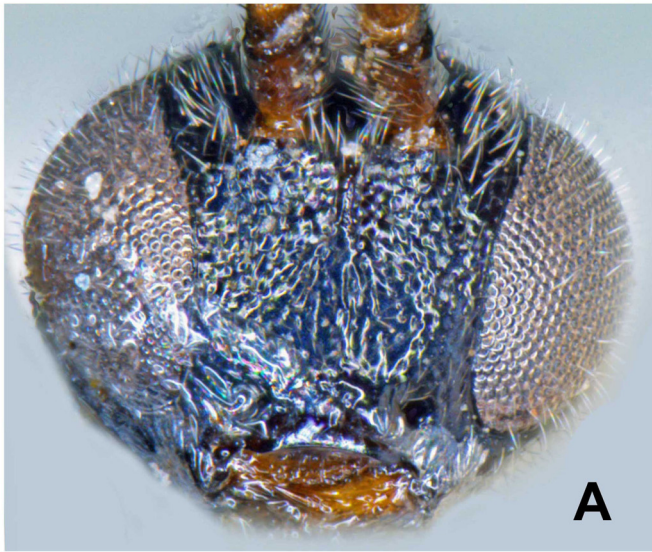


FIGURE 133. *Cotesia tiracolae* (female, ex. *Phaedyra columella*)—A. Profile view B. Head C. Apex of fore tarsus D. Mesosoma E. Metasoma.



A

B

C

134

D

FIGURE 134. *Cotesia vestalis* (Haliday) (female, Pune-IIE 23182)—A. Head B Mesosoma C. Metasoma D. Propodeum with first three tergites.

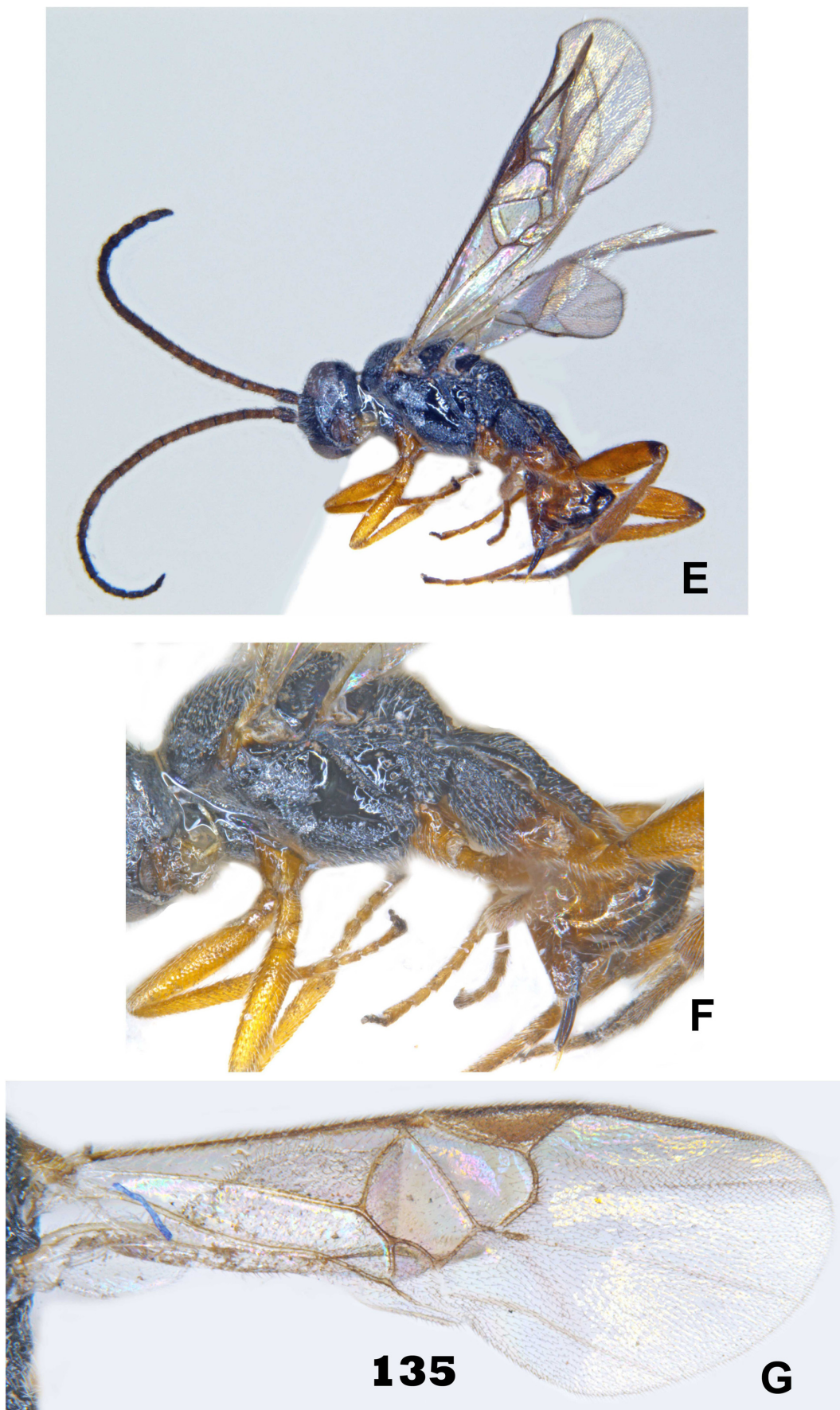


FIGURE 135. *Cotesia vestalis* (female, Pune-IIIE 23182)—E. Profile view F. Mesopleuron and metasoma G. Wings.



A



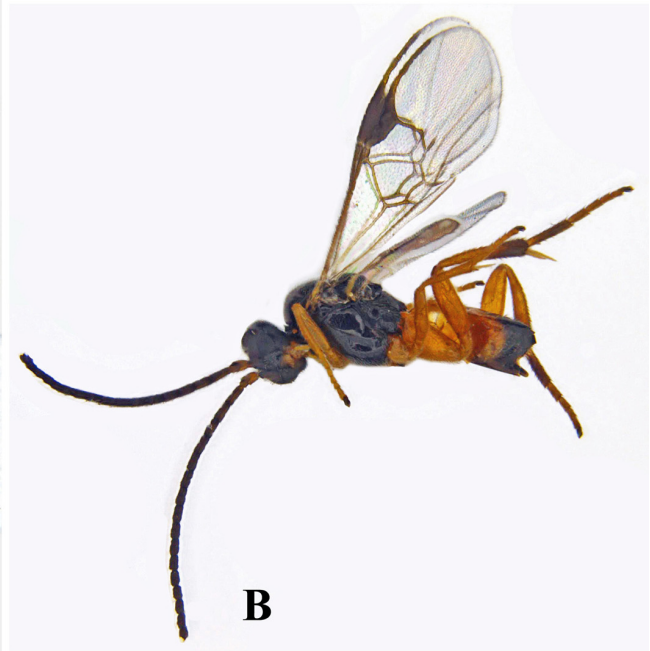
B



C

136

FIGURE 136. *Diolcogaster* sp. (female)—A. Dorsal view B. Mesosoma C. Metasoma.



D
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FIGURE 137. *Distatrix papilionis* (Viereck) (female)—A. Dorsal view B. Profile view C. Mesosoma D. Metasoma.

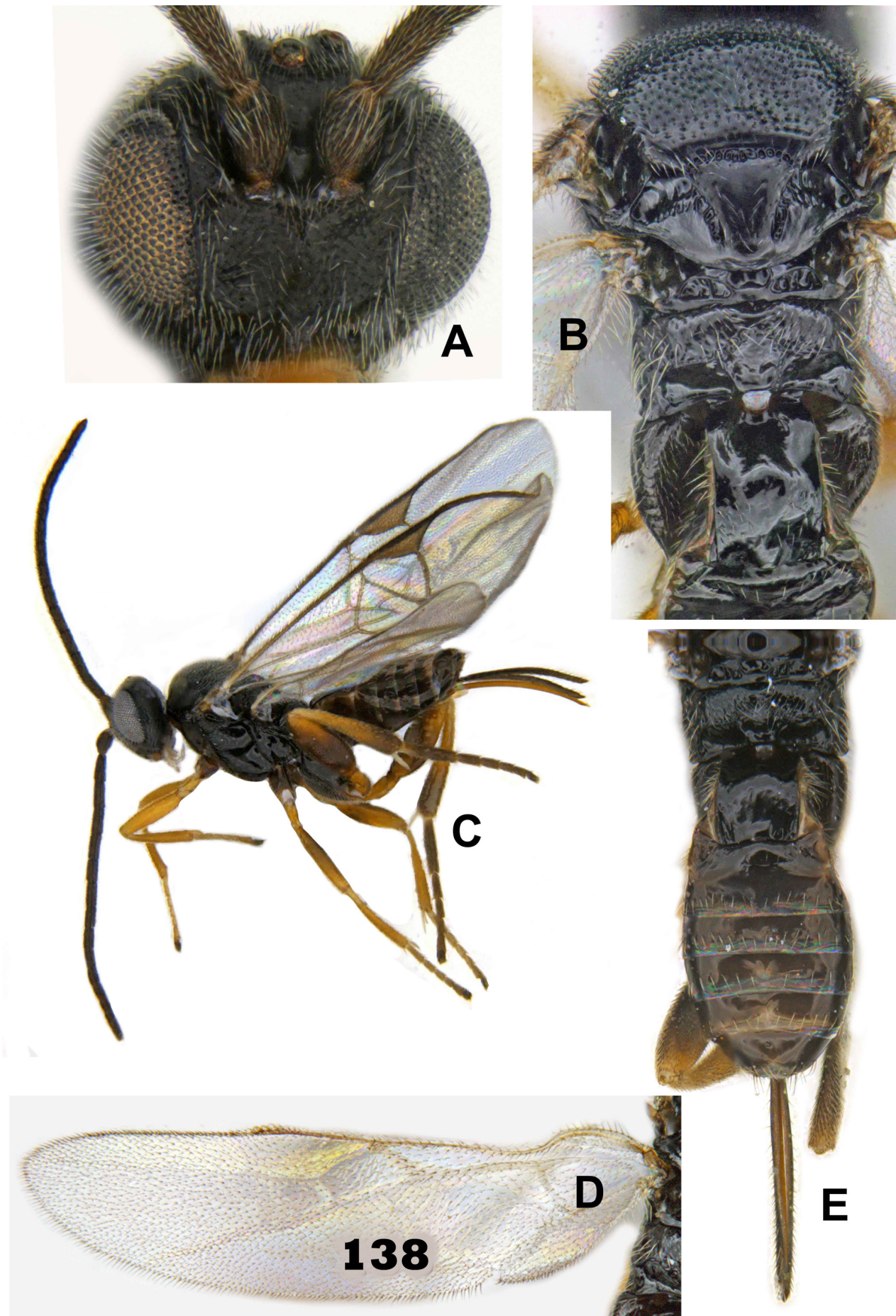


FIGURE 138. *Dolichogenidea cinnarae* Gupta, Lokhande & Soman (Holotype, Female, Maharashtra, ex. *Borbo cinnara*)—A. Head B. Mesosoma C. Profile view D. Hind wing E. Metasoma.

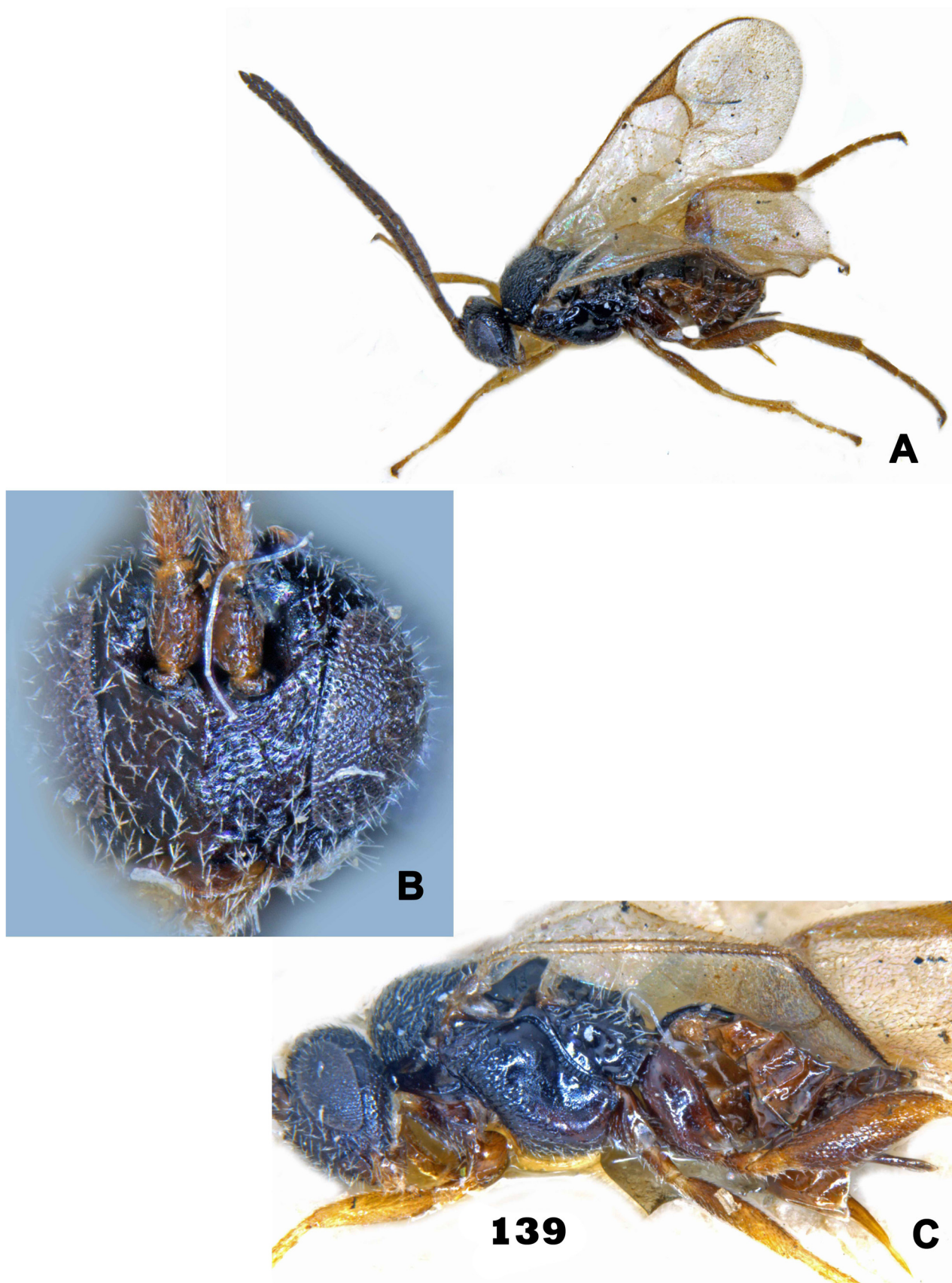


FIGURE 139. *Dolichogenidea hyposidrae* (Wilkinson) (Paratype, female, Java: Midden)—A. Profile view B. Head C. Body in lateral view.

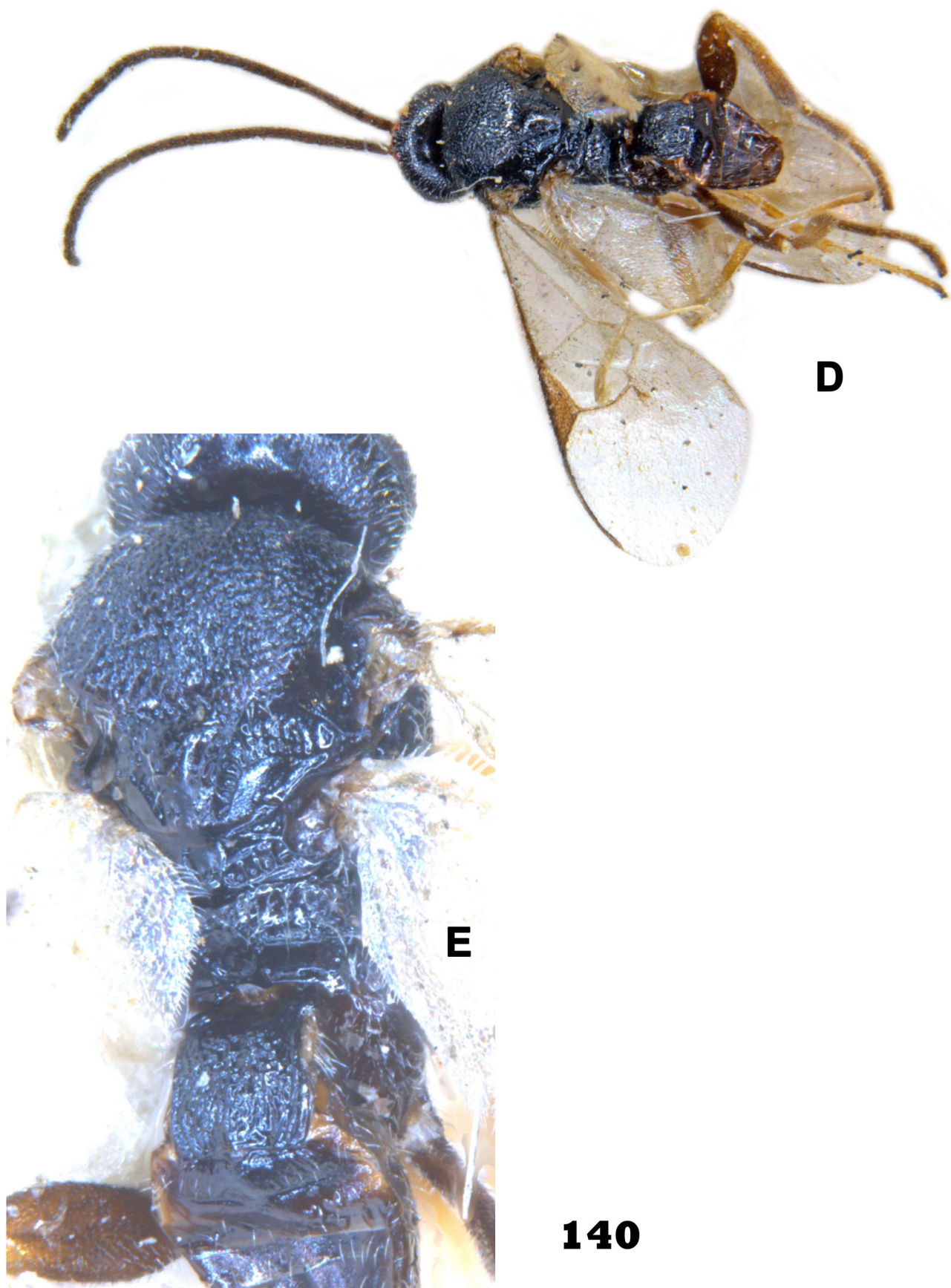
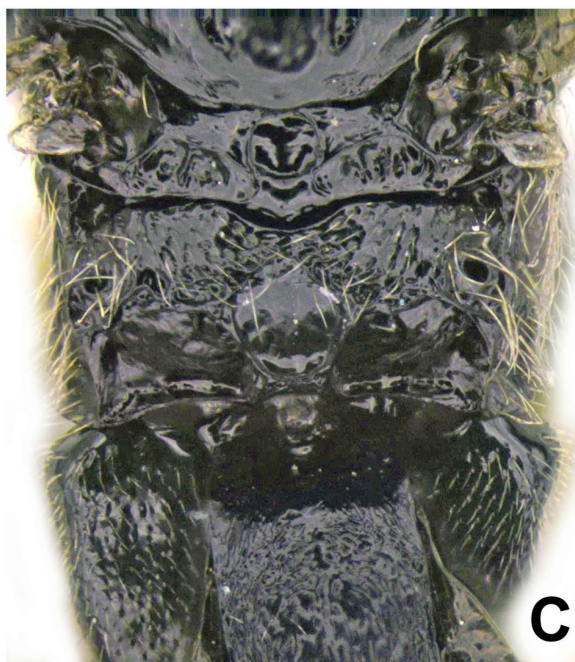
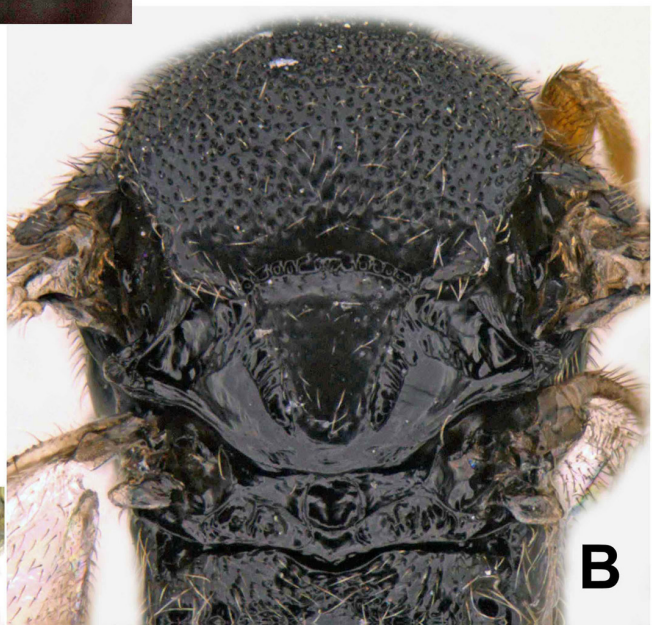
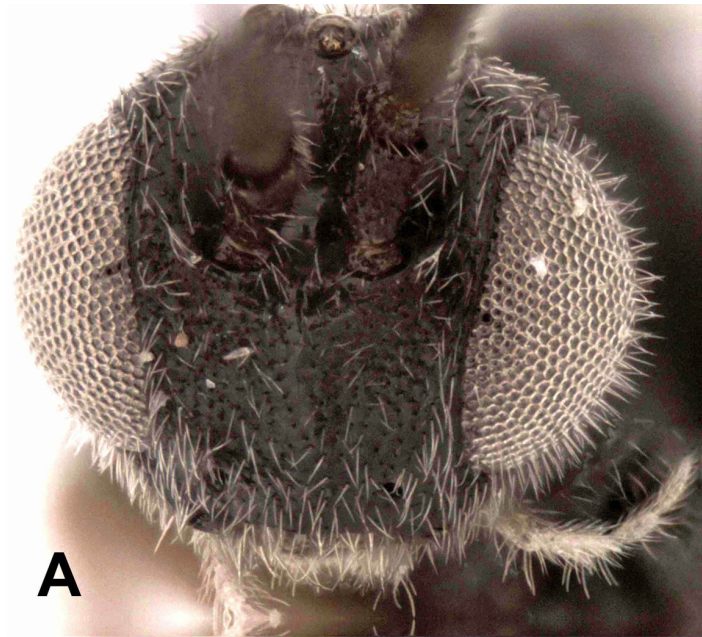


FIGURE 140. *Dolichogenidea hyposidrae* (Wilkinson) (male, Java: Midden)— D. Dorsal view E. Mesosoma & metasoma (in part).



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FIGURE 141. *Dolichogenidea kunhi* Gupta & Kalesh (Holotype, female, Kerala, ex. *Thoressa evershedii*)—A. Head B. Mesosoma C. Propodeum.



D



E



F

142



G

FIGURE 142. *Dolichogenidea kunhi*—D. Part of metasoma E. Metasoma F. Metasoma with hind leg G. Body in dorsal view.



FIGURE 143. *Dolichogenidea stantoni* (Ashmead) (Female, Malaya-Kuala Lumpur)—A. Profile view B. Head C. Mesosoma D. Metasoma.

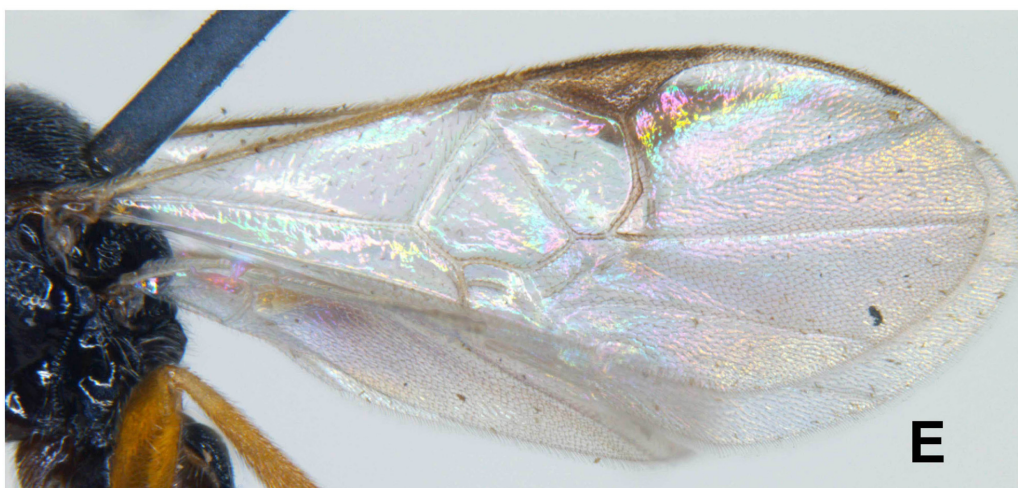
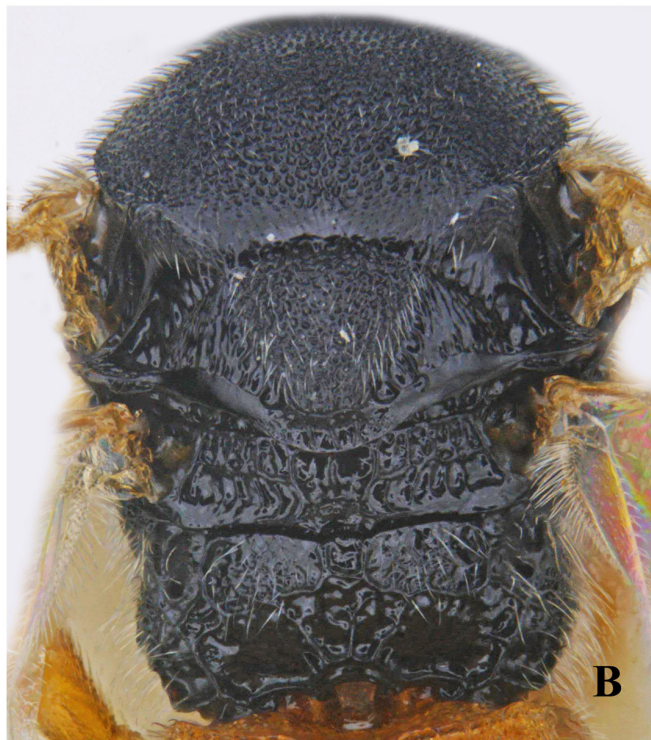


FIGURE 144. *Dolichogenidea stantoni* (*Apanteles fistulae* Wilk. Paratype, female, Madras)—E. Wings F. Propodeum with metasoma.



A



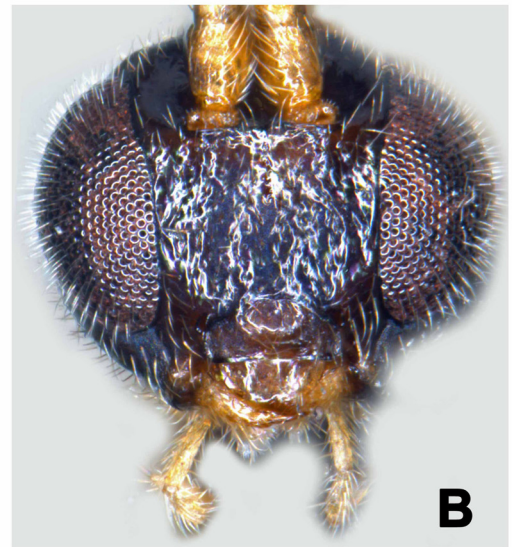
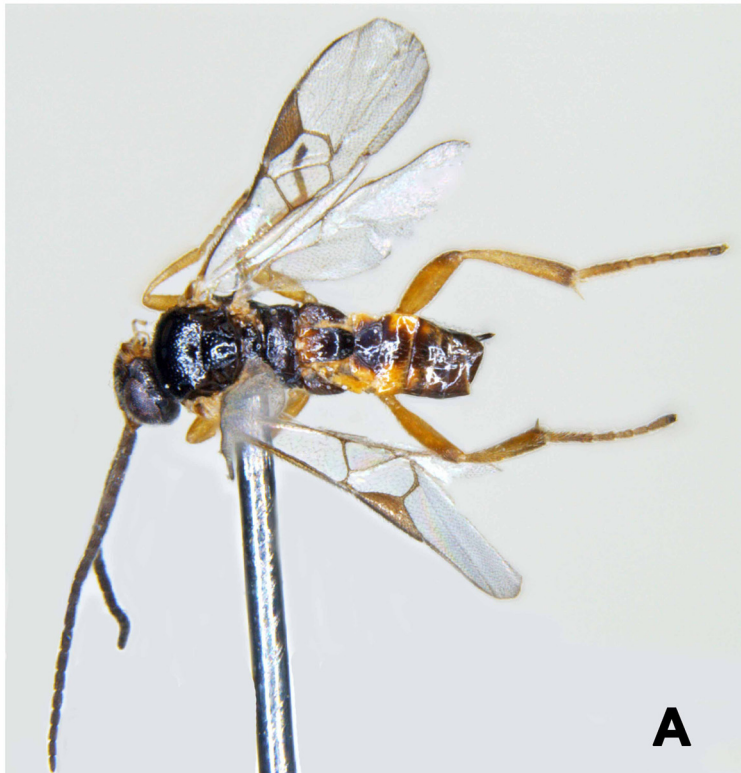
B



C

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FIGURE 145. *Fornicia ceylonica* Wilkinson—A. Dorsal view B. Mesosoma C. Metasoma.



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FIGURE 146. *Glyptapanteles aristolochiae* (Wilkinson) (female, Indonesia Sumba Is.)—A. Profile view B. Head C. Mesosoma D. Metasoma.

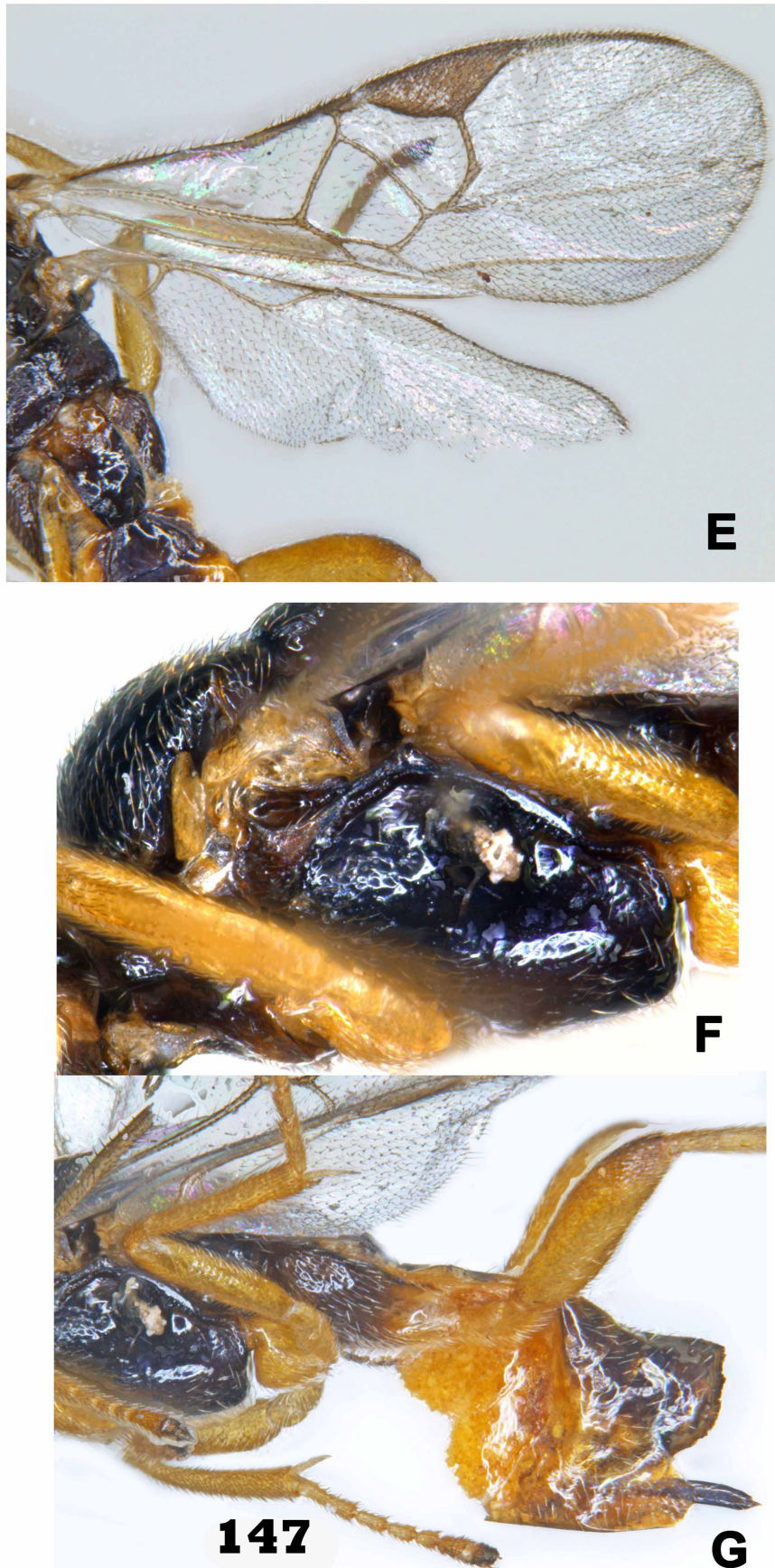


FIGURE 147. *Glyptapanteles aristolochiae* (Wilkinson) (female, Indonesia Sumba Is.)—E. Wings F. Mesopleuron G. Metasoma.

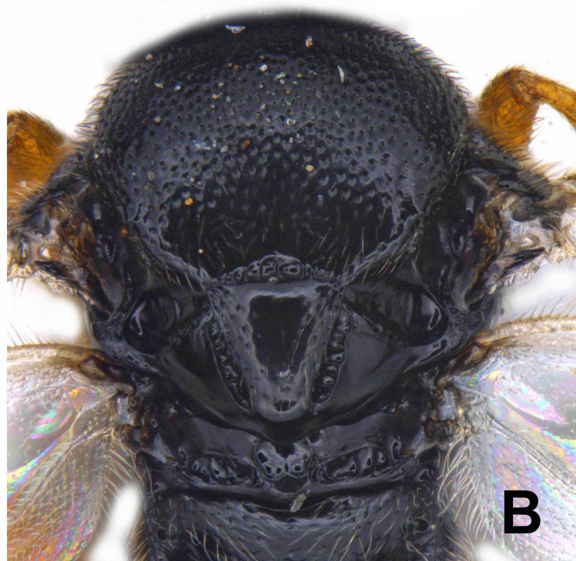
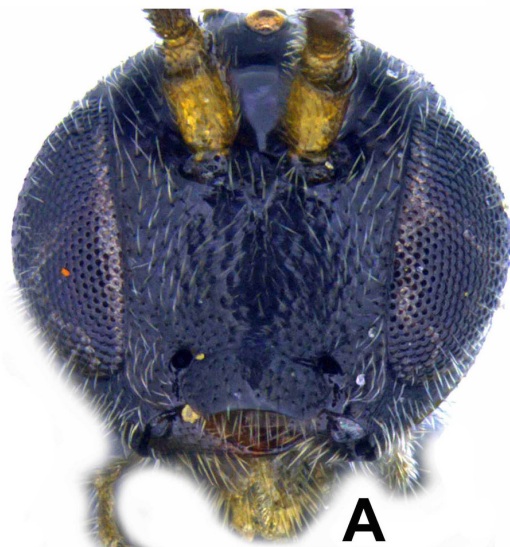


FIGURE 148. *Glyptapanteles clanisae* Gupta (females, Holotype & Paratype)—A. Head B. Mesosoma C. Metasoma D. Dorsal view E. Profile view.

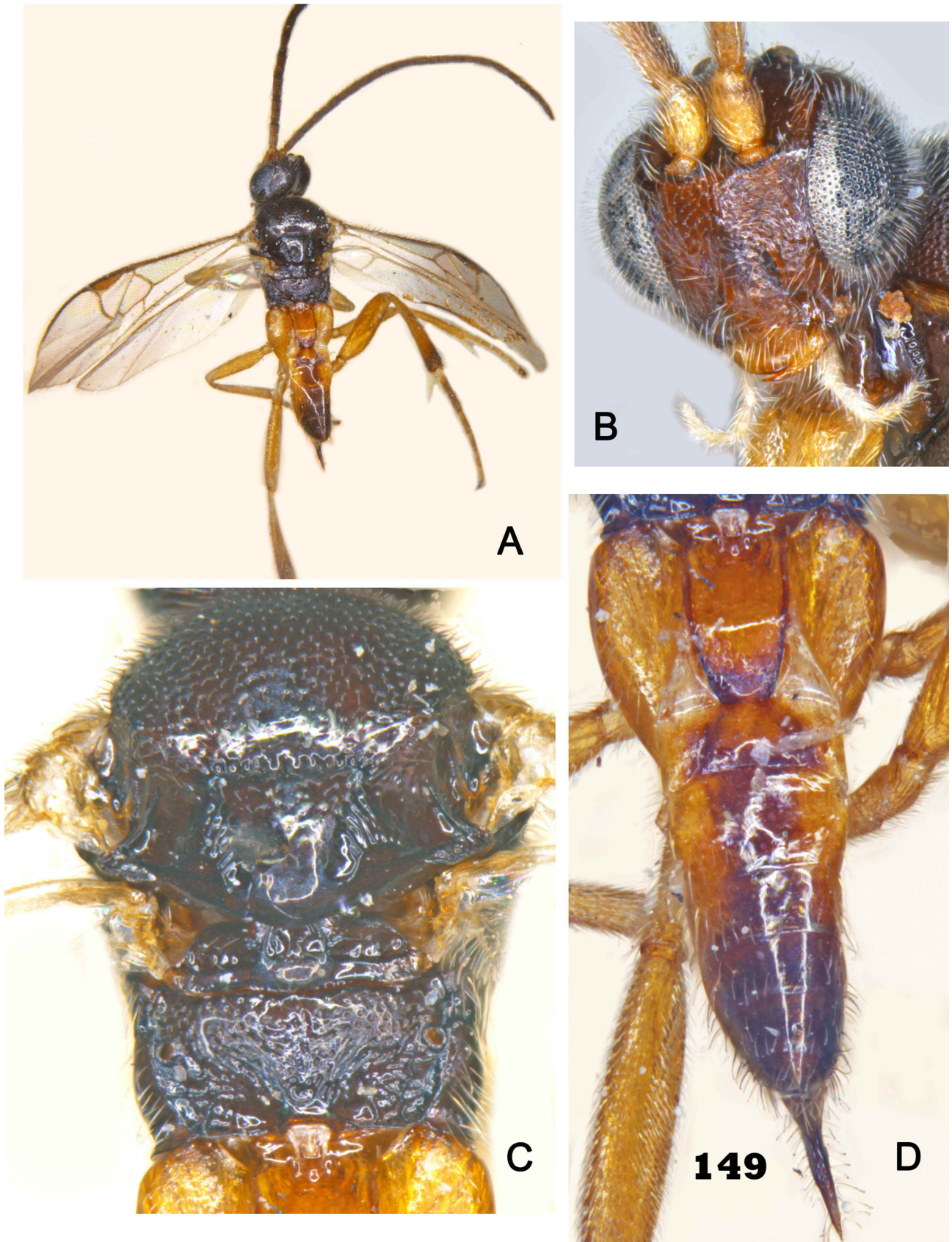


FIGURE 149. *Glyptapanteles creatonoti* (Viereck) (female, Malaya: Kuala Lumpur)—A. Dorsal view B. Head C. Mesosoma D. Metasoma.

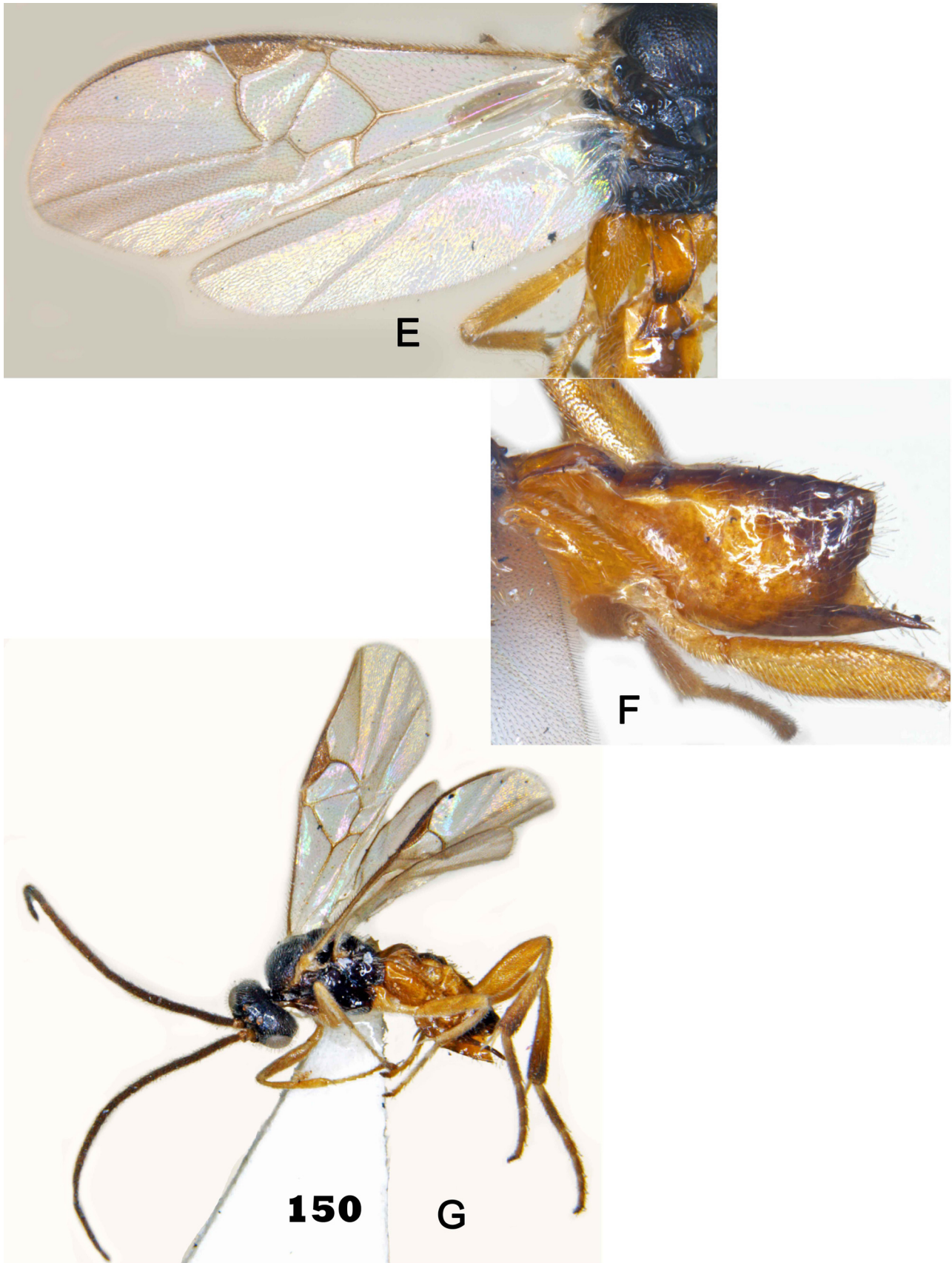


FIGURE 150. *Glyptapanteles creatonoti* (female, Phillippines Is.)—E. Wings F. Metasoma G. Profile view.

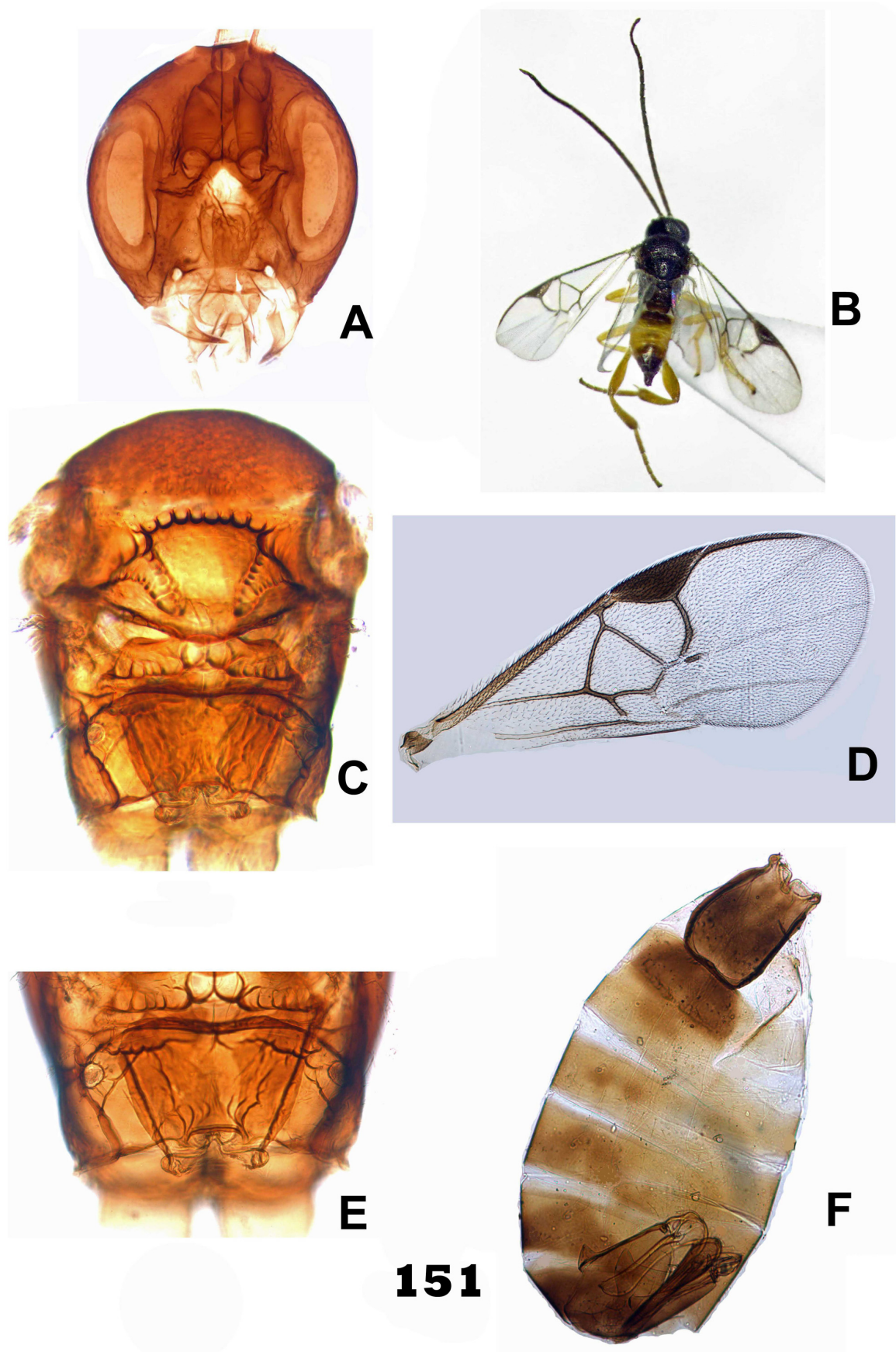


FIGURE 151. *Glyptapanteles hypermnestrae* Gupta & Pereira (Paratype, female)—A. Head (KOH treated) B. Dorsal view C. Mesosoma (KOH treated) D. Fore wing E. Propodeum (KOH treated) F. Metasoma (KOH treated).

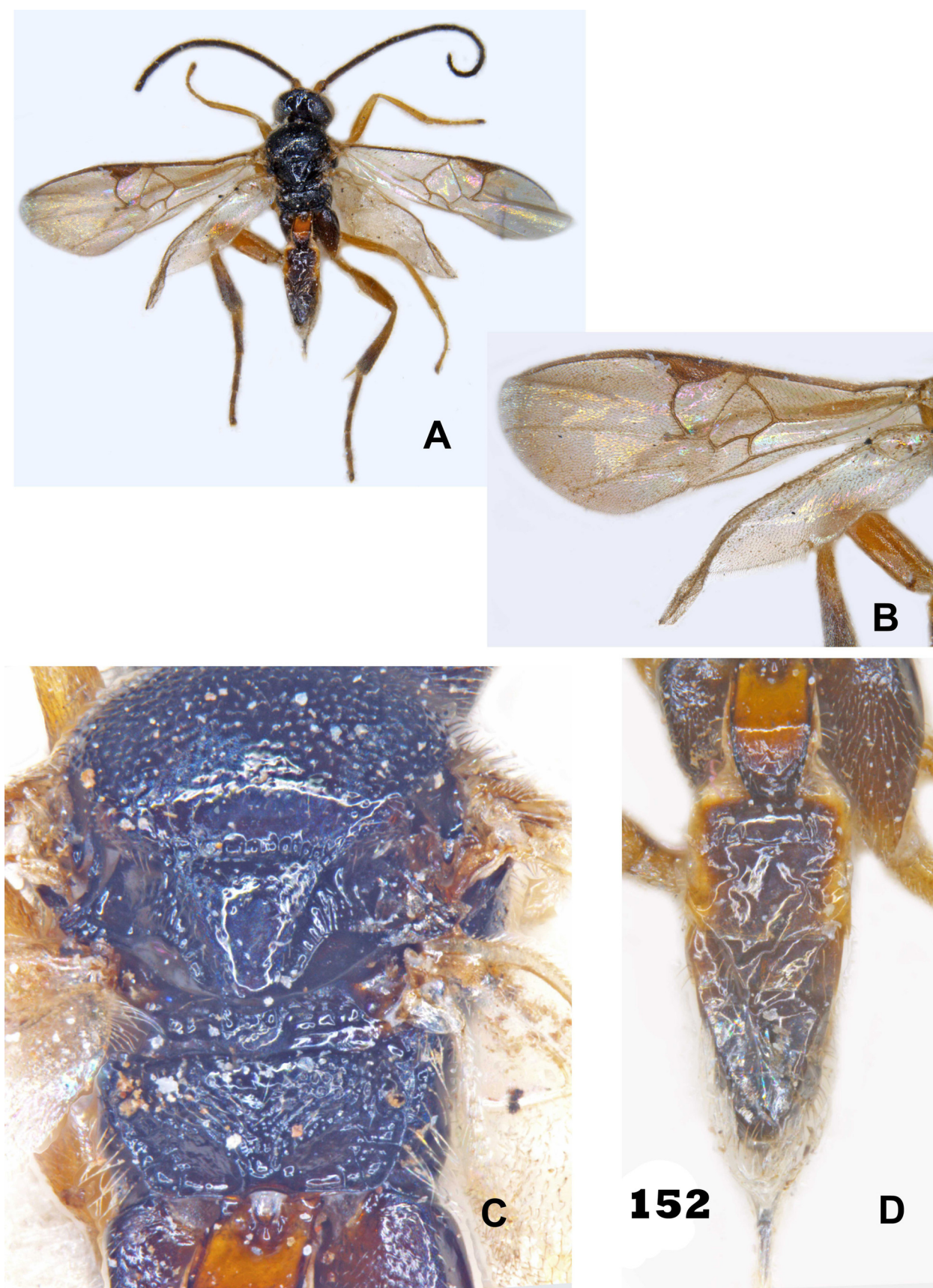


FIGURE 152. *Glyptapanteles obliquae* (Wilkinson) (Paratype, female, Madras)—A. Dorsal view B. Wings C. Mesosoma D. Metasoma.

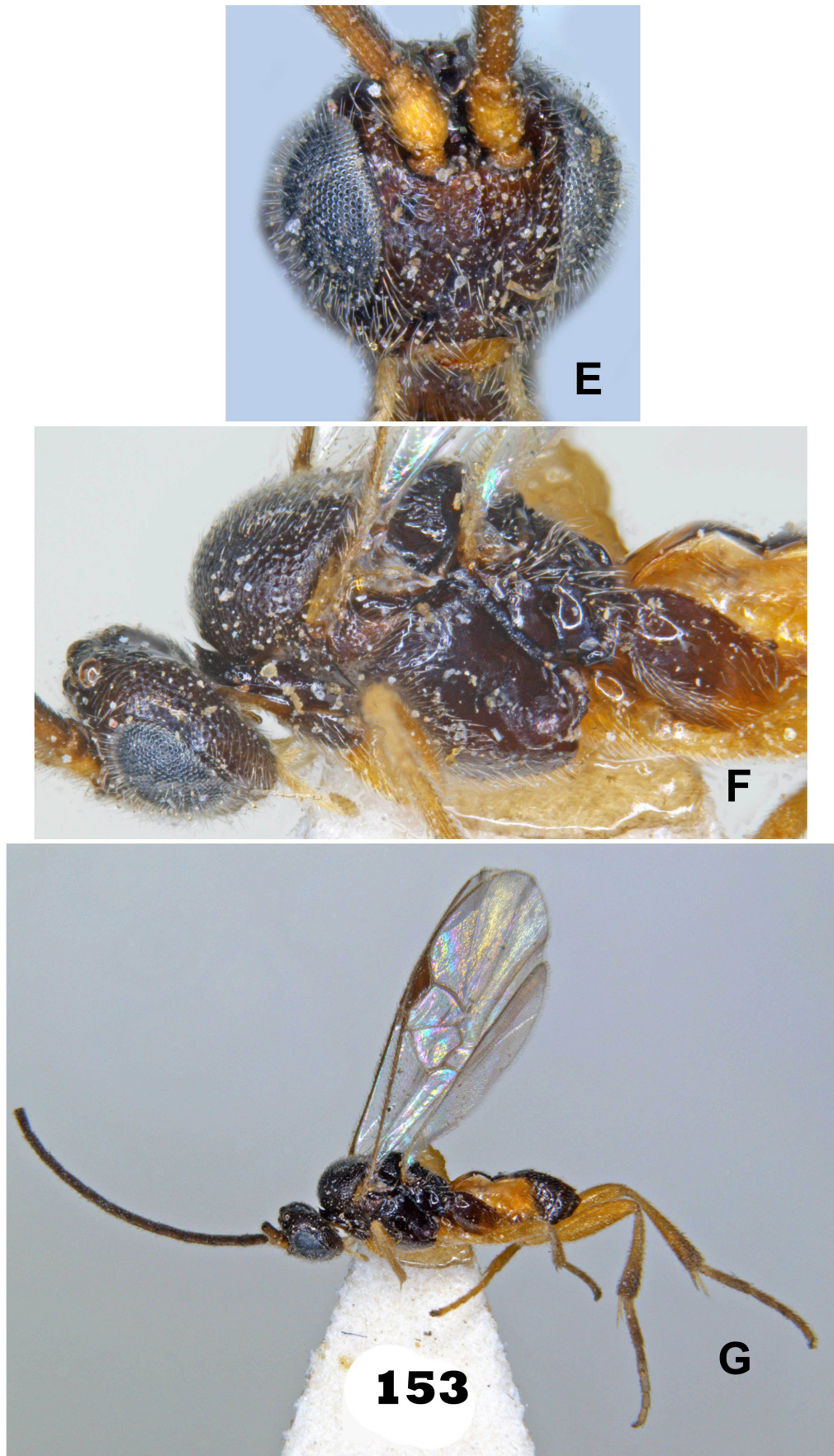


FIGURE 153. *Glyptapanteles obliquae* (male, Punjab)—E. Head F. Mesopleuron G. Profile view.

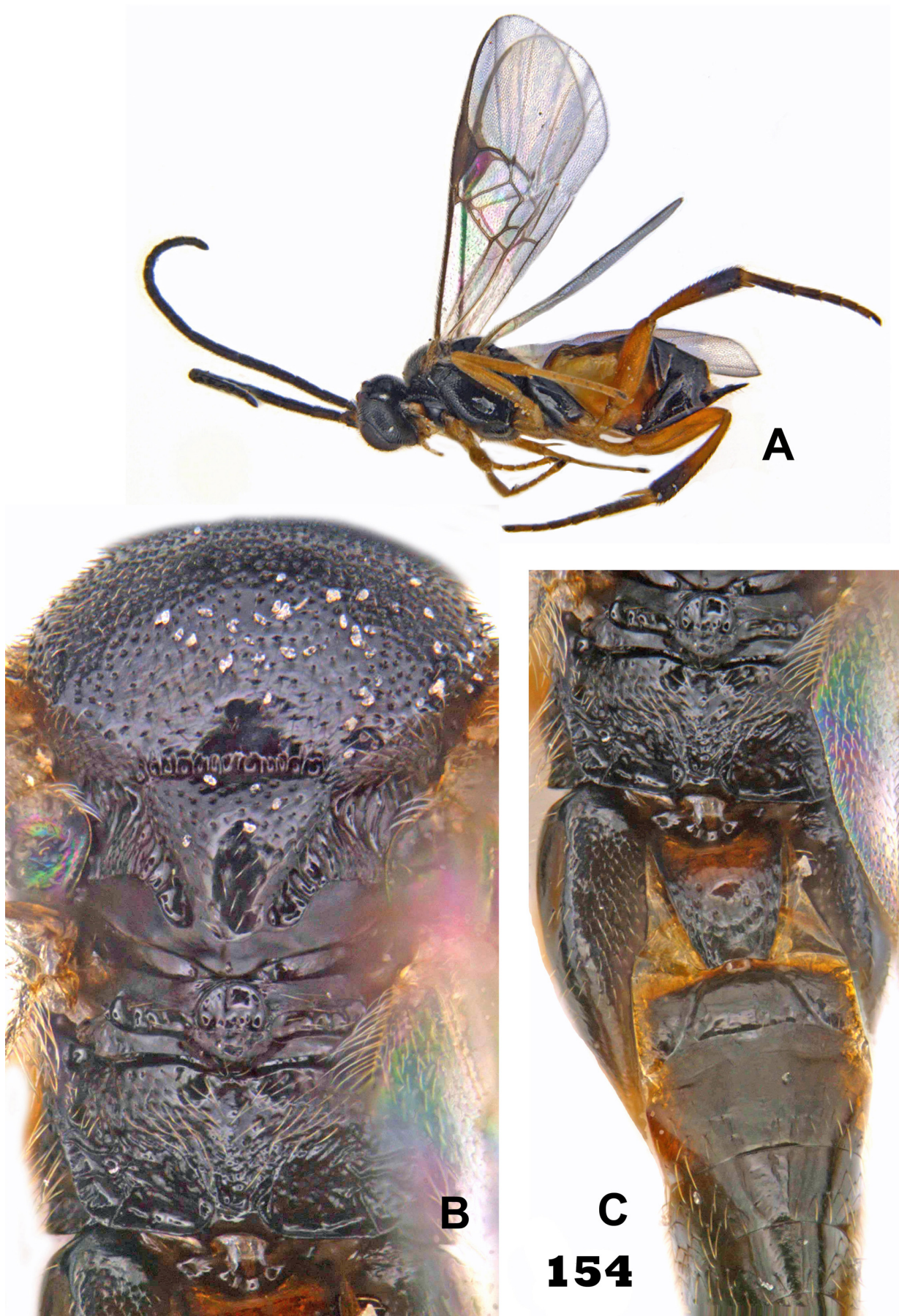


FIGURE 154. *Glyptapanteles obliquae* (Bangalore)—A. Profile view B. Mesosoma C. Metasoma with propodeum.

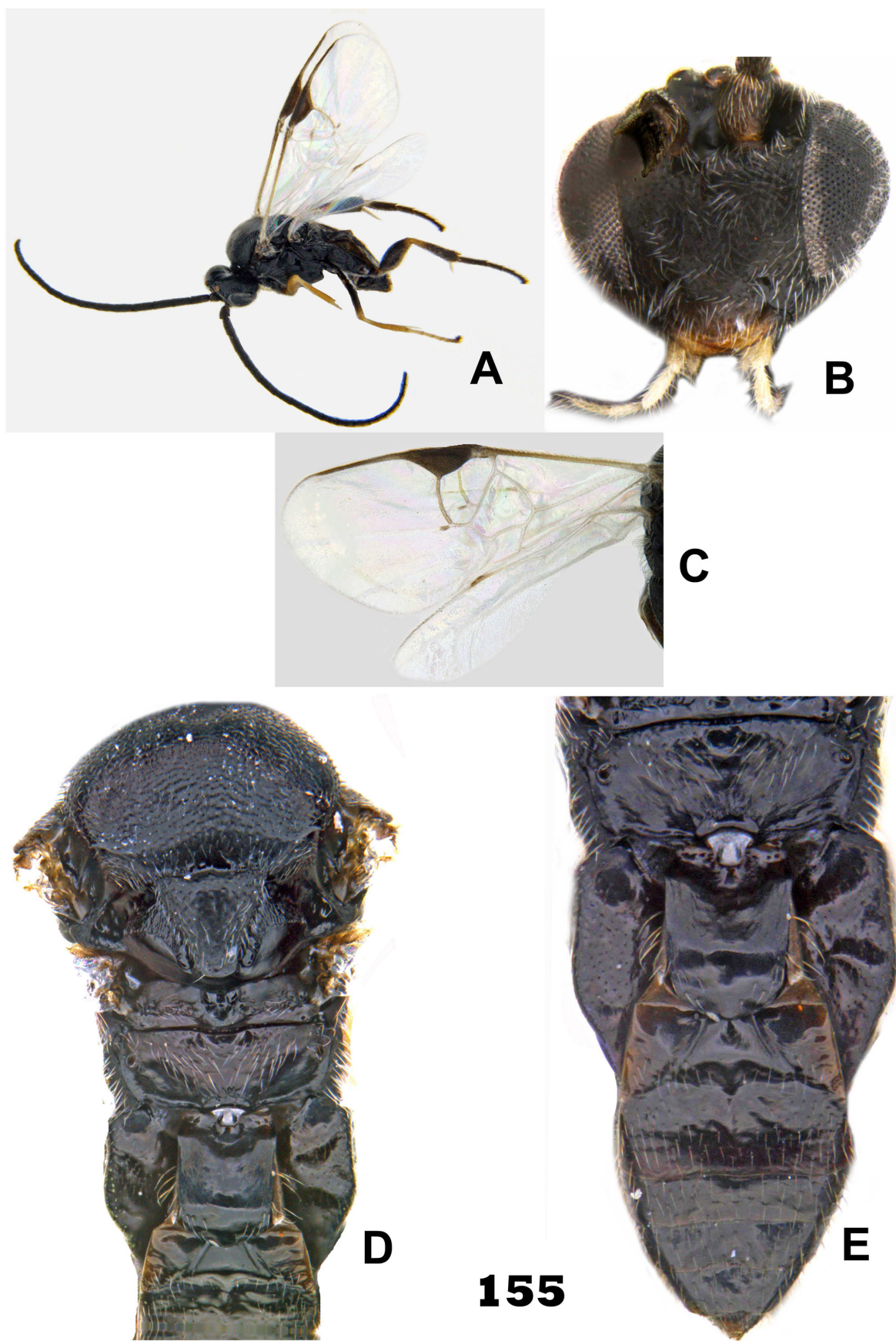


FIGURE 155. *Glyptapanteles spodopterae* Ahmad (female)—A. Profile view B. Head C Wings D. Mesosoma with metasoma in part E. Metasoma.



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FIGURE 156. *Glyptapanteles trilocha* Gupta (Paratype, female)—A. Profile view B. Mesosoma C. Metasoma.

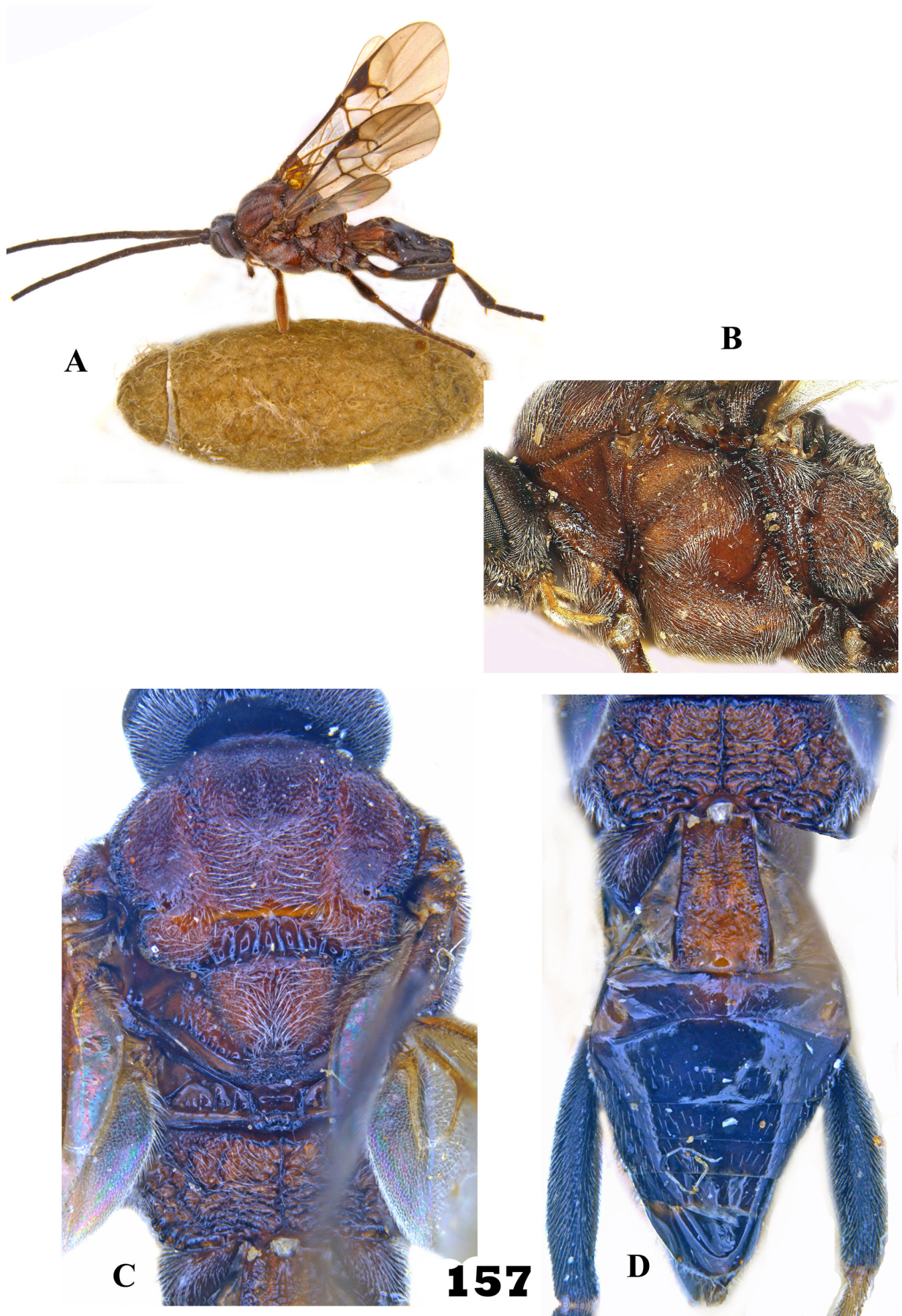


FIGURE 157. *Microplitis carinicornis* (Cameron) (female)—A. Profile view B. Mesopleuron C. Mesosoma D. Metasoma.

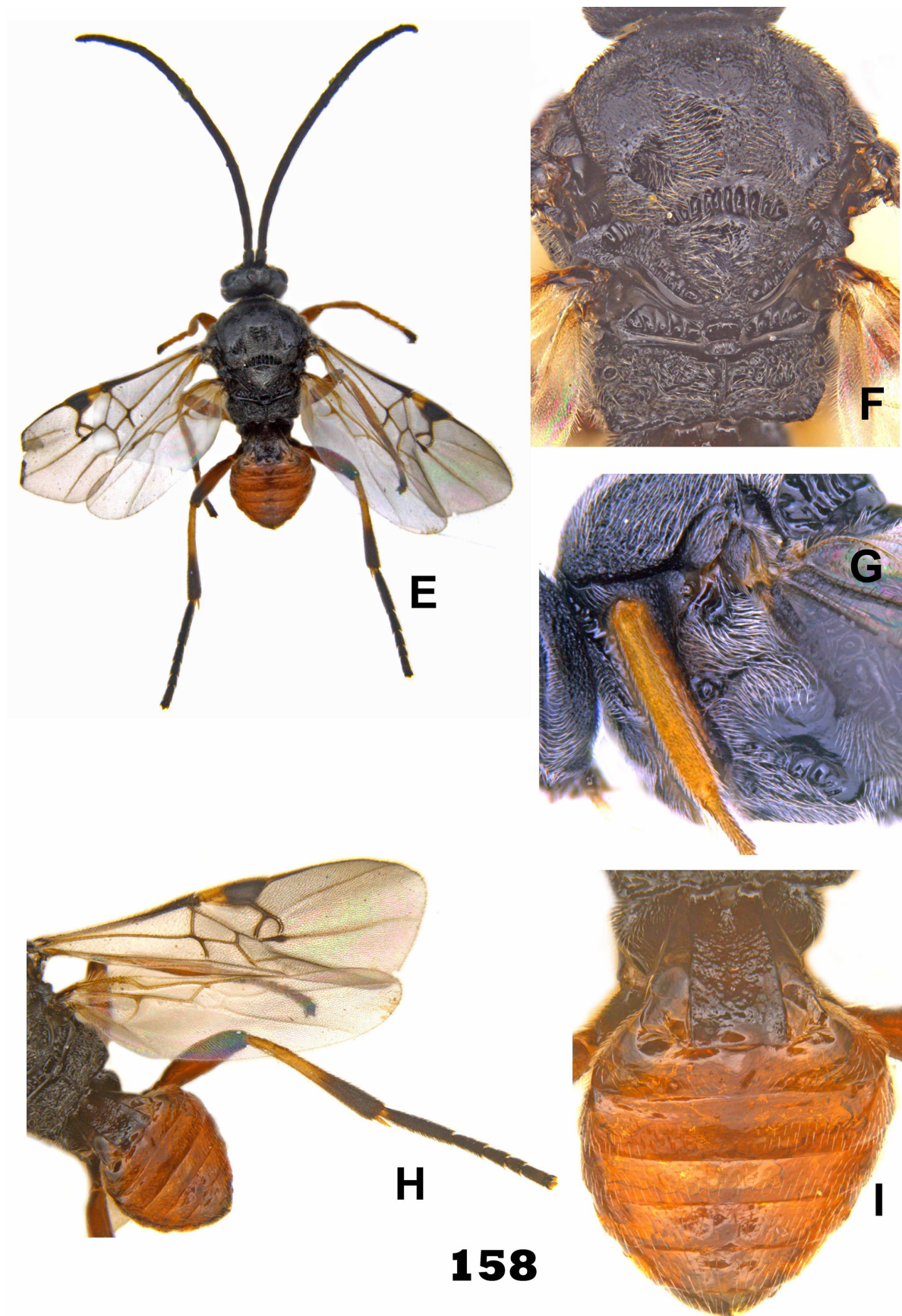


FIGURE 158. *Microplitis carinicollis* (male)—E. Dorsal view F. Mesosoma G. Mesopleuron H. Wings with part of body I. Metasoma.

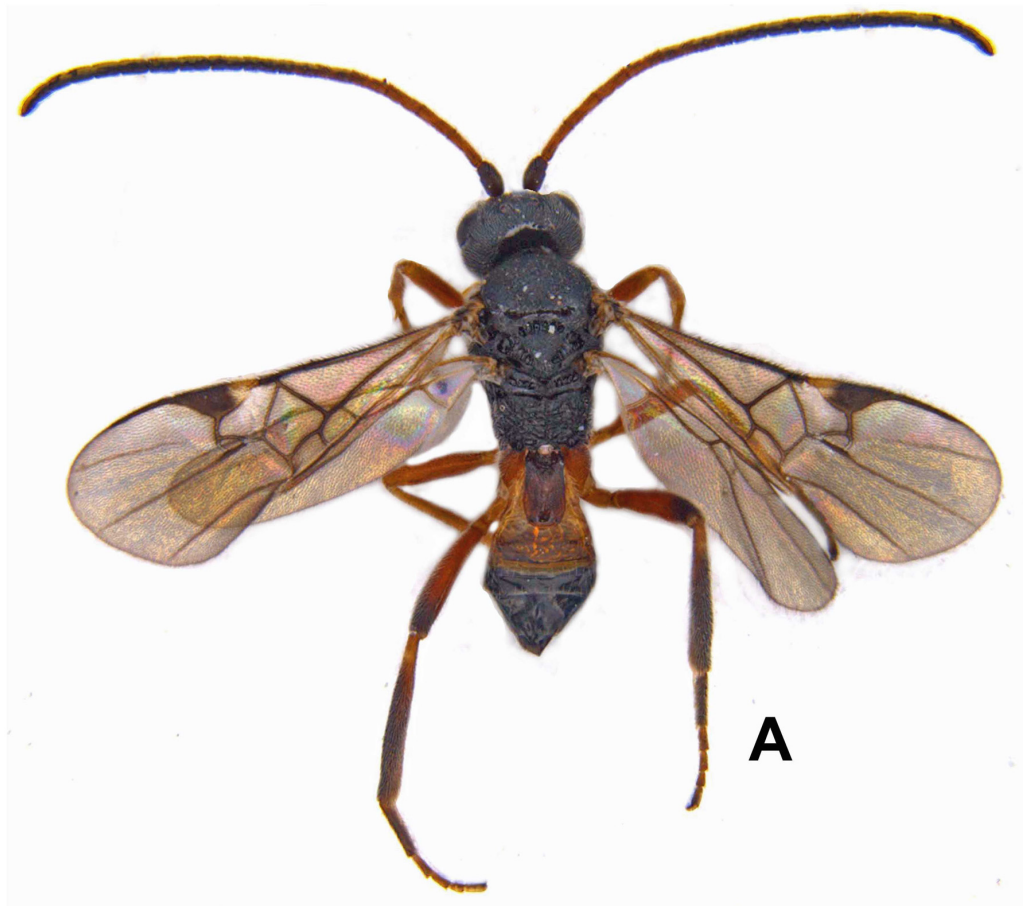
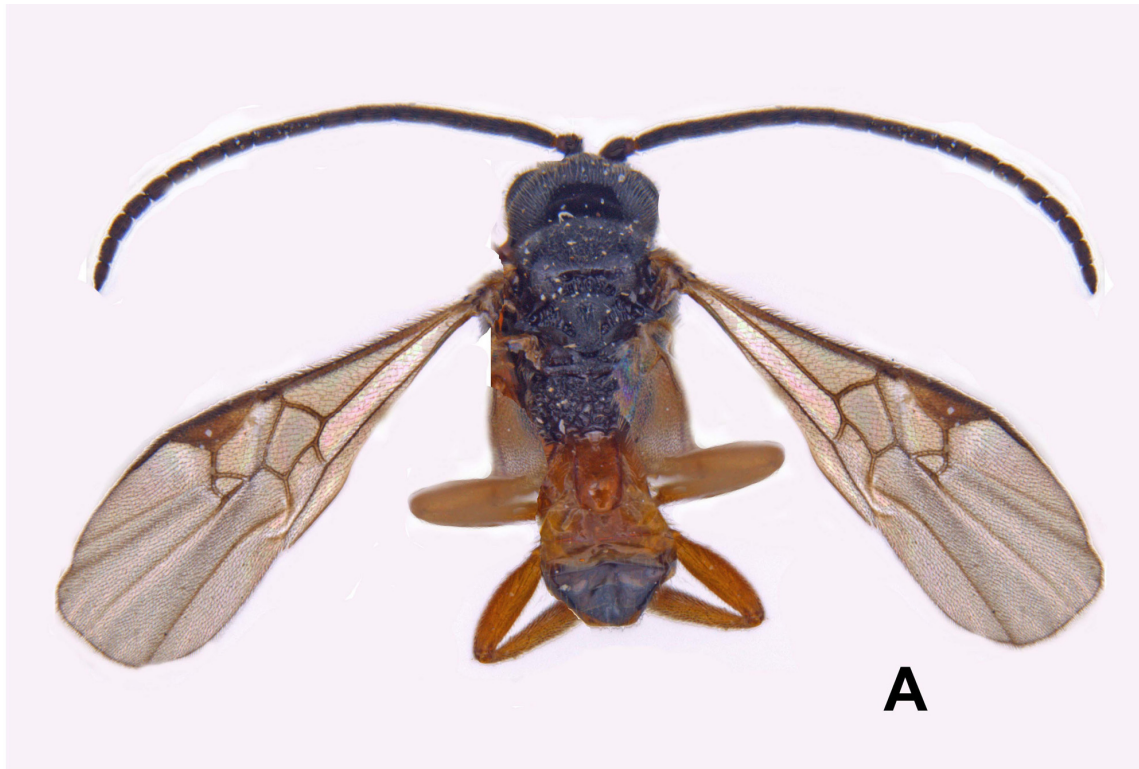


FIGURE 159. *Microplitis demolitor* Wilkinson (female)—A. Dorsal view B. Metasoma C. Mesosoma.



A



B

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FIGURE 160. *Microplitis indicus* Marsh (female)—A. Dorsal view B. Mesosoma & metasoma in dorsal view.

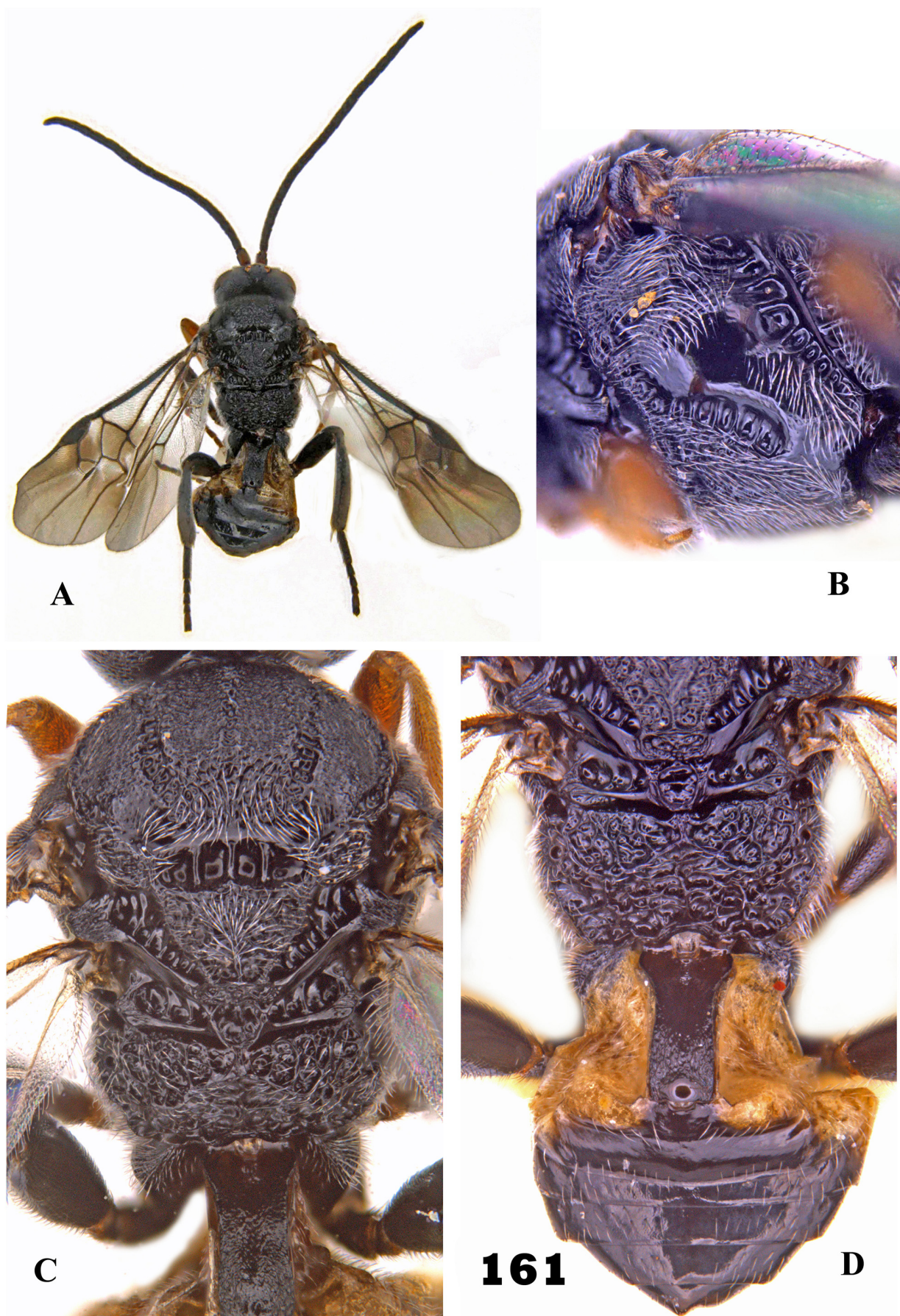


FIGURE 161. *Microplitis maculipennis* (Szepligeti)—A. Dorsal view B. Mesopleuron C. Mesosoma D. Metasoma.

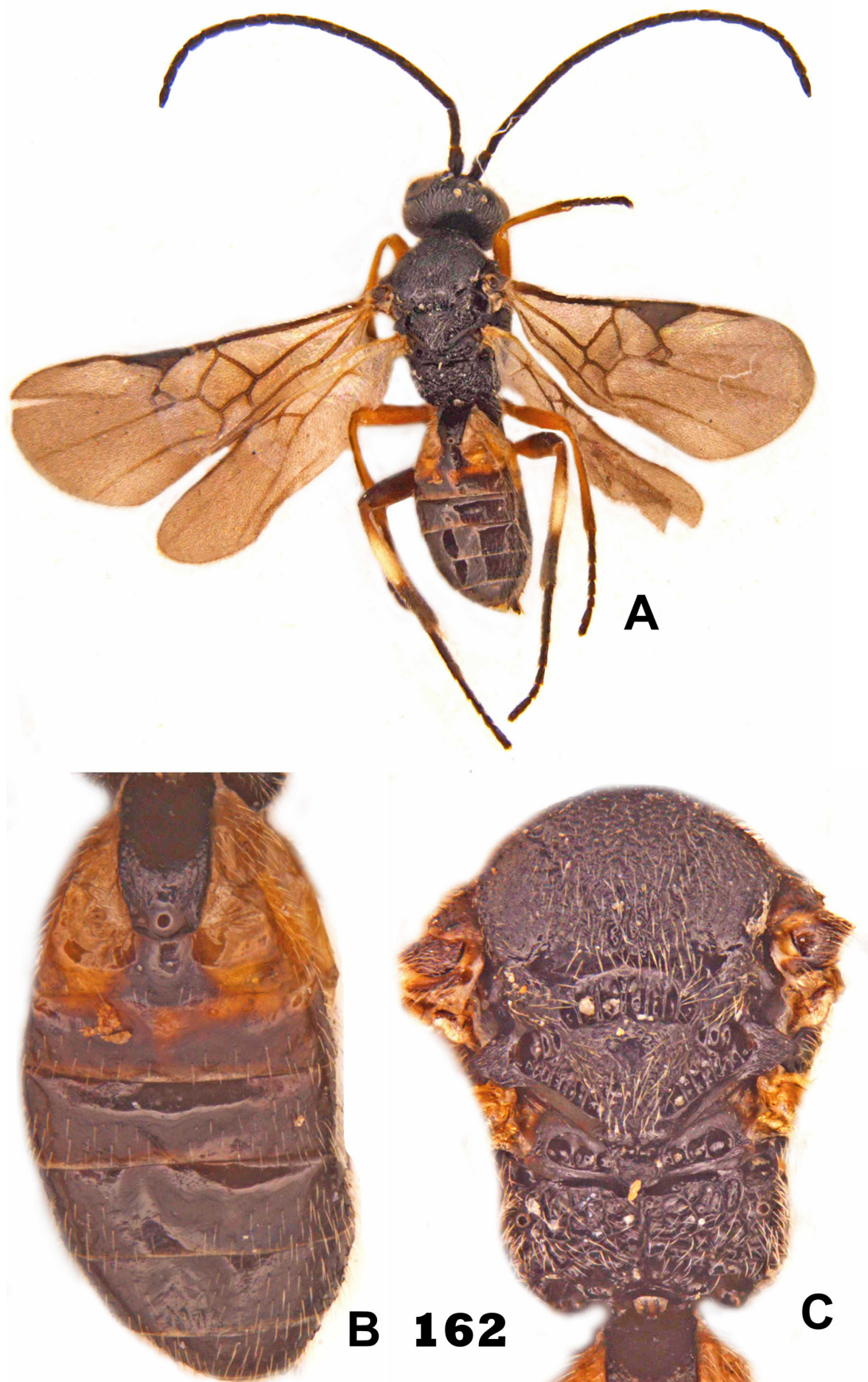


FIGURE 162. *Microplitis manilae* Ashmead (female)—A. Dorsal view B. Metasoma C. Mesosoma.

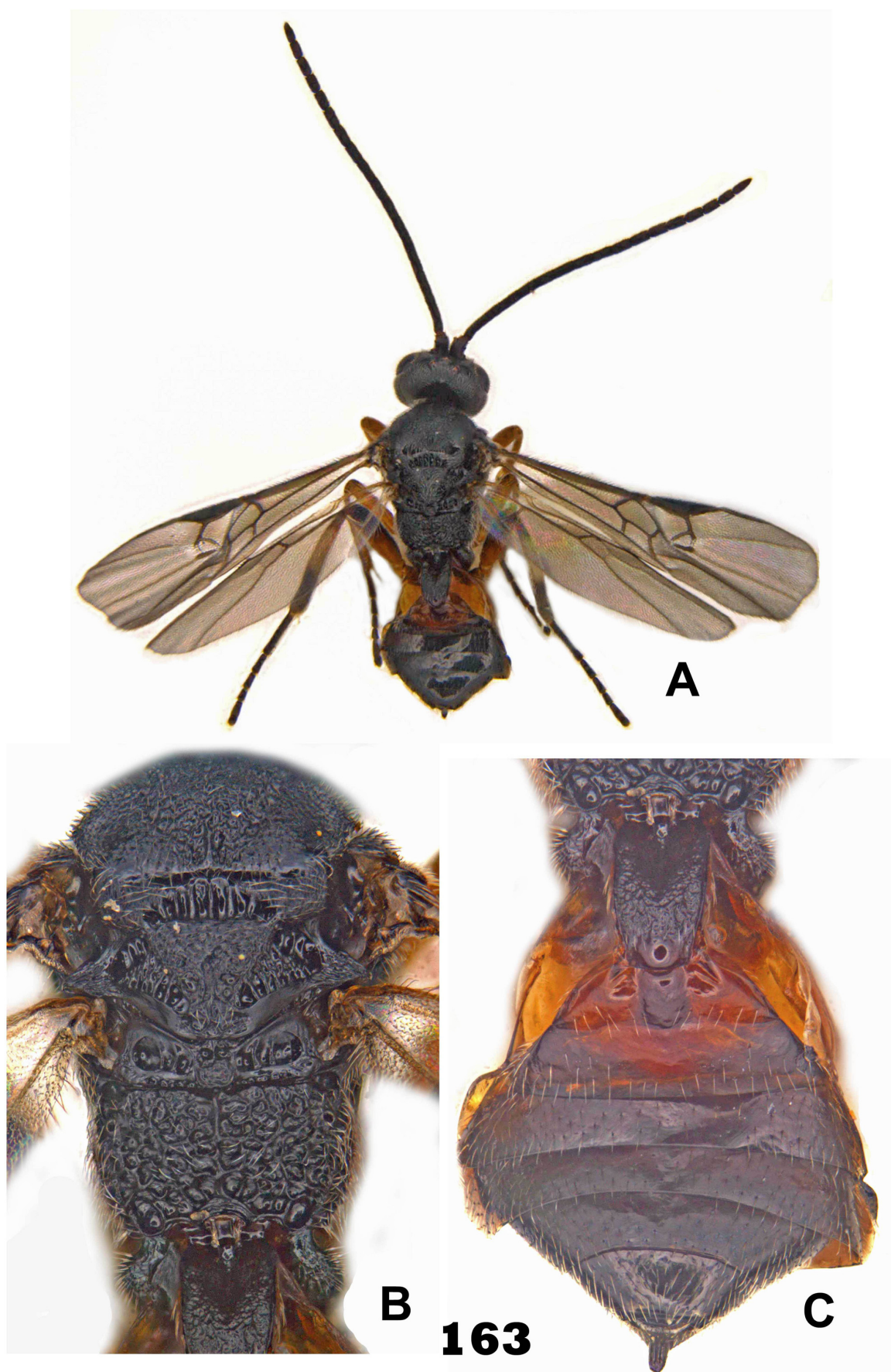


FIGURE 163. *Microplitis prodeniae* Rao & Kurian (female)—A. Dorsal view B. Mesosoma C. Metasoma.



FIGURE 164. *Microplitis spodopterae* Rao & Kurian (female)—A. Profile view B. Metasoma C. Mesosoma.

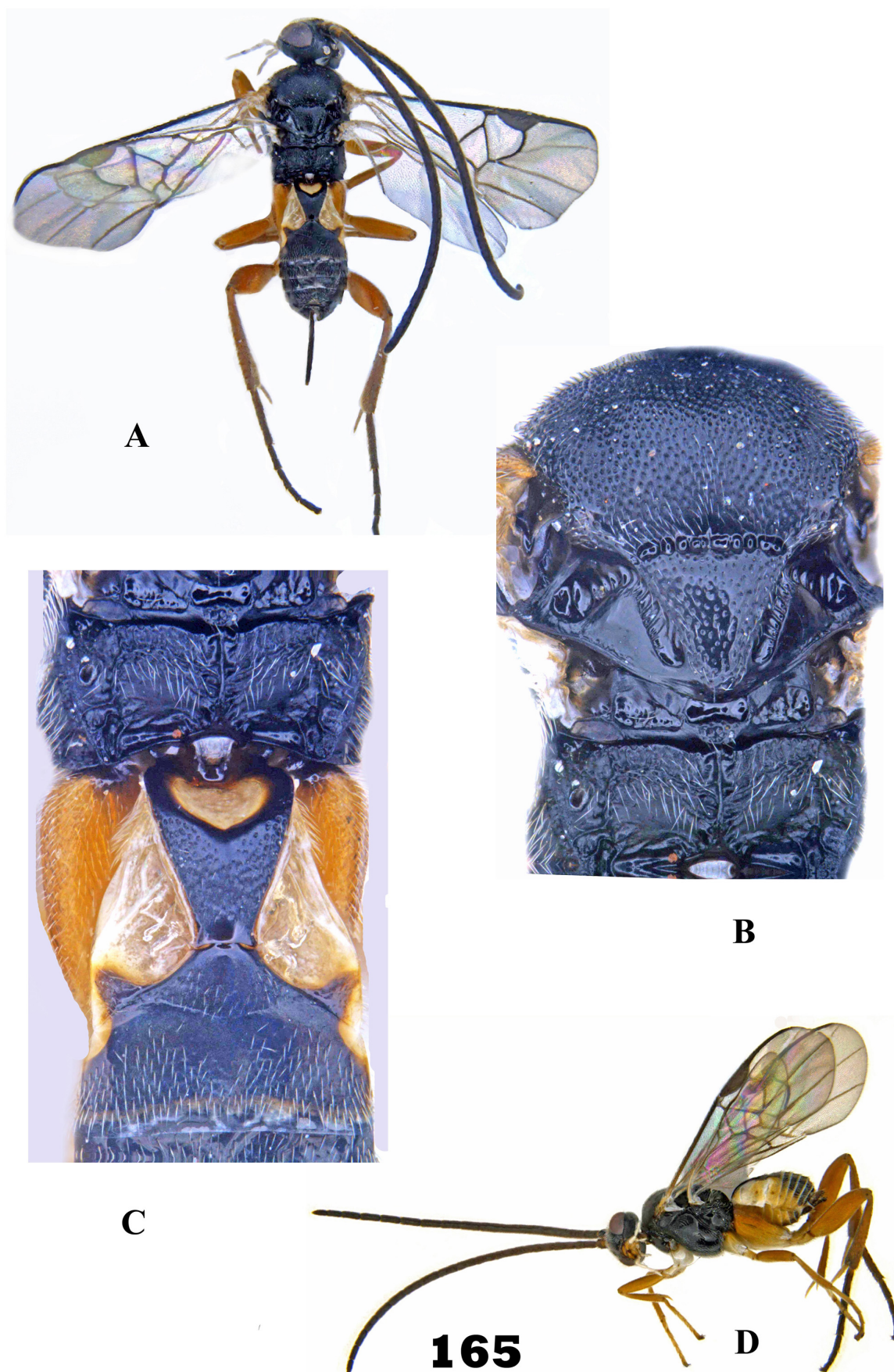
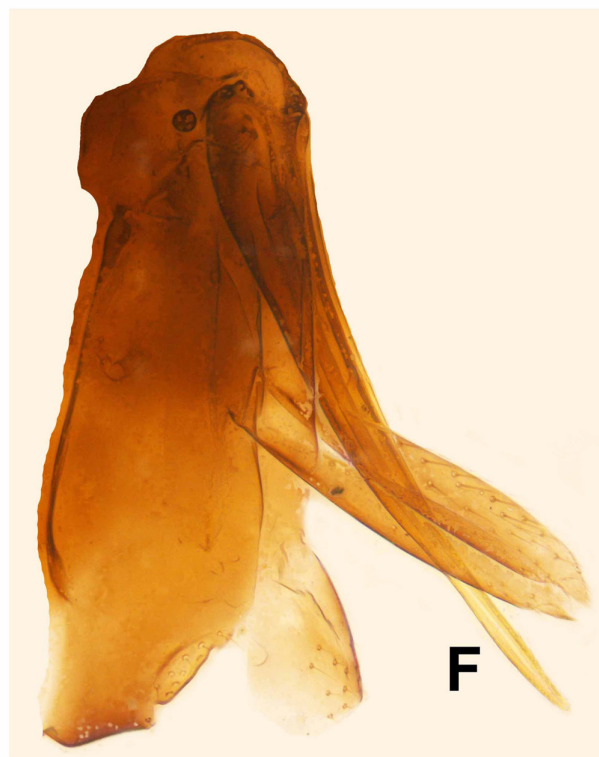


FIGURE 165. *Neoclarkinella vitellinipes* (You & Zhou) (female)—A. Dorsal view B. Mesosoma C. Propodeum with part of metasoma D. Profile view.

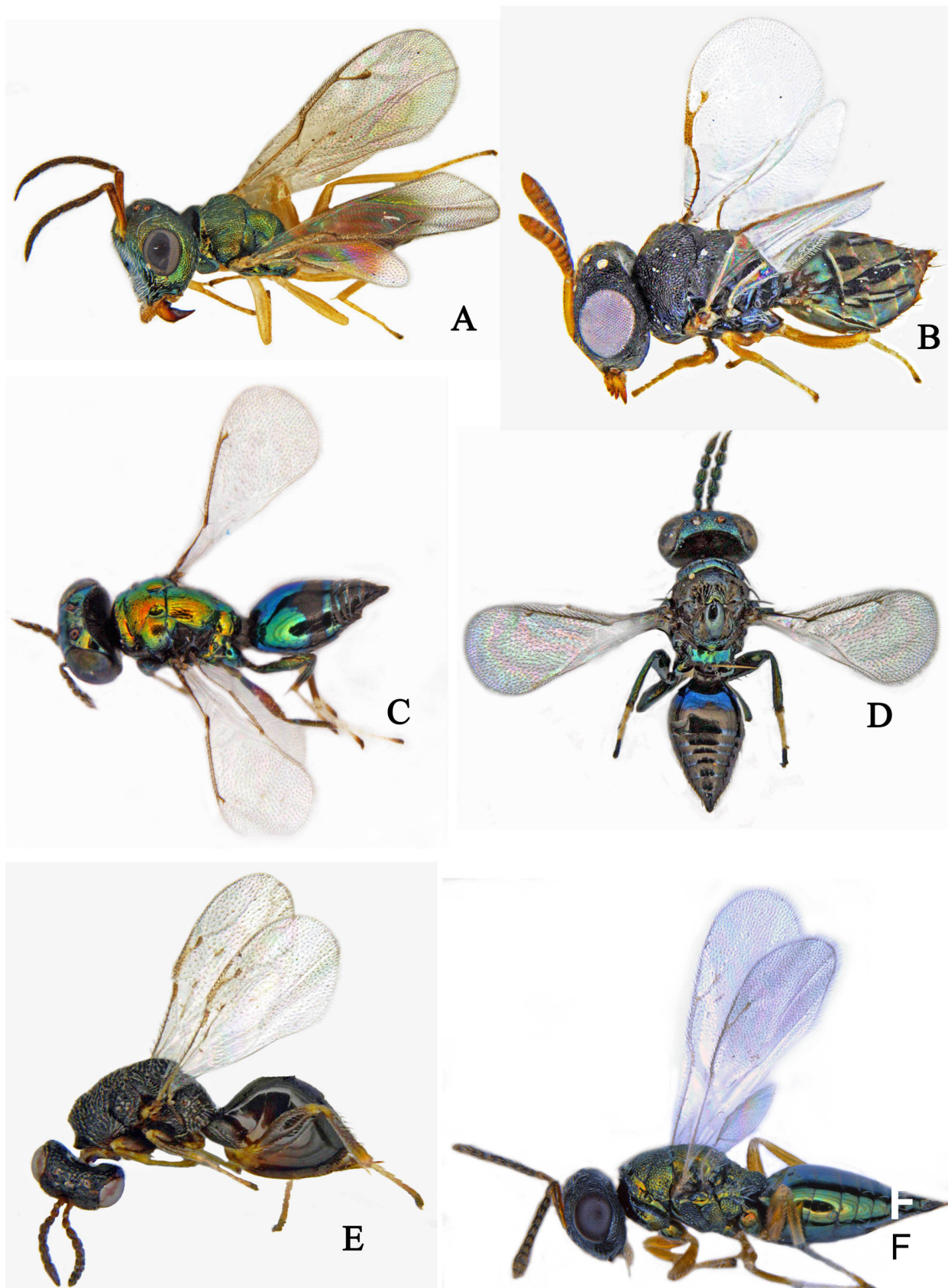


FIGURE 166. *Parapanteles echeriae* Gupta *et al.* (female)—A. Dorsal view (Holotype) B. Body in lateral view (Paratype).



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FIGURE 167. *Parapanteles echeriae* (Holotype, female)—C. Mesosoma D. Mesosoma (KOH treated) E. Metasoma F. Ovipositor.



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FIGURE 168. Hyperparasitoids: A. *Mokrzeckia menzeli* Subba Rao B. *Pachyneuron groenlandicum* (Holmgren) C. *Pediobius foveolatus* (Crawford) D. *Pediobius* sp. E. *Eurytoma* sp. F. *Trichomalopsis* sp..