RECORDS

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	Page
Distributional Records of Indian Acrididae. *B. P. Uvarov*	233
New Indian Ichneumonidae. *R. A. Cushman*	241
On two "Pug-headed" specimens of the Cat-Fish, ***Aoria gulio*** (Ham. Buch.). *D. D. Mukerji*	249
On the Morphology and Bionomics of ***Embia minor,*** sp. nov. with special reference to its spinning organ. A contribution to our knowledge of the Indian Embioptera. *S. Mukerji*	253
Notes on Lamellibranchs in the Indian Museum. *B. Prashad*	283
Enrico Brunetti. Obituary Notice	287

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DISTRIBUTIONAL RECORDS OF INDIAN ACRIDIDAE.

By B. P. UVAROV, *Imperial Bureau of Entomology, London.*

The Zoological Survey of India recently sent to me for identification the entire collection of Acrididae in the Indian Museum. The present paper, which is the first of the series, contains exact records of localities of the relatively well-known species, as information about the distribution of the Indian Acrididae is still very meagre. All doubtful or new species in the collection that require more detailed study will be dealt with in a subsequent communication.

Before proceeding with the list, I would like to draw the attention of field-entomologists in India to the relatively little information which we possess about the Indian Acrididae. Undescribed species and even genera are continually found in collections, and in view of the fact that practically no part of India has been sufficiently investigated for the Acrididae, a careful collector can do very useful work almost anywhere. The most interesting and promising areas are, however, the Himalayas, especially the western part (as Assam and Burma are better explored than many other parts of India), and the Indian desert regions. Collections of Acrididae from India would be thankfully received by me [1] and worked out as early as possible. I shall also be very pleased to offer any advice and help to collectors.

Sub-family ACRIDINAE.

Acrida exaltata (Wlk.).

Srinagar, 6000 ft., Kashmir, N. W. Himalayas, vii-ix-16 (*H. T. Pease*).
Kashmir, N. W. Himalayas, 1915 (*H. T. Pease*).
Lucknow, United Provinces, 360 ft., 2-xii-06 (*E. Brunetti*).
Kandaghar, Simla hills, 3,500-4,600 ft., viii-25 (*B. Chopra*).
Asmi, Simla hills, 3,000-4,000 ft., vii-ix-25 (*B. Chopra*).
Ghuma, Simla hills, 3,700 ft., 6-8-ix-25 (*B. Chopra*).
Pareshnath, Bihar, 4,000-4,400 ft., 12-iv-09 (*N. Annandale*).
Kulti, near Sitarampore, Bengal, 8-viii-09 (*B. Lord*).
Monghyr, Bihar, 24-ix-09 (*J. T Jenkins*).
Hoshangabad, Central Provinces, 14-18-iii-19 (*F. H. Gravely*).
Amanhar, Bijnor district, United Provinces, 12-ii-07.
Barkul, Puri district, Orissa, 9-13-xi-12 (*F. H. Gravely*).
Balighai, near Puri, Orissa, 16-20-viii-11 (*N. Annandale and F. H. Gravely*).
Calcutta, 2-ix-07 ; 25-ix-12.
Cherrapunji, Khasi Hills, Assam, 19-v-09 (*B. Warren*).

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[1] The specimens may be sent pinned or in papers either direct to the author c/o the British Museum (Natural History), London, S. W. 7, or c/o The Zoological Survey of India, Indian Museum, Calcutta.

Shillong, Khasi Hills, Assam, *ca.* 5000 ft. 22-ix-26 (*R. B. S. Sewell*).

Kalimpong, Darjiling district, E. Himalayas, 600-4,500 ft., 24-iv-10-v-25 (*F. H. Gravely*).

Sikkim, vii-12.

Tambi, Koyna valley, Satara district, *ca.* 2,100 ft., 24-26-iv-12 (*F. H. Gravely*).

Medha, Yenna valley, Satara district, *ca.* 2,200 ft., 17-23-iv-12 (*F. H. Gravely*).

Aulacobothrus luteipes (Wlk.).

Newadin, Bengal.

Mazbat, Mangaldai district, Assam, 11-15-x-10 (*S. W. Kemp*).

Aulacobothrus decisus (Wlk.).

Chiplun and Pimpli, Vashisti valley, Ratnagiri district, 0-300 ft., 25-v-12 (*F. H. Gravely*).

Leva indica (Bol.).

Khargpur, Bengal, 25-v-07 (*E. Brunetti*).

Kulti, near Sitarampore, Bengal, 6-viii-09 (*B. Lord*).

Representatives of the genus *Leva* are known from the Central Indian plains, from South India, Ceylon and Africa, but apparently do not penetrate into hills at all.

Sjostedtia darjeelingensis (Bol.).

Majkkali, 6,000 ft., Kumaon, 3-x-07 (*L. L. Fermor*).

Sikkim (*E. T Atkinson*).

Bhoraikund and the Doiphang valley, Assam-Bhutan frontier, Darrang district, 18-22-x-12 (*S. W Kemp*).

Rungeet valley, 700-800 ft., Darjiling district, E. Himalayas, 29-v-16 (*F. H. Gravely*).

Sibsagar, R. Saffree, N. E. Assam (*S. E. Peal*).

The species is very typical for Assam and the Kumaon record is the most western known.

Ceracris nigricornis (Wlk.).

Ukhual, Manipur, 6,400 ft. (*V Pettigrew*).

Bhim Tal, 4,500 ft., Kumaon, 19-22-ix-06 (*N. Annandale*).

Kurseong, 5,000 ft., E. Himalayas, 6-ix-09.

Aiolopus affinis (Bol.).

Bombay, ix-19.

Allahabad, United Provinces, 16-viii-09 (*B. Lord*).

Satpara, Orissa, 16-ix-13 (*N. Annandale*).

Balugaon, Puri district, Orissa, 21-30-vii-18 (*N. Annandale*).

Barkul, Puri district, Orissa, 13-xi-12 (*F. H. Gravely*).

Sub-family OEDIPODINAE.

Oedaleus senegalensis Kr.

Srinagar, 6,000 ft., Kashmir, N. W. Himalayas, vii-ix-16 (*H. T. Pease*).

Calcutta.

This species is distributed from Senegal to Mesopotamia, Transcaucasia, Persia, Turkestan and into the Indian plains, but its occurrence at a considerable altitude in Kashmir is somewhat surprising.

Oedaleus abruptus (Thnbg.).

A very common Indian species represented in the collection from numerous localities, hardly worth recording individually.

Gastrimargus transversus (Thnbg.).

Rawalpindi, Punjab, vi-vii-17 (*R. Hodgart*).

Paresnath, Bihar, 4,000-4,400 ft., 13-iv-09 (*N. Annandale*).

Kumaon (*L. L. Fermor*).

Chiplun, Ratnagiri district, Bombay Presidency 8-v-13 (*S. P. Agharkar*).

Bamnoli, Satara district to Akaipa, Ratnagiri district, 27-x-12 (*S. P. Agharkar*).

Dhom, Krishna valley, 2,400 ft., 29-30-iv-13 (*S. P. Agharkar*).

Sikkim, 7,000 ft., vii-12.

Cherrapunji, Khasi Hills, Assam, 19-v-09 (*B. Warren*).

Nongpriang, Khasi Hills, Assam, ix-v-09 (*B. Warren*).

Udalguri, Assam, 23-x-12 (*S. W Kemp*).

Heteropternis respondens (Wlk.).

Kalimpong, Darjiling district, E. Himalayas, 600-4,500 ft., 24-iv-10-v-15 (*F H. Gravely*).

Tea Gardens below Kurseong, E. Himalayas, 1,500-5,000 ft. (*B. Chopra*).

Northern Shan hills, Upper Burma (*J. C. Brown*).

Thingannyinaung to Myawadi, Lower Burma, 900 ft., 24-26-xi-11 (*F. H. Gravely*).

Pternoscirta cinctifemur (Wlk.).

Tea Gardens below Kurseong, E. Himalayas, 1,500-5,000 ft., iii-24 (*B. Chopra*).

Morphacris fasciata sulcata (Thnbg.).

Jubbulpore, 1,300 ft., 3-10-iv-05 (*E. Brunetti*).

Quilon, Travancore, v-15 (*G. P. Pillai*).

Marikuppam, S. India, 2,500 ft., 21-x-10.

Acrotylus humbertianus Sauss.

Large numbers of specimens from various localities.

Sphingonotus rubescens (Wlk.).

Peshawar.

A typical member of the Palaearctic desert fauna.

Sphingonotus longipennis Sauss.

Rungeet valley, 700-800 ft., Darjiling district, E. Himalayas, 29-v-16 (*F. H. Gravely*).

Doiphang valley, Assam-Bhutan frontier, Darrang district, 21-x-12 (*S. W. Kemp*).

Sub-family PYRGOMORPHINAE.

Atractomorpha himalayica Bol.

Siliguri, N. Bengal, 18-20-vii-07.

Pashok, 5,000 ft., Darjiling district, E. Himalayas, 26-v-16 (*F. H. Gravely*).

Ghumti, 4,000 ft., Darjiling district, E. Himalayas, vii-11 (*F. H. Gravely*).

Darjiling, 6,-7,000 ft., 12-vi-14 (*F H. Gravely*).

Kurseong, E. Himalayas, 6,200 ft., 4-viii-09 (*E. A. D'Abreau*).

Sub-family CATANTOPINAE.

Patanga japonica (Bol.).

Siliguri, N. Bengal, 18-20-vii-07.

Dow Hill, Kurseong, E. Himalayas, 6,000 ft., 8-iii-24 (*B. Chopra*).

Pachyacris vinosa (Wlk.).

Almora, Kumaon, 5,500 ft., xii-11 (*C. Paiva*).

Monda, Nepal, 12-v-08 (*R. Hodgart*).

Base of hills, S. of Chakardharpur, Chota Nagpur, 29-ix-11 (*F H. Gravely*).

Pass between Chakardharpur and Chota Nagpur, 2-4-iii-13 (*F. H. Gravely*).

Cyrtacanthacris tatarica (Linn.).

Barkuda I., Chilka lake, Ganjam district, Madras Presidency, 3-vi-22 (*N. Annandale*).

Calcutta.

Nilgiris.

Paraconophyma scabra (Wlk.).

Bhim Tal, 4,500 ft., Kumaon, 19-22-ix-10 (*N. Annandale*).

Originally described from Burdwan, Bengal, I have recorded it (*Ann. Mag. Nat. Hist.*, (9) vii, p. 501, 1921) from the Pusa collection without an exact locality, but now I am able to state that the specimens were from Mussoorie, 7,500 ft.

Oxya nitidula (Wlk.).

Garia, near Calcutta, 13-xii-10 (*S. W. Kemp*).
Fraserganj, 24 Perganas, Sunderbuns, 13-xi-09 (*J. T Jenkins*).

Oxya fuscovittata (Marsch.).

Rawalpindi, Punjab, vi-vii-17 (*R. Hodgart*).
Calcutta and environs, 20-xi-04 ; 13-viii-07 (*E. Brunetti*).

Oxya uvarovi Will. f. **brachyptera.**

Shillong, Khasi hills, Assam, 26-ix-26 (*R. B. S. Sewell*).

Oxya intricata St.

Bhubaneswar, Puri district, Orissa, 4-6-xi-12 (*F H. Gravely*).

Hieroglyphus banian F. var. **elongata** Uv.

Barkul, Puri district, Orissa, 9-13-xi-12 (*F. H. Gravely*).

Hieroglyphus nigrorepletus Bol. f. **macroptera.**

Allahabad, United Provinces, 13-viii-09 (*B. Lord*).

Oxyrrhepes extensa (Wlk.).

Sikkim (*E. T. Atkinson*).

Spathosternum prasiniferum (Wlk.).

One of the commonest grasshoppers represented in the collection by many specimens from various localities.

Traulia azureipennis (Serv.).

Kachin Hills (*Topin*).
Mergui.

Eucoptacra saturata (Wlk.).

Rampore Chaka, Bijnor district, United Provinces, 23-31-ii-07.
Barkul, 0-1,000 ft., Orissa, 1-3-viii-14 (*F. H. Gravely*).
Assam-Bhutan frontier, Mangaldai district, 26-xii-10 (*S. W Kemp*).

Eucoptacra binghami Uv.

Thingannyinaung to Sukli, Dawna hills, 900-2,100 ft., 23-27-xi-11 (*F. H. Gravely*).
Goktek gorge, below viaduct, L. Burma, 8-x-11 (*C. G. Rogers*).

Apalacris varicornis (Wlk.).

Rangamati, Chittagong Hill Tracts, Bengal, 11-16-vii-15 (*R. Hodgart*).
Kurseong, 5,000 ft., E. Himalayas, 8-ix-09 (*N. Annandale*)

Pirithous ramachendrai Bol.

Waltair, Madras presidency, 22-iv-10 (*S. W Kemp*).

Catantops humilis (Serv.).

Dekhat Bhuli, Nepal Terai, 30-iv-07
Assam-Bhutan frontier, Mangaldai district, 26-xii-10 (*S. W. Kemp*).
Kurseong, E. Himalayas, 6,000 ft.
Eagles Crag, Kurseong, 5,000 ft., 9-iii-24 (*B. Chopra*).
Tea Gardens below Kurseong, 1,500-5,000 ft., iii-24 (*B. Chopra*).
Port Blair, Andamans, 15-ii—15-iii-15 (*S. W Kemp*).

Catantops innotabile Wlk.

Jumnagwar, Gharwal district, base of W. Himalayas, 16-iv-10.
Simla, v-22 (*S. H. Ribeiro*).
Jubbulpore, Central Provinces.
Base of hills, S. of Chakardharpur, Chota Nagpur, 29-ix-11 (*F. H. Gravely*).
Chandipore, Orissa, 17-27-x-20 (*C. Dover*).
Khandagiri, Puri district, Orissa, 7-8-xi-12 (*F. H. Gravely*).
Chota Nagpur, 29-ix-11 (*F. H. Gravely*).
Puri, Orissa coast, 21-iii-09 (*N. Annandale*).
Satpara, Orissa, 17-ix-13 (*N. Annandale*).
Balugaon, Puri district, Orissa, 21-30-vii-13 (*N. Annandale*).
Bhubaneswar, Puri district, Orissa, 4-6-xi-12 (*F H. Gravely*).
Pusa, Bihar, 26-30-viii-25 (*H. S. Pruthi*).
Paresnath, Bihar, 4,000-4,400 ft., v-09 (*J. T Jenkins*).
Siripur, Saran, Bihar, 25-ix-10.
Calcutta, 8-vii-07.
Calcutta environs, 29-ix-04 (*E. Brunetti*).
Cheria I., Chilka lake, 22-vii-14.
Appa ently very common in the plains, but scarcely ranging into hills.

Catantops henryi Bol.

Khemsa, W. Ghats, 2,650 ft., 5-v-13 (*S. P. Agharkar*).
Helvak, Koyna valley, Satara district, 2,000 ft., 28-30-iv-12 (*F H. Gravely*).
Dhankai near Helvak, Satara district, 2,400-2,600 ft., 4-v-13 (*S. P. Agharkar*).

Caloptenopsis glaucopsis (Wlk.).

Between Kantadih and base of hills, Manbhum district, Chota Nagpur, 11-ii-12 (*N. Annandale* and *F H. Gravely*).

Caloptenopsis insignis (Wlk.).

Mahabaleshwar, Satara district, 4,200 ft., 13-16-iv-12 (*F. H. Gravely*).
Kas, Satara district, 3,700 ft., 23-24-iv-12 (*F H. Gravely*).

Peripolus pedarius (St.).

Sikkim.

Hygracris palustris Uv.

Tezpur, Mangaldai district, Assam, 8-9-x-10 (*S. W Kemp*).

Euprepocnemis alacris (Serv.).

Base of hills, S. of Chakardharpur, Chota Nagpur, 29-ix-11 (*F. H. Gravely*).

Yenangyaung, Magwe, Upper Burma, 300 ft., viii-ix-11 (*J. Coggin Brown*).

Coonoor, 6,000 ft., Nilgiris, vi-12 (*R. B. S. Sewell*).

Tylotropidius varicornis (Wlk.).

Helvak, Koyna valley, Satara district, 2,000 ft., 28-30-iv-12 (*F. H. Gravely*).

Kas, Satara district, 3,700 ft., 23-24-iv-12 (*F. H. Gravely*).

Medha, Yenna valley, 2,200 ft., 17-23-iv-12 (*F H. Gravely*).

Chiplun, Vashishti valley, Ratnagiri district, 0-360 ft., 3-6-v-12 (*F. H. Gravely*).

The size is smaller and the elytra shorter in the specimens from higher altitudes.

Thisoecetrus pulcher Bol.

Dharampur, W. Himalayas, 5,000 ft., ix-v-13 (*Phaku Ram*).

Balugaon, Puri district, Orissa, 21-30-vii-13 (*N. Annandale*).

Calcutta.

Eupreponotus inflatus Uv.

Calcutta, July 911.

I have described this remarkable genus and species from a single male from unknown locality, but later found out that it was from Cuttack. The Indian Museum collection contains both sexes and a description of the female will be given by me elsewhere.

NEW INDIAN ICHNEUMONIDAE.

By R. A. CUSHMAN, *Bureau of Entomology, United States Department of Agriculture.*

The insects described below have been received at various times from the Forest Zoologist at Dehra Dun, United Provinces, India.

Callipehialtes odinae, n. sp.

Female.—Length 12 mm.; antennae 8 mm.; ovipositor 16 mm.

Head twice as broad as thick, temples rather strongly receding; vertex, frons and temples polished, unsculptured; face with fine separated punctures and dense silvery pubescence interspersed with long hairs, slightly narrower than frons and slightly broader than long; clypeus medially hardly half as long as interfoveal line; malar space very short. Thorax about twice as long as deep, polished, mesoscutum sparsely and finely punctate, mesopleurum below and sternum more sparsely so; prescutum prominent, notauli deeply impressed anteriorly; upper part of metapleurum and propodeum rather coarsely and confluently punctate, the median groove sparsely punctate and apical slope polished; stigma and radial cell very narrow, second abscissa of radius strongly recurved at base; areolet large, more than twice as wide at base as at apex, first intercubitus nearly as long as second and strongly sloping; nervellus strongly reclivous, broken slightly above upper third, upper abscissa perpendicular to cubitella; legs slender, hind femur barely reaching apex of third tergite, basitarsus as long as remaining joints united. Abdomen slender, about two and one-half times as long as thorax, strongly punctate, confluently so medially on first five tergites; first two tergites not quite twice as long as broad at their junction, second with deep oblique grooves at base; third to fifth successively shorter, fifth about as long as broad at base, lateral elevations strong, round.

Black; clypeus piceous; palpi pale; tegulae and radices whitish; front and middle legs testaceous, paler in front; hind legs piceous black, sutures paler; wings hyaline with dark venation; abdomen more or less brownish at sides toward apex.

Male.—Face distinctly narrower than long; abdomen tapering slightly from apex of second tergite, elevations less prominent, tergites 5-7 nearly equal in length; genital sheath large, broad at apex; hypopigium very narrow; scape and pedicel white below; hind leg ferruginous, tibia black, its basal third stramineous, tarsus black. Otherwise essentially like female.

Host.—Odina wodier.

Type-locality.—Golatappar, Dehra Dun, United Provinces, India.

Type.—Cat. No. 40426, U. S. N. M.

One female and two males reared by N. C. Chatterjee, the males on January 3 and the female on January 13, 1923.

The male paratype is deposited in the British Museum.

Campoplegidea Viereck.

Campoplex Authors, not Gravenhorst.
Anisitsia Viereck, *Proc. U. S. Nat. Mus.*, XLII, p. 632 (1912).
Campoplegidea Viereck, *Proc. U. S. Nat. Mus.*, XLII, p. 633 (1912).
Viereckiana Strand, *Arch. Naturg.*, LXXX, p. 163 (1914).

Anisitsia, proposed for certain species of *Campoplex* Authors, was based entirely on characters of no more than specific significance; and, although he does not state so specifically, Viereck has apparently recognized this fact, for in his revision of the Charopsinae (*Trans. Roy. Soc. Can.*, sec. V, p. 259, 1925), he omits the genus from his key and uses the name *Campoplegidea* in that place in the key where the species formerly referred to *Anisitsia* will run.

Viereckiana is merely a renaming of *Anisitsia*, which was pre-occupied.

The following new species agrees with two of the five characters ascribed to *Anisitsia*, both of which are shared by *Campoplegidea* as originally restricted by Viereck, but disagrees with the other three.

Campoplegidea deodarae, n. sp.

Runs nowhere satisfactorily in either Morley's key to Indian species of *Campoplex* or Schmiedeknecht's key to Palaearctic species.

Female.—Length 9 mm.; antennae 7 mm.; ovipositor hardly 1 mm.

Head from above transversely oval, twice as broad as thick, the temples strongly receding and continuing the curvature of the eyes; postocellar and ocell-ocular lines subequal, diameter of ocellus a half longer, ocell-occipital line as long as breadth of ocellar triangle; eyes deeply emarginate; face distinctly wider than frons, combined face and clypeus as long as broad, clothed with long, dense, silvery hair, the clypeus very broad and broadly rounded at apex; malar space at its narrowest point much less than half as long as basal width of mandible; flagellum thick, first joint twice as long as thick, those toward apex slightly transverse. Thorax stout, about a half longer than deep; pronotum in humeral angles and mesoscutum closely finely punctate opaque; mesopleurum sparsely punctate, shining, speculum polished; propodeum sloping, only slightly arched, not reaching middle of coxae, medially channelled, without distinct carinae, opaque coriaceous; stigma small and narrow; areolet briefly petiolate, recurrent far before middle; nervulus strongly postfurcal; abscissula about twice as long as intercubitella; nervellus unbroken; legs moderate, the hind femur reaching apex of second tergite; longer hind calcarium reaching distinctly beyond middle of basitarsus. Abdomen much less than twice as long as head and thorax, moderately compressed from base of second tergite; first segment rather stout, in profile of nearly uniform thickness, postpetiole depressed, nearly twice as broad as petiole, with two deep lateral foveae and a shallower median fovea between the spiracles, spiracles at apical third, sternite reaching slightly beyond spiracles; second tergite two-thirds as long as first, its spiracles at apical two-fifths, its sternite a half longer than third, other tergites successively shorter; ovipositor sheath little more than half as long as first tergite.

Black, with abdomen beyond second tergite red; mandibles, palpi, tegulae and radices whitish; antennae black, dark reddish toward apex;

coxae black, front pair pale at apex; front legs otherwise stramineous, femora slightly reddish; middle and hind trochanters and femora black, sutures brown; middle tibia and tarsus stramineous; hind tibia ferruginous, tarsus fuscous; wings hyaline, venation blackish; first and second tergites more or less dark reddish apically and laterally, third black in basal middle.

Male.—Middle leg, except base of coxa, stramineous; abdomen more slender; otherwise essentially like female.

Type-locality.—Bodyar, 8,300 feet, Chakrata, United Provinces, India.

Type.—Cat. No. 40427, U. S. N. M.

One female and three males reared by F. K. Makins in March and April, 1924, from a "Deodar defoliator."

A male paratype is deposited in the British Museum.

Charops ganges, n. sp.

Female.—Length 10 mm.; antennae 5 mm.; ovipositor less than 1 mm.

Head thin, more than twice as broad as thick, opaque; temples weakly convex; diameter of ocellus two-thirds postocellar line and nearly twice ocell-ocular line; combined face and clypeus as long as broad, finely rugulose punctate, distinctly broader than frons; clypeus in profile strongly inflexed at apex; mouth distinctly narrower than face; malar space half basal width of mandible; antennae stout, slightly tapering toward apex. Thorax barely a half longer than deep; pronotum strongly foveolate in groove, opaque punctate in humeral angle; mesoscutum and scutellum finely confluently punctate, scutellum broader than long, concave, not margined laterally; mesopleurum reticulate rugose, without well defined speculum or groove; sternum densely punctate; propodeum extending nearly to apex of coxa, all longitudinal carinae more or less defined, transverse carinae wanting; median and pleural areas transversely rugose, lateral areas reticulate rugose; metapleurum irregularly transversely rugose; hind femur barely reaching apex of first segment; longer calcarium three-fifths as long as basitarsus. Abdomen very slender; second tergite three-fourths as long as first and nearly twice as long as third; third to sixth subequal; ovipositor sheath half as long as first segment.

Black; mandibles, palpi, radices of wings yellow; front leg, except coxa, basal trochanter joint and a spot on under side of femur yellow; middle and hind legs black, with articulation of femur with trochanter, apex of middle femur, its entire tibia and basitarsus, and extreme base of hind tibia yellow; wings hyaline, venation dark; abdomen with tergites black, sternites brown, membrane yellowish; petiole piceous.

Male.—Essentially like female. Genital sheath broad at apex, barely exerted.

Type-locality.—Dehra Dun, United Provinces, India.

Type.—Cat. No. 40428, U. S. N. M.

One female and two males reared by C. F. C. Beeson, February 5 to March 3, 1916, from larvae of an arctiid.

The male paratype is deposited in the British Museum.

Hyposoter lymantriae, n. sp.

Female.—Length 7 mm.; antennae broken, but apparently reaching at least to apex of second segment; ovipositor not exerted.

Head very thin, temples and vertex sharply receding from eyes and ocelli; eyes broadly but rather deeply emarginate; face very slightly broader than frons; head granularly opaque, somewhat shining behind, not distinctly punctate; ocelli in a low triangle, diameter very nearly as long as postocellar line and much longer than ocell-ocular line; clypeus broadly subtruncate; malar space nearly as long as basal width of mandible; antennae rather stout, tapering toward apex. Thorax barely a half longer than deep; opaque, densely obscurely punctate on mesoscutum, scutellum and mesopleurum; speculum subopaque, groove indistinctly transtriate anteriorly; propodeum short, precipitate behind, finely opaque above, irregularly transrugose behind; areola fully as broad as long, confluent with petiolar area, costulae sub-distinct, spiracular carina not extending above spiracles, latter rather large, subcircular; areolet small, petiolate, recurrent nearly at apex; hind femur reaching apex of third tergite. Abdomen twice as long as thorax, slightly compressed from base of third segment; petiole depressed, postpetiole twice as broad as petiole; second tergite nearly as broad at apex as long, third fully as broad at base as long.

Black; mandibles, palpi, tegulae, front leg, except femur, middle trochanter and tibia and apical joint of hind trochanter yellowish stramineous to yellow; hind coxa and basal joint of trochanter (largely) black; all femora red; hind tibia yellow, apically and sub-basally fuscous, tarsus black with base of first joint yellowish.

Male.—More slender; temples less strongly receding; but otherwise essentially like female.

Host.—*Lymantria concolor* (Walker).

Type-locality.—Kangra Forest, Punjab, India.

Type.—Cat. No. 40429, U. S. N. M.

One female and two males reared August 13-18, 1917, by O. H. Walters.

The male paratype is deposited in the British Museum.

Dioctes gardneri, n. sp.

Very closely related to *argenteopilosa* (Cameron) as identified below, differing conspicuously only in its black hind femur and darker tibia and tarsus and shorter ovipositor.

Female.—Length 7 mm.; antennae 4·5 mm.; ovipositor 1 mm.

Head and thorax clothed with dense silvery pubescence, longest on face and propodeum. Head rather thick, frons and vertex less densely pubescent, very densely and finely rugulose punctate, frons flat; ocelli rather large, their diameter about two-thirds length of postocellar line and nearly twice that of ocell-ocular line; malar space about one-third basal width of mandible; eyes distinctly emarginate opposite antennae; face distinctly though not much narrower than frons. Thorax hardly a half longer than deep, very densely and finely punctate opaque, the speculum opaque alutaceous; propodeum completely areolated, areola hexagonal, hardly longer than broad; stigma very small and narrow,

only a little more than half as long as radial cell (measured on metacarpus), fully four times as long as broad, and only slightly broader at junction of radius than at base; intercubitus longer than second abscissa of cubitus; hind legs short, femur barely reaching third tergite and tibia falling far short of apex of abdomen; tibia as thick at apex as femur; basitarsus little more than half as long as tibia and about as long as three following joints combined. Abdomen a third longer than head and thorax; second and third tergites subequal in length, first a half longer, postpetiole more than twice as broad as petiole; ovipositor sheath barely as long as first tergite.

Black, with abdomen beyond second segment red; mandibles, palpi, scape and pedicel except a black line dorsally, tegulae, radices, front and middle coxae and all trochanters whitish; flagellum fuscous, more reddish toward apex, wings clear hyaline, veins and stigma blackish; front and middle femora and tibiae testaceous, their tarsi paler; hind femur piceous black on outside, reddish piceous within; tibia black, with broad, indistinct reddish annulus in middle and paler at extreme base; tarsi black; second tergite with a subapical red band; third tergite black in basal middle.

Male.—Like female but areola narrower, and hind femur testaceous, tibia less extensively black, with paler annulus, and tarsi reddish fuscous; abdomen black dorsally throughout its length.

Host.—Hyblaea puera.

Type-locality.—Nilambur, Madras, India.

Type.—Cat. No. 40430, U. S. N. M.

Three females and one male, all reared from the same host by S. N. Chatterjee, the type and one paratype June 18, the other paratype June 15, and the allotype June 20, 1925.

In one of the paratypes the second abscissa of cubitus is as long as intercubitus, and the third tergite is somewhat shorter than second.

Dedicated to Mr. J. C. M. Gardner.

A female paratype is deposited in the British Museum.

Dioctes argenteopilosa (Cameron).

Zaporus ? argenteopilosus Cameron, *Journ. Bombay Nat. Hist. Soc.*, 1907, p. 590, ♀.
Dioctes argenteopilosa Morley, *Fauna Brit. India., Hym.*, III, Ichn., Pt. 1, p. 473, ♀ (1913).

Five specimens, two females and three males, that appear certainly to be of this species were reared by S. N. Chatterjee from the larvae of *Pyrausta macheralis* at Rahatgaon, Hoshangabad, Central Provinces. I had at first thought these specimens could not be referred to *argenteopilosa* because of their nearly circular propodeal spiracle and their yellow mandibles, scape and coxae. But Moreley says that the spiracle in the type is circular; and because of the close agreement of these specimens with the descriptions otherwise I am constrained to think that the red colour of the scape and mandibles in the type is due to staining.

The male, which has not been described, differs very little from the female, the most striking difference being in the extension of black medially the entire length of the abdomen. The hind tarsus is black rather than reddish fuscous and the basitarsus is hardly longer than the next three joints combined.

Very closely allied to *gardneri* Cushman, described above, but the hind basitarsus is distinctly more than half as long as the tibia and fully as long as the remaining four joints combined; the ovipositor sheath is distinctly longer than the first tergite; the hind femur is black only toward base, and the tarsus is distinctly red. Were it not for the structural differences in legs and ovipositor, I should be inclined to consider the two as no more than colour variants.

Pristomerus microdon, n. sp.

Female.—Length 6·5 mm.; antennae 3·75 mm.; ovipositor 2·7 mm.

Head very slightly wider than thorax; vertex, temples and frons opaque alutaceous, sparsely punctate; stemmaticum shining, medially longitudinally impressed; ocelli rather small, diameter slightly longer than ocell-ocular line, postocellar line nearly twice ocell-occular; face shining, rather densely punctate, not quite twice as broad as long; clypeus rather flat, about twice as broad as long, weakly rounded at apex; eyes parallel within, a fifth longer than their distance apart; malar space hardly half as long as basal width of mandible; antennae rather stout. Thorax rather stout, polished, evenly but not densely punctate, mesoscutum anteriorly faintly alutaceous; pronotum weakly foveolate in lateral groove; mesepisternal groove deep, weakly transtriate anteriorly; speculum polished; propodeum short, precipitate behind, punctate above and at sides, transrugose behind; areola pentagonal, much more than half as broad as long and a little shorter than petiolar area; stigma twice as long as broad, radius beyond middle; nervellus faintly broken below middle; legs rather slender; femoral tooth very small, at about apical third. Abdomen basally longitudinally striate, alutaceous beyond second tergite; ovipositor apically sinuous.

Black; clypeus and malar space ferruginous; mandibles whitish; antennae fuscous, scape, pedicel and base of flagellum testaceous; wings hyaline, not at all infumate apically, venation brown, base of stigma pale, tegulae and radices white; front and middle legs pale testaceous to stramineous; hind legs black and white, coxa and femur except their apices black, tibia blackish at apex and sub-basally, brownish stramineous below, tarsal joints narrowly brownish at apices, last joint black; abdomen black; petiole hardly paler at base; second tergite narrowly pale at apex; third and following tergites blackish at base, reddish at apex.

Male.—Ocelli larger, their diameter nearly as long as postocellar line and nearly twice ocell-ocular line; areola longer than petiolar area; hind femur stouter with the much larger tooth at apical two-fifths.

Hosts.—Pyrausta macheralis; Hyblaea puera.

Type-locality.—Rahatgaon, Hoshangabad, Central Provinces, India.

Type.—Cat. No. 40431, U. S. N. M.

Two of each sex from the type-host and one male from *Hyblaea*, all reared by S. N. Chatterjee, July 9 to September 24, 1926.

In the paratype female the black and red of the apical tergites are blended, forming a nearly uniform reddish brown.

A female paratype and one of the males are deposited in the British Museum.

Mesochorus facialis Bridgman.

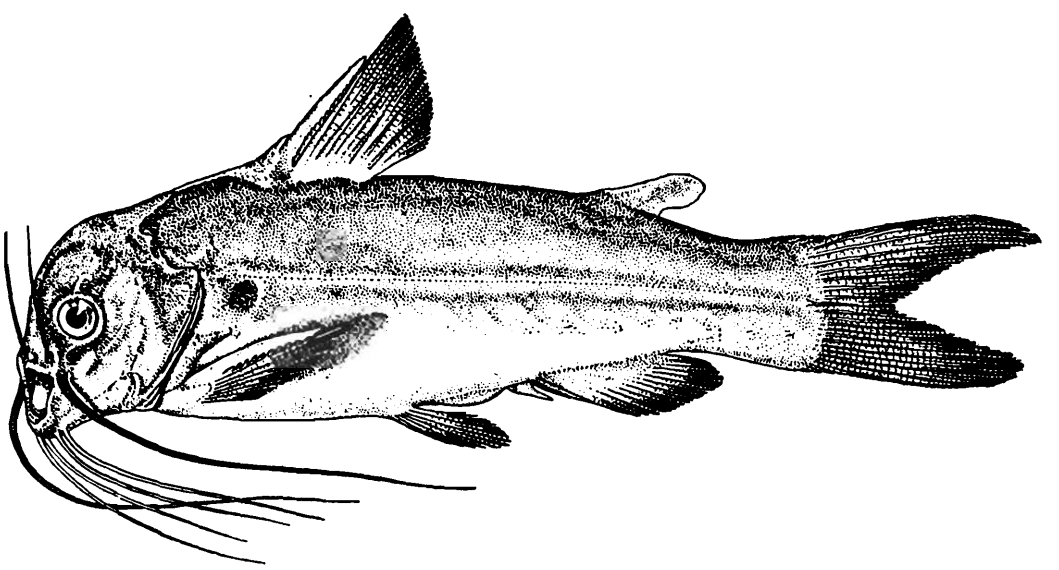
Four specimens, reared from some insect feeding on oak in Kangra Forest, Punjab, India, correspond to this species in both Morley's and Schmiedeknecht's keys, and differ from the description in no irreconcilable way.

Morley, who has seen cotypes of *facialis*, also records the species from India.

ON TWO "PUG-HEADED" SPECIMENS OF THE CAT-FISH, *AORIA GULIO* (HAM. BUCH.).

By D. D. MUKERJI, *M.Sc., Assistant, Zoological Survey of India.*

In May, 1927 a "pug-headed" specimen of the cat-fish was procured from a fish-market in Calcutta and later on a similar though much smaller specimen of the same species was sent to me for examination by Mr. J. N. Bhaduri, M.Sc., of the Zoological Department of the Calcutta University. I am obliged to Mr. Bhaduri for affording me an opportunity of examining this interesting specimen. Both the specimens were shown to Dr. S. L. Hora, who identified them as abnormal specimens of the cat-fish, *Aoria gulio* (Ham Buch). Besides identifying the fish Dr. Hora has helped me in the preparation of this note; for all this my best thanks are due to him.



TEXT-FIG. 1.—*Aoria gulio* (Ham. Buch.); lateral view of the larger specimen.

Aoria gulio (Ham. Buch.), unlike most of the freshwater representatives of the genus, is found in seas, estuaries and tidal rivers of India, Burma and the Indo-Australian Archipelago. This fish, on account of its peculiar habitat, is popularly known in Bengal as the "*Nuna-tenggara*" or brackish water "*tenggara.*"[1] On enquiry from local fishermen it has been found that the fish is fairly common in the salt-water lakes in the vicinity of Calcutta, and it is probable that the two abnormal specimens under report are from these lakes.

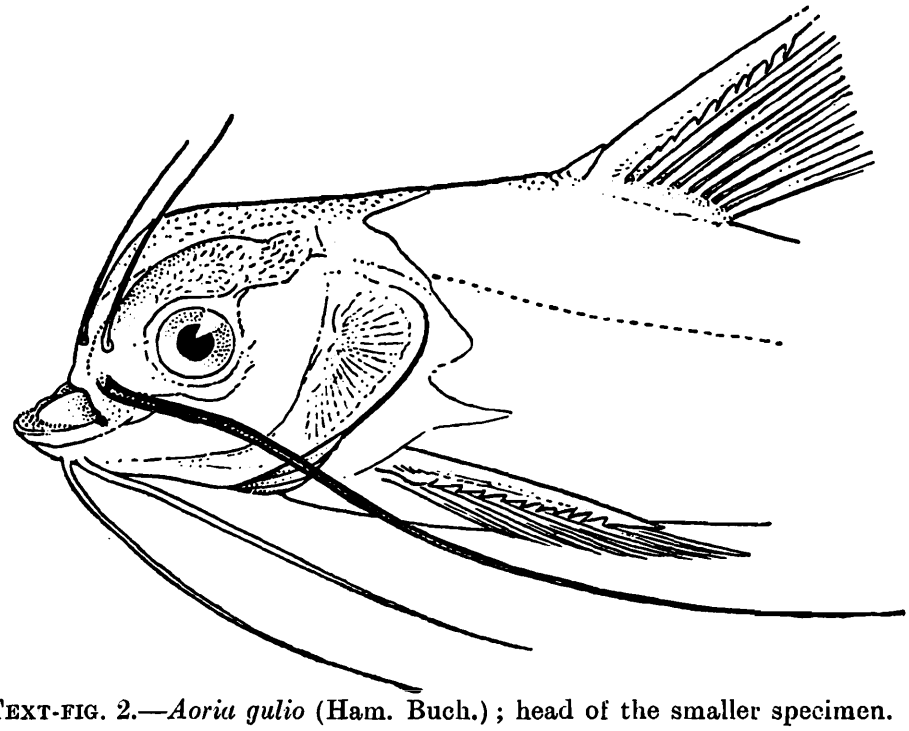
The local fishermen attribute the "puggineſs" to some injury to the parts in question. They believe that some voracious fish must have nipped off the upper jaw and the wound on healing has resulted in this peculiar form of the fish. From the very nature of the abnormality it is, however, clear that this view is unjustified. Further, according to the

[1] *Tenggara* is the Bengali name for most of the species of the genus *Aoria* Jordan.

fishermen similar " pug-headed " specimens, though not common, are also to be found from time to time among other species of fish.

Teratological occurrences of this nature have been recorded [1] among many groups of fish, but so far as I can find from the literature none have been found among the cat-fishes (Siluroidea). In view of the rarity of occurrence of such an abnormality and its importance, I propose to describe here the two specimens mentioned above.

The two specimens differ from normal specimens of *Aoria gulio* (Ham. Buch.) in their " pug-heads ;" they are perfectly normal in other respects. The upper jaw ends more or less abruptly midway between the eye and the anterior end of the lower jaw, which, however, is almost normal and projects a considerable distance in front of the head. Consequently the villiform teeth of the lower jaw and also a portion of the tongue are quite exposed (text-fig. 2).



TEXT-FIG. 2.—*Aoria gulio* (Ham. Buch.) ; head of the smaller specimen.

The front part of the skull is prominent. In the region of the frontals it is sharply humped upwards in two distinct and somewhat prominent boss-like structures, one on either side of the median longitudinal groove. The head of the fish as a result looks quite like that of a typical pug-dog.

The anterior part of the upper jaw arches rapidly downwards and instead of lying horizontal to the long axis of the body lies in a more or less vertical plane. The snout looks directly downwards to the floor of the mouth (text-fig. 2). In a normal specimen, on the other hand, it looks forward and away from it. The anterior margin of the snout is rather broad and straight.

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[1] For literature see :—
Atwood, *Proc. Boston Soc. Nat. Hist.* X, p. 68 (1864-66).
Bateson, *Materials for the Study of Variation*, pp. 57-59 (1894).
Patterson, *Zoologist* (4) I, pp. 275, 276, (1897).
Patterson, *Zoologist* (4) II, p. 130 (1898).
Pellegrin, *Bull. Soc. Zool. France*, XXXIII, pp. 25, 26 (1908).
Gemmill, *Teratology of Fishes*, pp. 48-50 (1912).

The median longitudinal groove, owing to the bulging of the frontal bones on either side of it, becomes more marked than in the normal individuals of the species (text-fig. 2). The bones of the skull, as also the interneural shield on the nape, appear to be more consolidated and are more firmly united to each other than they are in normal specimens.

The eyes, which are oval, with their long axes lying antero-posteriorly in normal specimens have become more or less rounded in the " pug-headed " individuals. This may be due to the shortening of the long axis of the normal eyes owing to some amount of compression in the antero-posterior direction.

I give below a table showing the measurements, in millimetres, of the head-region of a normal and of the larger " pug-headed " specimen (text-fig. 1) of *A. gulio* (Ham. Buch.) respectively ; both the specimens are of approximately the same size :—

	Normal.	Abnormal.
Length of head	30	23
Breadth of head	24	24
Height of head	14	19
Length of snout.	11	8
Interorbital width	13	13

ON THE MORPHOLOGY AND BIONOMICS OF *EMBIA MINOR*, SP. NOV. WITH SPECIAL REFERENCE TO ITS SPINNING ORGAN. A CONTRIBUTION TO OUR KNOWLEDGE OF THE INDIAN EMBIOPTERA.

By S. MUKERJI, *M.Sc.*

(Plate XXIII.)

CONTENTS.

		Page
1.	INTRODUCTION	253
2.	NOTES ON THE ORDER EMBIIDINA, ITS AFFINITIES AND GEOLOGICAL HISTORY	254
3.	DESCRIPTION OF *Embia minor*, sp. nov., FROM BIHAR	256
4.	INTERNAL ANATOMY	266
5.	(*a*) SPINNING APPARATUS	270
	(*b*) GLANDULAR RESERVOIRS	273
6.	SOME NOTES ON THE NATURE AND THE HABITAT OF *Embia minor*, sp. nov. ..	275
7.	SUMMARY	279
8.	BIBLIOGRAPHY	279

1. INTRODUCTION.

The Embioptera or Embiidina is an isolated group of rare insects possessing peculiar structural modifications. The members of the group are more or less gregarious, living in a fairly long mesh-work of tunnels, which are generally constructed over sheltered damp spots. Although some interesting features regarding the habitat of a few Indian Embiids have been recorded by MacLachlan (1877), Wood-Mason (1885), Imms (1913) and Lefroy (1923), very little is yet known about the actual feeding habits of these insects. Most of the previously published work on these insects deals with their systematic position and our knowledge of their internal anatomy is still poor. The papers by Grassi and Sandias (1897-98) and by Melander (1905) respectively, deal with certain anatomical features of two species which do not occur in India, but some of the internal features noted by them resemble those of the present species. Sharp (1895) in the "Insecta" volume of the *Cambridge Natural History* Series and Imms (1925) in "*A general Text-book of Entomology*" have touched on a few points of the internal anatomy but their descriptions are very short and incomplete.

In the present paper I propose to deal with the external morphology and the internal anatomy, as well as with some of the peculiar habits of a species of Embiidina collected in Bihar. I have also recorded my observations on the spinning apparatus of the insect; this work was undertaken with the object of clearing up the confusion regarding the exact position of this organ.

I desire to take this opportunity of expressing my sincere thanks to Mr. T. B. Fletcher, Imperial Entomologist to the Government of India,

for the generous way in which he helped me with some of the foreign literature on the subject : he also helped me materially in determining the systematic position of the new species. My thanks are also due to Rai Bahadur C. S. Misra, First Assistant to the Imperial Entomologist, who gave me every facility for carrying out the work. I should like also to record herein my indebtedness to Lt.-Col. R. B. S. Sewell, Director of the Zoological Survey of India, for the trouble he has taken in going through the paper ; his valuable criticism has also been of great help to me.

2. NOTES ON THE ORDER EMBIIDINA, ITS AFFINITIES AND GEOLOGICAL HISTORY.

The order Embiidina forms an isolated group of rather small and elongate insects with a comparatively wide distribution. They have so far been recorded from the Tropics (in which they appear to be cosmopolitan, except as regards the desert regions, where they do not occur), the sub-tropical areas and warm temperate zones (where they occur in moist coastal regions and in inland areas at high altitudes). Their structural complexities and the striking uniformity of certain other organs mark them off from other groups of insects. The peculiar features of the order are due partly to the retention of certain primitive ancestral characteristics, and partly to specialization which has gradually brought about secondary modification of some of the structures in response to altered functions. Another peculiar but constant characteristic of the group is the prevalence of sexual dimorphism in almost all the species. In a few cases the males again are dimorphic and hence a great deal of uncertainty exists with regard to the validity of the various species.

Enderlein (1912) in his monograph on the orde: mentions 10 genera and 61 species. Some more genera and species have recently been added to this number. According to Enderlein the structures of the two terminal abdominal segments in the case of the males furnish the most constant characters for the differentiation of the species, and I have followed Enderlein's method for the specific determination of the species discussed in this paper.

Throughout the group the body is elongate and flattened dorso-ventrally. The winged members of the order have two pairs of wings, which are similar to one another both in form and structure ; they are rather elongate, membranous and comparatively fragile, and are folded over the back when the insect is at rest. The venation of the wings is, in some cases, considerably reduced. The reduction of veins in the wing occurs by coalescence and atrophy of the veins, and in the forms where the venation has been reduced by atrophy, brown bands persist, indicating the positions of the veins which have disappeared. In general the males are alate and the females wingless, but in some genera the males also are without wings. The mouth-parts are adapted for biting and chewing and in the female the biting surfaces of the mandibles are specially well developed. Anal cercii are present in both sexes. The eyes are compound, and consist of numerous omma-

tidea of the eucone type ; ocelli are not found in any members of the order. The metamorphosis is more or less incomplete.

There has been a considerable difference of opinion regarding the systematic position of this order. Some of the earlier authorities grouped them with the Termites and the Psocids in the heterogenous order Neuroptera. Latreille (1825, 1829, 1839), and Savigny and Audouin (1826) placed the genus *Embia* close to the genus *Termes*, clearly believing in the interrelationship of the Embiids and the Isoptera ; in this they were followed by Westwood (1837), Burmeister (1839) and Rambur (1842). Burmeister, however, in another work (1839) placed the group as a family of his order Corrodentia. Brauer (1857, 1876) placed the family Embiidae in his Orthoptera-genuina, while MacLachlan (1877, 1878, 1879, 1883) remarked that the Embiids are closely allied to the Plecoptera. Wood-Mason (1883) pointed out that the interrelationship of the Embiids with the Blattids and Mantoids is shown by the asymmetry of the genital armatures, but such asymmetry is not uncommon in other ins cts, *e.g.*, (i) it occurs in all the 4 or 5 species of the genus *Glossosoma*, (ii) the terminal tergites and the cerci in the adults and nymphs of the males of *Nicrobia m culicollis* are asymmetrical. Hagen (1885) observed morphological resemblances between the Embiids and the Isoptera and grouped them together. Grassi (1889, 1894, 1897, 1898) suggested that the family Embiidae should form a separate order to be placed under a super-order of Orthoptera. Sharp (1895) grouped the Embiids with two other families, Termitidae and Psocidae, as a division of the Neuroptera and for which he suggested the name Pseudoneuroptera. He further pointed out the affinity between the Embiids and the Psocids as shown by the similarities which exist between the members of the family and those of the Cuban Psocid genus *Embidopsocus*. Enderlein (1903), following Hagen, grouped the Embiids and the Isoptera in a separate sub-order. Verhoeff (1904) again split up the old order Corrodentia of Burmeister (1839), which included a number of heterogenous groups, into a number of distinct orders. Subsequent authors have kept the Embiids and the Isoptera separate. Finally in 1909 and 1912 Enderlein again united them together in his super-order Aetioptera, which includes the orders Embiidina Enderl. and Isoptera Brullé.

According to Crampton (1917), the insects which are most closely related to the Embiids are the Plecoptera. He thus agrees with MacLachlan and suggests that the Plecopterans are probably the nearest living representatives of the ancestral Pterygota.

The Embiids are probably specialized representatives of the primitive group of insects known as Protorthoptera, which existed in the Palaeozoic age. In the Upper Carboniferous stratum the representatives of the Embiids were of a large or moderate size and possessed a complex venation. In the Lower Permian these insects became reduced and simplified, probably owing to adverse climatic conditions. The ancestors of th Embiids and Dermaptera are found in the Lower Permian strata, but no further links in the ancestral chain have been discovered. The absence of all fossil records, is due probably to the extreme delicacy of the late and more specialized forms. They, however, appear again in the Baltic amber of the Oligocene period as the direct ancestors

of the modern Embiids ; these resemble the later modified forms of the order to a considerable extent.

3. Description of *Embia minor*, sp. nov., from Bihar.

(*a*) *The Male Imago.*

(Pl. XXIII, fig. 2.)

The general colouration of the body is brownish black. The body is clothed with dark-brown or blackish hairs. The antennae consist of 21-25 joints (text-fig. 1A) and are longer than the thorax. The proportionate lengths of the head, thorax and abdomen are as 7 : 13 : 18. The total length of the body with cerci is 9·5—12·5 mm. ; the average length of the cerci being 1 mm. The first joint of the hind tarsus is provided with two arolia. The 10th tergum is completely divided by a suture into two plates, the right being distinctly larger than the left. The left plate is produced into a stout moderately curved process, while that of the right plate is represented by a thick, short, pointed spine. Mesially the 10th tergum is provided with a process, [1] the median process, which is distally rounded and curved. The basal joint of the left cercus is large and somewhat conical ; its inner basal surface is provided with minute denticles (text-fig. 5B). Fore-wing 6·75 mm. long and 2 mm. broad ; hind-wing 6·3 mm. long and 2 mm. broad.

Detailed description of the Male Imago.

Colouration.—Dorsally the head with the appendages, except the area between the eyes, the legs, the terminal and penultimate segments of the abdomen and the cerci (except their apices) vary in colour from deep brown to brownish black. In the prothorax the colour varies from chestnut brown to brownish black. The remaining thoracic and abdominal segments, except the two terminals, are light brown to brownish black. The claws of the feet vary in colour from light to deep brown. The articulations between the joints of the legs, the tarsi, the antennae, the maxillary palpi and the area around the bases of the eyes are of a lighter colour than the rest of the body. The ante-clypeus is light brown to deep brown, the rest of the labium and clypeus are comparatively darker. The dorsal portion of the head between the eyes is brownish yellow and conspicuous. The intersegmental regions between the head and the prothorax and the pro- and the mesothorax are distinctly membranous and are yellowish white. The pleurae are similarly membranous and form a yellowish white sinuous line along each side of the body and are more conspicuous than in the female. The apices of the cerci are fuscous.

The colour of the ventral surface is nearly the same as that of the dorsal.

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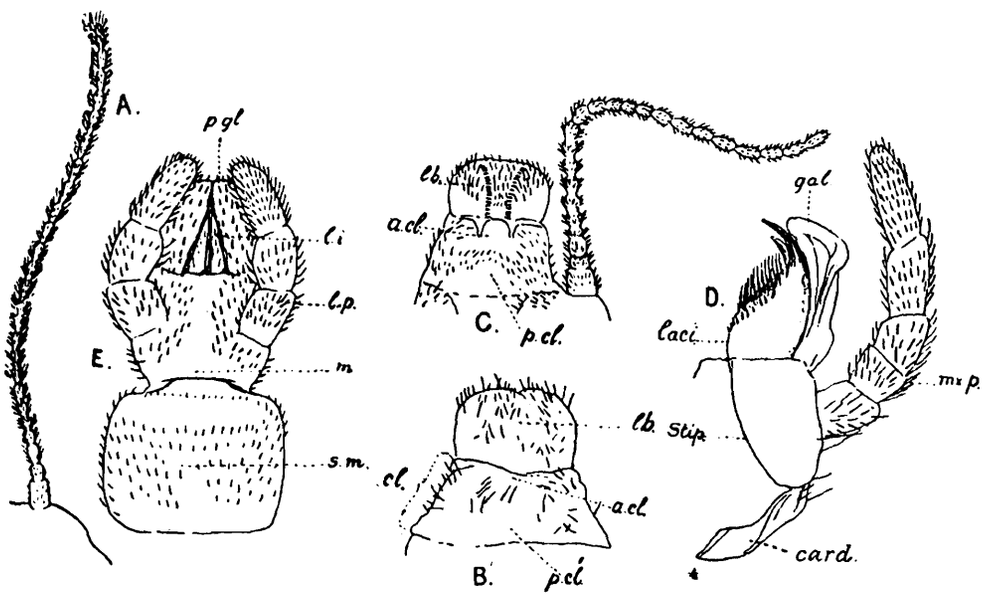
[1] This process, which is dorsal in position, is quite distinct from the ventral process or " anhang " of the 9th sternum, which is pointed and curved.

The head is covered with fine yellowish hairs. The eyes are reniform in shape and nearly half of them are visible from above (pl. XXIII, fig. 3).

The labrum is sparingly clothed with fine hairs and its distal margin is slightly depressed in the middle. The distal free-margin of the labrum (text-fig. 1B) is more rounded than that of *Embia major* Imms.



TEXT-FIG. 1.

Embia minor, sp. nov.

A. Antennae of the ♂, ×10.
B. Labrum and clypeus of ♂, ×20.
C. Labrum, clypeus and antenna of the ♀ as seen from below, ×12·5.
D. First pair of maxillae of the ♀, ×25.
E. Second pair of maxillae of the ♀, ×25.

a. cl.=ante-clypeus ; *card.*=cardo ; *cl.*=clypeus ; *gal.*=galea ; *laci.*=lacinia ; *lb.*=labrum ; *l. i.*=inner lobes of the second maxillae ; *l. p.*=labial palp ; *m.*=mentum ; *mx. p.*=maxillary palp ; *p. cl.*=post-clypeus ; *p. gl.*=outer lobes of the second maxillae or paraglossae ; *s. m.*=submentum ; *stip.*=stipes.

The antennae (text fig. 1 A) vary in length from 5·5 to 6 mm. and the number of joints of the antennae varies between 21—25.[1] In one specimen the total length of the 4th, 5th and 6th joints was 0·50 mm., while that of the 1st and 2nd joints was 0·41 mm.

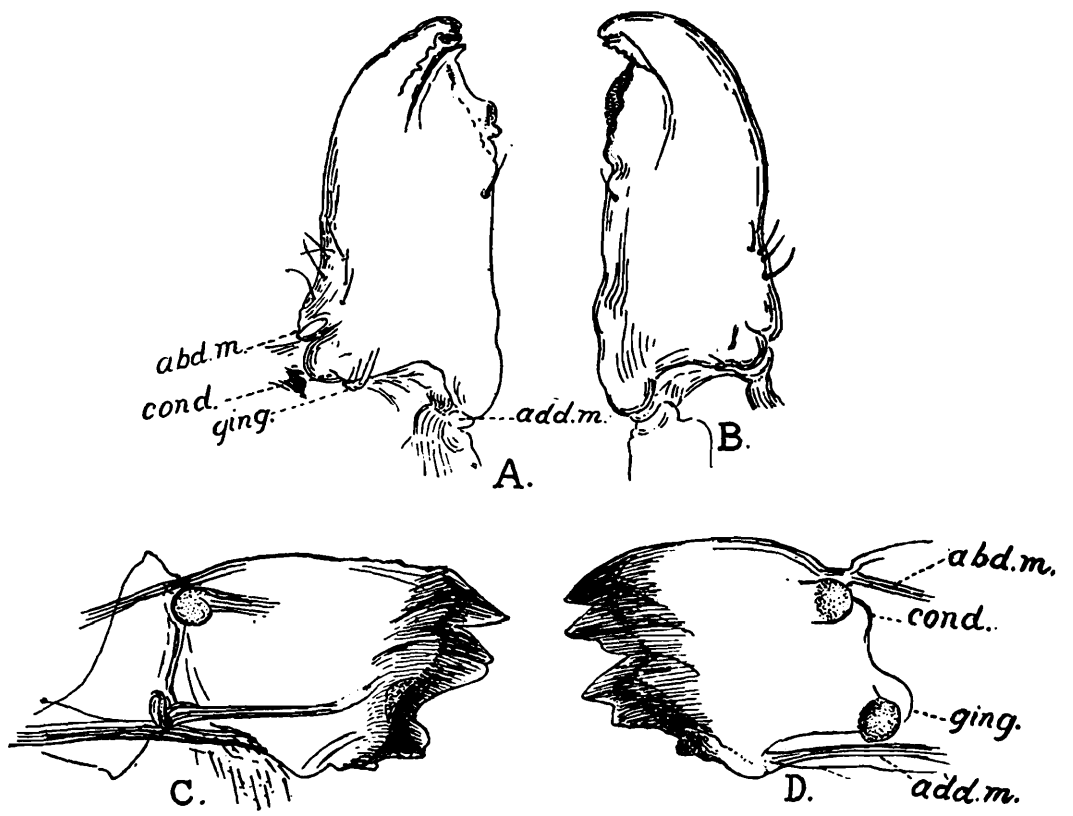
The mandibles are furnished with rudimentary apical denticles (text-fig. 2 A, B). A more or less broad and distally rounded denticle is situated on the outer margin of the mandibles and has an irregular, incomplete, median longitudinal suture which probably indicates its paired origin. A second rather small denticle lies behind the apical one ; its pointed apex appears to be bifid. On the inner surface of each mandible behind the denticles, the sides are produced into sharp straight cutting edges, which are provided with irregular, wavy serrations. The point of attachment of the adductor muscle (text-fig. 2 A, B ; *add. m.*), the ginglymus (*ging.*), the condyle (*cond.*) and the point of attachment of the abductor muscle (*abd. m.*) do not differ from those of *Embia major*.

[1] Owing to the fragile nature of the antennae it is not possible to be quite certain as to the exact number of the antennal joints.

Each mandible bears inwardly an elongate hair at the posterior end of the serrations on the cutting surface.

The first and second maxillae are similar in structure to those of the female (*vide infra*, p. 263).

The hypopharynx[1] is rounded at the distal corners, and the rounded corners bear a group of longish hairs, most probably sensory in function. The dorsal surface of the lingua has a covering of minute scales. These scales were noted by Enderlein (1909, p. 168, fig. 3) and by Imms (1913);



TEXT-FIG. 2.

Embia minor, sp. nov.

A. Left mandible of the ♂, ×40. C. Left mandible of the ♀, ×40.
B. Right mandible of the ♂, ×40. D. Right mandible of the ♀, ×40.

abd. m.=point of attachment of abductor muscle; *add. m.*=point of attachment of adductor muscle; *cond.*=condyle; *ging.*=ginglymus.

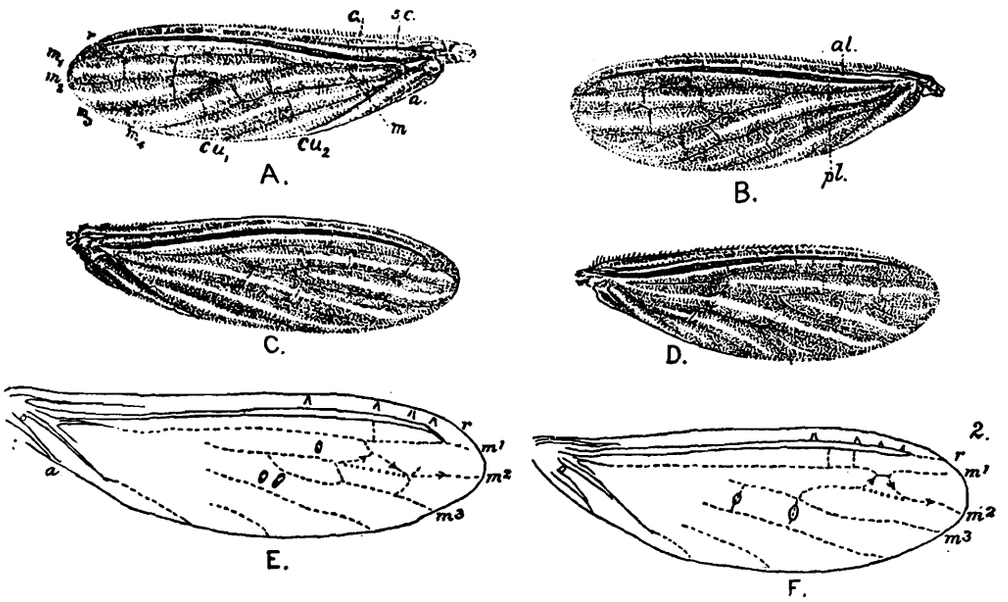
the former author designated them as the " Geschmacks-Schuppen " or taste-scales. The lingua is sharply marked off from the hypopharynx by a constriction and at its origin is about half the breadth of the hypopharynx. Ventrally a longitudinal groove runs throughout the length of the tongue and is continued a little on the dorsal surface.

The anterior third of the prothorax is marked off from the rest of the tergum by a moderately deep transverse sulcus. The posterior third of the tergum bears another shallow transverse sulcus. At right angles to both these transverse lines, crossing the deeper sulcus and reaching the margin anteriorly, there is a shallow median longitudinal groove. The tergum is sparsely covered with fine light brown hairs. The mesothorax has its proximal region sparsely clothed with fine

[1] I have adopted Huxley's terminology, according to which the attached base of the tongue is the hypopharynx and the free tip the lingua.

brownish hairs. The metathorax is shorter than the mesothorax, and its proximal region is sparsely clothed with fine brownish hairs.

The wings are tawny brown. The hyaline areas have a very definite arrangement with reference to the longitudinal veins, and almost always are devoid of the longer setae which are found over the rest of the wings. The hyaline areas in *Embia minor* are distributed as follows : (i) A rather broad but short strip above the sub-costal vein (text-fig. 3A ; *s. c.*), (ii) a pair of extremely narrow strips bordering the " two thin pink areas mentioned on p. 260 which represent the " Radiussaumlinien of Enderlein (text-fig. 3B ; *al*, *pl.*), (iii) a prominent area situated between the two branches m_1 and m_2 of the median vein, (iv) a short area between the branches m_2 and m_3, (v) a long and conspicuous space between the two veins m and m_1 and extending outwards to the outer margin of the wing, (vi) a rather short area between m_4 and the upper branch of the cubital vein cu_1, (vii) a short area between the forks of the cubital vein, *i.e.*, between cu_1 and cu_2, and (viii) a short, rather indistinct area between the thickened stem of the cubital vein and the less distinct one of the anal vein *a*. In some specimens where m_3 is bifurcated an additional very small hyaline area is present between its branches, and this joins with the main hyaline area between m and m_4. Sometimes at the points



TEXT-FIG. 3.

Embia minor, sp nov.

A. Left anterior wing of the ♂, ×6.
B. Left posterior wing of the ♂, ×6.
C. Right anterior wing of the ♂, ×6.
D. Right posterior wing of the ♂, ×6.
E. Abnormality in the venation of right anterior wing of ♂, ×7·5.
F. Abnormality in the venation of right posterior wing of ♂, ×7·5.

al.=anterior pseudoradial line ; *pl.*=posterior pseudoradial line.

where the cross-veins traverse the hyaline areas, the cross-veins become surrounded by small transverse hyaline strips which appear as small cross-pieces. The existence of rudimentary cross-veins in a few species points either to the retention of primitive characters in the wing-venation or to a reduction of the veins. The different individuals of the

species *Embia minor* exhibit considerable variation both in the length and the breadth of their wings. The length of the fore-wing varies from 7 to 7·5 mm. and the breadth from 2·0 to 2·33 mm. In the hind-wing the length varies from 6·5 to 6·75 mm. and its breadth from 1·75 to 2·25 mm. The venation also presents a great deal of individual variation especially as regards the number and position of the cross-veins and this variation is to be found even in the wings of the two sides of the same specimen (text-fig. 3A-F).

The costal (*c*), the sub-costal (*s. c.*), and the radial (*r*) veins do not present any special features and their courses are more or less similar to those of *Embia major*.

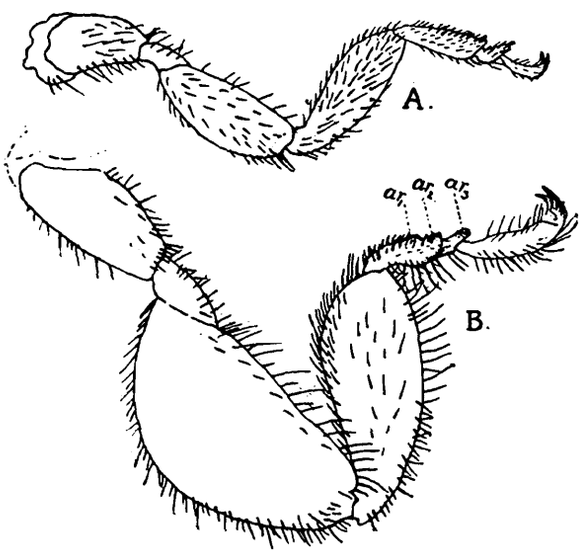
The thin dull pink areas which enclose the anterior and posterior margins of the radial vein represent the " Radiussaumlinien " or " Radio-limbolarien " of Enderlein (1912, p. 10), the " Radius-nebenlinien " of Krauss (1911, p. 7), or the " anterior and posterior radial lines " of Imms (1913, p. 171).[1] The courses of the media and its different branches (*m*, m_1—m_4), of the cubitals (cu_1, cu_2), and of the anal (*a*) are similar to those of *E. major*. The number of cross-veins in the anterior and posterior wings of a specimen is shown in text-fig. 3 A-D.

A peculiar case of abnormal venation was observed in the wings of the right side of a specimen of *Embia minor*. The wings of the left side, though apparently more normal than those of the right side, differed greatly in the number and position of the cross-veins and the distribution of the hyaline areas. The following were the outstanding features of this specimen. The anterior $\frac{2}{3}$rd of m_2 (text-fig. 3 E), after emergence from m_1, is more or less normal and when it reaches the portion marked by dots in the figure it suddenly turns upwards and meets a cross-vein which descends down from m_1 at an angle, the vein m_2 then descends and takes the normal course; at the point where it resumes the normal course it sends upwards a small incomplete cross-vein. The vein m_1 in this case is normal. In the case of the right hind-wing the abnormality in the venation is most marked. Here the anterior $\frac{4}{5}$th of m_1 (text-fig. 3F) is normal, it then abruptly bends downwards a little and proceeds horizontally a short distance, then rises up and follows the normal course and terminates without meeting the radial vein *r*, as was the case in the fore-wing. At about its middle, m_2 suddenly rises up and unites with the horizontal portion of m_1 and then descending down follows the normal course. The abnormal course of the veins in the figures of the wings is shown by arrows and the normal course by dots (text-fig. 3 F, F). The position and number of cross-veins and of the hyaline areas also exhibited considerable variation, but these are not of sufficient interest to be described here in detail.

The legs.—The arolia or ventral pads of the tarsi or " Sohlenbläschen " of Verhoeff (text-fig. 4 B; ar_1, ar_2, ar_3) are of great use to these insects for rapid locomotion inside their tunnels. The number and position of the arolia on the tarsi are similar to those of *Embia major*. The arolia on the metatarsus are furnished with a few elongate spines. The area around the arolia of the metatarsus is beset with numerous short,

[1] I suggest the non-committal name of " pseudoradial lines " for these areas.

thick and pointed spines besides the usual elongate setae which cover them. Beneath the thin transparent cuticle the arolia appear to be



TEXT-FIG. 4.

Embia minor, sp. nov.

A. Hind leg, ×20. B. Second leg, ×20.

ar_1; ar_2=arolia of the first tarsal joint; ar_3=arolium of the second tarsal joint.

spongy in character and are slightly darker in colour than the rest of the metatarsus. The arolium of the second tarsal joint bears on its inner aspect very short, thick, pointed, yellowish spines situated on an oval area. The arolium of the second tarsal joint is also spongy in character.

The abdomen.—The structures of the abdominal tergites and the sternites, except those of the 9th and 10th abdominal segments in this species, differ very little from those of *Embia major*. The following differences may, however, be especially noted; (i) The 9th tergum is more compressed in *E. minor* than that of *E. major* and this compression is clearly visible towards the left side of the tergum, (ii) in *E. minor* the right plate of the 10th tergite bears on its apex a small acuminate process (text-fig. 5 A, B; *sp.*), (iii) the left plate of the 10th tergite (ltg_{10}) is comparatively well developed in *E. minor* and the process ($prtg_{10}$) of the left plate of the 10th tergite is less curved and less acuminate apically than that of *E. major*, (iv) the median process is a well developed structure in *E. minor* and is of the same thickness throughout, (v) the ventral process (*v. pr.*) or " anhang " of the 9th sternite is somewhat triangular in shape and pointed apically[1]; it is firmly hinged to the distal end of the 9th sternite which forms the sub-genital plate.

The basal joint (*ba. j.*) of the left cercus is sub-conical in shape and bears on its broadest basal surface a prominent concavity (*co.*). The inner margin of the sub-conical basal joint bears several minute cone-shaped spines. The distal joints of the cerci are normal. Both the cerci are covered externally with hairs which are of three different types, numerous long setose hairs, interspersed with rather shorter and finer

[1] In the absence of a true " aedeagus " or intromittant organ, the complex appendages of the terminal abdominal segment serve to keep the aperture of the vas deferens closely applied to that of the oviduct during copulation.

spinous hairs, cover both the cerci uniformly (pl. XXIII, figs. 7, 8). In specimens cleared in caustic potash, the interspaces between these setose hairs were seen to be occupied by fine sensory hairs (pl. XXIII, fig. 6). The sensory pits (*s. pt.*) are situated at the bases of these hairs and it is only by means of these pits that sensory hairs can be distinguished from other types of hairs.[1]

The sensory hairs of the cercus are sparsely distributed over the dorsal and ventral surfaces of the basal joint of each cercus. The hairs are more numerous on the dorsal than on the ventral surface of the basal joints, and are arranged in a single row at the distal region of the joints. This arrangement of the sensory hairs is more distinct in the case of the basal joint of the left cercus. The second or distal joint of the right cercus does not appear to bear any sensory hairs, but the inner edge of the terminal joint of the left cercus bears a single sensory hair on the dorso-median region. The measurements of the different parts of the sensory hairs are as follows : diameter of the outer rim of the sensory pit 0·018 mm. ; diameter of the inner rim of the pit 0·0072 mm. ; length of a sensory hair 0·0288 mm.

(*b*) *The Female Imago.*

(Pl. XXIII, fig. 1.)

The general colouration of the body is light to deep brown. The body is clothed with light brown elongated hairs, and the hairs on the body are more numerous than in the case of the male.

The antennae are 22-23 segmented and are shorter than the thorax. The relative lengths of the head, the thorax and the abdomen are 2 : 4 : 5. The first tarsal joint of the hind-legs, as in the male, is furnished with two arolia. The 8th abdominal tergum is distinctly larger than the 9th, but both are shorter than any of the preceding segments. The 10th tergum is larger than the 9th, which is the smallest of all. The 10th tergum narrows terminally with its hind-margin distinctly rounded. Total length 14·5 to 15·75 mm.

Detailed description of the Female Imago.

Colouration.—Dorsally the colouration varies from light to dark brown, but the general colouration is always lighter than that of the male. The intersegmental regions between the head and the prothorax, between the pro- and the mesothorax, and between the meso- and the metathorax are yellowish white in colour and are more membranous than those of the male. The pleural region begins from the basal half of the metathorax and extends backwards to the distal extremity of the

[1] Verhoeff (1908) noticed these sensory hairs and termed them " Hörhaare " or the auditory hairs. Berlese (1909) termed them " Sensilli tattili ", and believed them to have auditory and tactile functions. The sensory hairs of the cercus are not of rare occurrence in insects. The cerci of *Mantis religiosa* and *Decticus albifrons* bear such sensory hairs and the sensory hairs of *Embia minor* (pl. XXIII, fig. 6) greatly resemble those of the latter species. According to Packard, Folsom and some other authors, the main function of sensory sacs, pits and other sensory structures of the cerci is olfactory, while the cerci themselves are tactile. The ability of the Embiids to run backwards with equal facility inside their tunnels and their being positively thigmotactic adds further support to the suggested tactile function of the sensory hairs of the cerci.

8th abdominal segment. The pleural region is membranous and yellowish white. Seen from the dorsal surface the pleural region appears as two lateral lines running longitudinally one on each side of the body (Pl. XXIII, fig. 1). The antennae are of the same colour as the head, but the articulations of the joints are paler. The ante-clypeus, the maxillary and the labial palpi, the area around the articulations between the joints of the legs, the apical joints of the tarsi, the tibiae and the tarsi of the two hind pairs of legs are somewhat paler in colour than the rest of the body. The claws are pale yellow with brown apices. The basal joints of the cerci are of the same colour as the body, while the apical joints are somewhat paler.

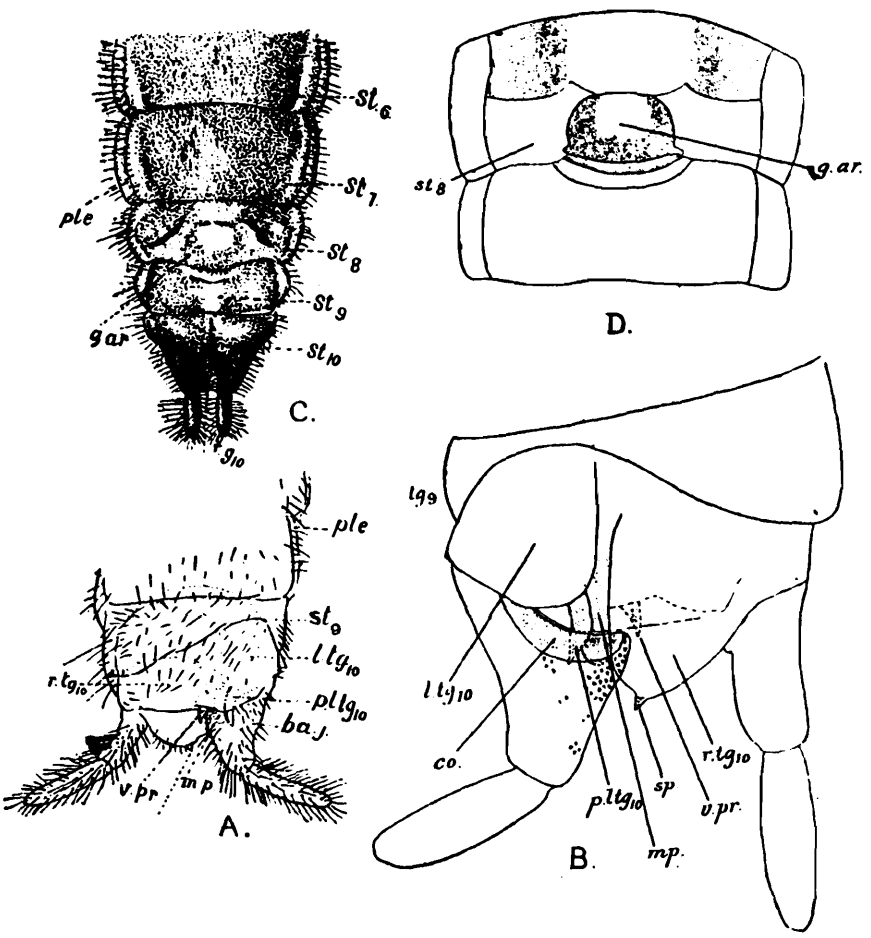
The ventral surface is lighter than it is dorsally, while the lateral margins of the sterna are slightly darker. The three terminal sterna are, with the exception of the middle portion of the 8th, darker in colour than the preceding abdominal sterna. In specimens which are of a lighter colour, a brownish line starts from the base of each antenna, meeting a third line of the same colour, which is produced a little backwards towards the posterior margin of the head in the middle line. The area bounded anteriorly by these lines contains 8 brownish longitudinal lines, which run backwards to the neck.

The head attains its maximum width behind the insertion of the eyes. The eyes are distinctly less reniform in shape than those of the male and are comparatively smaller in size. The antennae are 4 mm. in length, and consist of 22-23 joints when intact. The hairs on the labrum are more numerous and more uniformly distributed than in the male. The labrum of the female bears two rows of setose hairs, one on either side of the median region (text-fig. 1 C). Each of the mandibles bears 4 prominent teeth (text-fig. 2 C, D). The right and the left jaws differ to a certain extent so far as the dentition is concerned. The right jaw near its outer angle has four teeth. Of the first two, which are situated close to each other, the first is simple and sub-triangular, while the second is bilobed and is larger than the first. The third is a large bilobed tooth, and is situated behind the first two, while the rudimentary fourth is somewhat rounded in shape and lies on the inner angle of the biting surface. The process for the attachment of the abductor muscle (*abd. m.*) is moderately distinct. The condyle (*cond.*) is represented by a short distally rounded process. The ginglymus (*ging.*) is represented by a well developed distally rounded process which is larger than the condyle. The process for the attachment of the adductor muscle (*add. m.*) is small and less distinct. The first maxilla (text-fig. 1 D) consists of a 5-jointed palp (*mx. p.*), a membranous unarmed galea (*gal.*) and a well developed lacinia (*lac.*) attached to the cardo (*card.*) and the stipes (*stip.*).[1]

The labium formed by the fused second maxilla (text-fig. 1 E) consists of a quadrangular sub-mentum (*s. m.*) and a well developed mentum (*m.*). It differs from that of *Embia major* in the following points : (*a*) the triangular space at the distal end of the mentum, which encloses

[1] The lettering as well as the explanation of the figures of the cardo and stipes by Imms (1913) for *Embia major* are misleading. In his figure he calls the basal portion as the stipes, and the portion bearing the galea the maxillary palp, and the lacinia as the cardo. The correct name for the basal portion is the cardo and for the distal the stipes.

the inner lobes of the second maxillae, is more prominent in the case of *E. major* than it is in *E. minor*; (*b*) in *E. minor* the paired inner lobes (*l. i.*) of the second maxilla are apically acuminate and distinctly triangular in shape[1]; they occupy the entire space between the paraglossae (*p. gl.*), whereas in *E. major* they cover only a portion of the space; (*c*). the portion of the mentum bearing the inner lobes is not concave in *E. minor*. The labial palpi (*l. p.*) are three-jointed. The relative lengths of the joints are as 10 : 11 : 20.



TEXT-FIG. 5.

Embia minor, sp. nov.

A. External genetalia of the ♂ with the 10th abdominal segment as seen from below ×12·5.

B. External genetalia of the ♂ with the 10th abdominal segment as seen from above, ×27·5.

C. Last five abdominal sternites of a female showing the symmetrical arrangement of the 10th sternite, the normally developed cerci and the female genital aperture, ×13·5.

D. 8th abdominal sternum (sub-genital plate) of female showing the area of the female genital aperture, ×27·5.

ba. j.=modified basal joint of the left cercus; *co.*=concavity of the basal joint of the left cercus; *g. ar.*=area of the female genital aperture; *l. tg.*=left plate of the 10th tergite; *m. p.*=median plate; *ple.*=pleuron; *p. l. tg* $_{10}$=process of the left 10th tergal plate; *r. tg* $_{10}$=right plate of the 10th tergite; *sp.*=process of the right 10th tergal plate; st_1, st_2 etc.=sternites; tg_1, tg_2, etc.=tergites; *v. pr.*=ventral process of the 9th sternum.

The prothorax is sub-quadrate, being slightly narrower anteriorly, and has a deep transverse suture running across its breadth at the junc-

[1] These are the " Lobi-interni " of Enderlein, and according to him are the organs on which the external openings of the spinning glands are situated. On this subject, however, see *infra*, p. 271.

tion of the anterior and middle $\frac{1}{3}$rd; the posterior $\frac{2}{3}$rds bears a similar incomplete longitudinal groove running backwards to the distal margin. This groove is sometimes produced forwards in front of the transverse sulcus to meet the anterior margin of the pro-thoracic tergum. The mesothorax is also sub-quadrate and presents no special features. The metathorax is considerably broader than long; it is distinctly smaller than the mesothorax. The thoracic terga bear long brownish hairs especially at the margins.

The legs are similar to those of the male. The abdominal terga differ from those of *Embia major* only in size and present no special features. The 8th sternum forms the sub-genital plate. The posterior half of the 8th sternite contains a semicircular brownish area enclosing a small pale area, which bears a median transverse incision marking the position of the female genital aperture (text-fig. 5 C, D; *g. ar.*).[1] In the specimen examined the relative lengths of the 8th and 9th sterna were as 19 : 22. The anterior half of the 8th sternum bears laterally a pair of brownish longitudinal areas which gradually merge into their respective pleurae. The 9th sternum contains anteriorly a thin crescentic brownish area which runs anteriorly into the brownish area of the 8th sternum. The 10th sternum is divided longitudinally into two symmetrical halves (st_{10}). The cerci exhibit no asymmetry and are similar to each other.

In the case of the female, the distal thirds of the basal joints of the cerci bear on the dorsal surface more sensory hairs than on their proximal portions, while on the ventral surfaces of the basal joints the condition is reversed. Each of the distal joints of the cerci bears on the dorso-median region towards the inner edge a single sensory hair, but its position does not appear to be constant.[2] The presence of a single sensory hair on the distal joints of the cerci appears to be characteristic of the genera *Oligotoma* and *Embia*.

Table showing the differentiating characters of allied species of the genus Embia.

	Embia major Imms.	*Embia minor*, sp. nov.
1.	Length of the male 12·75—18 mm.	Length of the male 9·5—12·5 mm.
2.	Length of the female 14·75—20·75 mm.	Length of the female 14·5—15·75 mm.
3.	Number of antennal joints varies from 20—29.	Number of antennal joints varies from 18—25.
4.	9th tergum less compressed than that of *E. minor*.	9th tergum more compressed towards the left side than that of *E. major*.
5.	Process of the left plate short and very much curved.	Process of the left plate comparatively long, less curved and less pointed.
6.	Ventral process curved and appears to be larger than the process of the left 10th tergal plate.	Ventral process not curved, pointed and distinctly smaller than the process of the left 10th tergal plate.
7.	Median process smaller than the process of the left 10th tergal plate.	Median process nearly of the same length as the process of the left 10th tergal plate.
8.	Inner surface of the concavity of the thickened basal joint of the left cercus denticulate.	Inner surface of the concavity of the thickened basal joint of the left cercus does not bear any denticles.
9.	Arolia on the tarsal joints of the hind pair of legs glabrous.	Arolium on the second tarsal joint armed with minute yellowish spines.

[1] In young specimens the pale area containing the genital aperture was found to be situated more anteriorly than in adults.

[2] Okajima (1926) has described these hairs on the cerci of *Oligotoma japonica*.

4. Internal Anatomy.

Alimentary Canal.

The alimentary canal is extremely simple and in general structure resembles that of the primitive insects. It is almost straight without any diverticula, and is nearly of the same length as the actual length of the insect. Specialization of the different parts of the alimentary canal for separate digestive functions is a more or less constant characteristic of all insects, but in the case of the Embiids this specialization is not so marked. The relative sizes of the different parts of the alimentary canal as far as they can be distinguished are as follows :—

	mm.
Oesophagus	6
Gizzard	0·95
Chylific stomach	4·50
Small intestine	1·25
Colon	1·95
Rectum	1·55
Total length	16·20

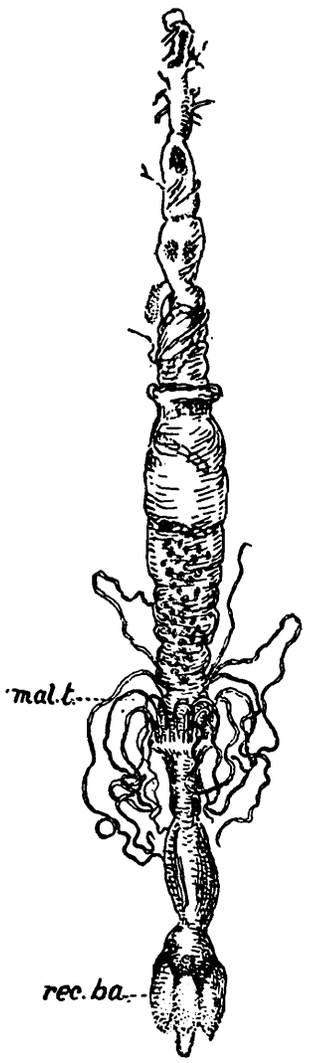
The mouth, the oesophagus and the crop form the stomodaeum, while the mesenteron of the Embiids, as in other insects, is very short and includes only the chylific stomach. The proctodaeum begins with the malpighian tubules and extends thence to the anus. Both the stomodaeum and proctodaeum have a chitinous lining which is absent in the mesenteron.

The mouth of the Embiids is enclosed by the labrum on top and the labium below, while it is bounded laterally by the mandibles and by the first pair of maxillae. The lingua or the tongue hangs like a flap from the posterior wall of the buccal cavity and covers about $\frac{3}{4}$ths of its depth. The hypopharyngeal part of the lingua is sub-quadrate with its posterior angles rounded. Each of the rounded ends is covered by a group of fairly long hairs, about 12 in number. At the posterior end of the hypopharynx there is a constriction which marks the beginning of the lingua. At the point of its origin from the hypopharynx the lingua is half as broad as the hypopharynx ; its breadth, however, increases as it runs posteriorly until it becomes almost as broad as the hypopharynx. Distally the lingua again diminishes in breadth and its posterior extremity becomes narrow and round. There is apparently a small groove at the posterior $\frac{2}{3}$rds of the lingua, while a longitudinal groove runs throughout the length of the tongue ventrally.[1] The chitinous sides of the lingua are furnished with very minute hairs.

The mouth leads into a narrow oesophagus, the anterior portion of which is beset with thick, short and pointed denticles (pl. XXIII, fig. 4, *dt.*). It passes through the neck into the thorax, where it gradually dilates into a bag-like crop, the dilated end of which extends into the

[1] Superficially the tongue is invested with taste-scales or " Geschmacks-Schuppen " of German authors.

fore-part of the abdomen. Numerous tracheal tubes are found all over its outer surface. The gizzard is like a blunt slightly curved cone. Its wall is thicker than that of the crop, and it is attached by its broader base to the hinder end of the crop. Along its distal end it appears like a rather narrower blunt tube which protrudes into the chylific stomach. The chylific stomach is a simple cylindrical tube without any caecal tubes. Posteriorly the chylific stomach opens into the intestine. At the hinder end of the chylific stomach there is a very short tube, the small intestine, which is broadest at its point of origin from the chylific stomach. It gradually narrows down till at its posterior end its diameter is roughly half that of the chylific stomach. At its junction with the chylific stomach about 20-30 malpighian tubules are attached.



TEXT-FIG. 6.

Embia minor, sp. nov.

Alimentary canal, ×6.
mal. t. = malpighian tubules;
rec. ba. = rectal bands.

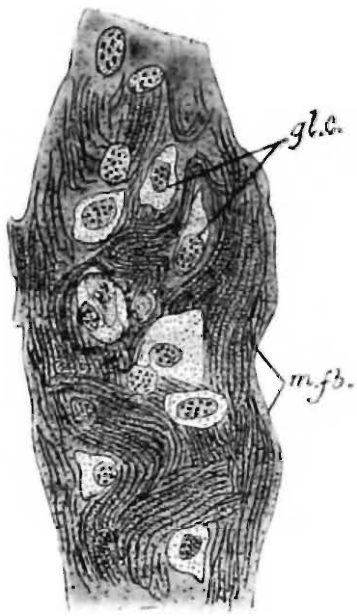
The junction of the small intestine with the colon is marked by a strong constriction, which is muscular and appears to function as a circular valve. The colon extends for about 2 mm. and its diameter is slightly greater than that of the small intestine, but is smaller than that of the chylific stomach. The colon is constricted both anteriorly and posteriorly at its junction with the small intestine and the rectum respectively. The middle portion of the colon is slightly dilated and its wall presents a striated structure.

The rectum is about 1·5 mm. long and when distended is dilated in the middle. The rectal bands are fairly well developed in these insects (text-fig. 6, *rec. ba.*) and are 6 in number. They are more or less crescentic in shape and are closely apposed, covering nearly $\frac{3}{4}$ths of the external wall of the rectal chamber, over which they are meridionally arranged.

In longitudinal sections of the rectal band the muscle fibrillae are found to run throughout the entire length of the bands ; only at certain places they are curved and leave a more or less clear space occupied by epithelial or glandular cells. The nuclei of these cells are granular and show up in the clear spaces between the fibrills (text-fig. 7).

No anal glands are found in the pygidial region of these insects. The rectum opens ventrally below the 10th tergum.

The salivary glands are paired, rather small, irregularly elongated structures, situated in the prothoracic region. The malpighian tubules (text-fig. 6, *mal. t.*) are elongate, slender tubules and are of nearly the same thickness throughout. As mentioned above, they vary in number



Text-fig. 7.
Embia minor, sp. nov.
Longitudinal section of a rectal band, showing the development of muscle fibrils and the presence of glandular (epithelial) cells, ×232·5.
gl. c.=glandular cells; *m. fb.*= muscle fibrils of the rectal band.

in different individuals and are situated at the junction of the chylific stomach and the small intestine.

Nervous System.

The nervous system, composed of ganglia and connectives, extends throughout almost the entire length of the body. In the Embiids there are 12 ganglia in all, 2 cephalic, 3 thoracic and 7 abdominal. Grassi (1897-1898) noted that there is no ganglion in the 5th abdominal segment, but in *E. minor* I found a distinct ganglion in this segment, but there was no trace of a ganglion in the 4th segment. The seven abdominal ganglia are connected with one another by a double chain, the component elements of which are very closely apposed. The last ganglion is larger than the others and probably represents several coalesced posterior ganglia. It supplies nerves to the reproductive organs, the rectum and the cerci.

In addition to the above a well-developed visceral part of the nervous system has been demonstrated by Melander (1903).

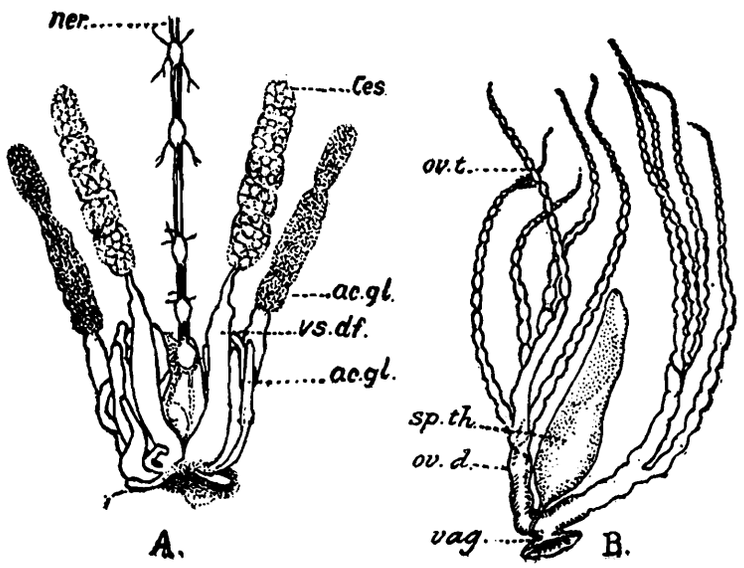
The Female Reproductive Organs.

As in other insects, the ovaries of the two sides are distinct and on each side consist of 4—5 fairly long tubes (text-figs. 8 B; *ov. t.*),[1] which open at intervals into a straight oviduct (*ov. d.*). The oviducts of the two sides meet posteriorly, forming a short vestibule or the vagina, which is slightly constricted anteriorly. Tracheae and fat cells permeate the ovarian tubules of each side, but the ends of the tubes appear to be quite free. Each tube is about 5·51 mm. long and is moniliform in appearance. The slender ends of the tubules gradually diminish in diameter anteriorly and passing upwards lose themselves in the fat body. The wall of the ovarian tubule is externally invested with a peritoneal layer of connective tissue, and is internally composed of a transparent elastic membrane lined by epithelium. Posteriorly the vagina (*vag.*) opens by a median transverse slit in the posterior half of the 8th sternum. The vaginal area can be distinguished from the outside as a brownish somewhat semi-circular area in the posterior half of the 8th sternum or the sub-genital plate (text-fig. 5 C, D; *g. ar.*). It encloses anteriorly a somewhat irregularly ellipsoidal rather translucent portion of the 8th sternum which acts as a flap for the vaginal slit.

The spermatheca is comparatively large and elongated, its distal free end is somewhat narrower and rounded and the free tip reaches the

[1] The ovarioles are of the panoistic or holoistic type.

3rd or even the 2nd abdominal segment. Its basal portion suddenly narrows to a thin tube (text-fig. 8 B ; *sp. th.*). The orifice of the spermatheca is situated on the dorsal wall of the genital pouch.



TEXT-FIG. 8.

Embia minor, sp. nov.

A. Internal genital organs of the ♂, ×12.
B. Internal genital organs of the ♀, ×10.

ac. gl.=accessory glands ; *ner.*=a portion of nerve chain of the abdominal region with ganglia ; *ov. d.*=oviduct ; *ov. t.*=ovarian tubules ; *sp. th.*=spermatheca ; *tes.*=testis ; *vag.*=vagina ; *vs. df.*=vas-deferens.

The oviduct is devoid of a chitinous lining. The vagina and the spermatheca, as also its short tubular duct, have a cuticular covering. The ovarian tubes contain ova in different stages of development encased in follicles. A ripe egg is somewhat oval in shape with a distinct micropylar area.

The Male Reproductive Organs.

The two testes lie one on each side. Each testis is a flattened, elongated structure and occupies a considerable portion of the terminal part of the abdomen, lying laterally to the alimentary canal (text-fig. 8 A ; *tes.*). The testes are concealed in the fat body from which they cannot be easily separated. Each testis consists of 5 lobes elongated and subcylindrical in shape arranged in a single row ; each lobe in its turn is composed of a large number of small rounded vesicles. The testis of each side is connected to the vas-deferens, which starts as a narrow tube from the posterior end of the testis ; it gradually increases in thickness until it becomes markedly thick, about 8 times as thick as its anterior portion. It is about 2·40 mm. in length (*vs. df.*). The dilated rounded ends of the vasa deferentia form the vesiculae seminales. The vasa deferentia of the two sides unite posteriorly to form a short, muscular, ejaculatory duct occupying a space between the 9th and the 10th sterna. The ejaculatory duct opens between the external chitinous parts of the genitalia and not, as is generally believed, through the median plate (text-fig. 5 A, B ; *m. p.*) or the aedeagus in other insects. In adults the

duct is distended with spermatozoa. The external genitalia have already been dealt with in the description of the external characters of the male.

The Respiratory System.

The respiratory system of the Embiids consists of ramified tracheal tubes which communicate externally through stigmata or spiracles. Of these spiracles the Embiids have ten pairs, two thoracic and eight abdominal, connected by longitudinal and transverse tracheae and forming a single connected system.

The first thoracic spiracle is the largest, being about 0·21 mm. in diameter. Its position is in front of the mesothorax between the bases of the first and the second pairs of legs, a little beneath the edge of the tergum. It is placed in an inclined position, the spiracular slit being oblique and pointing somewhat downwards and backwards.

The second thoracic spiracle lies in front of the metathorax between the bases of the second and the third pairs of legs. It is smaller than the first, its length being 0·15 mm. The free borders of both the thoracic spiracles are strengthened on their deep surfaces by chitinous rims.

The abdominal spiracles (plate XXIII, fig. 5) are smaller than the thoracic ones and occupy the anterior regions of the first eight abdominal pleura. Each lies in the anterior portion of the pleuron, *i.e.*, in the interspace between the tergum and the sternum. The external portion of the orifice of the stigmata shows no valvular structure. The orifice leads to a shallow ellipsoidal chamber which communicates with the tracheal trunk by a slit or an aperture situated inside the spiracular chamber. All the abdominal spiracles are funnel-shaped and the first, which is rather larger, is situated a little more dorsally than the others.[1]

The transverse connections are single and occupy a ventral position. The branches of the two sides unite and form transverse commissures between the trunks which originate from the spiracles. The dorsal longitudinal branches are formed by the union of the dorsal transverse branches, while the ventral branches form a transverse network. In the thoracic region two large tracheae run longitudinally on either side to the head. The ultimate endings of all the tracheal branches form a complicated mesh-work of very fine tubes which permeate all the tissues.

The spiracles of the Embiids, owing to their very minute size and differences in structure and position, are often difficult to locate.

5. (*a*) THE SPINNING APPARATUS.

The way in which the Embiids spin their tunnels has attracted the attention of several entomologists, but no definite conclusions regarding

[1] For studying the stigmata with their connectives a specimen was longitudinally divided into two and the halves were cleared in clove oil and mounted in Canada balsam. Further complete specimens mounted whole in Canada balsam were studied for determining the exact positions of the stigmata. For studying the minute structure of the spiracles on the other hand a longitudinally bisected specimen was boiled in dilute caustic potash and mounted in Canada balsam after clearing.

the position of the spinning apparatus and the mechanism of spinning have so far been published. Imms (1913) in his paper on *Embia major* remarks that the question of the mechanism of silk production in the Embiids is a much debated one, while a full discussion of the earlier literature is to be found in the works of Grassi and Sandias (1898), Melander (1903), Friedrichs (1906), Rimsky-Korsakow (1910), Krauss (1911) and Enderlein (1912).

My studies on this question have led me to the results described below. These are based on a prolonged series of observations and experiments made in the laboratory upon living specimens, and on the results of my studies of the whole organs and their sections.

Grassi and Sandias, Melander, Friedrichs and Rimsky-Korsakow are of opinion that the spinning glands are situated on the metatarsal joints of the forelegs. Enderlein (1903, 1912), on the other hand, from his studies on the mouth-parts and the metatarsus of the forelegs, came to the conclusion that the " lobi-interni " or the internal lobes of the second pair of maxillae constitute the external spinning apparatus. Imms (1913), from his work on *Embia major*, upholds the view of Grassi and Sandias, Friedrichs and Rimsky-Korsakow. These authors are unanimous in their opinion as to the situation of the spinning glands in the metatarsi of the forelegs. They, however, were unable to elucidate the complete mechanism for the extrusion of the fluid contents of the metatarsal glands, and even after the excellent histological work on the metatarsal spinning glands by Melander and Rimsky-Korsakow, the problem remained only partially solved.

From a series of experiments which I carried out to determine the function of the internal lobes of the second maxillae and the metatarsal joints of the forelegs, I am in full agreement with the authors who believe that the spinning glands are situated in the metatarsi of the forelegs.

Enderlein stated that the internal lobes of the second maxillae in the Embiids are pointed, closely apposed and characteristically shaped structures, like those of other spinning insects, especially the Copeognaths, and probably represent the site of the external spinning organ or the spinnerets. This remark of Enderlein appears to be entirely hypothetical, as sections through the head and thorax reveal no sign of the existence of any glands or ducts other than those of the salivary glands. It appears that Enderlein's analogy of the spinning organ of the Copeognaths with that of the Embiids is based only on the fact that the Copeognaths are the only adult insects allied to the Embiids which possess the spinning power. This is clear from Rimsky-Korsakow's (1910) remark, who added that Enderlein has taken the Copeognaths for comparison as in the earlier days these forms were classified with the Embiids under Corrodentia. Enderlein's figures of the " lobi-interni " or glossae of the labium show neither the position nor the shape of the spinnerets, and the ducts also are not indicated.

The " lobi-interni " or glossae of the labium are too small to contain an elaborate system of spinnerets, which would be capable of spinning a fairly long tunnel within a few minutes. Further, as I found from my observations on living specimens of *Embia minor*, the peculiar crossing and recrossing movement of the forelegs during spinning are quite

different from the ordinary movements of the legs, and are not connected with the movements of the labium. When the spinning is in progress, the metatarsi of the forelegs seldom approach the labium and so could not manipulate the threads which, according to Enderlein, issue from the internal lobes or glossae of the labium. Observations on a living specimen of *E. minor* under a binocular microscope showed that the threads are emitted in fair numbers at a time from the metatarsal tubular hairs, and that these threads are laid in nearly parallel and distinct lines along the tracks of the forelegs of these insects. The rapidity with which the tunnels are built, and the fact that the threads come out in fair numbers at a time, suggests the existence of an elaborate system of glands for spinning. This presumption is further strengthened by the peculiar arrangement of the glandular vesicles in the metatarsi of the forelegs and the openings at the tips of the fine setae mentioned already.

Regarding the secretion of the gland-vesicles Enderlein was of opinion that they are of little or no importance since the secreted fluid is granular and thin. It is evidently the chemical constituents of the gland-contents which are the main factors for the manufacture of the threads, and thus the importance of the gland-contents for the formation of the silk depends principally on the chemical constituents of the fluid rather than on its consistency. The gland-contents of other silk-spinning insects, *e.g.*, the silk spinning caterpillars, are thick, but this is no argument against the view that the fluid-contents of the glandular vesicles of the metatarsi of the forelegs of Embiids are concerned in the formation of the silk threads. It is not known what causes the solidification of the secretion, but there can be no doubt that the secretion solidifies almost immediately after the emission of the fluid from the tips of the tubular hairs, and apparently is independent of any other secretion.

Enderlein assigned quite a novel function to the metatarsal glands. He suggested that their role was to cause the hardening of the silk threads which he supposed to be discharged from the labium of the Embiids and was similar to that of the gland lying below the gula in the spinning caterpillars, *e.g.*, the silk worms. This comparison, however, is of no consequence, and, further, it is difficult to believe that such an elaborate system of glands as those on the metatarsal segments and situated at such a distance from the source of the main secretion, *viz.*, the labium, should have the function of hardening assigned to them. The only pair of glands in the head and thorax of the Embiids are the salivary glands and these certainly do not secrete any silky material.

Enderlein further stated that the thin oily secretion from the metatarsal gland-vesicles prevents the hairs of the metatarsus from sticking together during the manipulation of the threads which issue, as he supposed, from the spinnerets of the labium. It is difficult to conceive how the tubular setae containing the ducts and not the ordinary setae of the metatarsus help in the manipulation of the threads, especially when all the metatarsal setae are not connected with the glands. Further, the manipulation of the threads by the setae when they are oily

would, owing to capillary action, be a physiological impossibility. The thin layer of oil on the fine setae would make the extremely thin threads stick to the setae rather than spread them into bundles. The occurrence of such a type of lubricating arrangement in insects is doubtful and it is certainly not found in the web-spinners, *e.g.*, in the Araneae (spiders), where the hind legs help in the manipulation of the threads. The metatarsi of the forelegs in the Embiids alone, as has been described above, perform both the functions of secreting and manipulating the threads to form bundles.

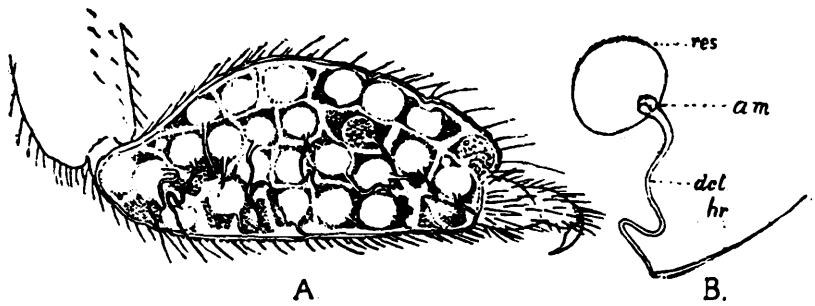
As regards the cementing up of the excretory orifices by the passage of the secretion through a microscopically fine canal, as stated by Enderlein, I am of opinion that the passage of the fluid without choking up the orifice of the canal does not seem to be a physiological impossibility, especially when the fluid flows out at a fairly rapid rate. It is also highly probable that the extreme fineness of the canal and the passage of the fluid through it helps to some extent to solidify the fluid.

Enderlein and Rimsky-Korsakow are to some extent justified when they remark that the problem of the emission of the fluid from the metatarsal glands, in the absence of a special arrangement for the extrusion of the secreted fluid, appears incomprehensible. Rimsky-Korsakow in his later paper (1910) added that this objection is not applicable to the Embiids only, but is common to other Arthropods such as Araneae, where no contrivance for the extrusion of the fluid has been discovered. He noted that in the case of comparatively tubular spinning glands, a special contrivance for pressing out the fluid is present, but that the small dimensions of the canals from the glands in the Embiids eliminates the necessity of such a contrivance. There is some difficulty in accepting this theory of Rimsky-Korsakow since, in the absence of other factors, capillary action would set in within these extremely fine tubes and render the out-flow of the secreted fluid well nigh impossible.

5. (*b*) THE GLANDULAR RESERVOIRS.

The glandular reservoirs containing the secretion lie in the swollen metatarsi of the forelegs. Each of the reservoirs opens separately to the exterior by means of a curved hollow seta situated on the plantar surface of the metatarsus. In *E. minor* these reservoirs are arranged longitudinally in 4 to 5 rows and vertically there are 3 to 4 layers of them (text-fig. 9 A), while each row contains on an average 6 to 7 reservoirs. The reservoirs are ovoid in shape, their largest diameter being 0·066 mm., and the shortest 0·02 mm. The portion from which the duct arises and the portion just opposite to it are slightly depressed. The length of the duct which leads to the seta 0·16 mm. (text-fig. 9 B ; *dct, hr, res.*). The duct originates from a peculiar structure—the ampulla of Rimsky-Korsakow (text-fig. 9 B ; *am.*), which is a thin-walled ovoid sac with the proximal and distal regions slightly thickened. This ovoid sac is in continuation with the duct and the thickened mass at its proximal pole is continued laterally into 4 to 5 radiating arms equidistant from each other, and passing as meridional lines to the opposite pole, where they meet again. In a section of the ampulla the opening of the duct is seen as a minute

centrally situated lumen, while the ampulla is provided with 4-5 ellipsoidal or semilunar lateral lacunae. The function of the ampulla and the lateral openings are perhaps to prevent too sudden a flow of the fluid through the thin lumen of the fine canal.



TEXT-FIG. 9.

Embia minor, sp. nov.

A. Metatarsus of the foreleg showing the gland-vesicles and their ducts (*in situ*), ×50.

B. Individual gland-vesicle with its duct, ×150.

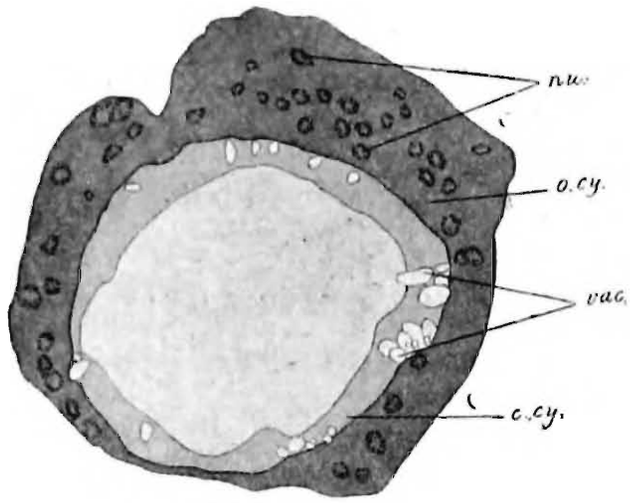
am.=ampulla; *dct.*=duct of the glandular reservoir; *hr.*=spinning seta; *res.*=reservoir of the metatarsal gland vesicle.

Histology.—In *Embia minor* the thickness of the wall of a vesicle varies at different parts. The external contours of the walls of different vesicles in a section are so variable that no two glands appeared to be similar. In a section of the metatarsal gland two distinct layers of cytoplasm are visible in the wall of a vesicle, *viz.*, (*a*) an inner rather thin rim of clear vacuolated cytoplasm (text-fig. 10, *c. cy.*) devoid of any nucleus. The vacuoles (*vac.*) are of different sizes and their number in each vesicle is extremely variable, 1-29 vacuoles being present in a gland. The vacuoles are unevenly distributed in the clear cytoplasm, but in some places were found to be collected in groups; (*b*) an outer rather thick layer of reticulated cytoplasm (*o. cy.*) over which the nuclei (*nu.*) are scattered. The nuclei are more or less rounded and are almost uniform in size. Their number in a gland-vesicle varies considerably; as many as 43 were counted in a single vesicle. The chromatin granules of the nuclei are distinct and lie more or less towards the periphery of the nuclear membrane. No cell boundaries could be distinguished. The secretion appears to be finely granular in sections and occupies the central lumen of the glandular reservoirs.

The minute structure of the metatarsal gland of *Embia minor* described above resembles that of *Embia texana* and *Embia ramburi*, described and figured by Melander (1903) and Rimsky-Korsakow (1905) respectively, in that the individual cell-walls of the gland-vesicle are indistinct, but differs in (*a*) a comparatively more variable thickness of the wall of the gland-vesicle; (*b*) the presence of a clear inner layer of vacuolated cytoplasm and (*c*) the nuclei distributed along the periphery on the reticulated cytoplasm.

Rimsky-Korsakow (1905) is of opinion that the glandular reservoirs are not multicellular since the cell boundaries are not distinct, and that no multicellular secretory glands are known to occur in the legs of insects. I am, however, of opinion that the glands are multicellular in origin. The individual cell-walls have disappeared owing probably to the pecu-

liar function of the glands and only the numerous nuclei remain to demonstrate the original multicellular nature of the glands.



TEXT-FIG. 10.

Embia minor, sp. nov.

Section of a metatarsal gland-vesicle, × 400.

nu. = nucleus ; *c. cy.* = inner layer of clear cytoplasm ; *o. cy.* = outer layer of reticulated cytoplasm ; *vac.* = vacuoles on the clear cytoplasm.

The spinning glands of the Embiids are probably to be compared with the isolated glands which are present in the feet of various insects. In the Embiids these glands are, however, more evolved in that they are united together to form a group and do not occur separately. The presence of the spinning apparatus in the metatarsi of the forelegs of the Embiids is not very extraordinary, as it is only a specialization of certain hypodermal glands for a special function in response to their peculiar habits. The interspaces between the glandular reservoirs in the swollen metatarsi are filled with a somewhat granular secretion, which apparently is extruded through minute openings situated at the base of the hollow setae lying in the second metatarsal joint. I have, however, failed to distinguish any cellular elements in the interspaces which could produce the secretion described above.

Numerous fine muscle-fibrils are present at the proximal end of the metatarsus. They originate from the dorsal surface of the main tendon of the foot as it runs through the constricted proximal end of the first joint of the metatarsus and are attached distally to the dorsal wall of the metatarsus. I believe them to be specially connected with the control of the expulsion of the fluid-contents of the metatarsal glands. By the simultaneous contraction of the muscles mentioned above a reduction of the space in the metatarsus takes place and the pressure so exerted causes the fluid-contents of the gland-vesicles to be forced out through the tubular setae.

6. SOME NOTES ON THE NATURE AND THE HABITAT OF *EMBIA MINOR*, SP. NOV.

On the 17th September 1924 I found both the male and female forms of *E. minor* in several complicated mesh-works of tunnels spun under

pieces of damp wooden planks in a godown of stored pulses at the Pusa farm (Bihar). The godown was badly lighted and very damp. The mesh-work of silken tunnels were 9-11 inches long and nearly as much in breadth, and were constructed under the sacks containing stored grains, or under piles of sacks and ropes. A large number of tunnels were examined, and it was found that the number of male insects in them was much smaller than that of the females.

All stages of the insect were found inside the tunnels. The males are usually smaller in size than the females and are winged. Some immature forms were also found, but it was impossible to determine their sex at that early stage. A few male nymphs, however, were found with the wings not fully developed and containing only a few nervures. In confinement individuals were seen to spin a rather flimsy tunnel within 15-20 minutes. When confined in a corked tube, they were found to nibble the cork, and the bits of cork thus chewed were found on the webbing along with the pellets of excreta of a greenish grey colour. A completed tunnel is fairly thick and is sometimes furnished with a few lateral branches which arise from the original tunnel and meet it again further on. In spite of their thickness, the tunnels are more or less translucent. The time taken to finish a tunnel depends upon the size of the tunnel and the number of individuals present in the colony. Under laboratory conditions it was seen that several insects lived comfortably in one and the same tunnel when plenty of food of the right kind was available.

A single fibre from the wall of a tunnel is extremely fine and a tunnel is composed of innumerable such threads irregularly gummed and webbed together to form bundles. These bundles are not of a uniform thickness and Melander (1902) attributes this to a selective action in the secretion of some or all the glands at different times. From my observations, however, I am of opinion that the difference in the thickness of the bundles is due to the manipulation of the forelegs while the secretion is being laid, and is in no way dependent on the secretion by the glands themselves. The colour of the threads is milky white.

In addition to the lateral branches there are a few openings along the sides of the tunnels and the insects use them for ingress and egress from the tunnels when disturbed. The insects can move backwards and forwards with equal facility and in their backward movement the cerci appear to serve as feelers for finding the lateral openings.[1]

During spinning the anterior pair of legs move sharply in their acetabula. From the openings at the tips of the metatarsal setae numerous white threads are secreted and these threads are laid down into bundles by the rapid movements of the legs mentioned above.

Irregular rhombohedral crystals of a chalky white substance were also found in the tunnels, but their exact nature could not be determined.

Scolytid and Bruchid beetles with a few species of Microlepidoptera were also found in association with *Embia minor*.

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1 This may explain the presence of the sensory hairs on the cerci of the Embiids.

Various kinds of food material, as for example wheat flour, dead insects, dry leaves, dry wood shavings, bits of cork, green vegetables, were supplied to the insects and it was found that the wheat flour was preferred to all other kinds. Adult females kept together without food were found to have lost some of their appendages wholly or in part. No appendages were, however, found in the breeding jars, and it is, therefore, possible that under extreme conditions of starvation the insects begin to feed on each other.

Males of this species when frightened can fly short distances, otherwise they behave like apterous insects and their wings are not functional in the usual sense of the term. This loss of the function of flight may be due to the sedentary habits of the insects or the disuse of the wings over a very long period of their existence.

From my observations on the nature of the silken tunnels I am of opinion that, though the tunnels of the Embiids serve to some extent as a protection against the attacks of small insects, they are not so perfect in their function as has been stated by Imms (1913). The following observations were made in the Entomological laboratory at Pusa to investigate the efficiency or otherwise of the tunnels as protective recesses. On the 7th October nymphs of several Reduviid bugs were collected by the Imperial Entomologist as the suspected carriers of Leishmania bodies (kala-azar). These were kept in glass crucibles for observation and were fed with the Embiids, both nymphs and adults. The Embiids supplied as food to the bugs rushed about for a few minutes but afterwards settled down and began to spin tunnels. Within 10-15 minutes a fairly long (about 2-3 inches) zig-zag tunnel was spun. The tunnel was more or less thick but semi-transparent, and the movements of the Embiids could be clearly observed through it. The Reduviid nymphs walked sluggishly over the tunnels several times but, as mentioned by Imms (1913), they were never seen to become entangled in the webbings of the tunnel. Some of them were observed to pierce the meshes of the webbings with their strong proboscis and suck the juices from the bodies of the Embiids.

Grassi and Sandias (1897) consider that these tunnels serve to protect the body from excessive transpiration and help in maintaining a sufficiently humid atmosphere for the Embiids living in them. It is difficult, however, to substantiate this statement, as among the Embiids kept in the laboratory for observation during the hot month of June, when the maximum temperature rose to as much as 113° Fahrenheit (5th June, 1924), a high percentage of mortality was observed, though practically all the insects were living inside their tunnels. Thus the remark of Grassi and Sandias, that the tunnels help in keeping a humid atmosphere around the Embiids, has to be taken with some reserve. So far as my experience goes, the Embiids cannot survive in too low a temperature. Thus when the temperature at Pusa went down to 40·6° Fahrenheit (17th January, 1925), a high percentage of mortality was again observed among the Embiids kept in confinement.

In a few instances when disturbed or teased out of the tunnel some of the insects were seen to feign death.

That these insects prefer cool shady crevices to brightly illuminated spots was confirmed by the following experiment. A rectangular glass trough was taken and half of the trough was covered with black paper. A piece of cardboard of about the same height and length as the trough was taken and two holes were punched at the sides at heights of about $\frac{3}{4}$ths of an inch from the base. The piece of cardboard, which was placed in the middle of the trough, thus divided it into two chambers—one dark and the other fully exposed to light. Three adult females of *Embia minor* were placed in the uncovered part of the trough which was fully exposed to the light. The insects became restless and scurried about from one end of the chamber to the other. They were left in this condition in the trough for a whole day. Next morning they were found in the darkened half of the trough quietly resting inside a tolerably long tunnel spun in one of the corners of the trough. In passing from the lighter to the darker half of the trough the insects must have travelled through the holes in the cardboard partition. This experiment clearly proves the negative phototropic habits of these insects.

To find out whether the shape of the web depends on the place of confinement of the insects the following experiment was tried. Three females of *Embia minor* were kept confined in a watch-glass for observation. In this case only flat webs, and not tunnels, covering nearly the whole base of the watch-glass was spun by the insects. It is quite possible that they cannot spin tunnels on flat smooth surfaces, where points of attachment for the threads for the construction of the tunnels are absent.

Carnivorous nature of the male.

Michael and Westwood (1876) were the first to definitely state that the Embiids are vegetable feeders. Melander (1902), on the other hand, observed that the insects are more or less carnivorous, and that they do not normally eat anything of a vegetable origin. They were also noticed occasionally to nibble at small pieces of worms or flies, but Melander's observations on the subject are not sufficiently extensive or detailed to be conclusive. Friedrichs (1906) suggested that in the case of the European species only the males are carnivorous. Imms (1913) was of opinion that the slender mandibles of the male without the crushing edge greatly resemble those of other carnivorous insects. He further noted that the larvae could be reared to nymphs purely on vegetable food.

From the above it would seem probable that the males take to a carnivorous habit under special conditions, but that the females are always averse to it. It would, however, be wrong to dogmatize from these laboratory experiments as to what is the exact nature of the food of these insects under natural conditions. I carried out the following experiments under laboratory conditions in a petri dish. Three male nymphs of *Embia minor* were allowed to starve for a day and afterwards supplied with 4 dead nymphs of the Homopteran, *Pyrilla* sp. Three of these nymphs were apparently eaten overnight by the Embiids. On the other hand female Embiids under similar conditions died of starvation rather than feed on dead *Pyrilla* or *Lepisma*.

Adults of both sexes, however, probably nibble at one another's antennae, and this is suggested by the fact that bits of antennae were found in the alimentary canal of a female specimen (text-fig. 6).

7 SUMMARY.

1. The affinities of the order Embiidina, its relationship with other groups of insects, and the geological history of the order are discussed (p. 254).

2. A detailed description of the ♂ and ♀ of *Embia minor*, a new species from Pusa, Bihar, is given and a table showing the differences of this species from the only other known Indian species of the genus is appended (p. 256).

3. The internal anatomy of *Embia minor* is described in detail (p. 266).

4. In the case of the respiratory system, the tracheal connectives, the position, the structure and the size of the spiracles of different regions of the body are dealt with in detail (p. 270).

5. The views of the earlier authors as to the position of the spinning glands are discussed, and Enderlein's statements as regards the position of the spinning glands are considered. Rimsky-Korsakow's view about the apparent absence of a contrivance for the extrusion of the fluid contents of the metatarsal gland vesicle is also discussed (p. 270).

6. A detailed description of the size and the structure of the metatarsal gland-vesicles or the glandular reservoirs and their ducts is included and the minute structure of the glandular reservoirs in the metatarsi is described. The controlling mechanism for the pressing out of the fluid-contents of the glandular reservoirs in the metatarsi is also described in detail (p. 273).

7. Some observations on the habitat of these insects and their feeding habits are recorded. The views of the various authors regarding the formation of the tunnels and their function are considered in detail, and experimental evidence is adduced to show that they are by no means perfect protective recesses in nature (p. 275).

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EXPLANATION OF PLATE XXIII.

Embia minor, sp. nov.

FIG. 1.—Adult female, ×8.

„ 2.—Adult male, ×8.

„ 3.—Eye and the basal segment of antenna, ×60.

„ 4.—Section of the anterior portion of oesophagus showing the chitinous denticles, ×310.

„ 5.—Abdominal spiracular opening, ×150.

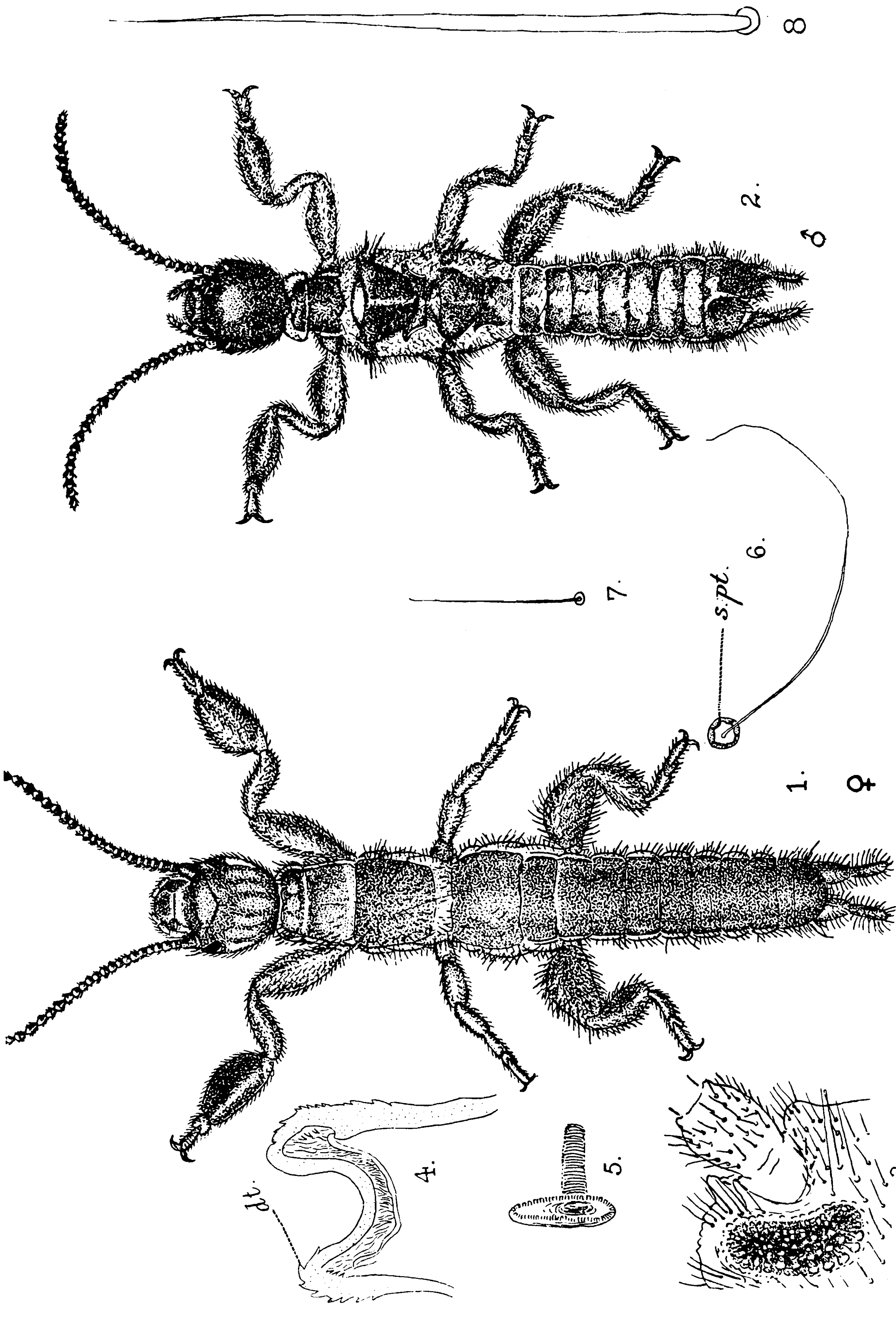
„ 6.—Sensory seta of cercus with sensory pit, ×310.

„ 7.—Ordinary short seta of cercus, ×310.

„ 8.—Ordinary long seta of cercus, ×310.

LETTERING.

dt.=denticles on the anterior region of oesophagus; *s. pt.*=sensory pit of a sensory hair of the cercus.



Embia minor, sp. nov.

S. M. & P. Narayan del.

NOTES ON LAMELLIBRANCHS IN THE INDIAN MUSEUM.

By B. PRASHAD, *D.Sc., F.R.S.E., Zoological Survey of India.*

7. ON A NEW SPECIES OF *VILLORITA* GRIFFITH & PIDGEON FROM BOMBAY WITH NOTES ON A JAPANESE SPECIES.

In 1921[1] I published a revision of the Indian species of the genus *Villorita* Griffith & Pidgeon, and from the available records concluded that species of this genus are confined to the brackish water areas on the Malabar Coast of Peninsular India. While working through the extensive collections of Corbiculidae in the Indian Museum, and those of various European Museums the authorities of which have been kind enough to lend me their collections for study, I found a form from Bombay, which could not be referred to the genus *Corbicula* Meg. v. Mühlfeldt, and appeared to be a primitive member of the genus *Villorita*. There is a single adult shell of this species in the collection of the Indian Museum, and a good series of shells of all ages was found among the Paris Museum collections labelled *Corbicula*; these shells are from the collections made by Mons. Dussumier in Bombay in 1837. It is described below under the name *Villorita corbiculoides*.

Deshayes in 1854 [2] described from the Cuming Collection a species of unknown habitat under the name *Corbicula incrassata*. It was considered by Prime [3] to be synonymous with *C. cuneata* (Jonas) from Orinoco River, South America, and Clessin [4] followed him in this conclusion. I am unable to agree with these authors, and am of opinion that the specimen from the Cuming Collection, which Prime received as *C. incrassata*, must have been wrongly labelled.

In the Indian Museum collection I found a specimen from Japan presented by the late Dr. Anderson, and hitherto kept with the unnamed material of the genus *Corbicula*. This specimen agrees very well with Deshayes's description of *C. incrassata*, and with the figure, probably of the type, in Conchologia Iconica.[5] In my notes on the Corbiculas in the British Museum (Natural History) collection I had further made a note that the species *C. incrassata* was wrongly assigned to the genus *Corbicula*, and should, in my opinion, be placed in the genus *Villorita*. Prime's figure (*loc. cit.*) *of C. cuneata* (Jonas) is quite different from the shell which I saw in the British Museum labelled as *C. incrassata* Deshayes, and the hinge is quite different in the two cases.

This record of a species of the genus *Villorita* from Japan greatly extends the range of distribution of the genus. It is, so far as is known, very discontinuous, and points to the members of the genus having originated independently from marine ancestors in areas so far apart as

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[1] Prashad, *Rec. Ind. Mus.* XXII, pp. 111-119, pl. xv (1921).

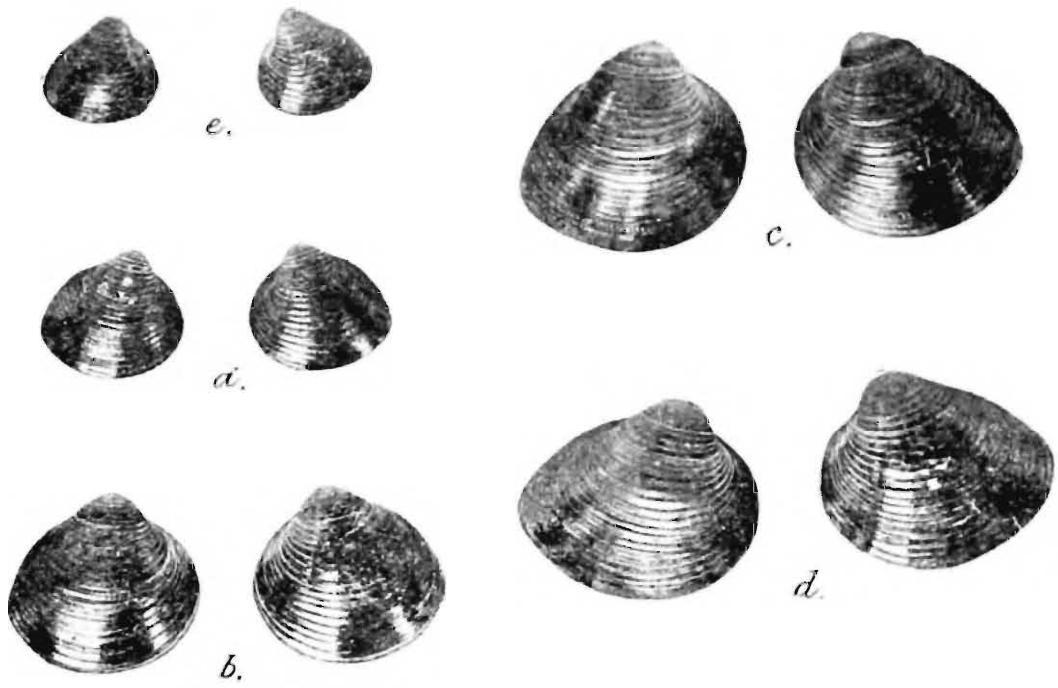
[2] Deshayes, *Proc. Zool. Soc. London*, p. 342 (1854); also see *Cat. Conch. Brit. Mus.* II, p. 233 (1854).

[3] Prime, *Smithson, Misc. Coll., Mon. Amer. Corbicul.* p. 6 (1865).

[4] Clessin, *Martini & Chemn. Conch.-Cab. (n.f.), Cyclādeen*, p. 158 (1877).

[5] Sowerby, *Conch. Icon.* XX, *Cyrena*, pl. xvi, fig. 86 (1876).

Japan on the one hand and the west or Malabar Coast of Peninsular India on the other. It is, however, likely that other species of the genus yet remain to be discovered from the intervening areas.



TEXT-FIG. 1. *a-d.* Four shells of different ages of *Villorita corbiculoides*, sp. nov., from Bombay; figure 1 *d* is a photograph of the holotype of the species; *e.* Photograph of *Villorita incrassata* (Deshayes) from Japan. All the figures are direct natural sized photographs.

It may also be noted that Preston's *Corbicula cochinensis*[1] is based on young shells of *Villorita cyprinoides* (Grey) and is not a new species of the genus *Corbicula*, as the author supposed.

Villorita corbiculoides, sp. nov.

Shell fairly large, trigonal, distinctly oblique, swollen in the umbonal and the middle regions of the shell, and greatly compressed below; umbones lying near the anterior margin, recurved forwards and inwards, nearly approaching each other and the hinge-line, hollow; anterior margin short, regularly curved; ventral border greatly arched, posteriorly curving up and produced into an acuminate beak-like region; posterior margin slightly arched, in adult shells much longer than the anterior margin and produced into a low keel; shell moderately thick, with low, almost equidistant, concentric ridges, somewhat less prominent in the middle and becoming almost obsolete in the posterior beak-like region; umbonal ridges prominent; a broad heart-shaped lunule anteriorly and a moderately thick external ligament posteriorly; epidermis shining yellow to light brown with in some cases darker zones in the posterior half of the shell; nacre white to light violet, slightly iridescent.

The hinge is more delicate than in the other forms of the genus figured by me (*loc. cit.*, p. 117, text-fig. 2). It is nearer that of *V. cyprinoides* var. *delicatula* (Preston), but the laterals are more elongate and

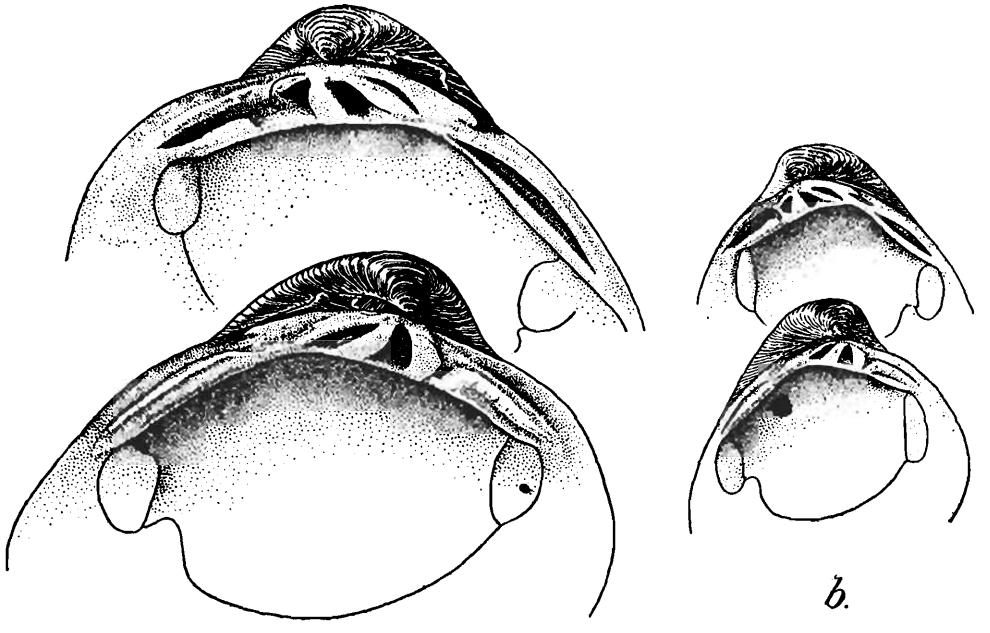
[1] Preston, *Rec. Ind. Mus.* XII, p. 36, figs. 12, 12*a*, *b* (1916).

relatively thinner. The cardinals also are not so strongly developed. The pallial line is slightly arched and the sinus is very distinctly marked.

Measurements (in millimetres).

	Holotype				
Length	30	30	29	24	17·4
Height	26·8	26·7	26·8	27	16·3
Maximum thickness	18	17·8	18·2	15	11

Holotype No. M. $\frac{12703}{2}$ in the collection of the Zoological Survey of India (Indian Museum), Calcutta. Paratypes in the Natural History Museum, Paris.



TEXT-FIG. 2. Hinge teeth of (*a*) *Villorita corbiculoides*, sp. nov., and (*b*) *Villorita incrassata* (Deshayes).

Locality.—All the specimens, which I have seen are from Bombay.

Remarks.—The species, as the name suggests, has a *Corbicula*-like facies, and is apparently one of the least highly evolved species of the genus *Villorita*. It is easily distinguished from all the other species by its more elongate shell, less pronounced sculpture and the weakly developed hinge. In young shells the posterior acuminate area is not fully developed, and the young shells appear less triangular. The sculpture on the young shells, on the other hand, is more prominent.

Villorita incrassata (Deshayes).

1854. *Corbicula incrassata*, Deshayes, *Proc. Zool. Soc. London*, p. 342.
1854. *Corbicula incrassata*, Deshayes, *Cat. Conch. Brit. Mus.* II, p. 233.
1876. *Cyrena incrassata*, Sowerby, *Conch. Icon.* XX, *Cyrena*, pl. xvi, fig. 86.

The general considerations with reference to this species have already been dealt with in the introductory part, while the descriptions of the species by Deshayes and Sowerby are fairly complete.

The only shell before me is a half-grown specimen measuring (in millimetres) $14 \times 13{\cdot}8 \times 10$, and in it the posterior margin is not so acuminate as is shown in Sowerby's figure of the species. As is shown in text-figure 2, the anterior lateral teeth are much shorter than the posterior, and are more or less transversely placed as in other species of *Villorita*. Both the pairs of lateral teeth are rather feebly developed, and so are the cardinals which in their arrangement are similar to those of the other species of the genus. The pallial line is only slightly arched and the sinus is well marked.

Remarks.—As noted above the only specimen before me now is from Japan (exact locality not stated), and is in the collection of the Zoological Survey of India (Indian Museum), Calcutta No. M. ($\frac{12704}{2}$). The species appears to be closely allied to *V corbiculoides* Prashad described above.

ENRICO BRUNETTI.

By the death of Enrico Brunetti on the 21st of January 1927, the Zoological Survey of India has lost a very valuable collaborator, who had been connected with it from its foundation in 1916, and with its predecessor the Zoological and Anthropological Section of the Indian Museum since 1904. For the greater part of this period his connection with these institutions was purely informal, and he used to work on the Indian Museum collections on a piece-work basis without holding any definite appointment, but on two occasions he served temporarily as an Assistant Superintendent in the Zoological Survey of India, and was in charge of the Insect collections. He was undoubtedly one of the outstanding figures amongst those entomologists of the present century, who have devoted the greater part of their lives to the study of the Indian Fauna.

Unfortunately we have no information about the date or the year of Brunetti's birth. From the information supplied by his sister, Mrs. M. A. Cotton, it is certain that he was born in London, and this is also confirmed by a paragraph in one of the official letters sent by the late Dr. N. Annandale to the Government of India regarding Brunetti's temporary appointment in the Zoological Survey of India. The Government of India for some unknown reason believed that Brunetti, though of Italian nationality, was born in New York. Dr. Annandale, apparently on information supplied by Brunetti, replied, " I understand that Mr. Brunetti was born in London and was the son of an Italian naturalized as a British Subject. He was never in America either to be born or for any other purpose." His sister has informed me that their father was an Italian, a native of Fossombrome, a little suburb of Rome. He migrated to England and was employed as a Chef in one of the big London restaurants. Their mother came from Bath, Somersetshire. Brunetti from a very early age showed a marked musical talent and appears to have had very little in common with his father, or the rest of the family. According to his sister he showed unusual talent for musical composition from an early age, and was fortunate enough to have had musical instruction among others from Mons. Giacomo Ferraris and Sig. Enrico Mattei. His earliest musical engagement was apparently in 1901, when he used to play the piano at the Empire, Islington. In 1902 he conducted bands at Plymouth and Llandrindod Wells, and in 1903 was appointed bandmaster at Harwich. He came out to India in 1904 as musical conductor at the Tivoli Theatre, Calcutta. For several years he was connected with the Bandman Opera Co., Ltd., and toured with the various travelling companies brought out by this company to various parts of India and the Far East. Unfortunately few details are available regarding his various musical engagements, but from the collections which he brought back with him, there can be no doubt that he visited the Strait Settlements, Java, and the Treaty Ports of China. From 1906 onwards, however, he was mostly in Calcutta, and only paid flying visits to some hill stations. He used from time to time to conduct the band or play the piano in the Globe Opera House, the Great Eastern Hotel, the Grand Hotel or some other place of entertainment.

Brunetti was strongly opposed to any musical or dramatic performances on Sundays and often got into trouble by refusing to conduct after " God Save the King " had been played. His strict adherence to these principles was undoubtedly responsible for his musical career being financially unsuccessful though there can be no doubt that he was a very clever and a gifted musician. According to his sister, he has left a fairly comprehensive library of several hundred compositions of musical, operatic and other works.

Besides music and insects, he was interested in th collection of postage stamps and had built up a fairly representative, if not very valuable, collection of stamps, both by exchange and by purchase so far as his meagre purse permitted.

By nature Brunetti was quiet and somewhat reserved. To his friends and acquaintances he appeared as one dissatisfied with his surroundings, and was always complaining of a number of worries that to others might appear trivial, but were to him none the less real. In addition to the climate of Calcutta, which caused him to suffer severely from prickly heat, Brunetti used to complain of the barking of dogs, the cawing of the crows, the almost constant noise of the Calcutta Tram cars which run past the Indian Museum, and within recent years the incessant hooting of motor car horns. Brunetti's hatred of the crows of Calcutta amounted almost to an obsession and every morning and evening he used to go about shooting crows with a small collector's gun. This feeling of hatred seems to have been fully reciprocated by the crows of Calcutta for invariably one or more crows were found to be sitting on the venetian blind of one of the windows outside his laboratory on the top floor of the Indian Museum and incessantly worrying poor Brunetti while he was working. I have also seen him walking without his gun in the Museum compound and in other parts of Calcutta with a regular flock of crows flying overhead, and following him with their shrill cries. Most of us can quite well remember the day after a severe cyclonic storm in Calcutta when Brunetti greeted everyone with a very happy expression on his face. He pointed to the large numbers of crows lying dead on the Maidan and thought that their death was probably a just retribution for all the worries which these birds caused him.

Brunetti was essentially a Dipterist and his interest in other insects, at least during the later years of his life, did not extend beyond that of a collector. With the meagre information which we unfortunately possess about his early life, it is impossible to say for certain what made him select the Diptera as the special group for his studies, but, as Mr. Senior-White has suggested further on, it may probably have been due to his early acquaintance with Verrall. For various reasons, however, I believe that it was the influence of the late Dr. Nelson Annandale which was responsible for Brunetti taking seriously to the study of Diptera, and that it was this interest which transformed Brunetti from an amateur collector of insects to an expert Dipterist. Brunetti, from the very year of his arrival in India, used to spend his spare time in making collections of insects which he later brought over to the Museum for identification, mostly by comparison with the named collections in the Indian Museum. Very early, however, he found that the collections of Diptera in the Indian Museum, even though they had been partly named by such

authorities as Bigot, Becker and others, were not sufficiently extensive for the identification of all or even most of the forms which he himself had collected and others which he found in the unnamed collections of the Indian Museum. In spite of the fact that he had neither any academic qualifications, nor had had any definite training as an entomologist, the late Dr. Annandale at a very early stage recognized the outstanding merits of Brunetti as a Systematist, and gave him every facility for starting work on the Indian Diptera. He had, as far as I can find, not published any work on any group of insects previously. and under the circumstances I have very little doubt that in the selection of this group, the influence of Dr. Annandale must have been supreme. Further, Dr. Annandale helped Brunetti financially by arranging for the purchase by the Trustees of the Museum from him of his collections of insects in groups other than the Diptera and as time went on employed him to work on the Museum collections on a piece-work basis.

In the first few years after his arrival in Calcutta Brunetti was doing gratuitous work in the Indian Museum, but from 1907 onwards he received special honoraria varying from £30 to £300 a year for the work he did on the collections of the Indian Museum. As noted already he also worked temporarily as an Assistant Superintendent in charge of the Insect Section in 1919-1920, and in 1921, for a period of three months in each case.

In 1921 at the suggestion of Dr. Annandale a second class passage was sanctioned by the Government of India for Brunetti to go to London and revise his work on the Indian Diptera by examination of the original type-specimens in the British Museum (Natural History), London. It was expected that a period of one year would be sufficient for him to finish this work and the Government of India with the approval of the Secretary of State for India sanctioned a special grant of £300 as Brunetti's remuneration for this period. Brunetti sailed from Calcutta in May 1921 and took with him most of the named collections of the Zoological Survey of India (Indian Museum) which he wished to revise. Though he was actually paid for only a year by the Government of India, Brunetti found that it was impossible to finish all the work during this period, and was carrying on the revision work till very shortly before his death. In 1923 the Bureau of Entomological Research, London, employed Brunetti for working on African and other flies and since that date it was only during his spare time that he could carry on his studies on the Indian Diptera. Since his return to England he often went to Paris to spend the winter there and also worked on the collection of Diptera in the Musee d'Histoire Naturelle, Paris.

He was taken seriously ill while in Paris in the winter of 1926-27 and returned to London when a little better, but he never recovered and died in a hospital in London on the 21st January 1927.

He bequeathed his valuable collection of Diptera and other insects and his entomological library to the British Museum (Natural History), London.

The following two sentences of the late Dr. Annandale admirably describe Brunetti's interest in Diptera, his work and the conditions of

his life in Calcutta, and I cannot do better than quote them in *extenso:*
" His profession is that of a musician and it is hardly too much to say that for the greater part of ten years he has devoted his evenings to earning his daily bread and his days to the study of Diptera. "
" The school to which Mr. Brunetti belongs, and to which it is natural and proper that an amateur should belong, is that of the rigid taxonomists, who are interested in the naming and classification of specimens rather than in morphological relationships or biology."

Brunetti was unfortunately never well off financially and did not belong to any scientific Society or Association except to the Asiatic Society of Bengal of which he was elected an Associate member in March 1915.

A list of Brunetti's scientific publications prepared by Mr. C. O. Bateman, Librarian, Zoological Survey of India, is appended (pp. 294-296). From this it will be seen that he published 33 papers in the "*Records of the Indian Museum*" and 3 volumes in the "*Fauna of British India*" on Indian Diptera.

The following pages which deal with Brunetti's work as a Dipterologist have been kindly written by Mr. Ronald Senior-White, who was personally acquainted with Brunetti and is in a better position than myself to write regarding Brunetti's work on the Indian Diptera.

B. P.

Brunetti as a Dipterologist.

The history of Oriental dipterology divides itself into two parts, separated by a well marked pause at the close of the Nineteenth Century. The death of Bigot in 1893 had put a term to the endless flow of description, insufficient and loosely worded, which Francis Walker and himself had been producing for forty years, whilst the chaos resulting therefrom had, in 1896, been ably summarized by van der Wulp in his classical 'Catalogue of the described Diptera from South Asia.'

Without Wulp's catalogue, or an analogous work, further progress would have been impossible, but even with it anyone proposing to take up the study of Oriental Diptera might well have paused appalled before the lists of species therein recorded. Walker was notoriously incapable of correctly locating a species generically, in fact this point does not seem to have greatly interested him, he seemingly having been solely concerned to publish a new specific name. As the types of both Bigot and himself, together with those of the fewer though much more adequately characterized species put out in the last half of the century by Schiner, Doleschall and Thomson, were all in Europe, any progress from the Asiatic end might well have been considered impossible.

But this was not all. Among the families of the order one had so far not suffered from over description, but now, following on Ross' discovery, this, the Culicidae, became the subject of equally indiscriminating publication, and from 1900 onwards floods of new species, and, worse, of genera, poured forth from the Medical Press, from workers largely ignorant of the principles of taxonomy and the elementary rules of zoological nomenclature, until it might well have appeared to a detached zoologist that

Oriental Dipterology had descended into such a slough as to be almost without hope of rescue.

But, during the full flood of mosquito description, and after the rest of the Diptera had lain in chaos for ten years, there appeared the subject of the present notice, an amateur who, prior to his coming to the East in 1904, had worked on the European fauna, and who seems to have been at least a scientific acquaintance of Verrall, from whom, perhaps, he had acquired his method of meticulous description and power of insight into the obscurities of the earlier authors. For three years after his arrival in India, to which he came as musical conductor of the Bandman Comedy Company, Brunetti seems to have had time for nothing but the amassing of large collections at the places visited by the company, with which he toured most of the Orient, including the Chinese Treaty Ports, but in 1906 he settled down in Calcutta, heading his own string band, and devoted his leisure time to determining Diptera in the Indian Museum, to the library and collections of which he was given access by the late Dr. Annandale, always prepared to recognize enthusiasm and merit in any scientific worker, however academically unqualified. That, in no small measure, Annandale ' discovered ' Brunetti will be not the least of the stones in the temple of fame of the greatest of Indian Zoologists.

Brunetti's position at the Museum was an irregular one. When budget funds permitted, he was in the receipt of a salary from the Zoological Survey, and his types, etc., became the property of the Museum ; when there was no money to pay him with he worked there as an outside specialist, retaining ' half duplicates ' and types, if these came from his own collection. It is fortunate that the latter will not be dispersed on his death, as the twenty thousand specimens comprising it have been left to the National Museum at South Kensington.

There was, at this time, in the Indian Museum, a not inconsiderable collection of Diptera, which had been worked through by Bigot during a visit to India many years before. However, though Bigot had, (whilst destroying most of the locality labels and substituting ' Inde ' only), affixed names to many of the specimens, the larger part of these were found never to have been published, and were rescued from oblivion by Brunetti, who adopted many of them when describing these specimens during the course of his work. A few other specimens had been named for the Museum many years previously by Becker, but the total quantity of available named material was insignificant.

It was this collection, therefore, and those amassed by himself, that about 1906 Brunetti sat down to work upon. With very few authentically named specimens, and *all the types in Europe*, his task must have appeared almost hopeless, but he possessed in exceptional degree the power of ' visualization', (as Osten-Sacken called it), that is, of constructing from a description a mental image of the specimen before the original author, thus amplifying and elucidating an otherwise inadequate description, instead of becoming fogged by the discrepancies and omissions encountered in merely comparing a specimen with such. Witness his footnote in his first paper on the description of *Odontomyia claripennis* Thoms.. "this hardly reads like a distinct dorsal stripe, or wide transverse bands." It was this power of reading himself into the mind of an author

which enabled him to elucidate so many obscure descriptions without reference to the types. His other great advantage, of course, an advantage even to-day obtainable nowhere else in Asia, was access to an almost complete file of the literature.

Using Schiner's ' Fauna Austriaca,' with which his European work had rendered him amiliar, as a generic basis, he took description by description from Wulp's Catalogue, and sought to allocate these generically and to prepare keys, (not always published), to the species thus sorted out, thereafter working through the actual specimens and describing nothing as new until he had tried it against all existing descriptions.

In this fashion material for the ' revision ' of a family or group was gradually got together, and his work is noteworthy almost more for the number of old species that he recognized and adequately re-described than for the immense number of *spp. nov.* of which he was the author.

His method of work was never more clearly seen than in his very first paper, ' Revision of the Oriental Stratiomyidae,' in the introduction to which he says " Baron Osten-Sacken's view to the effect that writings on the fauna of a region imperfectly known should be considered as preparatory and not final results seems correct, and his opinion that a writer is not ' called upon to describe as new every specimen that he cannot identify' is echoed by my own. Therefore I am not sure whether analytical tables of genera and species should have been presented, for owing to my inability to obtain specimens of the majority of the species, the tables have had to be drawn up mainly from descriptions, and will be open to improvement on a better personal acquaintance with a larger proportion of the species." How good, however, these tables, concerning the use of which he was thus doubtful, really are, the present writer can testify. It was by their aid that I originally attempted the identification of my first collections of Oriental Diptera, and beyond his papers for some time I had access to no descriptive literature whatever. None the less, subsequent checking has proved that by this means it was possible to identify correctly the majority of specimens taken, so be it that they belonged to described species, and to decide with some certainty when an undescribed species was before one. I remember well, on the first occasion that I met him, in his room on the top floor of the Museum, in 1919, putting before him for opinion a solitary specimen which by his tables I had made out to be *Acraspidea felderi* Brauer, (now *Aulana confirmata* Wlk.). He checked the specimen against the actual original description, not quoted in his paper, and confirmed my diagnosis, remarking that he had often vainly tried to fit something to that description. I have a vivid recollection of his pleasure in finding that his tables were of value and use to others.

Gradually, on these lines, he cleared up the whole of the Nematocera Brachycera and Aschiza, with the exception of Cecidomyidae, Chironomidae, (on which, during his period at the Museum, he was supplying the late Abbé Kieffer with Indian material), Culicidae, Tabanidae, (in which he sent home to Miss Ricardo the material on which her revision of the Oriental species is mainly based), Asilidae and Dolichopodidae (sending the Museum material of the last to Becker). From 1920 onwards I know he himself was working on the Asilidae, and my collection, now in

the British Museum, contains many Dasypogoninae and Leptogastrinae with his ms. names attached. It is greatly to be hoped that his ms. is available and will be handed to some other specialist for completion or incorporation.

In other words, either he himself, or specialists furnished with material through him, made a clean sweep through practically the whole of the Order except Muscoids, and even in these, here and there, as in Sepsidae and the haematophagous Muscids, he cleared up a corner when some distinctive limiting characters to a group were available. Finally his work on the Indian forms was compiled into the three 'Fauna of British India' volumes that bear his name. These include large numbers of new species not included in the original revisions of the individual groups, and though increasing collections will for many years to come bring undiscovered forms to light in every family, those who, like the present writer, have done most of the subsequent description, have no difficulty in building on the foundations erected by Brunetti, and it is only when undertaking a *de novo* revision of a family he never touched that those who come after him can have any conception of the situation he faced throughout the entire Order.

Towards the end of his time in India, his acquaintance with the fauna was literally astounding. I remember accompanying him to the Colombo Museum, when he was on his voyage home, (as he mentioned, by the old P. & O. 'Somali' that had brought him to India seventeen years previously), with a view to dividing with him the then entirely unnamed dipterous collection of that Institution for working out. Being shown the collection, he said, 'let's see what we can name straight off', and from box after box, with only an occasional glance at a file of his own papers, he named specimen after specimen, once again finding, in *Eriocera meleagris* O. S., a species which he had never hitherto seen but had correctly visualised from its description.

Though he never touched either identificatory or descriptive work in the family himself, his work in Oriental Culicidae stands as something apart from the rest of his activities. As an all-round Dipterist, he was aghast at the flood of unscientific general erection of the Theobaldian School, and in his three catalogues, (two devoted to Culicidae alone), and in his paper, 'Critical Review of Genera in Culicidae,' strove to render himself a Court of Appeal and lessen the mischief done by the Medical Entomologists of the day, replacing their synonyms by at least un-preoccupied names, irrespective of whether the genera thus re-named had validity or not. Though this part of his work has now only historical interest, it had value in its day as an attempt to stem the tide of unscientific procedure, and to bring the work of the 'Culicidologists' into line with the rest of Zoology.

Even whilst in India, he was not entirely centered on the Oriental Fauna. For years he kept a manuscript catalogue of Australian Diptera up to date, and it is to be hoped that the manuscript of this will be rendered fit for publication.

Brunetti confined himself entirely to the descriptive side of dipterology. For bionomics he had no interest. To tell him that you had

recently bred one of his species left him quite cold. He thus lies under the stigma of being 'typically museum minded', but at the epoch at which he appeared what was wanted as a pre-requisite to bionomical work was an out-and-out systematist, whose interest in an insect finished with the affixing of a correct name label, and biologists who will come after him will always have cause to bless one who saved them the drudgery of separating and identifying the species they may work with. '*Nomina Insectorum distincte tradere convenit. Nomina si pereunt, perit et cognitio rerum; nomina si confundantur, confundantur omnia necesse est.*'

Brunetti was an entomologist of the old school, relying up to the limit of its powers on a hand lens, (he had a $\times 50$ Zeiss with a working distance of about $\frac{1}{8}$ inch which it was always a wonder to me how he managed to use) and seldom concerning himself with genitalia in classification,—he told me " he loathed a dissected specimen," and in consequence in years to come many of his species in certain groups may prove complices, but his work will stand for all time as the foundation of our modern knowledge of Oriental Diptera. Though a *bon viveur* with a discriminative palate he cheerfully faced comparative poverty in pursuit of his life's interest, and his passing leaves a gap which it will be hard to fill. The circumstances of modern research confine it perforce more and more to its economic applications, and many of the families of flies he touched, and those he was forced through lack of time to leave in obscurity, will probably remain as they were left until their members are found in some fashion to come in contact with human activities. Peace be to his cheerful soul and laurels on the work he accomplished,—we may ne'er look on his like again.

R. S.-W

LIST OF BRUNETTI'S PAPERS.

1. Revision of the Oriental Stratiomyidae, with *Xylomyia* and its allies.
Rec. Ind. Mus. I, pp. 85-132 (1907).
2. Notes on Oriental Diptera.
Rec. Ind. Mus. I, pp. 163-170, 211-216, 381-385, pl. xv (1907).
3. Note on *Rutilia nitens*.
Rec. Ind. Mus. I, p. 172 (1907).
4. Annotated Catalogue of Oriental Culicidae.
Rec. Ind. Mus. I, pp. 297-377 (1907); IV, pp. 403-517 (1912).
5. Notes on Oriental Syrphidae with descriptions of new species.
Rec. Ind. Mus. II, pp. 49-96 (1908); XI, pp. 201-256, pl. xiii (1915).
6. Indian Psychodidae.
Rec. Ind. Mus. II, pp. 369-384 (1908).
7. Revision of the Oriental Leptidae.
Rec. Ind. Mus. II, pp. 417-436 (1909).
8. Revised and annotated catalogue of Oriental Bombylidae, with descriptions of new species.
Rec. Ind. Mus. II, pp. 437-492, pl. xii (1909).
9. New Indian Leptidae and Bombylidae, with a note on *Comastes*, Os. Sac., V. *Heterostylum*, Macq.
Rec. Ind. Mus. III, pp. 211-230 (1909).

10. New Oriental Sepsinae.
Rec. Ind. Mus. III, pp. 343-372, pl. xiii (1909).
11. Taxonomic Values in Culicidae.
Rec. Ind. Mus. IV, pp. 53-58 (1910).
12. Revision of the Oriental Bloodsucking Muscidae.
Rec. Ind. Mus. IV, pp. 59-93, pls. vii, viii (1910).
13. New Oriental Nemocera.
Rec. Ind. Mus. IV, pp. 259-316 (1911).
14. Synonymy in Corethrinae.
Rec. Ind. Mus. IV, pp. 317-318 (1911); VI, pp. 227-229 (1911).
15. Contributions to the Fauna of Yunnan. Part V.—Bibionidae and Mycetophilidae.
Rec. Ind. Mus. VI, p. 31 (1911).
16. Rivision of the Oriental Tipulidae with descriptions of new species.
Rec. Ind. Mus. VI, pp. 231-314 (1911); XV, pp. 255-310, pls. vii, viii (1918).
17. Description of *Aphiochaeta ferruginea*, a hitherto undescribed species of Phoridae that causes myasis in man.
Rec. Ind. Mus. VII, pp. 83-86 (1912).
18. New Oriental Diptera.
Rec. Ind. Mus. VII, pp. 445-513, pl. xxxvii (1912).
19. Note on the Life History of *Aphiochaeta ferruginea*.
Rec. Ind. Mus. VII, pp. 515-516 (1912).
20. Zoological Results of the Abor Expedition, 1911-12. Diptera.
Rec. Ind. Mus. VIII, pp. 149-190, pl. vi (1913).
21. New Indian Empidae.
Rec. Ind. Mus. IX, pp. 11-45 (1913).
22. New and Interesting Diptera from the Eastern Himalayas.
Rec. Ind. Mus. IX, pp. 255-277, pl. xiv (1913).
23. Critical Review of "Genera" in Culicidae.
Rec. Ind. Mus. X, pp. 15-73 (1914).
24. Diptera of the Simla District.
Rec. Ind. Mus. XIII, pp. 59-101 (1917).
25. Descriptions of two new species of Diptera from Seistan, Eastern Persia.
Rec. Ind. Mus. XVI, pp. 299-301 (1919).
26. Catalogue of Oriental and South Asiatic Nemocera.
Rec. Ind. Mus. XVII, pp. 1-300 (1920).
27. Second Revision of the Oriental Stratiomyidae.
Rec. Ind. Mus. XXV, pp. 45-180 (1923).
28. A new Indian Drosophilid Fly.
Rec. Ind. Mus. XXV, pp. 303-304 (1923).
29. Diptera of the Siju Cave—Tipulidae, Tabanidae, Anthomyidae, Acalyptrate Muscidae and Phoridae.
Rec. Ind. Mus. XXVI, pp. 99-106 (1924).
30. *Microdon apiformis* Brun. renamed.
Rec. Ind. Mus. XXVI, p. 153 (1924).
31. Some notes on Indian Syrphidae, Conopidae and Oestridae.
Rec. Ind. Mus. XXVII, pp. 75-79 (1925).

32. Notes on Oriental Bibionidae, with descriptions of new species.
Rec. Ind. Mus. XXVII, pp. 443-450 (1925).
33. Description of a new species of Oriental Stratiomyidae : also a change of name.
Rec. Ind. Mus. XXVII, p. 451 (1925).
34. Oriental Culicidae.
Canad. Entom. XLI, pp. 121, 122 (1909).
35. Review of our knowledge of the Oriental Diptera.
Jr. As. Soc. Bengal (n.s.) VI, pp. 135-140 (1910).
36. Some noxious Diptera rom Galilee.
Jr. As. Soc. Bengal (n.s.) IX, pp. 43-45 (1913).
37. Notes on Ceylon Diptera.
Spol. Zeylan. VI, pp. 170-172 (1910).
38. A new species of blood-sucking fly (*Simulium*) from Ceylon.
Spol. Zeylan. VIII, pp. 90-91 (1913).
39. A new Pipunculid parasitic on Leaf-hoppers in India.
Bull. Ent. Research, XII, p. 469, pl. xv, fig. 6 (1922).
40. Two new species of Tabanidae from Cuba.
Bull. Ent. Research, XIII, pp. 401-402 (1923).
41. Nouvelles espèces de Stratiomyidae de l'Indo-Chine recueilles par M. R. Vitalis de Salvaza.
Encyc. Ent. Ser. B. II, Dipt. I, pp. 67-71 (Paris, 1924).
42. New African Conopidae.
Ann. Mag. Nat. Hist. (9) XV, pp. 97-112 (1925) ; XVI, pp. 101-112 (1925).
43. The Fauna of British India. Diptera Nematocera. (London, 1912).
44. The Fauna of British India, Diptera Brachycera, Vol. I. (London, 1920).
45. The Fauna of British India. Diptera, Vol. III. Pipunculidae, Syrphidae, Conopidae, Oestridae. (London, 1923).

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