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DESCRIPTIONS OF SOME INDIAN AND MALAYAN MYRIAPODA CAMBALOIDEA.

By F. Silvestri.

In the collection of Myriapods of the Zoological Survey of India there are some Diplopoda Cambaloidea, which I think to belong to new species. I describe them in this note together with a species I received from Madras and two belonging to the Cambridge Museum.

Family TRACHYIULIDAE.

Two genera, *Trachyiulus* Peters and *Cambalopsis* Poc., have hitherto been referred to this family, but after study of the species here described I consider *Cambalopsis* to be a synonym of *Trachyiulus*, the differences pointed out by Pocock being neither very important nor constant; in fact the collum can have its posterior part carinate through the entire superficies as in *T ceylanicus* and *T modestior* or partly as in *T annectens*.

Trachyiulus ceylanicus Pet., subsp. **minor** nov.

(Fig. I.)

♀. Corpus plus minusve fuscum medio dorso, spatio angusto, ventre pedibusque rufescentibus.

Caput laevigatum, clypeo 5-dentato, oculis ocellis 5, uniseriatis compositis, antennis articulo quinto c. $\frac{1}{3}$ longiore quam ad apicem latiore.

Collum margine laterali latiusculo exciso sulcis integris duabus praemarginalibus integris, parte postica brevi tractu sulcis longitudinalibus inter sese aliquantum remotis, carinis parvis limitantibus, instructa, superficie cetera laevigata.

Trunci segmentum primum quam collum vix minus latum, praezona laevigata, metazona supra et lateraliter carinis parvis 17 instructa; segmenta 2^{um} et 3^{um} quam primum gradatim aliquantum angustiora; segmenta cetera praezona postice lineata; metazona supra inter tuberculo porigera carinis 5, sub tuberculis porigeris carinis 5, ceteris similibus, et carinis 2–3 obsoletis aucta, carinis omnibus sulco transversali parvo affectis; tuberculis porigeris latiusculis ovalibus quam carinae haud altioribus, a segmento quarto incipientibus. Sterna, ut praezonae parte antica, foveolis minutis instructa. Segmentum praeanale laevigatum, postice rotundatum valvulas anales vix superans. Valvulae anales immarginatae; lamina infraanalis lata, brevis, postice subtruncata.

Pedes breves setosi, ungue terminali magno, spina basali quam unguis totus fere triplo breviore.

Segmentorum numerus ad 65.

Long. corp. ad mm. 36, lat. colli 1·9, lat. segmenti vigesim 2, long. antennarum 1·96, pedum 1·60.

♂. Mandibularum stipes infra haud productus; hypostoma eidem feminae simile.

Pedes primi paris subcoxis coalitis mediis in processum longum antrorsum reversum productis et articulo alio quam subcoxarum processus medianus haud longiore, setis brevibus instructo, constituti.

Pedes secundi et tertii paris et organum copulativum vide fig. I, 7-8 et 11-12.

Habitat. Ceylon: Namunakuli (E. Green legit).

Observatio. Forma haec a specie typica ex Rambodde (Ceylan) statura saltem c. dimidio minore distincta est.

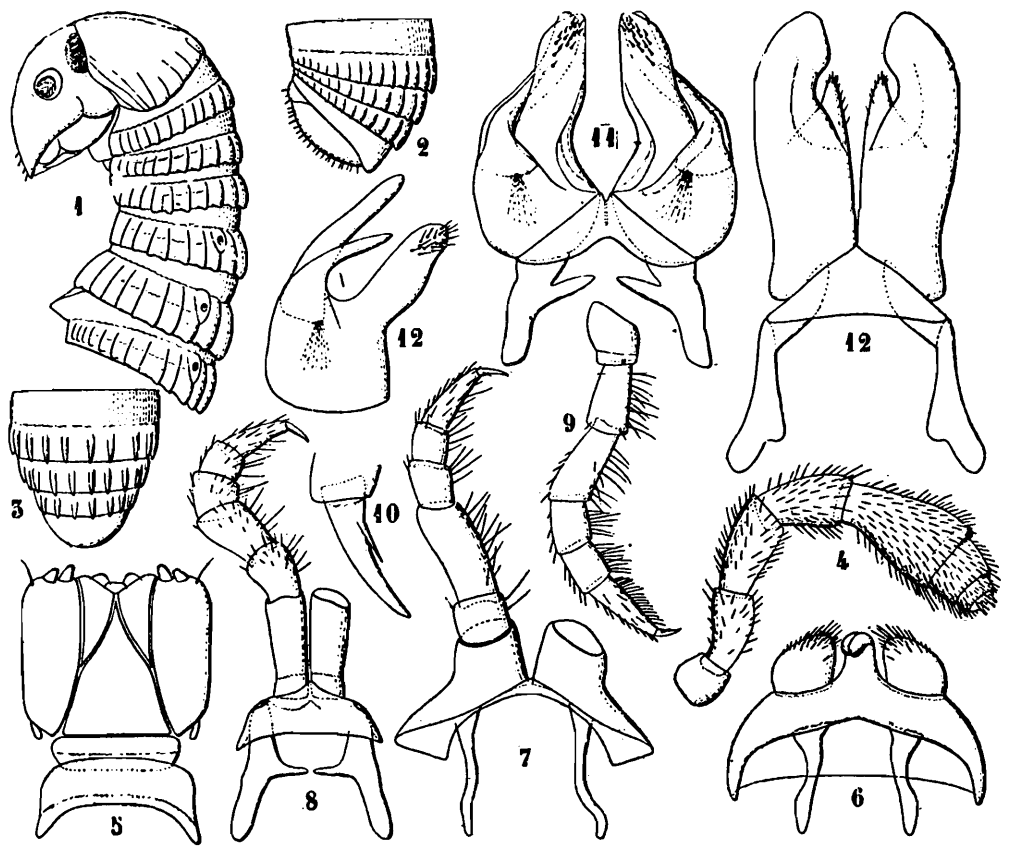

FIG. I.

Trachyiulus ceylanicus subsp. *minor*: 1. corporis pars antica lateraliter inspecta; 2. corporis pars postica lateraliter inspecta; 3. eadem prona; 4. antenna; 5. maris hypostoma; 6-8. maris pedum par primum, secundum et tertium antice inspecta; 9. pes paris decimi; 10. ejusdem pars apicalis; 11. organi copulativi pars antica antice inspecta; 12. organi copulativi pars postica antice inspecta.

Trachyiulus modestior, sp. nov.

(FIG. II.)

♀. Corpus fuscum, capite, collo, ventre pedibusque isabellinis.

Caput laevigatum, clypeo 5-dentato, oculis ocellis 4, uniseriatis compositis, antennis articulo quinto c. $\frac{1}{3}$ longiore quam ad apicem latiore.

Collum laevigatum postice breviter 6+6-carinatum, lateraliter carina integra submarginali, margine laterali postice parum sinuato.

Trunci segmenta 1–3 carinis 11 et carinis 2–3 lateralibus inferis obsoletis; segmenta cetera inter poros carinis 5, sub poris carinis 4 et carinis 2–3 minoribus aucta, carinis omnibus a segmento tertio ad 4-ultimo transverse sulcatis; tuberculis porigeris prominulis crassiusculis. Sterna minutissime foveolata. Segmentum praeanale laevigatum postice rotundatum, valvulas anales spatio brevissimo superans.

Valvulae anales immarginatae, parum convexae; lamina infraanalis brevis, lata, postice subtruncata.

Pedes breves setis parum numerosis sat longis, ungue terminali seta antica quam unguis totus fere dimidio breviore.

Segmentorum numerus 50.

Long. corp. mm. 18, lat. corp. 1·1, long. antennarum 0·96, pedum paris decimi 0·85.

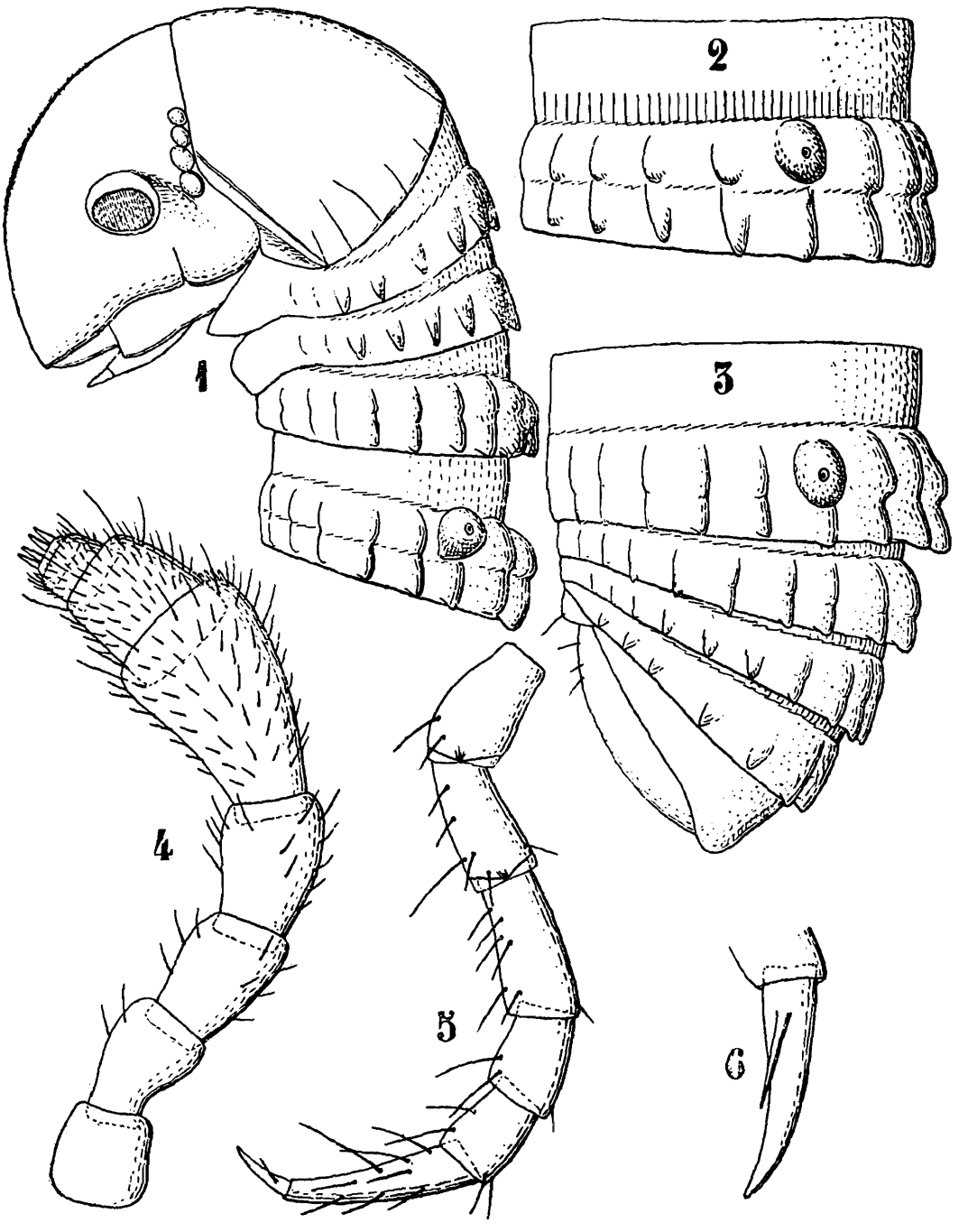

FIG. II.

Trachyiulus modestior: 1-3. corporis pars antica, segmentum 20^{um} et corporis pars postica lateraliter inspecta; 4. antenna; 5. pes paris decimi; 6. ejusdem pars apicalis.

Habitat. Exemplum descriptum tantum vidi ad Forest Tramway, mile 10 to 14, alt. 0-300 ft., Cochin State, collectum (F. Gravely).

Observatio. Species haec ad *T ceylanicus* proxima est, sed statura multo minore, carinis lateralibus minus numerosis et pedum unguium seta antica aliquantum longiore distincta est.

Trachyiulus annectens, sp. nov.

(FIG. III.)

♀. Corpus subcastaneum lateraliter fuscescens, capite, ventre pedibusque terreis.

Caput laevigatum clypeo 5-dentato, oculis ocellis 4, uniseriatis compositis, antennis articulo quinto parumminus quam duplo longiore quam ad apicem latiore.

Collum quam caput parum latius, bene convexum supra laevigatum, tantum lateraliter et postice carinatum, margine laterali latiusculo postice sat profunde sinuato, carina submarginali integra duabus parum remotis sat longis, 3 brevissimis vix elevatis, medio dorso carinis nullis.

Trunci segmentum primum quam collum parum minus latum, praezona laevigata, metazona supra et lateraliter carinis parvis 15

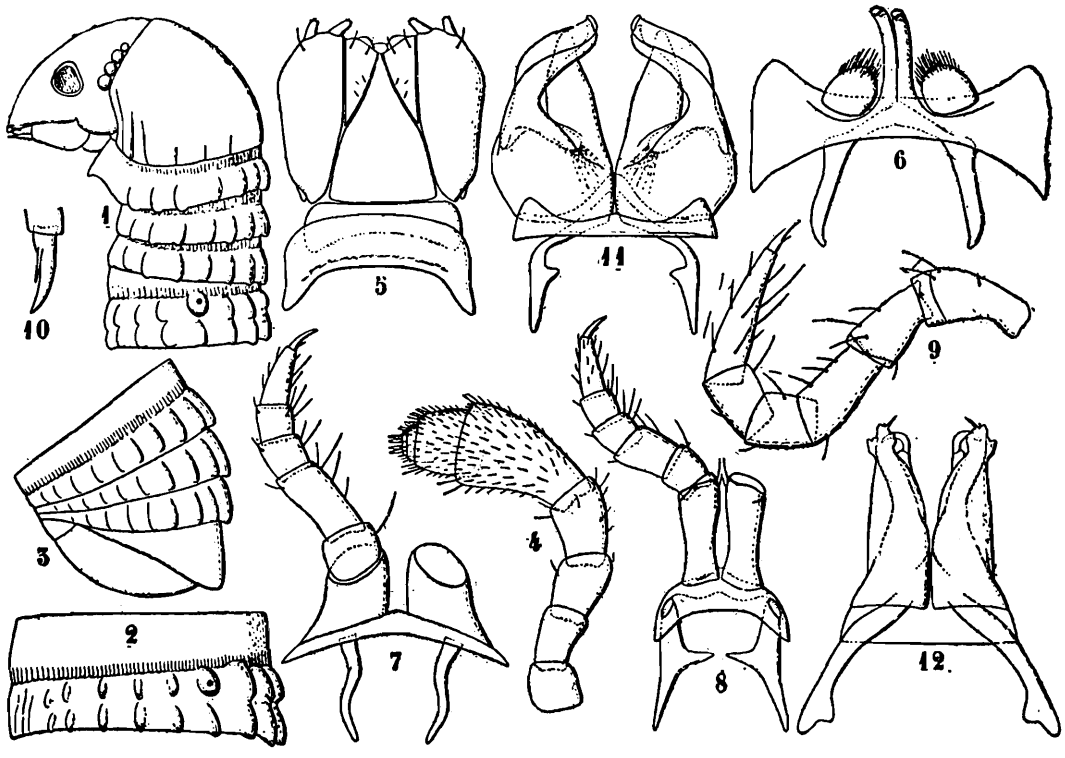

FIG. III.

Trachyiulus annectens: 1-3. corporis pars antica, segmentum 20^{um} et corporis pars postica lateraliter inspecta; 4. antenna; 5. maris hypostoma; 6-8. maris pes primi, secundi et tertii paris antice inspecta; 9. pes paris decimi; 10. ejusdem pars apicalis; 11. organi copulativi pars antica antice inspecta; 12. organi copulativi pars postica postice inspecta.

instructa; segmenta porigera metazona carinis 5 inter poros, carinis 4–5 sat evolutis et 2–3 plus minus obsoletis vel striis sub poris aucta, carinis a segmento tertio transversaliter profunde sulcata; tuberculis porigeris prominulis a segmento quarto ad 5-ultimum distinctis. Segmentum praeanale laevigatum, postice rotundatum, valvulas anales vix superans. Valvulae anales immarginatae; lamina infraanalis, brevis, lata, postice subtruncata.

Pedes breves setis paucis sat longis instructi, ungue terminali seta antica quam unguis totus parum magis quam dimidio breviore. Sterna ut segmentorum praezona vix foveolata vel sublaevigata.

Segmentorum numerus ad 58

Long. corp. ad mm. 23, latitudo colli 1·3, lat. segmenti vigesimi 1·4, long. antennarum 0·96, pedum paris decimi 0·75.

♂. Hypostoma eidem feminae simile. Pedes primi paris biarticulati, brevissimi, subcoxis coalitis mediis in processus duos angustos antrorsum curvatos sat longos, et externe triangulariter aliquantum productis et articulo secundo brevissimo apice setoso constituti; pedes secundi et tertii paris et organi copulativi pars antica et postica vide fig. III, 7-8 et 11-12.

Habitat. Exempla nonnulla vidi ad Madras collecta.

Observatio. Species haec ad *T. tyampeanus* (Attems) proxima est, sed clypeo tantum 5-dentato, metazonarum carinarum numero minore et maris pedum primi paris et organi copulativi forma bene distincta est.

Trachyiulus heteropus, sp. nov.

(FIG. IV.)

Cambala calva, Poc., var. nov., Sinclair, *Proc. Zool. Soc. London* 1901, p. 522.

♀. Corpus (in alcool) isabellinum totum.

Caput laevigatum clypeo dentibus 5 parvis instructo, oculis ocel-

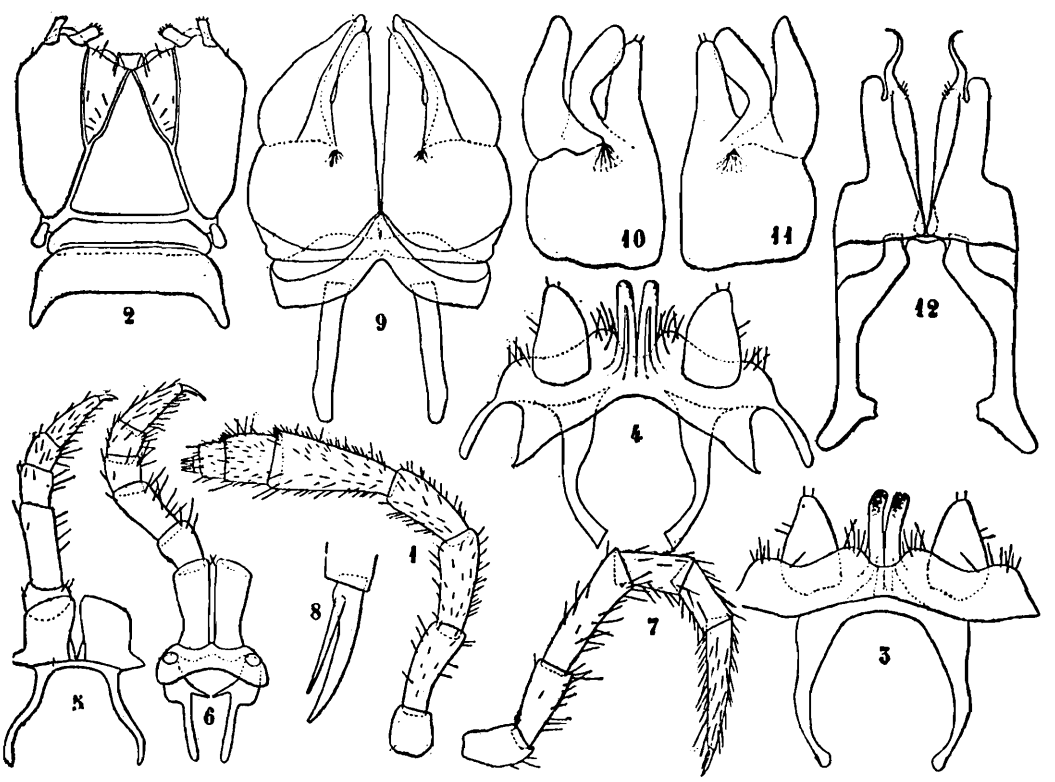

FIG. IV.

Trachyiulus heteropus, mas: 1. antenna; 2. hypostoma; 3-4. pes primi antice et postice inspectus; 5-6. pedes secundi et tertii paris antice inspecti; 7. pes paris decimi; 8. ejusdem pars apicalis; 9. organi copulativi pars antica antice inspecta; 10-11. organi copulativi dimidia pars dextera postice et antice inspecta; 12. organi copulativi pars postica antice inspecta.

lis 3, uniseriatis compositis, antennis elongatis, articulo quinto duplo longiore quam ad apicem latiore.

Collum supra laevigatum, margine laterali latiusculo stria marginali integra et alia abbreviata instructum, parte laterali inflexa postice aliquantum sinuata.

Trunci segmentum primum et secundum metazona carinis perparvis 9+9 instructa, segmenta cetera metazona supra, inter poros, carinis 5 parum elevatis, transverse vix sulcatis, et sub poris carinis 7 gradatim minoribus; tuberculis porigeris quam carinae parum magis prominentibus, circumlitione subovalibus, a segmento quarto ad penultimum sistentibus; praezona minutissime areolata, postice lineata. Sterna minutissime areolata. Segmentum praeanale laevigatum, postice rotundatum valvulas anales vix superans. Valvulae anales vix marginatae, convexiusculae; lamina infraanalis lata, brevis, postice truncata.

Pedes elongati, setosi, ungue terminali magno, spinula basali antica quam unguis totus fere $\frac{1}{3}$ breviore.

Segmentorum numerus 48.

Long. corp. ad mm. 20, lat. colli 1·2, lat. segmenti vigesimi 1·4, long. antennarum 1·70, pedum paris decimi 1·20.

♂. Mandibularum stipes infra haud productus angulo antico infero subrecto; hypostoma eidem feminae simile.

Pedes primi paris subcoxis coalitis brevibus latis, interne in processum longum angustum productis et ad latus internum articuli secundi in laminam brevem rotundatam setis nonnullis instructa productis, angulo infero laterali rotundato, articulo secundo brevi, subconico, setis duabus apicalibus et duabus lateralibus externis instructo.

Pedes secundi et tertii paris et organi copulativi pars antica et pars postica vide fig. IV, 5-6, 9-12.

Habitat. Peninsula Malayana: Jalor, Patani. Exempla vidi tres a Cantabrigense Museo mihi donata sub nomine *Cambala calva* var. nov.

Observatio. Species haec ad *T annectens* proxima est, sed collo carinulis tantum lateralibus, praetarsi spinula antica longiore et maris notis bene distincta est.

Trachyiulus proximatus, sp. nov.

(FIG. V.)

♂. Corpus fuscescens dorso linea longitudinali angustiore nigra, ventre pedibusque terreis.

Caput laevigatum clypeo 4-dentato, oculis ocellis 4, uniseriatis compositis, antennis articulo quinto fere dimidio longiore quam ad apicem latiore, mandibularum stipite in processum longum, angustum, acutum producto; hypostomate basilare magno.

Collum quam caput parum latius supra etiam postice laevigatum, margine laterali lato parum sinuato, stria submarginali et alia paullum remota subintegris et stria brevi instructum.

Trunci segmentum primum quam collum parum minus latum, praezona laevigata, metazona supra et lateraliter carinis perparvis 17 instructa, segmenta porigera metazona carinis 5 inter poros carinis 5 sat evolutis, et 3–4 obsoletis sub poris aucta, carinis transversaliter allquantum profunde sulcatis; tuberculis porigeris prominulis a segmento quarto incipientibus usque ad segmentum 4-ultimum distinctis. Sterna, ut praezona parte antica, minutissime foveolata. Segmentum praeanale laevigatum, postice rotundatum valvulas anales vix superans. Valvulae anales immarginatae, lamina infraanalis lata postice late rotundata.

Pedes breves setis parce instructi, ungue terminali seta antica quam unguis totus c. dimidio breviore ; pedes primi paris articulo secundo elongato apice setoso, subcoxis coalitis lateraliter in processum longum latiusculum extrorsum aliquantum vergentem productis, mediis in processus duos angustos dimidia parte proximali connatos, apice antrorsum parum reverso.

Pedes secundi paris et tertii et organi copulativi pars antica et postica vide fig. V, 7-8 et 11-12.

Segmentorum numerus 50.

Long. corp. 20, ejusdem lat. 1·5, long. antennarum 1·20, pedum paris vigesimi 0·90.

Habitat. Exemplum typicum ad Barkuda, Chilka Lake (Chilka Survey, 1914) lectum est.

Observatio. Species haec ad *T. mimus* Silv. affinis, sed collo minus inflato nec non pedum primi paris et organi copulativi forma distinctissima est.

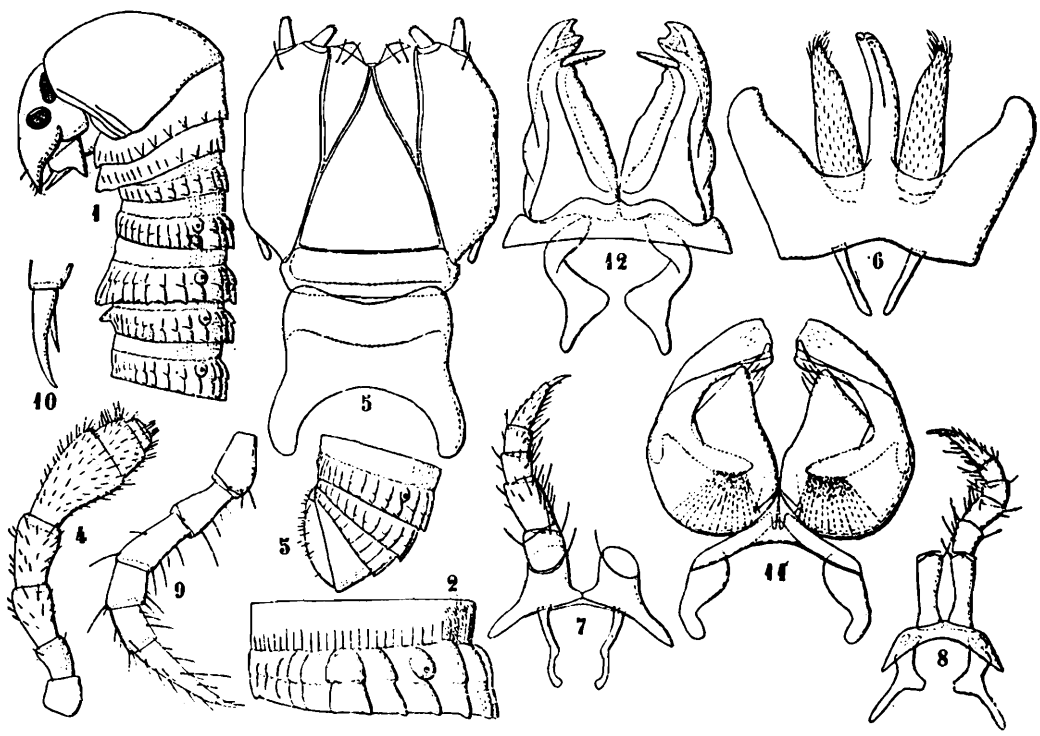

FIG. V.

Trachyiulus proximatus, mas : 1-3. corporis pars antica, segmentum 20^{um} et corporis pars postica lateraliter inspecta ; 4. antenna ; 5. hypostoma ; 6-8. pedes primi, secundi et tertii paris antice inspecti ; 9. pes paris decimi ; 10. ejusdem pars apicalis ; 11. organi copulativi pars antica antice inspecta ; 12. organi copulativi pars postica antice inspecta.

Trachyiulus pauper, sp. nov.

(FIG. VI.)

♀. Corpus fuscum ventre pedibusque rufo-castaneis.

Caput laevigatum tantum lateraliter carinula integra submarginali, alia abbreviata et alia breviore instructum, margine laterali postice parum sinuato.

Trunci segmenta primum et secundum metazona medio dorso laevigato, lateraliter carinis perparvis 4–5 instructa. Segmenta cetera metazona inter poros carinis 5, sub poris carinis 3–4 parvis, carinis a

segmento quarto transverse sulcatis; tuberculis porigeris sat brevibus, crassiusculis a segmento quarto usque ad 4-ultimum sistentibus. Sterna minute foveolata.

Segmentum preanale laevigatum, postice rotundatum valvulas anales spatio brevi superans; valvulae anales elongatae, immarginatae, parce convexae; lamina infraanalis brevis, lata, postice subtruncata.

Pedes breves setis parum numerosis longiusculis, ungue terminali seta antica quam unguis totus c. dimidio breviore.

Segmentorum numerus 64.

Long. corp. mm. 30, lat. corp. 1·3, long. antennarum 1·30, pedum paris decimi 1·10.

Habitat. Exemplum typicum lectum fuit ad Chilcada, 3,644 ft. (N. B. Kinnear).

Observatio. Species haec ad *T nordquisti* (Attems) proxima est, sed clypei dentium numero, carinis sub poris minoribus et paucioribus, segmentis praeanali et anali magis elongatis distincta est.

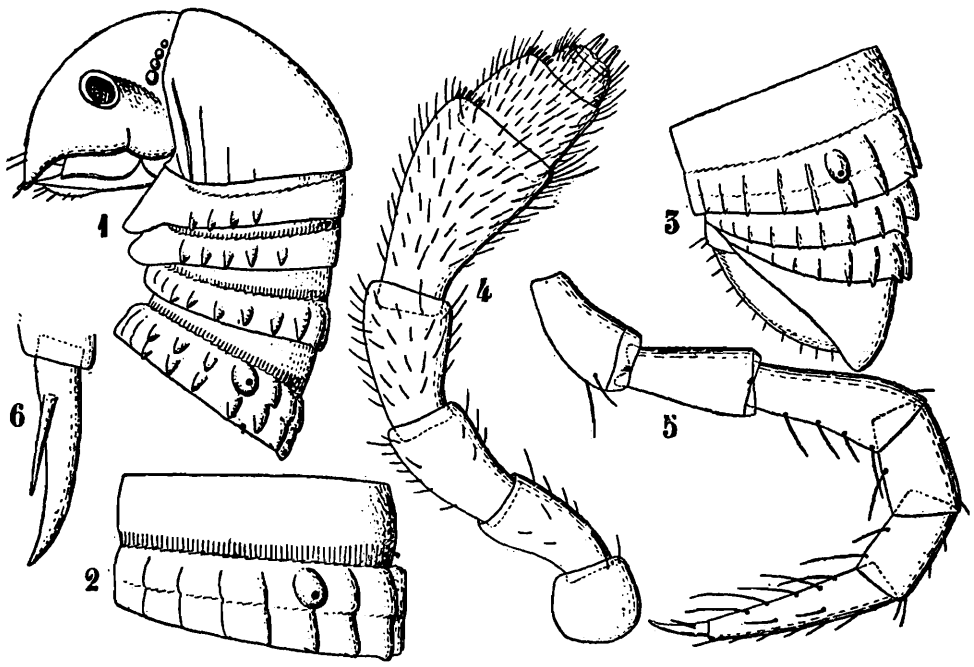

FIG. VI.

Trachyiulus pauper: 1-3. corporis pars antica, segmentum 20^{um} et corporis pars postica lateraliter inspecta; 4. antenna; 5. pes paris decimi; 6. ejusdem pars apicalis.

Family CAMBALIDAE.

One genus and a subgenus of Cambalidae having the body carinate have been described from Oriental countries, viz.: *Glyphiulus* subgen. *Podoglyphiulus* Attems and *Cambalomorpha* Pocock. The differences between *Glyphiulus* and *Cambalomorpha* were tabulated by Pocock thus :—

(*a*) Segments with 11 (12) bituberculiform crests—three on each side below the poriferous crest and on the dorsal area three tubercles behind and four in front	*Glyphiulus* Gerv.
(*b*) Segments with only 9 crests—three between the poriferous crests and two on each side below them	*Cambalomorpha* Poc.

It appears to me that the differences are not so great, particularly in view of the fact that the two median tubercles of the anterior part of the tergites unite in the three posterior segments of the body in such a way that the number of crests between the poriferous is three as in *Cambalomorpha*. The crests of the collum are also interrupted in *Glyphiulus* in the median part of the dorsum and are also long and two in number anteriorly, short and three in number posteriorly. I am inclined to consider *Cambalomorpha* at most as a subgenus of *Glyphiulus*. The subgenus *Podoglyphiulus* differs from *Cambalomorpha* in the characters of the first pair of legs of the male only.

Glyphiulus (Podoglyphiulus) elegans, sp. nov.

(FIG. VII.)

♀. Corpus fusco-castaneum medio dorso fascia angusta longitudinali rufescente carinis nigris, ventre pedibusque rufis.

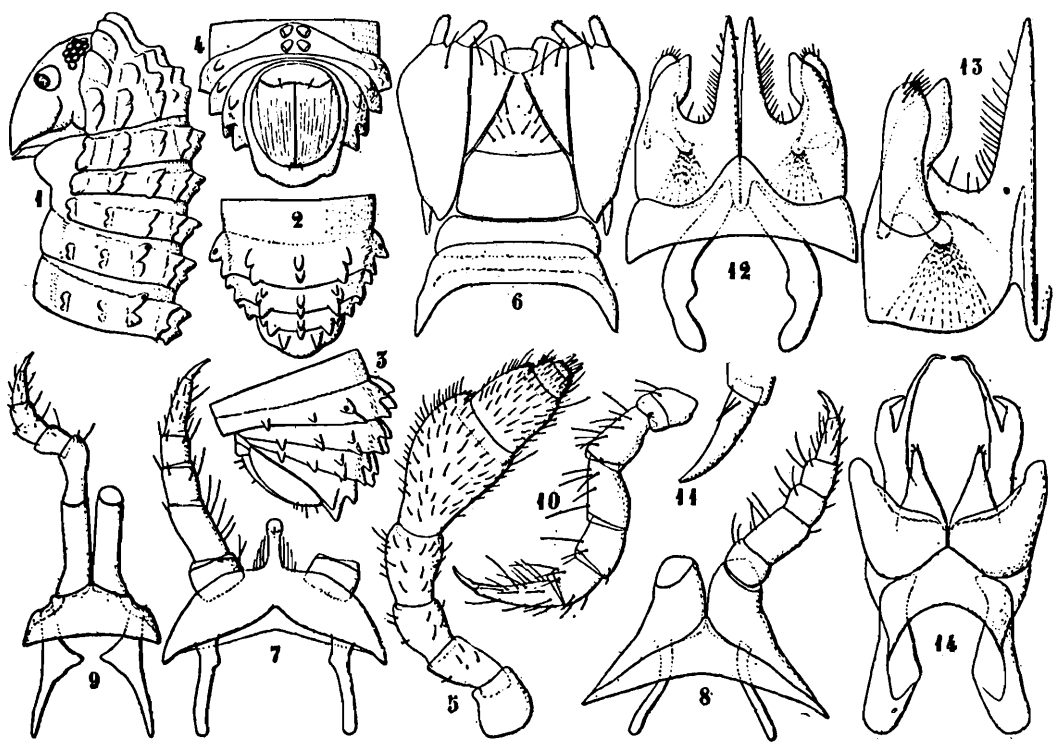

FIG. VII

Glyphiulus (*Podoglyphiulus*) *elegans*: 1. corporis pars antica lateraliter inspecta; 2-4. corporis pars postica supra, lateraliter et subtus inspecta; 5. antenna; 6. maris hypostoma; 7-9. maris pedes primi, secundi et tertii paris antice inspecti; 10. pes paris decimi; 11. ejusdem pars apicalis; 12. organi copulativi pars antica antice inspecta; 13. ejusdem dimidia pars postice inspecta; 14. organi copulativi pars postica antice inspecta.

Caput laevigatum, clypeo 3-dentato, oculis ocellis parvis 10-11, inter sese parum remotis compositis, antennis articulo quinto aliquantum minus quam duplo longiore quam ad apicem latiore.

Collum antice carinis 10 longitudinalibus integris sat magnis instructum, postice carinis 9 transverse profunde sulcatis et in medio dorso transversaliter serie tuberculis subacutis 7 aucto, margine laterali latiusculo paullum sinuato.

Trunci segmentum primum metazona carinis 9 transverse aliquantum divisis ; segmentorum secundi et tertii metazona eidem primi subsimili ; segmenta cetera carinis tribus inter poros, carinis duabus sub poris, carinis omnibus profunde divisis, parte postica quam antica minore ; tuberculis porigeris sat brevibus, parum incrassatis, a segmento quinto usque ad 4-ultimum sistentibus. Sterna ut praezonae partis anticae et metazonarum superficies minute foveolata.

Segmentum praeanale supra tuberculis duobus longiusculis subconicis basalibus submedianis armatum, postice latum trilobatum lobo mediano quam ceteri latiore, valvulas anales spatio brevi superans. Valvulae anales immarginatae, maxima pro parte rugoso-sulcatae ; lamina infraanalis lata, brevis, margine medio parum sinuato.

Pedes breves, setis haud numerosis sat longis instructi, ungue terminali seta antica quam unguis totus c. ¾ breviore.

Segmentorum numerus ad 62.

Long. corp. ad mm. 25, lat. corp. 1·5, long. antennarum 1·10, pedum paris decimi 0·70.

♂. Hypostoma eidem feminae simile.

Pedes primi paris articulis 5 liberis et ungue bene evoluto, subcoxis coalitis processu mediano sat longo, parum spatuliformi instructis.

Pedes secundi et tertii paris, organi copulativi pars antica et postica vide fig. VII, 8-9 et 12-14.

Habitat. Satara District: Koyna Valley, c. 2,100 ft., et Nechal, W Ghats, c. 2,000 ft.

Observatio. Species haec ad *Glyphiulus* (*Podoglyphiulus*) *ceylanicus* Attems proxima est, sed segmenti praeanalis et maris organi copulativi forma bene distincta est.

Glyphiulus (Cambalomorpha) superbus, sp. nov.

(FIGS. VIII-IX.)

♀. Corpus fusco-castaneum ventre pedibusque rufo-terreis.

Caput laevigatum, clypeo breviter 6-dentato, oculis magnis, transversis, ocellis c. 50 parvis, haud bene seriatis, et inter sese paullum remotis compositis, antennis articulis 2–4 elongatis inter sese subaequantibus, articulo quinto fere duplo longiore quam ad apicem latiore.

Collum supra carinatum carinis 4 medianis anticis pone medium collum desinentibus et carinis 3 medianis posticis brevioribus, carinis submedianis duabus integris, carina sublaterali integra et carina abbreviata antica inter carinam lateralem et carinas submedianas auctum, margine laterali parum sinuato angulo postico subacuto.

Trunci segmentum primum metazona medio dorso carinis parvis 3, lateraliter carinis 3 quarum infera quam ceterae parum major est ; segmenti secundi et tertii metazonae eidem primi similes sed tertii carinis transverse magis sulcatis ; segmenta cetera metazonis medio dorso carinis tribus, lateraliter utrimque carinis quatuor, carinis omnibus transverse profunde lobatis, carinarum medii dorsi parte antica quam postica minori et carinarum lateralium parte antica quam postica majore ; tuberculis porigeris carinae superae lateralis partem anticam longiusculis, subconicis usque ad segmentum 4-ultimum distinctis ;

praezonis antice sublaevigatis postice parum verrucosa et ad metazona breviter lineata. Sterna sublaevigata.

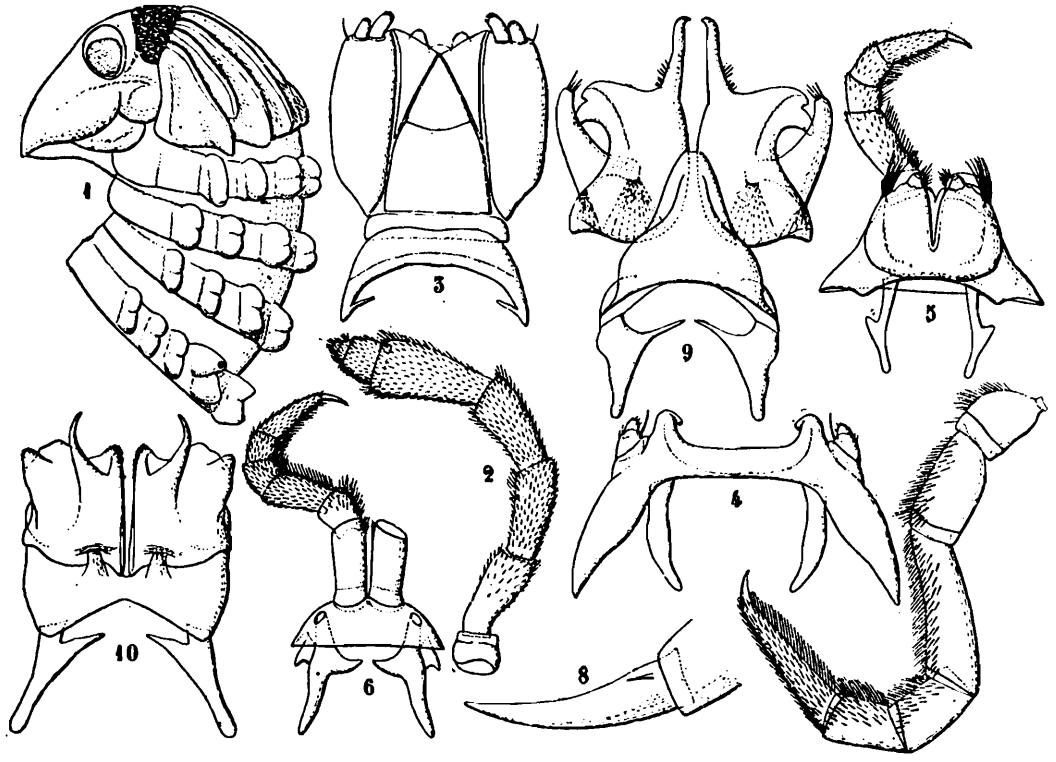

FIG. VIII.

Glyphiulus (*Cambalomorpha*) *superbus*: 1. corporis pars antica lateraliter inspecta; 2. antenna; 3. maris hypostoma; 4-5. maris pes primi et secundi paris postice inspecti; 6. pedes tertii paris antice inspecti; 7. pes paris decimi; 8. ejusdem pars apicalis; 9. organi copulativi pars antica antice inspecta; 10. organi copulativi pars postica antice inspecta.

Segmentum praeanale supra medium crasse carinatum, antice utrimque vix tuberculatum, margine postico obtuse angulato valvulas anales parvo spatio superans; valvulae anales marginatae ad marginem profunde sulcatae, cetera; superficie sulcata; lamina infraanalis breviore, lata, postice subrecte truncata.

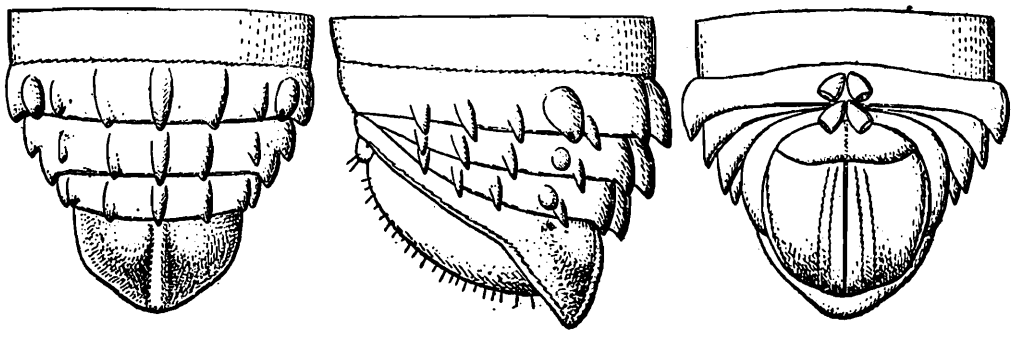

FIG. IX.

Glyphiulus (*Cambalomorpha*) *superbus*: corporis pars postica supra, lateraliter et subtus inspecta.

Pedes infra breviter persetosi, ungue terminali longo et seta antica breviore.

Segmentorum numerus ad 79.

Long. corp. ad mm. 85, lat. corp. 5, long. antennarum 4·2, pedum paris decimi 4.

♂. Hypostoma (Fig. VIII, 3) eidem feminae simile.

Pedes primi paris brevissimi articulis liberis duobus coalitis ad latum internum articuli secundi in processum quam articuli secundus et tertius aliquantum longior et antrorsum curvatus productis.

Pedes secundi et tertii paris et organi copulativi pars antica et postica vide fig. VIII, 5-6 et 9-10.

Habitat. Dalat, Langbian Province, South Annam, 5,000 ft. (C. Boden Kloss, March–May 1918).

Observatio. Species haec inter omnes hucusque descriptas magnitudine, carinarum forma, maris notis distinctissima est.

Glyphiulus (Plusioglyphiulus) cavernicolus, sp. nov.

(Fig. X.)

♀. Corpus pallide testaceum totum.

Caput laevigatum clypeo breviter 4-dentato, oculis ocellis parvis 5, biseriatis (4 +1) compositis, antennis articulo quinto parum minus quam duplo longiore quam ad apicem latiore.

Collum supra bene carinatum, carinis integris 5+5, praeter marginalem, et carinis 2+2 marginem anticum haud attingentibus inter tertiam et quartam, quartam et quintam sistentibus, margine laterali latiusculo, carinula marginali aucto, margine laterali postico infra parum producto.

Trunci segmentum primum metazona carinis 15 sat magnis dorsualibus subintegris, lateralibus transverse sat profunde divisis; segmenta secundum et tertium metazonae parte postica carinis tantum instructa, carinis dorsualibus parvis integris tuberculiformibus, lateralibus transverse profunde divisis; segmenta cetera usqua ad 5-ultimum metazona inter poros carinis 5 transverse profunde separatis bituberculiformibus et sub poris carinis 3 etiam tuberculiformibus acutis, tuberculo pone poros acuto, segmenta 4-ultimum ad penultimum carinis gradatim integris; tuberculis porigeris subcylindraceis quam carinae paullum brevioribus a segmento quarto ad segmentum 4-ultimum sistentibus; praezona postice areolis latiusculis, cetera superficie areolis minutissimis; sterna etiam areolis minutissimis.

Segmentum praeanale supra tuberculis duobus submedianis anticis instructo, postice late rotundato.

Valvulae anales marginatae et superficie lata interna subplana; lamina infraanalis lata brevis, postice paullum sinuata.

Pedes breves ungue terminali robusto simplici, spinula antica destituto (tantum in maris paris tertii pedibus spinulam brevissimam vidi).

Segmentorum numerus ad 56.

Long. corp. ad mm. 24, lat. corp. 1·5, long. antennarum 1·40, pedum paris decimi 1·15.

♂. Mandibularum stipites infra haud producti; hypostoma eidem feminae simile.

Collum et trunci segmenta primum et secundum aliquantum inflata.

Pedes primi paris biarticulati, pedes secundi paris quam ceteri multo crassiores, ungue minimo forma vide fig. X, 4.

Pedes paris tertii et organi copulativi pars antica et pars postica vide fig. X, 5 et 11-12.

Habitat. Bidi Caves (Cambridge Museum).

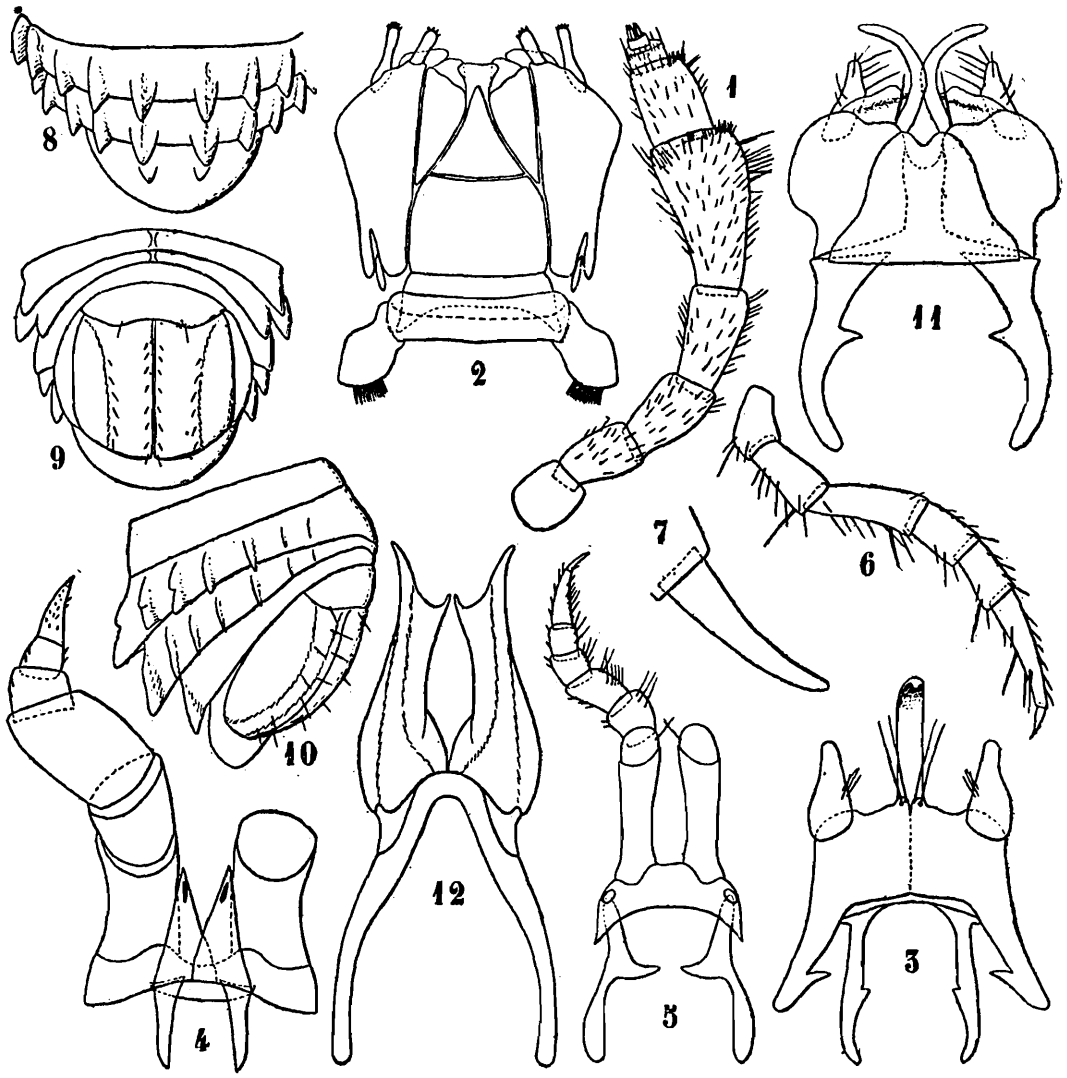

FIG. X.

Glyphiulus (*Plusioglyphiulus*) *cavernicolus*, mas: 1. antenna; 2. hypostoma; 3. pedes primi paris antice inspecti; 4. pedes secundi paris cum penibus postice inspecti; 5. pedes terti paris antice inspecti; 6. pes paris decimi; 7. ejusdem pars apicalis; 8-10. corporis pars postica supra, subtus et lateraliter inspecta; 11. organi copulativi pars antica antice inspecta; 12. organi copulativi pars postica antice inspecta.

Observatio. Species haec a ceteris generis *Glyphiulus* carinarum numero inter poros praesertim distinctissima est et subgeneri novo *Plusioglyphiulus* nov. appellando referenda est. Maris pedum primi et secundi paris forma etiam sigularis est.

A BLIND AMPHIPOD FROM A MINE IN BENGAL.

By CHAS. CHILTON, *M.A., D.Sc., F.L.S., Professor of Biology, Canterbury Museum, Dunedin.*

Dr. Annandale, Director of the Zoological Survey of India, has been good enough to send me a number of blind Amphipoda from a coal mine in Bengal which had been sent to the Indian Museum by Dr. John W Tomb, Chief Sanitary Officer, Asansol Mines Board of Health, with the following information:—

"I am informed by the Manager of the Jamuria Colliery that the pit in which these Crustacea were found is 300 feet deep. Jamuria Colliery is situated in the thana of Jamuria in the Asansol Sub-Division."

There are many specimens, all of the small size, about 5 mm. long; they are delicate and fragile and unfortunately many of the appendages had broken off in transit. There is no trace of eyes and although the specimens do not agree quite closely in all points with the definition of *Niphargus* as given by Stebbing[1] they are sufficiently near to be placed under that genus for the present.

The following brief description and figures will probably be sufficient for their identification.

Niphargus indicus, sp. nov.

Body slender, dorsal surface with a few fine scattered hairs, one or two stouter setules on each of pleon segments 4, 5 and 6.

No trace of eyes seen.

Antennae about one-third the length of the body, first rather longer than second, the first two joints of its peduncle subequal, the third shorter; flagellum with about 18 joints, accessory flagellum of two small joints; second antenna with last joint of peduncle a little shorter than the preceding; flagellum of about 7 joints. Mouth parts on the whole normal but the palp of the mandible has the third joint rather shorter than the second, and in the lower lip the inner lobes were not made out; the inner lobe of maxilla 1 is small, slender, tapering and bears 2 or 3 setae as in typical species of the genus.

The first gnathopod shorter and stouter than the second, its basal joint broad, carpus with hinder margin produced into a lobe bearing several setae, propod oval, about the same size as the carpus, palm oblique, slightly convex.

The second gnathopod long, basal joint not broadened, merus produced posteriorly into a rounded lobe, carpus with lobe as in the first gnathopod, propod rather longer and broader than the carpus, narrow at base, widening distally, the palm transverse, distinctly marked off from the rounded lobe at the end of the short acute dactyl.

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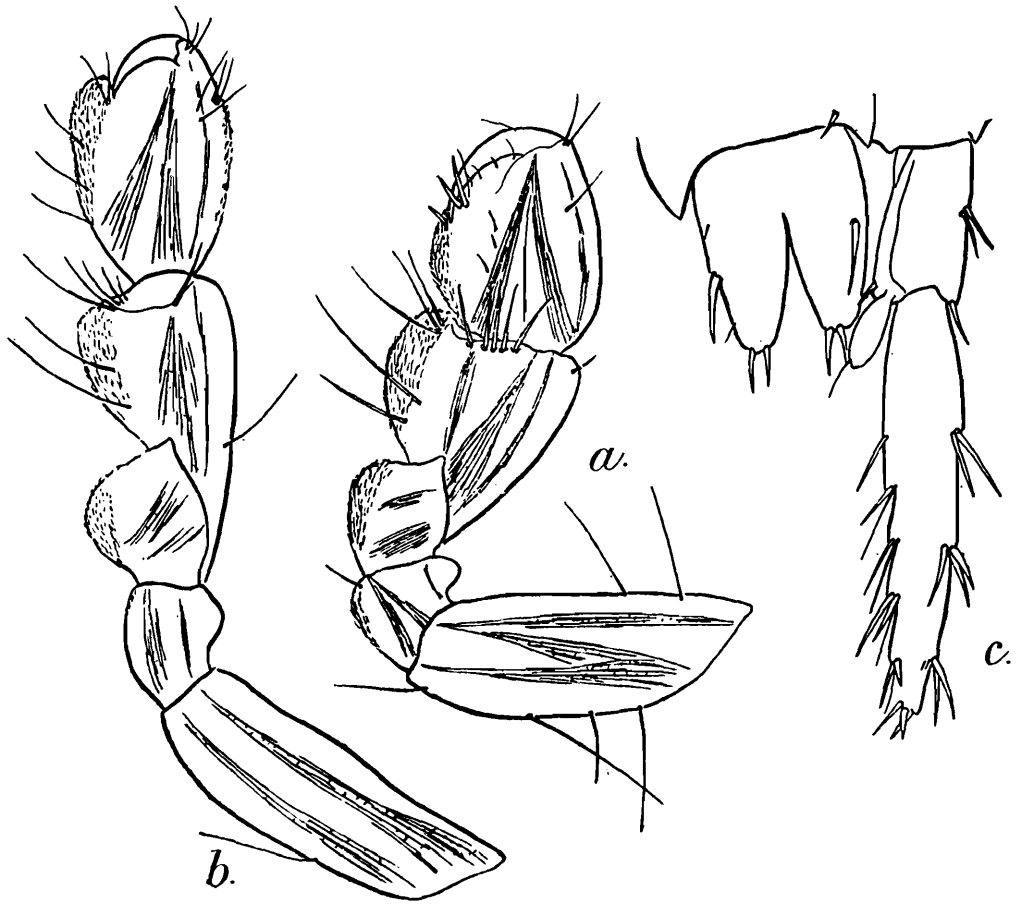
[1] Das Tierreich, Amphipoda, p. 405.

In both gnathopoda the posterior surface of the merus, carpus and propod is thickly covered with fine, minute setae.



Niphargus indicus, sp. nov.
a. First gnathopod. *b*. Second gnathopod. *c*. Third uropod and telson.

First and second peraeopods slender, rather shorter than the third; third, fourth and fifth peraeopods long, increasing successively in length; in all the basal joint is well broadened, oval, its posterior margin fringed with small setae.

The third uropod not greatly elongated, its peduncle not reaching to the end of the telson; outer branch about twice as long as the peduncle, formed of one joint only or with the terminal joint small and not clearly marked, both margins bearing 3 or 4 tufts of setae; inner branch very small with 1 or 2 minute setae at the extremity.

Telson very deeply cleft, each lobe narrowing posteriorly, the rounded end furnished with 2 setae, a stout seta (or sometimes two) situated near middle of outer margin of each lobe.

Length—5 mm.

Colour.—Whitish.

Locality.—In Jamuria Colliery, 300 ft. deep, Asansol, Bengal.

A FURTHER NOTE ON *ILISHA PARTHENOGENETICA* SOUTHWELL AND PRASHAD, 1918, A CESTODE PARASITE OF THE INDIAN SHAD.

By T. SOUTHWELL, *M.Sc., A.R.C.Sc. and* B. PRASHAD, *D.Sc.*

When describing this parasite in 1918 we believed that we were dealing with an adult degenerate Cestode that was peculiar in having a special mode of reproduction, viz., parthenogenetic reproduction. We have recently re-examined the original material and some fresh material and have again fully considered, in view of our further work, whether the conclusions then arrived at were justified.

The method of reproduction exhibited by this worm is very similar to the production of the germ-balls in the sporocysts of Trematodes like *Fasciola hepatica*. The resemblance, however, is purely superficial, for whereas in *I. parthenogenetica* the parthenogenetic development leads directly to the production of forms exactly similar to the parental form, in the Trematode the asexual reproduction results in the formation of rediae, and finally of cercariae, both of which are very different from the sporocyst in which they are produced.

The exact manner in which endogenous embryos arise in larval Cestodes described by Hornell (1901), Willey (1907) and Southwell (1910) is not known, as in all these cases the endogenous larvae were described from fully developed forms and in no case had the intermediate stages been observed. In the parasite of the Indian Shad, however, we were fortunate in being able to study the development of the parthenogenetically developed forms. The method of endogenous reproduction, described by the authors referred to above, does not materially differ from what occurs in *I. parthenogenetica*, and as a result of our recent work, we are of opinion that the parasite of the Indian Shad is not an adult degenerate Cestode but a Plerocercoid larva, the adult of which is unknown.

The larvae described by Hornell, Willey and Southwell were all found in the Pearl Oyster (*Margaritifera margaritifera* Linn.) or the Window-pane Oyster (*Placuna placenta* Linn.) of Ceylon. Haswell and Hill (1894) had previously described a similar worm with an identical mode of reproduction from an Australian earthworm. The only two instances of the occurrence of such asexual modes of reproduction in the Cestode parasites of the Vertebrates are those described by Ijima (1905) and Beddard (1912). The parasite of the Indian Shad provides the first instance of endogenous reproduction taking place in a Plerocercoid form found parasitic in any fish.

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ON THE ANATOMY OF *INDOPLANORBIS EXUSTUS* (MOLLUSCA PULMONATA).

By H. Srinivasa Rao, *M.A.*, *Research Assistant, Zoological Survey of India.*

In their paper on the Aquatic and Amphibious molluscs of Manipur Drs. Annandale and Prashad[1] have touched on some points in the anatomy of *I. exustus* and given reasons for establishing a new genus as different from the true *Planorbis* of Müller (with the European *Planorbis corneus* Linn., as type-species).

At the suggestion of Dr. Annandale I took up a detailed study of the anatomy of *I. exustus* with special reference to *P. corneus* and the smaller Indian Planorbids belonging to the genera *Gyraulus*, *Segmentina*, and *Intha*. Of the latter, the Zoological Survey collection contains some amount of well-preserved unnamed material obtained by Dr. Gravely from the Central Provinces, while Dr. Annandale kindly gave me two large preserved examples of the former taken by him at Edinburgh. I have had also the opportunity of examining a small collection of the smaller Planorbids from Manipur and the Inlê lake.

My sincere thanks are due to Dr. Annandale for his constant guidance and valuable suggestions in the course of my work, and for going through the manuscript with me.

Indoplanorbis exustus (Desh.) is the largest Planorbid known in India and is widely distributed in the Oriental region. It resembles in some respects the European *P. corneus* Linn., the type-species of the genus *Planorbis*, but is well differentiated by anatomical characters.

The shell is discoidal and sinistral with the whorls convex and has a wide ear-shaped aperture.[2] The living animal usually carries the shell with the broader end of the aperture on its right and the narrower on its left. In this position the upper extremity of the shell corresponding to the spire (which is flattened in such forms) is on the animal's left, and the lower on its right. The sinistral nature of the shell can be readily recognised when it is held with the aperture facing the observer and on his left.

If the body and penultimate whorls are carefully broken off, the remaining shell, which consists of the innermost whorls, is Physa-like. It is noteworthy that the very young shell of *I. exustus*[3] has a similar form.

When the animal crawls in a fully expanded state the portion of the body exposed is roughly boot-shaped, with the broad anterior region corresponding to the heel and the narrow posterior extremity of the foot to the toe, and consists of the head, foot, and neck.

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[1] Annandale and Prashad, *Rec. Ind. Mus.*, XXII, pp. 577—582 (1921).
[2] Annandale and Prashad, *op. cit*, pp. 578—581.
[3] Germain, *Rec. Ind. Mus.*, XXI, pp. 40—41, text figs. 12—14.

The head is anterior, moderately convex, slightly longer than broad and anteriorly produced into a short, rounded snout. The lower anterior margin of the head is expanded into a flattened, roughly rectangular, lobe, deeply emarginate in the middle of the anterior margin, and gradually sloping to the sides. In outline this expansion resembles that of the hammer-head shark. It is highly mobile in life, and is always extended in front of the anterior margin of the foot. The mouth is a Y-shaped or T-shaped slit in the middle of the lower surface of the head a little anterior to the foot. At the upper end of the head on each side is a moderately long, filiform tentacle, with two semicircular expansions at its base. Of the latter the outer is the larger, and is innervated by three or four branches from the tentacular nerve. The inner is smaller, and has no supply of nerves. A groove is formed between the two expansions. The male genital aperture opens at the base of the outer expansion on the left side. At the inner base of each tentacle lies the eye, which is a small spherical mass of dark pigment placed below the integument.

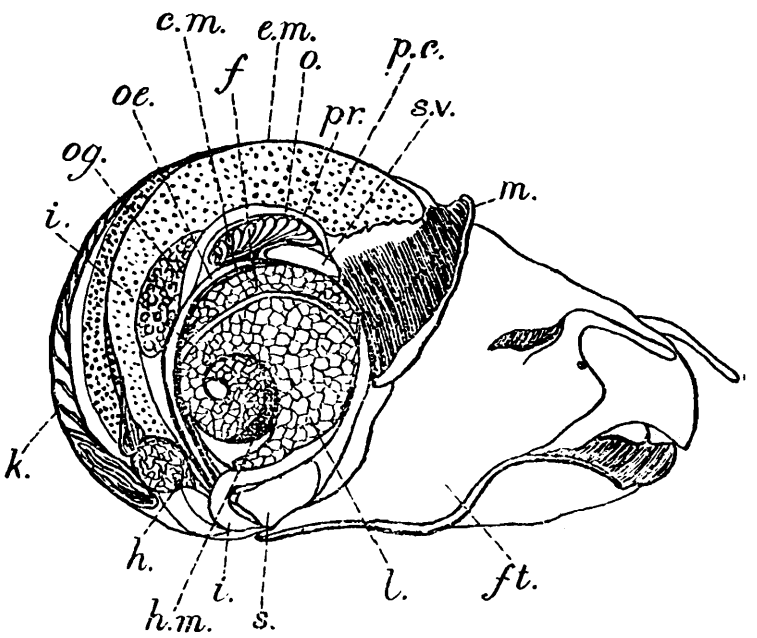

Fig. 1.—*Indoplanorbis exustus*: Viewed from the right. The right half of the mantle and the thin membrane covering the internal organs have been removed. *c.m.*, columellar muscle; *e.m.*, external membrane; *f.*, first loop of the intestine; *ft.*, foot; *h.*, heart; *h.m.*, hermaphrodite gland; *i.*, intestine; *k.*, kidney; *l.*, liver; *m.*, mantle-edge; *oe.*, oesophagus; *og.*, 'Organ de la glaire'; *p.c.*, palleal cavity; *pr.*, prostate; *s.*, stomach; *s.v.*, spermatheca.

The foot is ventral, leaf-shaped, broadly rounded in front and tapering behind.

The neck is a somewhat elongated cylindrical structure stretching obliquely backwards above the head.

The edge of the mantle is slightly thickened and does not extend beyond the margin of the aperture. At the base of the neck and on its left is a small rounded aperture through which bubbles of air may be seen to escape. This is the opening of the pulmonary siphon. Close to the narrower side of the aperture and projecting from below the mantle is a broad roughly triangular lobe with transverse folds on its upper and lower surfaces, and with its free extremity often curled up.

This is the branchial process or pseudobranch.[1] Between the pulmonary siphon and the base of the pseudobranch is the circular anal aperture. This is not clearly seen as a rule, but its position can be made out in the living animal by the occasional ejection of long threads of fæcal matter consisting of mud and sand grains.

The animal as a whole is capable of great contraction, and when disturbed withdraws itself to the inner extremity of the body-whorl. In the fully expanded animal the head, foot, and neck with the associated structures mentioned above are alone to be seen, the remaining organs of the body being confined to the inner whorls of the shell.

The body on removal from the shell may be seen to consist roughly of three regions. The anterior region includes the head, neck and foot; the middle the pallial cavity (with the pulmonary siphon and the pseudobranch), the œsophagus, the columellar muscle, the kidney and heart,

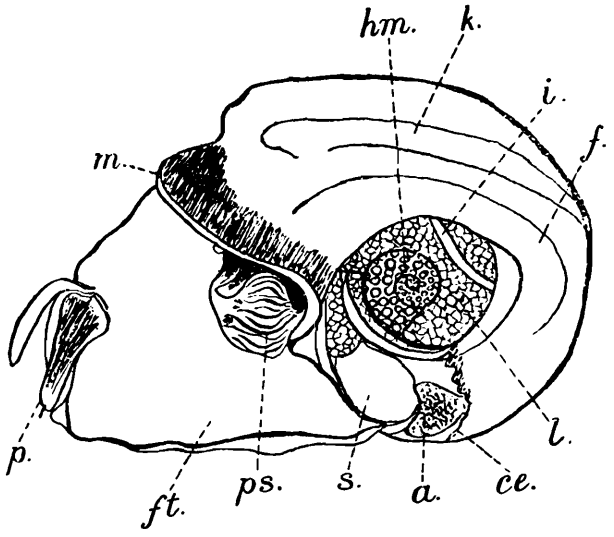

Fig. 2.—*Indoplanorbis exustus*: Viewed from the left. The thin membrane covering the inner whorls has been removed. *a.*, auricle; *ce.*, cut edge of thin membrane covering the internal organs; *f.*, fold hanging from the roof of the pallcal cavity; *ft.*, foot; *hm.*, hermaphrodite gland; *i.*, intestine; *k.*, kidney; *l.*, liver; *m.*, mantle-edge; *p.*, everted penis; *ps.*, pseudobranch; *s.*, stomach.

part of the genitalia, and the rectum; and the posterior the stomach, the intestine and liver, and the rest of the genitalia. A thin membrane covers the middle and posterior regions. It is pigmented black on the middle region, and is transparent on the posterior, but the depth of colour varies in different parts of the regions, and in different individuals. On removing this thin membrane the disposition of most of the internal structures can be made out with great facility.

On the right side, the middle region has the pulmonary cavity roofed over by the tabular part of the kidney in the middle. On slitting open the pulmonary cavity on this side, part of the genitalia and the œsophagus lying above the columellar muscle may be seen. The stomach, the liver and intestine may be seen in the posterior region.

On the left side, a small portion of the pulmonary cavity with the rectum below may be seen in the middle region, while a portion of the

[1] The term 'pseudobranch' has been proposed by Dr. Annandale for this process, as it is quite different in structure from the typical molluscan branchiæ. I adopt this term throughout in the present description.

liver and intestine, and the entire hermaphrodite gland occupy the posterior region.

The mantle is thin and vascular over the pulmonary cavity, and is attached anteriorly to the neck of the animal on the right of the pulmonary siphon. Its free margin is slightly thickened, smooth, vascular, and has short longitudinal muscle fibres.

On cutting the mantle above the pseudobranch along the length of the pulmonary cavity and reflecting it to the right, it may be seen that the pulmonary siphon is formed by the broad superior pallial lobe. On its left separated by a short space lies the pseudobranch, which is the modified inferior pallial lobe. Between the two, but close to the base of the pseudobranch is the circular anal aperture. The female opening is a small round aperture at the base of the neck, and a little below the right side of the siphon. The floor of the pulmonary cavity is lined by a thin membrane which shuts off the underlying structures. This membrane is continued upwards over the posterior part of the cavity separating the structures of the posterior region from it. There are two vascular folds lying parallel to and above the rectum. From the roof of the pulmonary cavity depend two vascular folds, a large one close to the kidney, and a small a little to the left. The kidney is an elongated tubular structure running obliquely from the posterior to the anterior end of the roof of the pulmonary cavity. It will thus be seen that the latter is an incompletely closed chamber communicating with the outside by means of the siphon. In the living animal it is filled with air which may be expelled when required through the siphon. The air, however, never seems to be completely expelled, a small residue being always left even in individuals killed in a contracted state.

The colour varies to some extent in different examples of the species from different localities. The head, foot, and neck are deep reddish brown, or dark grey speckled with minute yellow dots. The margin of the foot is yellowish brown. In the living condition the red blood of the spacious sinuses is responsible for the deep reddish colour, which fades frequently with the rushing back of the blood into the upper parts of the body. In preserved examples the colour is dark brown fading to a deep slaty gray. The sole of the foot is paler than the rest of the foot. The tentacles have dark spots or transverse bands, and are minutely dotted yellow. A small mass of dark pigment is sometimes found at the tip of the tentacle, and has the appearance of an eye. The mantle has a layer of black pigment above, traces of which may be seen on the membrane covering the upper whorls of the animal.

The Alimentary System.—The mouth, as has already been described, is a narrow Y-shaped slit. But it may also be T-shaped when tightly closed. When the animal feeds, or hangs upside down from the surface-film the aperture of the mouth is oval, and frequently opened and closed. A little behind the aperture are to be found the chitinous jaws, which consist of a transverse and two vertical pieces. The former is a strongly chitinised semicircular piece of a dark brown colour, which has its inferior margin uneven. The latter are less strongly chitinised, slightly curved, narrow strips of a yellowish colour, and are placed one on each side close to the outer and inferior margins of the transverse piece with the concave

side directed outwards and the inner convex sides often meeting in the middle. Under a low power of the microscope they are seen to be indistinctly divided into numerous, narrow, transverse segments. Close to each of the vertical pieces on the inner side is often found a thin, yellow strip of chitinous structure which is divided into a number of club-shaped filaments directed towards the buccal cavity.

In *P. corneus* and in some species of *Gyraulus* the jaw is of the same type, whereas in other species of *Gyraulus* and in species of the genera *Segmentina* and *Intha* it is a single, narrow, chitinous strip of a yellowish brown colour bent in the form of an inverted U, and is distinctly segmented.

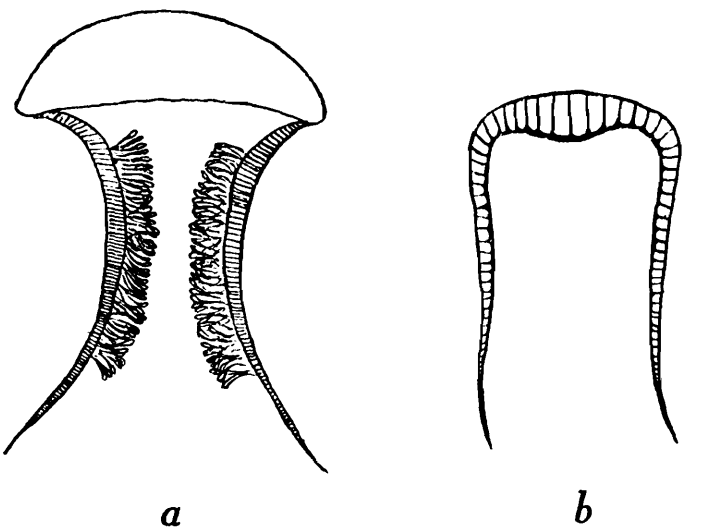

Fig. 3.—*a.*, jaw of *Indoplanorbis exustus*; *b.*, jaw of *Gyraulus* sp.

The mouth leads upwards and backwards into the narrow buccal cavity, the roof and sides of which have muscular walls, while the floor is formed by the odontophore. The latter consists of a soft but thick and tough, saddle-shaped structure supported by a pair of vertical muscle-pads. The radula lies over this structure, and stretches downwards and backwards into the radular sac, which is a short digitiform process projecting from below the posterior end of the buccal mass. When the animal actively feeds, or floats upside down from the surface-film of water, the radula is worked upwards, forwards and backwards. It is a broad chitinous ribbon with several rows of teeth, usually 77 to 83 longitudinal rows of teeth in the broadest portion of the radula, with the approximate dental formula 26·12·1·12·26. Each tooth consists of a broad basal part and an overhanging flap above bearing triangular or conical cusps on its free margin. The cusps are worn out and consequently blunt in some of the anterior rows of teeth. The marginals vary in number to some extent, while the central and laterals are always constant. The outermost lateral, which has traces of a division of the entocone into small secondary cusps, may be considered as the first marginal, and all the teeth centrad of it with only three cusps on each as the laterals. The central is small and has only two cusps slightly unequal in size. A minute cusp is sometimes seen at the base between the two. In the laterals the mesocone is the largest cusp, and

the ectocone small and shorter than the rest. In the first marginal the entocone is usually divided into smaller secondary cusps, while the base of the ectocone and the outer margin of the flap bear very minute cusps. In the second and third marginals generally the innermost cusp of the entocone has its inner base somewhat deeply divided. In the next few marginals the cusps of the entocone and the mesocone stand out in a single, more or less, transverse row with the ectocone much below the base of the mesocone. The ectocone may often be divided into two nearly equal cusps with several minute ones at its base. In all these marginals the mesocone remains unchanged and is the largest cusp. In the next few marginals the mesocone gradually becomes smaller and smaller until it is of the same size as the secondary cusps of the entocone. Some of these latter are entirely suppressed so that there are fewer cusps on an elongated, narrow body. The cusps themselves become blunt and rounded. The ectocone is also gradually reduced until it disappears. In the last few marginals the cusps are all gradually reduced until the last marginal loses all traces of them and becomes a narrow strip of chitin with its free extremity blunt and rounded.

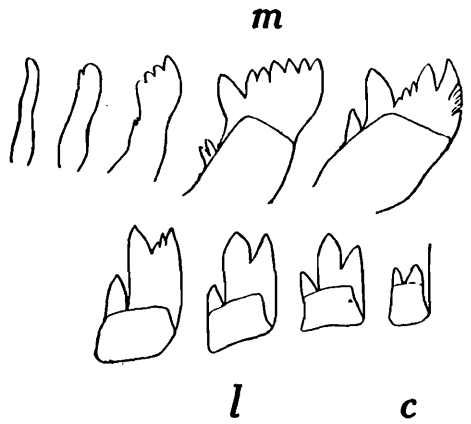

FIG. 4.—*Indoplanorbis exustus* Radular teeth. *c.*, central; *l.*, laterals; *m.*, marginals.

A pair of salivary glands lies above, or in close relation with the male genital duct, and passes close to the inner side of the cerebro-pleural commissure to open into the buccal cavity one on each side of the commencement of the œsophagus. Each gland is a long tube which may, for convenience, be divided into three regions. The posterior region lies behind the nerve collar and has small diverticula. It gradually narrows to a fine tube which crosses the nerve collar, and enlarges into a wide lobed sac lying on the posterior face of the buccal mass. This is the middle region. The posterior and the middle regions form the gland proper, while the anterior which is a short fine tube commencing from the sac, is the duct. At the posterior extremity the glands of the two sides are united by a very short narrow connective.

In *P. corneus* the salivary glands are of the same type with slight differences. The saccular middle region is much larger, and is in the form of a mushroom with a large number of thin finger-shaped diverticula, while the posterior tubular region is much longer with prominent diverticula on them.

In the smaller Planorbids belonging to the genera *Gyraulus*, *Segmentina*, and *Intha* the salivary glands are much simpler and almost uniformly tubular.

The buccal cavity leads backwards and upwards to the œsophagus which commences as a median narrow tube from the top of the buccal mass near its posterior end. On leaving the buccal mass the œsophagus descends to pass through the nerve collar, and runs parallel to and on the right margin of the columellar muscle as a narrow compressed tube. It passes below the albumen gland on its right and enters the stomach. It is pigmented dull gray, and has longitudinal folds in its lumen which give it a striated appearance externally. The stomach is roughly barrel-shaped with both ends gradually tapering. The wide central part is smooth, and provided with thick, shining, transverse muscle-fibres. It has a spacious lumen filled with small grains of sand. The anterior and posterior tapering portions have longitudinal folds in the lumen.

The colour of the stomach is usually reddish pink. The intestine is a long cylindrical tube with smooth walls, and commences from the posterior end of the stomach. It turns sharply to the right and passes parallel to the stomach up to the anterior end, and then to the left bordering the anterior part of the stomach. It runs obliquely backwards in a groove on the liver towards the right side and surrounds the entire liver in a wide loop. On passing obliquely forwards nearly touching the first loop it slightly descends to emerge from the hind end of the pallial cavity as the rectum. The latter has a straight course to the anus and is roofed over by two parallel vascular folds about which mention has already been made. The intestine is usually of a dull pink colour which deepens on the rectum. A small finger-shaped cæcum is present at the commencement of the intestine in the bend formed between the latter and the stomach. Its lumen has minute longitudinal folds. The ducts of the liver which are usually four in number open into the stomach at the base of the cæcum.

The disposition of the alimentary tract is essentially the same in *P. corneus* and the smaller Planorbids, but some variations in the length and nature of the intestinal loop, and in the size of the cæcum occur in the latter. In some species of *Gyraulus*, as for instance *G. euphraticus* Mousson, the intestinal loop round the liver is either very short or totally absent, the intestine in the latter case proceeding forwards straight from the stomach instead of coiling round the liver; and the cæcum is well developed. In other species of *Gyraulus* and in *Segmentina taia* Annandale and *Intha capitis* Annandale the intestine is long and surrounds the liver more or less completely. The cæcum in these is very small, and is often overlooked.

The liver is a large brownish mass extending from the posterior end of the albumen gland up to the base of the hermaphrodite gland. It is often heavily infected with cercariæ of a parasitic trematode. Most of the individuals that I examined from Calcutta and Nagpur had the liver disintegrated to a slight extent on account of the infection. The hermaphrodite gland, being close to the liver, is also frequently affected.

The pallial cavity.—The pulmonary chamber occupies a greater portion of the body whorl, and is about a third of the length of the whole

animal. The sides and roof are formed by the mantle, while the hind end is shut off from the structures of the upper whorls by a membranous partition which also paves the floor of the chamber, separating off the underlying organs, while the front end is shut off from the head by the union of the mantle with the neck. It communicates with the outside by means of the pulmonary siphon. The mantle is highly vascular over the roof and sides of the chamber, and branching lacunæ may be seen through the pigmented membranous covering. The respiratory surface of the interior of the chamber is increased by the presence of longitudinal vascular folds projecting into it from the roof and the floor. A comparatively large thick fold commencing from about the level of the heart extends along the left margin of the kidney to the front end of the chamber, and hangs down as a vertical flap just above

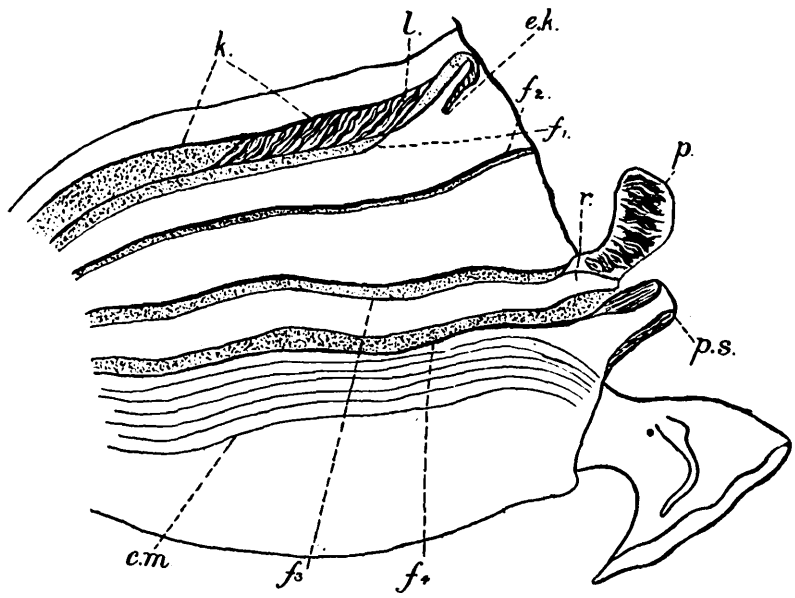

FIG. 5.—*Indoplanorbis exustus*: Mantle cut open longitudinally on the right side and reflexed to the left showing the folds of the palleal cavity. The kidney is partly opened from below to show the internal folds. *c.m.*, columellar muscle; *ek.*, external opening of kidney; *f.1*, *f.2*, folds on the roof of the palleal cavity *f.3*, *f.4*, rectal folds of the palleal cavity; *l.*, folds in the lumen of the kidney; *k.*, kidney; *p.*, pseudobranch; *p.s.*, pulmonary siphon; *r.*, rectum.

the rectum roughly dividing the cavity into two chambers. It seems probable that in life, when the pulmonary chamber is distended, even this temporary division does not take place. A little to the left of the large fold is another small one lying parallel to the kidney from the hind end of the chamber to a little behind the margin of the mantle. Above the rectum and parallel to it on each side runs a prominent, thin, vascular fold, the right continuous with the left margin of the siphon, and the left with the right margin of the pseudobranch. So far as I have been able to make out in the examples of *P. corneus* before me the right fold is absent,[1] but in its place there is a broad convex ridge.

In the smaller Planorbids the vascular folds are very minute, and are found in the same positions.

[1] Pelseneer has figured two folds above the rectum in *P. corneus*. Vide *Arch. de Biol.*, XIV, pl. xvii, fig. 27 (1895-96).

Running close to the base of the renal and rectal folds are two principal veins which may be observed on removing them. Spherical calcareous concretions are found in great numbers on all the folds. They are also found on other structures of the pallial cavity and on the walls of the vascular sinuses.

The air in the pulmonary chamber is often expelled in small bubbles through the siphon, and this act is probably an expulsion of impure air. When the animal is disturbed at the surface of the water it usually discharges a few bubbles of air with a simultaneous contraction of the body to a slight extent, and drops to the bottom. It does not rise up to the surface directly from the bottom, but crawls over weeds and other supports to the surface of water. It seems to me therefore that the pulmonary chamber is not, strictly speaking, a hydrostatic organ as well.

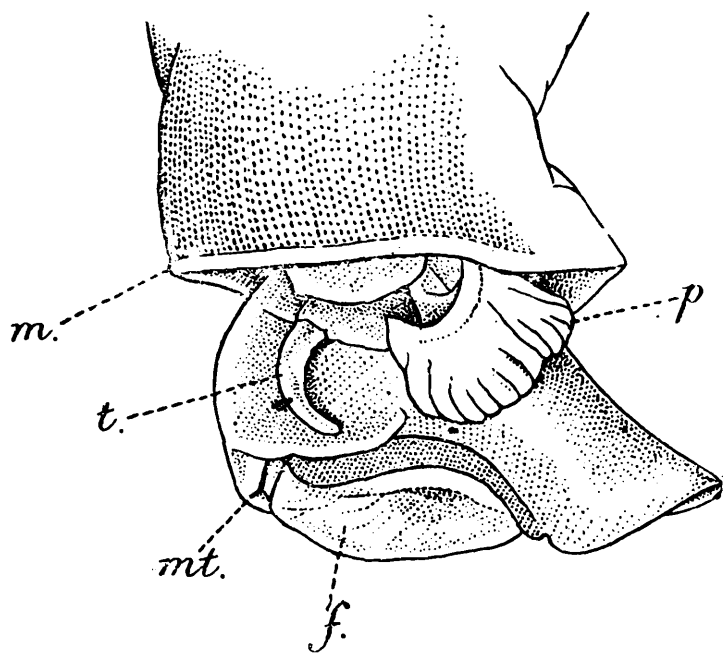

Fig. 6.—*Indoplanorbis exustus*: Left view of the anterior region showing the pseudobranch. *f.*, foot; *m.*, mantle; *mt.*, mouth; *p.*, pseudobranch; *t.*, tentacle.

The siphon is a broad thin lobe, deeply emarginate in the middle of the anterior margin, and when the sides of the lobe overlap above, a temporary tube is formed, through which the air in the pulmonary chamber escapes to the outside. Usually the whole siphon is well within the margin of the mantle, but at the time of expulsion of the air it is slowly protruded slightly beyond the edge of the mantle with its extremity expanded into a funnel. As soon as a bubble has been discharged the extremity of the siphon is flattened and is the first to touch the surface film of water. It then suddenly contracts so that the wide funnel-shaped opening is reduced to a small circular aperture, through which water does not pass into the pulmonary chamber.

In *P. corneus* the siphon is short, broad, thick and prominent. In the smaller Planorbids it is always present,[1] but varies in form and size.

[1] Drs. Annandale and Prashad have observed a spirally coiled, epipodial siphon in *Camptoceras lineatum* Blanford (*Rec. Ind. Mus.*, XXII, p. 586). A similar siphon in *C. hirasei* Walker from Japan is figured by Walker in *Occ. Papers Mus. Zool. Univ. Michigan*, no. 64, pl. 1 (1919).

In some species of *Gyraulus* it is short and broad while in others long and narrow ; and in *Segmentina taia* and *Intha capitis* it is small and less conspicuous.

The pseudobranch is a broad leaf-shaped lobe attached by its broader end below the anal opening on its left. The upper and lower surfaces are thrown out into a number of prominent pleats or folds, three or four of which are grouped together. Each group of folds is separated one from the other by a short deep gap. The free margins of the pseudobranch are not involved in the folding, but form a border to the central folded area. The colour is a dull brown or slaty gray speckled with yellow dots. In the expanded animal the free terminal portion is curled up against the edge of the mantle, or rarely of the shell. In this position the folds of the upper surface are not visible, and even when uncurled appear much less prominent than those of the lower surface. They are very complex as may be seen in transverse and longitudinal sections

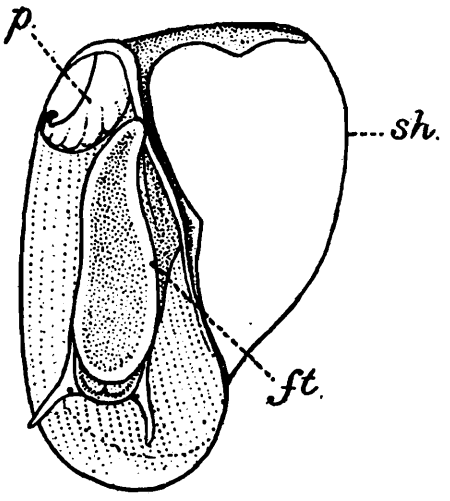

FIG. 7.—*Indoplanorbis exustus*: Ventral view of a living young specimen. *ft.*, foot ; *p.*, pseudobranch ; *sh.*, shell.

of the pseudobranch. In several living examples that I observed the pseudobranch had its free extremity always curled up both in the expanded and contracted state.[1] It is vascular and has well developed efferent and afferent veins, and has a supply of muscle-fibres and nerves. In young individuals it has the same structure and disposition as in the adult. From its position and structure the pseudobranch appears to be an accessory respiratory organ.

In *P. corneus* the pseudobranch is a simple leaf-shaped lobe without the folds of *I. exustus*. In the examples before me it is very much contracted and hardly distinguishable as a distinct lobe owing to the effect of spirit in which they were killed and preserved. The figures of Simorth[2] and Pelseneer,[3] however, show clearly the position, form, and extent to which it can be extended. One of the chief

[1] Dr. Annandale informs me that he has observed the pseudobranch in a straight condition in living examples on the Barkuda Island under certain abnormal conditions such as foulness or salinity of the water in which they live.

[2] Simroth, in Bronn's *Tier-Reich*, III, 3, p. 453, text-fig. 152c.

[3] Pelseneer, *Arch. de Biol.*, XIV, pl. xvii, figs. 23, 24, 26 (1895-96).

general differences between *I. exustus* and *P. corneus*, therefore, lies in the nature of the pseudobranch.

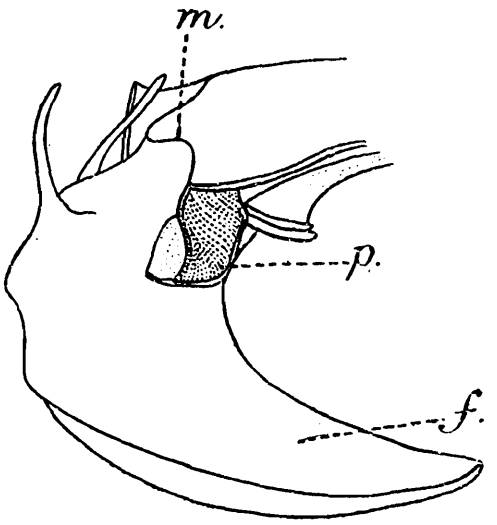

Fig. 8.—*Gyraulus euphraticus* : *f.*, foot ; *m.*, mantle edge; *p.*, pseudobranch.

In *Pulmobranchia lamellata*[1] Pelseneer the pseudobranch is remarkably of the same type as in *I. exustus*, and in some respects the anatomy of the latter resembles more closely that of the former than *P. corneus*.

Fig. 9.—*Indoplanorbis exustus* ; Transverse section of pseudobranch through the anterior part.

In species of *Gyraulus* the pseudobranch is a simple, thin, leaf-shaped vascular lobe without the transverse folds. There is, however, an oblique

[1] Probably a species of *Physastra* (*cf.* Prashad, *Rec. Ind. Mus.* XXII, p. 475).

vertical fold on the upper surface extending from the base to the free extremity. Faint transverse striations may often be seen on either side of the fold. Slight variations in the size and shape of the pseudobranch may also occur. The presence of the vertical fold apparently distinguishes the structure of the pseudobranch from that of *Planorbis* s.s.

It is curious that there is no trace of a pseudobranch in *Segmentina taia* and another unnamed species of the same genus or in *Intha capitis*. If this structure is proved to be absent in all other species of these genera it would afford an important generic distinction between them and the larger Planorbids, and indicate the close relationship of the genera *Segmentina* and *Intha*. As will be seen later these latter are closely related in anatomical characters.

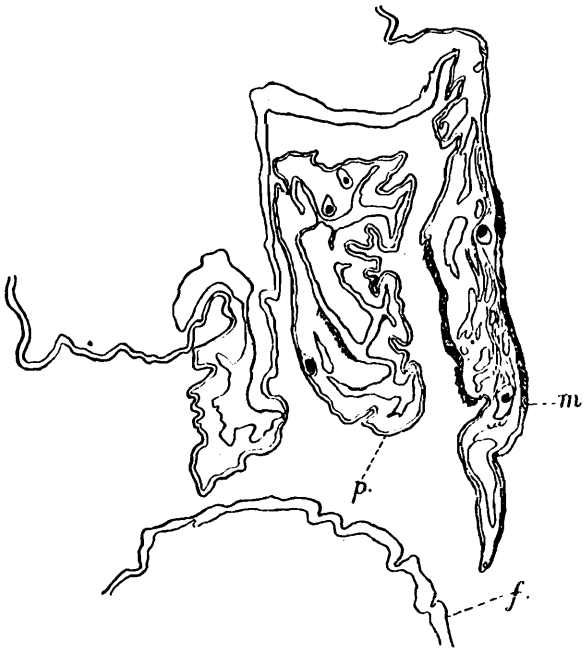

FIG. 10.—*Indoplanorbis exustus*: Longitudinal section of pseudobranch and mantle.

The vascular system.—This consists of the heart enclosed within a pericardial chamber, the thin-walled vessels carrying blood to the various organs, the so-called veins with no definite walls taking blood to the respiratory organs, and the large sinuses which place the two systems in communication. The latter are very numerous in the foot, mantle, head, pseudobranch, and folds of the pallial cavity. In preserved examples the veinous vessels have a wide lumen filled with a whitish cheese-like mass, while the others have thin, collapsed, pigmented walls with numerous calcareous concretions. The heart lies at the extremity of the pallial cavity on the right side and may be seen through the pigmented membrane of the mantle as a whitish triangular structure. The pericardial membrane is extremely thin and closely adherent to the lower surface of the mantle. The heart has the kidney on its left below and in front, and posteriorly the albumen gland and a portion of the alimentary tract. It consists of an anterior elongated roughly triangular auricle with thin spongy walls and a posterior broad pear-

shaped ventricle with somewhat thicker walls having a reticulate appearance.

From the ventricle arises a short vessel from which branches are given off to the various organs of the posterior region. The chief of these may here be mentioned. Immediately on starting from the ventricle a short branch is given off to the kidney, and a little behind, the main vessel passes over the anterior loop of the intestine, and at this point gives off a large branch which immediately divides into right and left branches. The left is a short, narrow vessel supplying the intestine, and the right on crossing the stomach gives off a short branch passing downwards between the œsophagus and the cæcum and supplying the

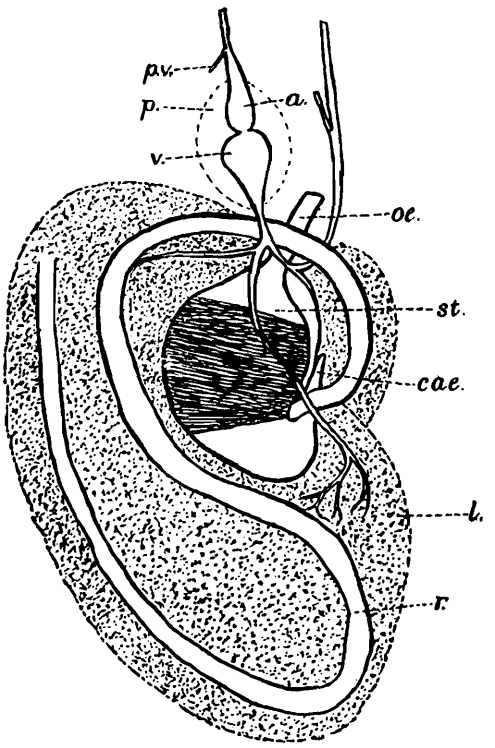

FIG. 11.—*Indoplanorbis exustus* : Circulation in the region of the stomach, *a.*, auricle ; *cae.*, cæcum ; *l.*, liver ; *oe.*, œsophagus ; *p.*, pericardium ; *p.v.*, pericardial vein ; *r.*; rectum ; *st.*, stomach ; *v.*, ventricle.

stomach. It is continued on as a long narrow vessel and crosses the intestine to enter the liver, immediately dividing into smaller branches. The main vessel after giving off the branch to the intestine curves round underneath the anterior loop of the latter and proceeds straight in front below the genitalia. A small branch is given off to the cæcum from the bend of the main vessel. About the level of the albumen gland a large branch arises from the main vessel and soon breaks up into smaller vessels distributing blood to the various parts of the genitalia. The main vessel is continued below the oviduct and close to the columellar muscle below the œsophagus finally crossing the pedal commissure. Various small branches arise from it in its course to the brain. It gradually widens until it enlarges to form an elliptical sinus below the buccal mass. From the front and lower sides of this sinus fine branches reach the foot and the anterior part of the head. A small vessel from the sinus supplies the penis-sheath closely following the course of the nerve.

The veinous circulation is difficult to make out satisfactorily in freshly killed examples, and even in well-preserved individuals the thin-walled veins are usually damaged. The course of the veins can, however, be traced by the presence of a whitish, coagulated, cheese-like mass in them. So far as my observation goes the veinous circulation closely resembles that of *Pulmobranchia lamellata*.[1]

On the right margin of the kidney, commencing from the anterior end, lies the renal efferent vein which is in close relation with the highly vascular roof of the pulmonary chamber on its right. This vein at its posterior extremity opens into the auricle and at its junction with the latter, a small short branch is given off to the pericardial membrane on the right side. On the left margin of the kidney lies the renal afferent vein, which breaks up into several minute capillary-like vessels below the transverse folds of the kidney. The blood is distributed to the renal efferent vein by means of a similar set of vessels on the right margin of the kidney.

The renal afferent vein has its origin in a closed sinus in the mantle at its junction with the neck of the animal. The right pallial vein, running parallel to the edge of the mantle a little behind it, and the efferent pseudobranchial vein, which runs along the right border of the pseudobranch and then below the base of the siphon, empty themselves into the closed sinus. The rectal vein which runs close to the rectum on its left is joined by the left pallial vein at the base of the pseudobranch and enters the left border of the latter as the pseudobranchial afferent vein, which breaks up into smaller branches among the folds of the pseudobranch. I have been unable to make out the course of the sub-intestinal vein, which runs parallel to the rectum on its right. It probably joins the left pallial vein at some point above the pseudobranch or breaks up into sinuses in the mantle.

It will thus be seen that the pseudobranch is an important organ of respiration. It receives veinous blood from the left side of the animal and, after aërating it, sends it on to the large dorsal sinus, which receives aërated blood from the mantle and the vascular roof of the pulmonary chamber.

The renal system.—This organ consists of a posterior saccular and an anterior tubular region. The former is a pear-shaped body lying immediately above the albumen gland and separated from the latter by a thin membrane. On its right a little in front lies the heart on a slightly higher level, while on its left the hind extremity of the pulmonary chamber. It has the liver on its posterior side. Its lumen is narrow on account of the presence of a number of longitudinal folds, which are yellow in colour in the freshly killed animal. The tubular region of the kidney commences from the neck of the saccular part, and extends obliquely forwards on the roof of the pulmonary chamber, as a broad compressed tube up to the junction of the mantle with the neck. It then curves sharply to the left as a short narrow arm directed backwards, and carries at its extremity the minute renal aperture. In some preserved individuals the renal aperture is distinctly slit-like and

[1] Pelseneer, *Arch. de Biol.* XIV, pl. xv, fig. 14 ; pl. xvi, fig. 22.

provided with a pair of tumid lips. In *P. corneus* the external opening of the kidney is a circular aperture on a prominent papilla.

The floor and roof of the tubular part of the kidney are raised into a number of short digitiform processes or vertical folds arranged in more or less equidistant transverse rows. These folds are lined by cubical cells which give them a moniliform appearance in sections.

The reno-pericardial opening is minute, and is found as a very short, backwardly directed, tubular passage at the neck of the saccular portion of the kidney on its right.

The Reproductive system.—The male and female ducts are separate, each having a distinct opening to the outside. The position of these openings has been described in connection with the external features.

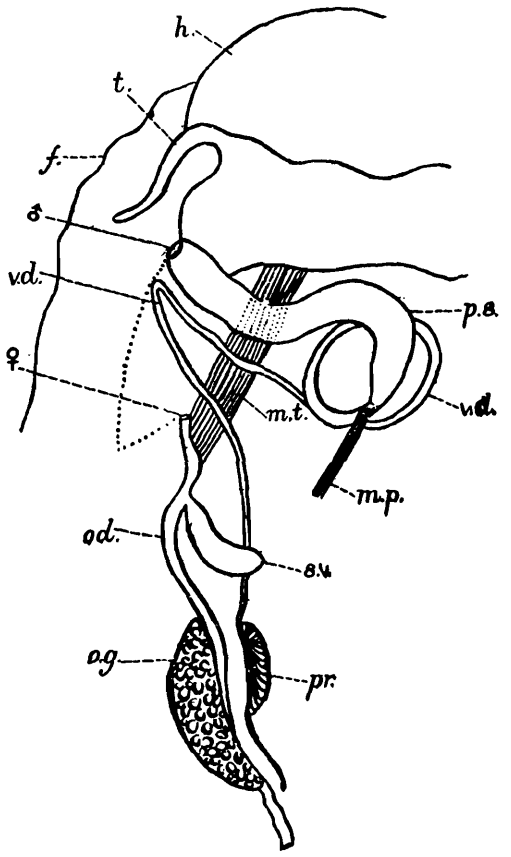

FIG. 12.—*Indoplanorbis exustus*: Anterior part of the genitalia, *f.*, foot; *h.*, head; *mt.*, retractor muscle of the tentacle; *m.p.*, retractor muscle of the penis; *od.*, oviduct; *og.*, 'Organe de la glaire'; *pr.*, prostate; *ps.*, penis sac.; *sv.*, spermatheca; *vd.*, vas deferens.

The various parts of the reproductive system are essentially the same as in *P. corneus*.[1] But differences of considerable taxonomic value occur in the structure of the terminal portion of the male duct.

The hermaphrodite gland is an elongate triangular body lying coiled at the apex of the spire, when viewed from the left. The colour is a bright orange or yellowish brown in the freshly killed individual. The apex of the gland is tightly coiled and occupies the top of the spire, while its base is in close contact with the posterior extremity of the liver. The gland consists of a number of small finger-shaped processes

[1] A good description of the reproductive system of *P. corneus* with an excellent plate is given by Baudelot in *Ann. Sci. Nat.* XIX, pp. 197—203, pl. iv, figs. 2—5 (1863).

opening into a median, narrow, hermaphrodite duct below. A few small ovate eggs with a single, rounded nucleus in the centre are often found in sections of the gland. Clusters of spermatozoa with long tails are often found in the spaces between the ova. They are more deeply stained than the latter. The hermaphrodite duct, on leaving the gland, is continued obliquely forwards below the liver, and at the level of the stomach passes upwards to the albumen gland situated just in front of the former. The proximal portion of the duct has very small diverticula opening into it.

The hermaphrodite duct joins a short duct from the albumen gland. A little in front of the junction of the two ducts the male and female ducts can be distinguished. The albumen gland is a dark gray fan-shaped body convex above and concave below. It has its posterior border broadly rounded while its anterior is deeply concave. The two ducts arise from below this concavity and run close together parallel to the œsophagus on its left. The ducts and the associated glands lie on the right half of and below the pulmonary chamber separated from the latter by a thin membrane. The male duct is narrow and lies below the oviduct and in close contact with it. The female duct is large and has thin walls. It passes below a large oval gland in front, called the 'Organe de la glaire' 'the gelatinous secretion of which appears to serve the purpose of preserving the ova from contact with water.' It is broad and flattened, and has a striated appearance. There is no definite duct by which the products of the 'Organe de la glaire' are led into the oviduct, apparently the gland opens into it by means of numerous small pores. The oviduct on emerging from below the gland is slightly enlarged, but soon becomes narrowed into a short, cylindrical tube into which opens a pear-shaped sac by means of a short duct. This sac is called variously the copulatory pouch, the seminal vesicle, or the receptaculum seminis. It has thin walls, and is usually filled with an orange-colour fluid. The duct of the seminal vesicle varies in length. In not a few individuals it is very short, but occasionally examples with long ducts are also to be met with. Baudelot's figure of the genitilia of *P. corneus* shows the duct to be long, but he does not mention whether any variation occurs in this species. The oviduct in front of the junction of the seminal vesicle with it is a short duct with fairly thick walls and opens to the outside a little below the pulmonary siphon.

The male duct, as has been described above, passes close below the oviduct and to the right margin of the 'organe de la glaire,' and near the anterior end of the latter receives the flattened, elliptical prostrate gland, which is closely pressed to the right anterior margin of that organ. The male duct passes below the prostrate, receiving its products, and is continued forwards as a very fine rounded tube. The prostrate gland consists of a large number of diverticula closely bound together and hardly distinguishable as such. It has no definite duct, and probably like the 'organe de la glaire' opens by means of minute pores into the flattened male duct below. The vas deferens is long and coiled, and on leaving the prostrate runs nearly parallel to the oviduct, and passing close to the female opening proceeds in front to the integument near the male opening. It then curves sharply backwards as a somewhat

wider tube. It crosses the tentacular retractor muscle, and running parallel to the penis-sheath lies coiled up behind the buccal mass, and finally joins the penis-sheath. A single retractor muscle[1] arises from the left half of the columellar muscle, and running between the coils of the vas deferens joins the terminal portion of the latter just before it reaches the penis-sheath. It is usually smooth and shining but may be dark gray owing to the presence of a small blood-vessel which is frequently pulled off in cleaning the muscle.

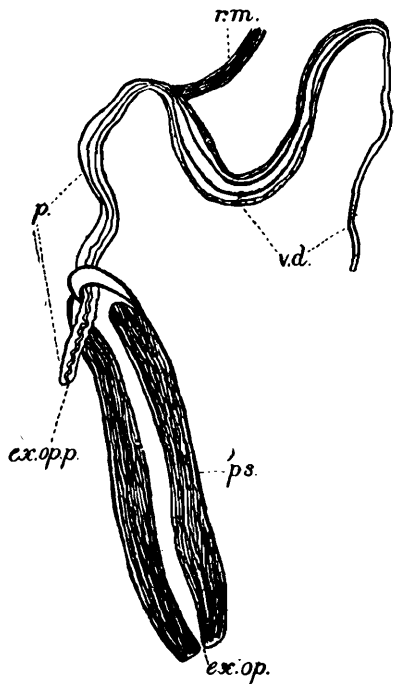

Fig. 13.—*Indoplanorbis exustus :* Male genitalia. The penis-sac and the vas deferens are cut open. *ex. op.*, external opening of penis-sac ; *ex. op. p.*, external opening of penis ; *p.*, penis ; *ps.*, penis-sac ; *r. m.*, retractor muscle of the penis ; *v. d.*, vas deferens.

The penis-sheath is a long, stout, cylindrical, muscular organ lying close to the integument posterior to the left tentacle. It is covered over by a thin, black membrane, and is held in position by short, thin muscles and shredded membranes above and below. The lumen of the sheath is somewhat compressed, and has on each side an elongated muscular pad. Between these pads hangs the long tubular penis, which is often broken or else extremely contracted in preserved examples. Though contracted into the upper part of the sheath it maintains a cylindrical form. It has thin walls and is continous with the thin zig-zag tube in the lumen of the vas deferens. It is often as long as the sheath itself, and has at its free end a minute circular opening. The outer wall of the penis is continuous with the tube inside it at the external opening. In preserved individuals the penis-sheath undergoes great contraction and is consequently stout and bulbous with part of the vas deferens everted into it ; or it may be completely protruded inside out from the external opening with the penis at its extremity ; or everted

[1] Drs. Annandale and Prashad evidently overlooked this muscle. In a later paper the former mentions two retractor muscles, but it is probable that the small blood-vessel and nerve supplying the penis-sheath, and reaching the same point on the vas deferens as the retractor muscle, were mistaken for a second muscle.

with the pads curled out on each side of the external opening with even a part of the vas deferens protruded in the centre.

In *P. corneus* the penis-sheath is short and stout, and the penis appears to be developed as a stout invaginated process from the walls of the sheath and has an open groove-like duct opening on a gland-like apical structure. There are two well developed retractor muscles divided terminally into two or three short branches. One of them is attached to the sheath, while the other to the terminal part of the vas dèferens, a branch of which goes to the penis-sheath.

It will be seen, therefore, that the essential differences in the genitalia between *I. exustus* and *P. corneus* lie in the form and structure of the penis, and in the number and arrangement of the retractor muscles.

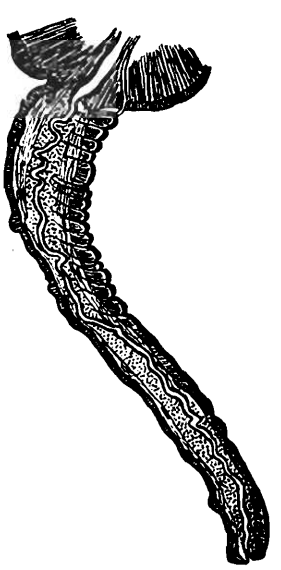

Fig. 14.—*Indoplanorbis exustus*: Penis (Highly magnified).

Buchner[1] recognises four types of penis in the Planorbidae. It is evident that the type in *I. exustus* is not identical with any of Buchner's, though closely allied to his third type. I agree, therefore, with Dr. Annandale[2] in recognising a fifth type represented by the penis of *I. exustus*.

The reproductive organs of the smaller Indian Planorbids (*Gyraulus*, *Segmentina* and *Intha*) have the same arrangement as in the larger forms but differ in some respects, chiefly in the structure of the genital glands and the penis. In these forms the hermaphrodite gland is usually long, and consists of longer and more distinct digitiform processes than in the larger Planorbids. The albumen gland has an irregular outline, and is much less compact than that of *I. exustus* or *P. corneus*. It has long diverticula, and is of a pale white colour. The prostrate gland is remarkably different. It is an elongated, flattened structure consisting of a few, usually eighteen to twenty, long club-shaped processes arranged

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[1] Buchner, *Jahreshefte d. Vereins f. Vaterl. naturkunde in Württemburg*, XLVII, pp. 68-69, pl. vi (1891).

The figures are reproduced by Simroth in Bronn's *Tier-Reich*, III, 3, p. 502. I am indebted to Dr. Prashad for drawing my attention to the first named reference.

[2] Annandale, *Rec. Ind. Mus.* XXIV, p. 359 (1922).

in a linear row alongside the vas deferens, each opening individually into the latter. The penis-sheath is not covered by a pigmented membrane, but is more or less transparent. It is broad posteriorly and gradually narrows anteriorly, where it has a bulbous swelling, which is continued as a short cylindrical tube to the external opening. The penis is long, and in *Gyraulus* bears at its free end a reddish brown chitinous stylet. There is only a single retractor muscle attached to the penis-sheath near the bulbous swelling. In *Segmentina taia* and *Intha capitis* both the bulbous swelling and the penial stylet are absent. The structure and arrangement of the rest of the genitalia are the same as in *Gyraulus*.

The muscular system.—This consists of the columellar system extending antero-posteriorly on the ventral surface of the animal, and the muscles of the buccal region. The former is a broad sheet of muscle consisting of thin and thick fibres, and gradually narrowing towards the posterior end near the apex of the spire. Anteriorly the fibres are very closely arranged. On the ventral side of the greater part of the body-whorl the columellar muscle can be divided into a broad, median, almost transparent region consisting of thin fibres, and a narrow whitish, shining region on each side of the former consisting of thick fibres. From the columellar muscle arise two pairs of muscles, namely, the retractors of the foot, and of the buccal mass. The single retractor muscle of the penis takes its origin from the left side of the columellar muscle. Each retractor of the foot consists of thick fibres and comes off from the lateral region of the columellar muscle. It is closely adherent to the integument, somewhat narrow at its origin but gradually widening towards the antero-lateral part of the foot, which it supplies. A few fibres from the left retractor of the foot pass obliquely towards the left, close to the base of the pulmonary siphon and supply the pseudobranch. A broad sheet of thin fibres extends from the retractor of the foot on each side to the base of the tentacles. This is the tentacular retractor muscle. Two long narrow strips of shining muscle have their origin at about the middle of the columellar muscle one on each side of the central transparent region, and proceed forwards parallel to the visceral nerves. They pass through the circum-œsophageal nerve-ring close to its sides, and reach the ventro-lateral surface of the middle of the buccal mass. These are the buccal retractors. The penial retractor muscle is a slender muscle with minute fibres and has its origin at the junction of the median and lateral areas of the columellar muscle on the left side. It proceeds forwards and upwards between the coils of the vas deferens, and is attached to the terminal portion of the latter.

The buccal mass is also supplied with intrinsic muscles, the chief of which may be mentioned. Posteriorly, near the ventral surface of the buccal mass a fan-shaped muscle take its origin, and passes obliquely forwards and upwards widening gradually in its course to the top of the buccal mass, and joins with its fellow of the opposite side in a broad, transverse band of muscle fibres across the anterior half of the buccal mass. Below this fan-shaped muscle is a broad band with fibres running concentrically round the buccal mass. It extends behind the fan-shaped muscle, and is tucked in to form a groove in the median ventral surface.

A small band of muscle from the sides of the buccal mass a little behind the buccal ganglion passes forwards to the anterior end. Besides these larger muscles there are fine strands arising from above and below the buccal mass, which are attached to the integument of the snout and head above, and to the foot below.

The nervous system.—A full account of the nervous system of *P. corneus* has been given by Lacaze Duthiers.[1] So far as I have been able to ascertain, the nervous system of *I. exustus* agrees in every particular with that of *P. corneus*. The cerebral, pleural, and pedal ganglia form the circum-œsophageal nerve-ring behind the buccal mass near its ventral surface. The visceral ganglia are also found close together and united with the pleural ganglia. They present a granular appearance, and are usually of a pink or yellowish brown colour in the freshly killed individuals. The buccal ganglia are a pair of small, roughly triangular bodies placed close to the sides of the œsophagus at its commencement from the buccal mass, and connected by a short nerve-commissure below the œsophagus. From each of the buccal ganglia arise five nerves. From the outer angle in front is given off a small nerve to the salivary gland, and from the inner angle close to the beginning of the buccal commissure is given off a short fine nerve to the posterior face of the buccal mass. From the outer angle below arise three nerves of which two pass close to the sides of the buccal mass, while the third proceeds backwards to join the anterior ventral surface of the cerebral ganglion. The cerebral ganglia are somewhat elongated triangular bodies united by a short commisure above the œsophagus, the two together forming a horse-shoe shaped structure. They are broader near the middle and slightly taper towards the sides. From these arise the nerves to the tentacles, eyes, otocysts, skin and muscles of the head and snout. The tentacular and optic nerves together with those supplying the skin and muscles of the head and snout are given off from the lower outer angle of the cerebral ganglia. At the base of the tentacle a few small branches from the tentacular nerve supply the semicircular expansions on the outer side. The optic nerve is fine and is united with the tentacular nerve for some distance. The eye is simple in structure, and has a central spherical lens surrounded by a thick layer of black pigment. The nerve to the otocyst is very short and minute and recognised only in balsam mounts. It starts from the posterior face of the cerebral ganglion and proceeds parallel to it until at its outer angle it sharply turns downwards to join the otocyst. The otocyst is a minute, whitish, spherical mass at the posterior outer angle of each pedal ganglion. Its cavity is filled with numerous elliptical otoliths. From the outer extremity of the left cerebral ganglion arises a long thin nerve which runs backwards to supply the penis-sheath. The pleural ganglia are small squarish bodies placed ventral to the cerebral ganglia. The pleuro-pedal and the cerebro-pedal commissures may be seen in front of the pedal ganglia at their outer angle. There are three visceral ganglia somewhat un-

[1] Lacaze Duthiers, *Arch. Zool. Exp.* I, pp. 476—482 and 484—487, pl. xx; also pp. 155—156, pl. iii, figs. 9—10 (1872).

equal in size and arranged in the form of a U. They are roughly four-sided bodies placed close together dorsal to the pedal ganglia and behind the cerebral. From the left visceral ganglion is given off a fairly stout nerve from which branches arise supplying the pulmonary siphon, the pseudobranch, and the left side of the mantle. A little above the origin of this nerve a small branch proceeds upwards in the mantle where it joins the neck of the animal, and supplies the osphradium situated next to the right border of the siphon. The osphradium, also known as the organ of Spengel or Lacaze Duthier's new organ of innervation, is a flask-shaped structure of whitish colour opening by means of a broad, funnel-shaped aperture to the outside. The nerve supplying it enters the broad end of the structure. From the middle visceral are given off three nerves, branches of which supply the floor and roof of the pallial cavity. A long nerve passes over the 'organe de la glaire' supplying the genital organs and the pericardium. From the right visceral are given off two nerves, a small nerve to the œsophagus and a stout one to the right side of the mantle. The pedal ganglia are flattened quadrilateral bodies rounded posteriorly, and give off three or four stout nerves with several branches supplying the foot. A short commissure connects the left visceral ganglion with the pallial nerve from the middle visceral.

In spite of the greater development of the pseudobranch in *I. exustus* its nerve does not seem to be any better developed than in *P. corneus*.

THE FAUNA OF AN ISLAND IN THE CHILKA LAKE.

Contents of Part III[1].

THE TERMITES OF BARKUDA ISLAND.

By F. Silvestri.

Dr. N. Annandale has carefully investigated the fauna of the small island Barkuda in the southern part of the Chilka Lake, and with the assistance of various specialists has already given an account of some part of this interesting collection. I have received the Termites and have found that they are represented by 10 species and 3 varieties of which 2 species with a subgenus and 3 varieties are described here as new; the others belong to species which have a wide distribution in South India.

My best thanks are due to Dr. N. Annandale for the very kind communication of this and other interesting material.

Genus **Odontotermes** Holmgr.

Subgenus **Euscaiotermes,** nov.

Miles. Caput antice parum angustatum, supra vix convexum, antennis 17-articulatis, labre paullum longiore quam latiore, mandibula laeva parte basali dente obtuse armata, parte distali excavatione magna, angule acute infere et dente obtuse supero limitata, affecta, parte apicali attenuata aliquantum curvata; mandibula dextera parte distali simplici inermi.

Pronotum lobe antice sat parvo.

Observatio. Subgenus hoc militis mandibulae laeva forma bene distinctum est.

Odontotermes (Euscaiotermes) primus, sp. nov.

(Fig. I.)

Miles. Corpus melleo-ochroleucum capite latericio mandibulis nigris. Caput c. 1/9 longius quam latius, antice parum angustatum supra parum convexum, setis nonnullis instructum, labro paullum longiore quam latiore, antice triangulari, lateribus convexis, supra setis 7+7 sat

[1] For Part I see *Rec. Ind. Mus.* XXII, pp. 313—422 (1921); for Part II see *ibid* XXIV, pp. 289—311 (1922).

longis instructo, antennis 17-articulatis articulo tertio quam secundus c. 1/3 et quam quartus parum breviore, mandibulis vide fig. I, 3.

Pronotum lobi antici margine supero parum sinuato, margine postico vix sinuato, superficie setis nonnullis brevibus et brevioribus instructa; meso et metanoti margine postico subrecto, angulis lateralibus rotundatis.

Pedes primi paris bene setosi, tibiae calcare externo quam interna parum breviore, secundi paris tibia setis distalibus externis duabus quam ceterae parum robustioribus.

Abdomen setis sat longis, brevibus et brevioribus sat numerosis instructum. Cerci breviores parte distali conica.

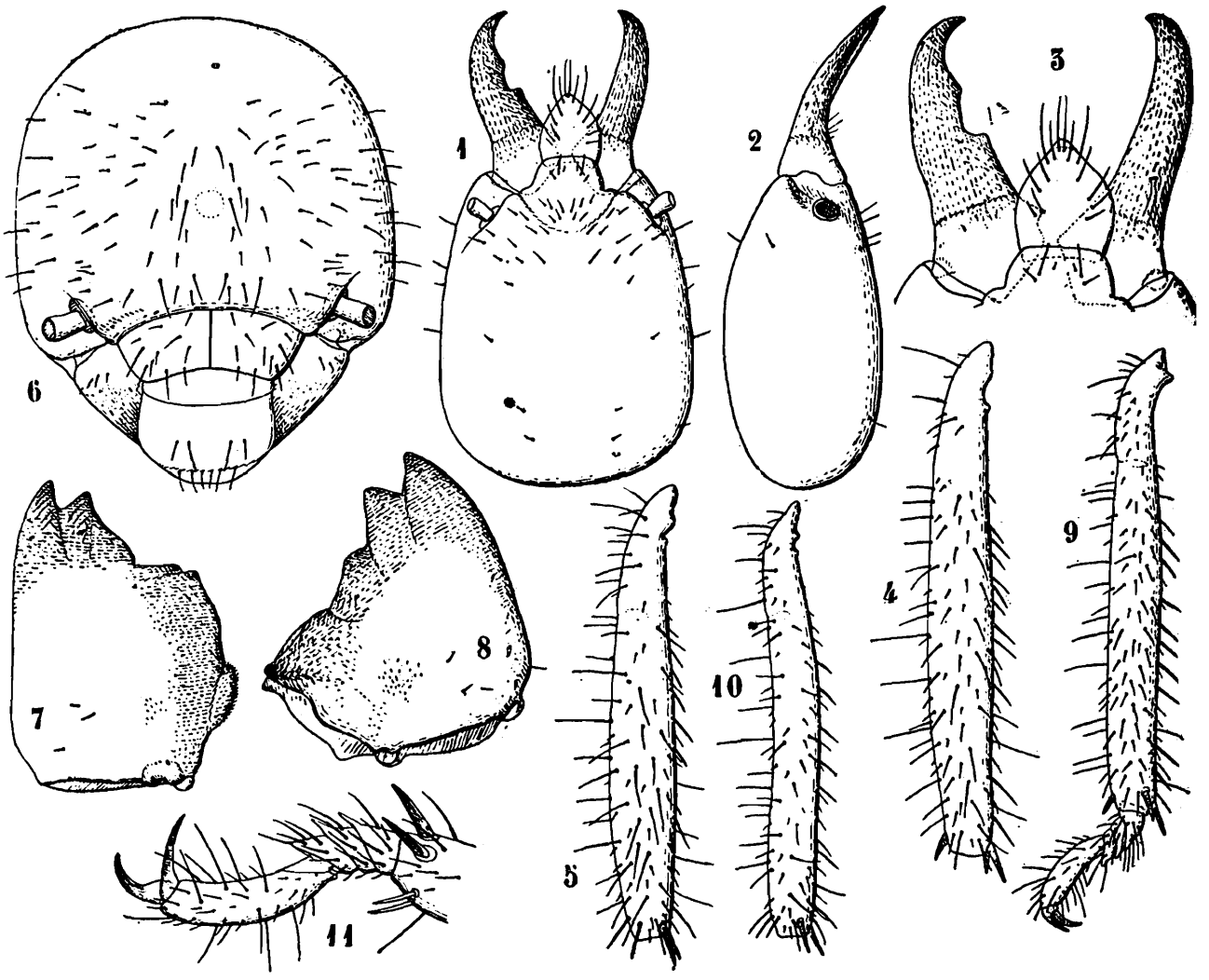

Fig. I.—*Euscaiotermes primus:* 1. militis caput pronum; 2. idem lateraliter inspectum; 3. ejusdem pars antica cum mandibulis prona; 4. militis tibia primi paris; 5. militis tibia secundi paris; 6. operarii caput pronum; 7, 8. ejusdem mandibulae; 9. operarii pes primi paris a tibia; 10. operarii tibia secundi paris; 11. tibiae ejusdem apex cum tarso et praetarso.

Long. corp. 8 mm., long. capitis 2·85, ejusdem lat. 2·40, long. mandib. 1·60, antennarum 2, tibiae III, 2·2.

Operarius. Corpus ochroleucum capite ochraceo-ferrugineo, abdomine cibi contenti causa cinereo parum conspurcato.

Caput parum latius quam longius, clypeo bene inflato, ejusdem dimidia parte c. 1/3 latiore quam longiore, fontanella ochroleuca circulari sat magna, antennis 19-articulatis, articulo secundo quam tertius

parum minus quam duplo longiore, articulo quarto quam tertius parum breviore et quam quintus parum longiore, mandibulis vide fig. I, 7-8.

Pronotum lobi antici margine supero medio parum sinuato, margine postico ut idem mesonoti medio parum sinuato, metanoti margine postico medio vix sinuato.

Pedes et abdomen eisdem militis subsimilia.

Long. corp. 5·5 mm. long. capitis 1·62, ejusdem lat. 1·78, long. antennarum 2·70, tibiae III 1·85.

Habitat. Barkuda I. A few workers and a soldier under stone.

Subgenus **Odontotermes** Holmgr.

Odontotermes (O.) feae (Wasm.)

Winged specimens "swarming in middle of night," 12·vi·1920, and a few soldiers and workers collected among roots of a dead tree; a few workers found in interior of a dead tree-trunk.

This species is widely distributed in South India.

Odontotermes (O.) oblongatus Holmgr.

I refer to this species a few soldiers and workers collected in a dead tree-trunk.

The soldiers have the head (always without mandibles) 1·85 mm. long, 1·27 wide, with mandible 0·92 long, antennae 16-jointed with the fourth the shortest.

This species was hitherto recorded only with doubt from "Hinter Indien."

Subgenus **Cyclotermes** Holmgr.

Odontotermes (C.) obesus (Ramb.)

(Fig. II.)

This is the commonest species of Termite on Barkuda I. I refer to the typical form most of the specimens collected by Dr. Annandale.

Winged specimens collected on the 12th of June have the following dimensions:

Female: body with wings 27 mm. long, without wings 15, head 2·25 long, 2·15 wide between the eyes, the latter 0·75 in longitudinal diameter. Antennae of 19 joints of which the third is the shortest, about half as long as the second and a little shorter than the fourth.

Soldier major with head 1·34 long (without mandibles), 1·24 wide, mandibles 0·90 long, antennae 17-jointed with the third the shortest.

Soldier minor with head 0·97 long, 0·93 wide, mandibles 0·64 long, antennae 5-jointed with the third the shortest.

Between the forma major and forma minor there are intermediates.

The queen and a king of a nest collected by F. H. Gravely in Aug., 1909, have a lesser stature than the above: in the king the head (Fig. II, 2) is 2·15 long, 1·95 wide between eyes, the latter with a longitudinal diameter of 0·65.

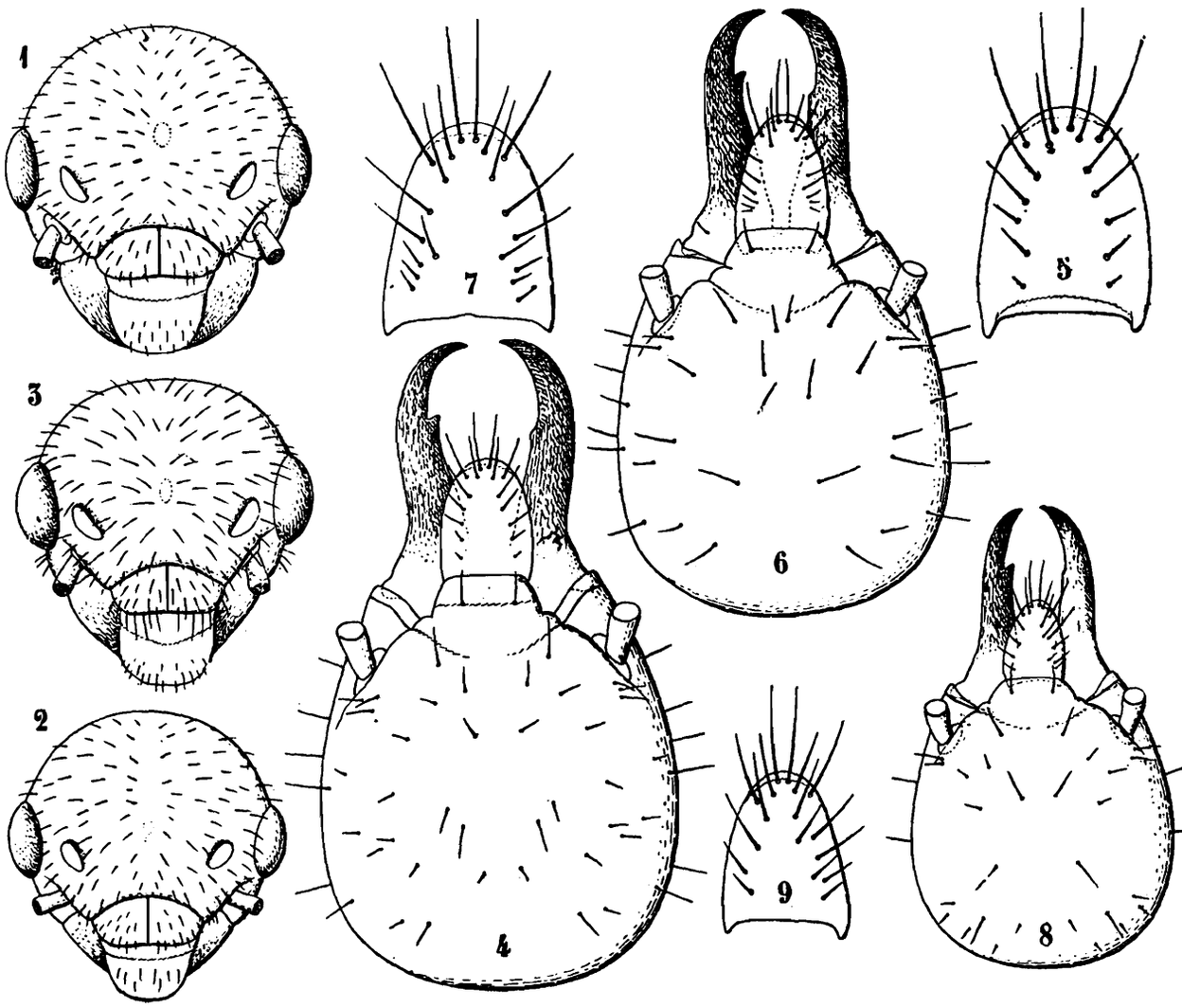

Fig. II.—1. *Odontotermes obesus*, forma typica: alati caput pronum; 2. *Odontot. obesus*, forma typica minor: regis caput pronum; 3. *Odontot. obesus* v. *oculatus*: reginae caput pronum; 4, 5. *Odontot. obesus*: militis maioris caput et ejusdem labrum; 6, 7. militis intermedii caput et ejusdem labrum; 8, 9. militis minoris caput et ejusdem labrum.

Odontotermes obesus (Ramb.) var. **oculatus,** nov.

(Fig. II.)

In a nest opened by Dr. Annandale on Oct. 30th, 1920, he found a big queen 60 mm. long, which has the head 2·15 mm. long and 1·95 wide between the eyes. The eyes are bigger than in the typical form; they have a longitudinal diameter of 0·78 and are very distinctly more prominent. For this reason, and at any rate until we do know the variations of the widely distributed *Odontotermes obesus* more exactly, I regard the form as new.

The soldiers and workers are indistinguishable from those of the typical form.

Microtermes anandi Holmgr.

Few soldiers and workers in dead tree-trunk, numerous workers and few soldiers in galleries.

This species is widely distributed in South India.

Coptotermes heimi Weism.

Specimens were collected under the bark of a dead tree-trunk (*Ficus bengalensis*) lying on the ground. This species also is widely distributed in South India.

Coptotermes parvulus Holmgr.

A good number of specimens : workers and soldiers. This species was recorded hitherto only from the Bombay Presidency.

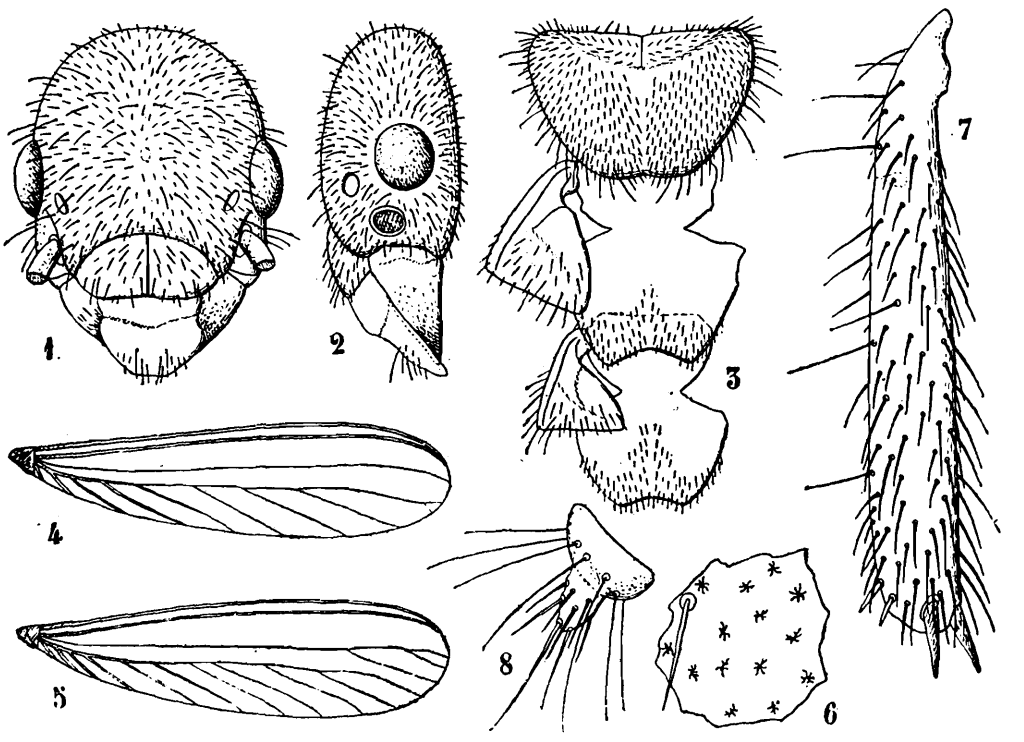

FIG. III.—*Microcerotermes annandalei*, femina : 1. caput pronum ; 2. idem lateraliter inspectum ; 3. thorax, pronum ; 4, 5. ala anterior et ala posterior ; 6. alae particula multo ampliata ; 7. tibia secundi paris ; 8. cercus.

Microcerotermes annandalei, sp. nov.

(Figs. III, IV.)

Femina alata. Corpus castaneum ventre rufescente urosternorum maxima pro parte rufo-castanea.

Caput c. 2/9 longius quam inter oculos latius, supra setis brevibus parum numerosis et setis brevioribus magis numerosis instructum, fenestra parva fusca, clypeo parum inflato, ejusdem dimidia parte paullum latiore quam longiore, oculis parvis bene convexis, ocellis parvis ab oculis quam ocelli diametros transversalis parum minus distantibus, antennis 14-articulatis articulo tertio quam secundus dimidio breviore et quam quartus c. 1/3 breviore.

Pronotum quam caput cum oculis parum magis quam 1/8 minus latum, antice breve tractu sursum vergente lateribus gradatim aliquan-

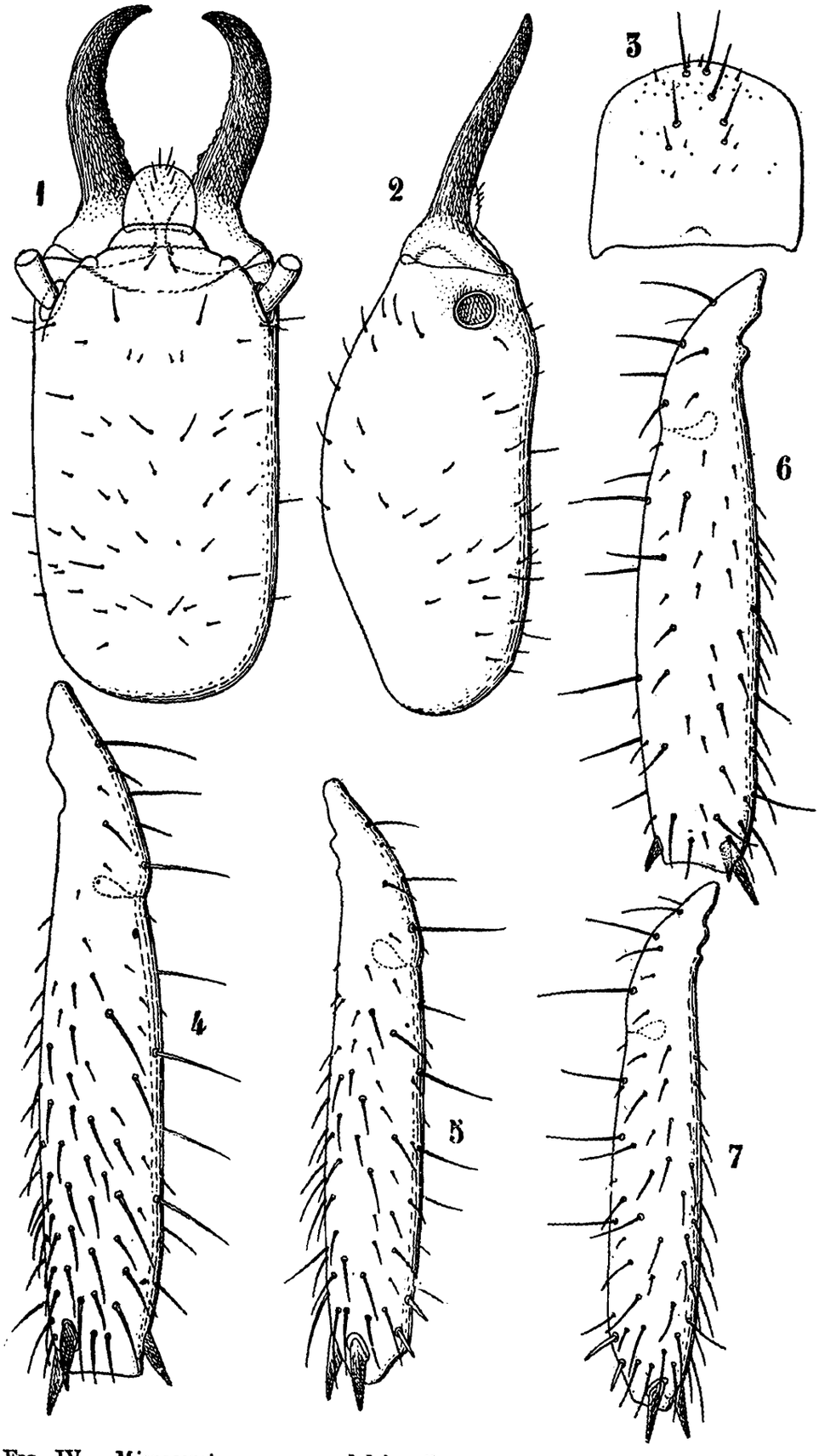

FIG. IV.—*Microcerotermes annandalei*, miles; 1. caput pronum; 2. idem lateraliter inspectum; 3. labrum; 4. tibia primi paris; 5. tibia secundi paris; 6. operarii tibia primi paris; 7. Operarii tibia secundi paris.

tum convergentibus, margine postico medio paullum sinuato, angulis posticis rotundatis ; meso et metanotum lateribus partem posticam versus parum convergentibus, margine postico lato, mesonoti aliquantum, metanoti parum sinuato.

Alae superficie setis sparsis et tuberculis minimis 5-6 radiatis obsessa, venis vide fig. III, 4-5.

Pedes bene setosi, tibia secundi paris spinis duabus distalibus externis brevibus, sat robustis, approximatis.

Abdomen tergitis et sternitis setis brevioribus et brevissimis numerosis, nec non urosternitis setis nonnullis sat longis instructis, pleuris setis brevissimis obsessis. Cerci breviores setis vide fig. III, 8.

Long corp. cum alis 9, sine alis 5, long capitis 0·94, ejusdem lat. inter oculos 0·74, long. antennarum 1·30, alae anterioris 7·3, ejusdem lat. 1·9, long tibiae III, 1.

Miles. Corpus ochroleucum capite ochraceo vel ochraceo-latericio praesertim antice, mandibulis maxima pro parte nigris.

Caput rectangulare fere duplo longius quam latius, ante mediam frontem paullum concavum, antice discendens, labro paullum latiore quam longiore antice paullum convexo setis superis 5-6 brevibus et nonnullis brevissimis, mandibulis quam capitis longitudo fere dimidio brevioribus aliquantum arcuatis, margine interno irregulariter serrato, antennis 13-articulatis, articulo tertio quam secundus dimidio et quam quartus 1/3 breviore.

Pronotum lobi antici margine supero medio aliquantum sinuato, superficie setis nonnullis sat longis, brevioribus et brevissimis instructa, mesonoti margine postico paullum, metanoti vix sinuato.

Pedes vide fig. IV, 4-5.

Abdominis tergita et sternita setis paucis sat longis, aliis brevioribus et setis brevissimis sat numerosis instructa.

Cerci parte distali parum elongata, subconica.

Long. corp. 5 mm., long. capitis 1·90, ejusdem lat. 1, long. mandibularum 1·04, antennarum 1·56, tibiae III, 0·90.

Operarius major. Corpus stramineum capite ochroleuco, abdomine cibi contenti causa plus minusve cinereo maculato.

Caput parum longius quam latius, supra setis brevibus sparsis et setis brevioribus sat numerosis instructum, fontanella sat parva, circulari, clypeo parum inflato, ejusdem dimidia parte subaeque longa atque lata, antennis 13-articulatis articulo tertio quam secundus dimidio et quam quartus parum breviore.

Pronotum lobi antici margine supero medio aliquantum sinuato, cetero thorace et abdomine eisdem militis similibus.

Pedes vide fig. IV, 6-7

Long. corp. 4·8 mm., long. capitis 1·15, ejusdem lat. 1·04, long. antennarum 1·18, tibiae III, 0·78.

Operarius minor. Long. corp. 4 mm., long. capitis 0·84, ejusdem lat. 0·78, long. antennarum 1·10, tibiae III, 0·70.

Antennae 13-articulatae eisdem operarii majoris similes.

Habitat. A small number of specimens was collected under bark of a dead tree-trunk, June 1920.

Observatio. Species haec ad *M. fletcheri* Holmgr. proxima est, sed statura minore et militis labri forma distincta.

Eurytermes assmuthi Wasm.

Not having winged forms, I refer with some reserve to this species a number of nymphae, workers and a soldier collected from a bank of earth among roots of *Hemigyrosa canescens* (24-29·x·20), and a few specimens from small chambers at the roots of a fig tree (11·x·1920).

The nymphae, with alar paiths 2 mm. long, have the body 8 mm. long.

The soldier has head 1·82 mm. long, 1·17 wide with mandibulae 0·90 long, antennae of 14 joints, of which the third is a little shorter than the second and a little longer than the fourth.

In workers the head is 0·94 mm. wide.

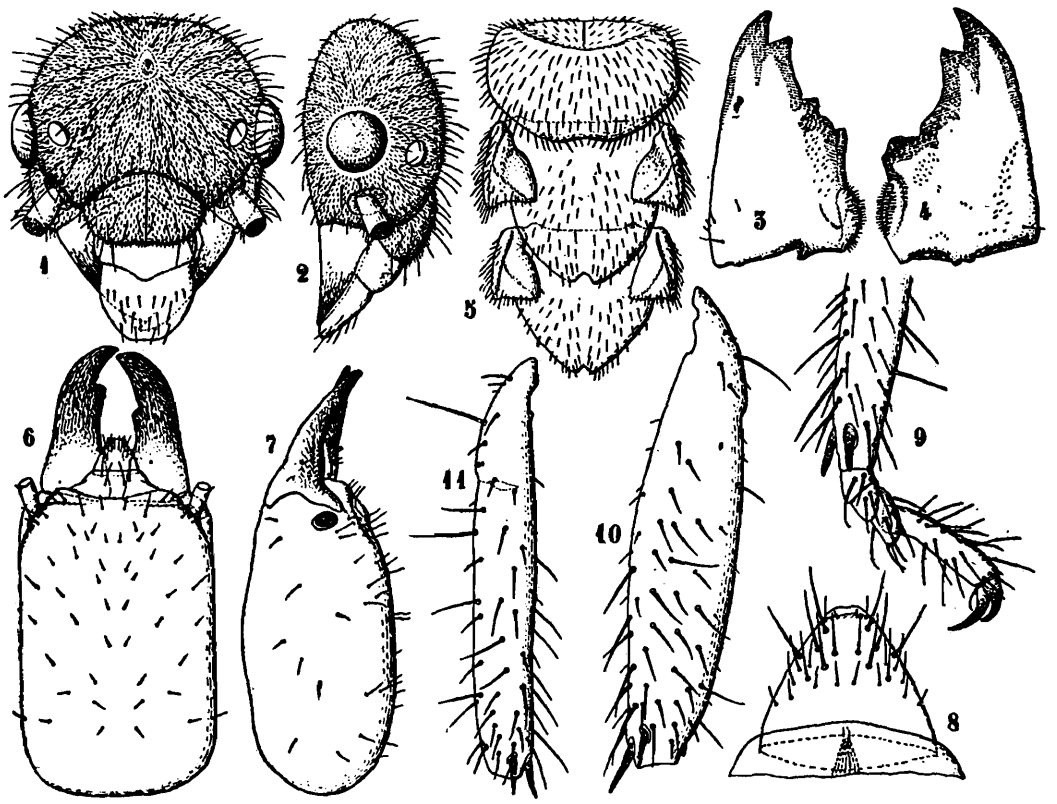

Fig. V.—*Eurytermes assmuthi* v. *modestior*, femina: 1. caput pronum; 2. idem lateraliter inspectum; 3, 4. ejusdem mandibulae; 5. thorax pronus; 6. militis caput pronum; 7. idem lateraliter inspectum; 8. ejusdem labrum; 9. militis pes tertii paris a tibiae parte distali; 10. operarii tibia primi paris; 11. operarii tibia secundi paris.

Eurytermes assmuthi Wasm. var. **modestior,** nov.

(Fig. V.)

A small nest with very young queen and king, a number of workers and a soldier. The specimens from this nest are smaller than the typical form. The difference of size of worker and soldier may be related to the age of the nest, but the royal pair is smaller than in *Eurytermes ceylonicus* Holmgr. and the eyes larger than in *Eurytermes assmuthi* Wasm. from Kandala.

Queen. Length of body 6 mm., of head 0·96; width of the same between the eyes 0·90; length of antennae 1·72; of tibia III, 1·18,

Antennae composed of 15 joints of which the second is double the length of the third which is subequal to the fourth.

Soldier. Head 1·70 mm. long, 1·08 wide, mandible 0·78 long.

Antennae 14-jointed, second joint *ca.* 1/3 longer than third which is a little longer than fourth.

Worker. Head 0·84 mm. wide.

Capritermes obtusus sp. nov.

(Figs. VI, VII.)

Femina alata. Corpus castaneum capite, clypeo et labro rufis exceptis, et meso- et metanoti parte postica aliquantum obscurioribus, sternorum parte mediana cremea vel ochroleuca, pedibus rufescentibus, alis fumosis.

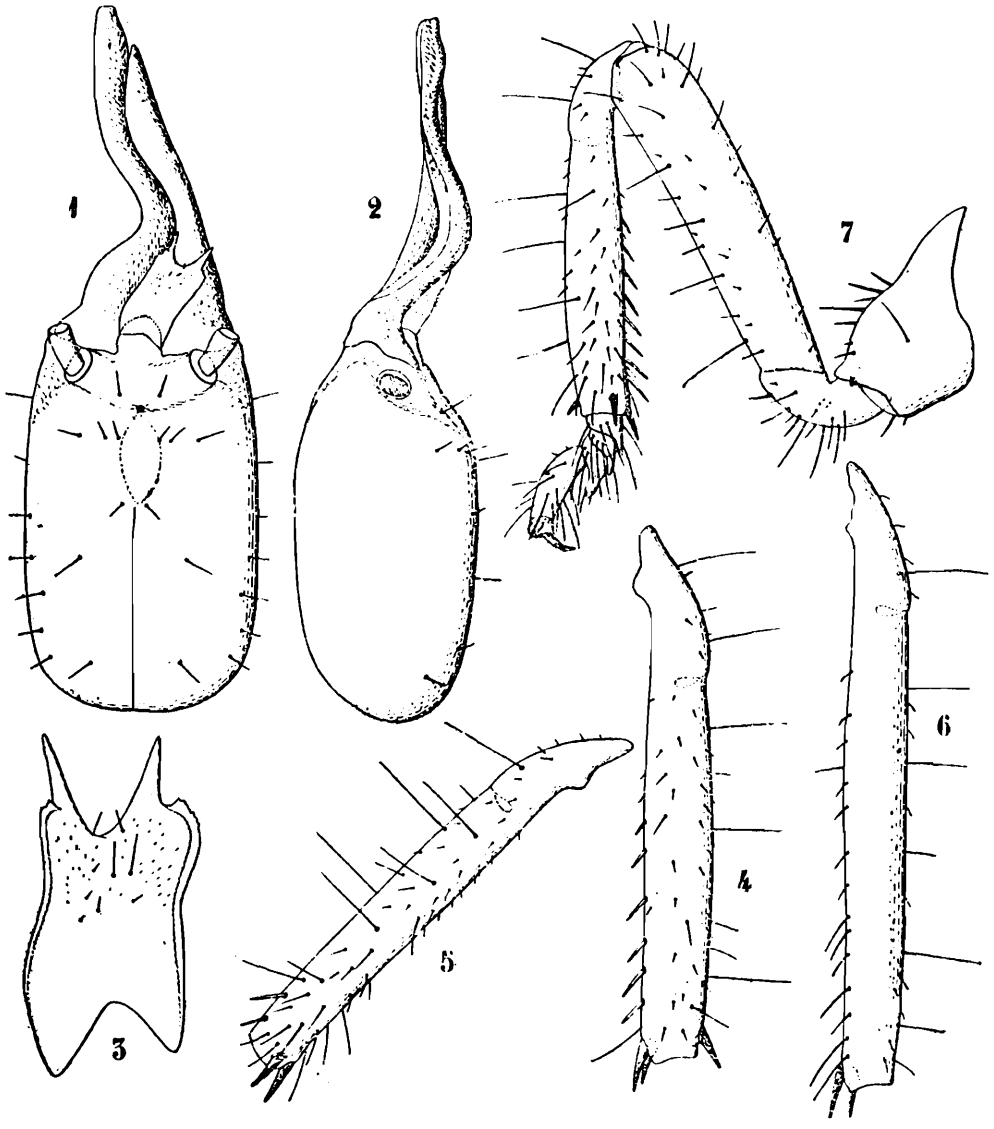

FIG. VI.—*Capritermes obtusus*, miles: 1. caput pronum; 2. idem lateraliter inspectum; 3. labrum; 4. tibia primi paris; 5. tibia secundi paris; 6. tibia tertii paris; 7. operarii pes primi paris.

Caput subaeque longum atque inter oculos latum, supra setis sat numerosis, sat longis et setis brevioribus magis numerosis instructum, fenestra parva angusta elongata quam ceterum caput pallidiore, clypeo

sat inflato, ejusdem dimidia parte subaeque longa atque lata, oculis parvis, bene convexis, ocellis ab oculis quam ocelli diametros transversalis parum magis distantibus, antennis 14-articulatis, articulo tertio secundum longitudine aequante, quam quartus c. 1/4 longiore.

Pronotum quam caput cum oculis aliquantum (8·5 : 7) minus latum, antice brevi tractu sursum vergens, lateribus postico convergentibus, angulis rotundatis, margine postico medio parum sinuato; meso- et metanotum lateribus convergentibus, margine postico angulatim profunde inciso, angulis posticis plus minusve acutis.

Alae superficie tuberculis 6-7 radiatis obsessa et setis nonnullis brevibus sparsis instructa, venis vide fig. VI, 4-5.

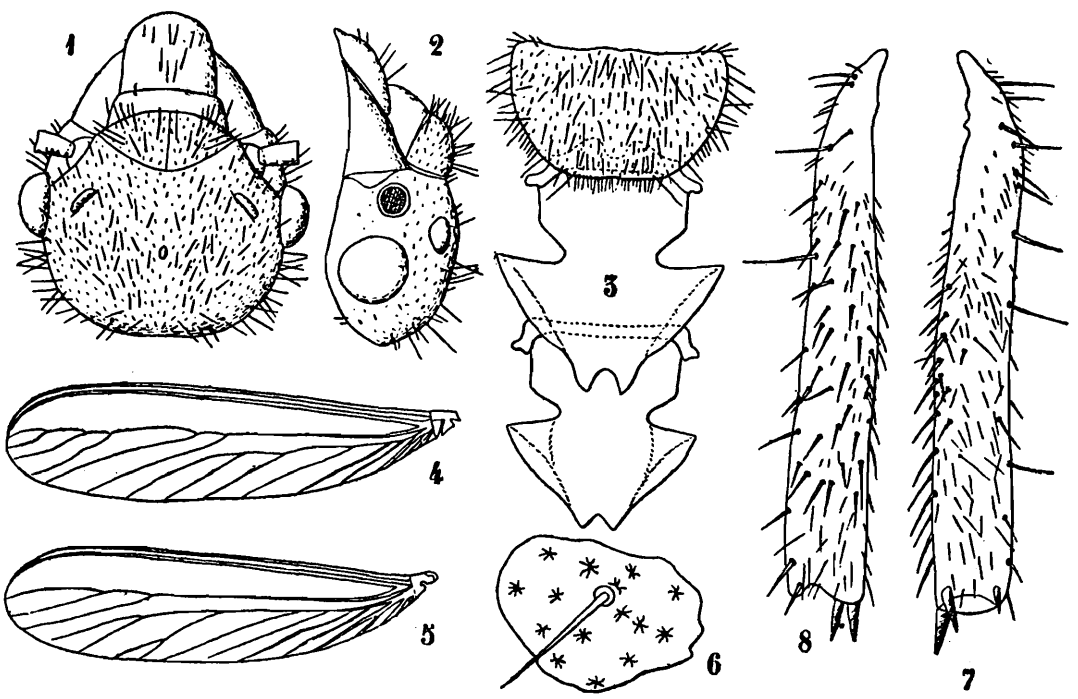

Fig. VII.—*Capritermes obtusus*, femina: 1. caput pronum; 2. idem lateraliter inspectum; 3. scuta thoracalia prona; 4, 5. ala superior et ala inferior; 6. alae particula multo ampliata; 7. tibia pedis primi paris; 8. tibia secundi paris.

Pedes primi paris tibia interne setis sat numerosis et sat robustis, calcare externo quam interno paullum breviore, secundi paris tibia setis spiniformibus duabus subapicalibus sat robustis, calcaribus bene evolutis.

Abdominis tergita et sternita setis brevibus sat numerosis (per sterna magis numerosis) et brevioribus pernumerosis instructa, pleuris setis brevioribus numerosis vestita.

Long. corporis cum alis 12 mm., sine alis 7, long. capitis 1·09, ejusdem lat. inter oculos 1·10, diametros long. oculi 0·28, long. antennarum 2, alae anticae 10, ejusdem lat. 2·6, long. tibiae III, 1·38.

Miles. Corpus cremeum capite ochraceo antice plus minusve ochraceo-ferrugineo, mandibulis nigris.

Caput c. 1/3 longius quam latius, lateribus subparallelis, margine antico sublaterali obtuso, haud producto, fontanella perparva, glandula parva, dorso subplano, parte antica discendente, superficie setis paucis instructa, labro longo, a media basi ad medium marginem anticum,

menso, subaeque longo atque lato, antice profunde sinuato angulis attenuatis elongatis corniformibus, ad processuum anticorum basim externam minute et irregulariter inciso, mandibula laeva capitis longitudinem aequante, forma vide fig. VI, 1-2, antennis 14-articulatis, articulo tertio quam secundis fere 1/4 breviore et quartum longitudine subaequante.

Pronotum quam caput parum minus quam dimidium minus latum, lobi antici margine supero medio vix inciso, setis nonnullis sat longis et aliis brevibus instructum, mesonoti margine postico paullum sinuato, metanoti margine postico subrecto angulis rotundatis.

Pedes primi paris coxis setis nonnullis brevioribus robustis, tibia interne setis robustis 6-7, calcare externo bene evoluto, secundi paris tibia spinis duabus distalibus externis attenuatis.

Abdomen setis sat longis, brevibus et brevioribus instructum.

Cerci breviores parte distali subconica.

Long. corp. 5·2 mm., long. capitis 2, ejusdem lat. 1·30, long. mandibulae laevae 2, antennarum 2·20, tibiae III, 1·20.

Operarius. Corpus cremeum capite ochroleuco abdomine cibi contenti causa cinereo.

Caput c. 1/10 latius quam longius supra setis brevibus et brevioribus parum numerosis instructum, fontanella circulari sat magna, straminea, clypeo bene inflato ejusdem dimidia parte aeque longa atque lata, antennis 14-articulatis, articulo tertio quam secundus fere dimidio breviore et secundum longitudine subaequante.

Pronotum lobi antici margine supero rotundato, cetero thorace et abdomine eisdem militis similibus sed setis aliquantum brevioribus.

Pedes vide fig. VI, 7

Long. corp. 4 mm., long. capitis 0·92, ejusdem lat. 1·02, long. antennarum 1·40, tibiae III, 0·94.

Habitat. Barkuda I. A few specimens under stone on damp soil at base of small fig-tree (N. Annandale, 20·vii·1920). Many winged females with workers and soldiers (N. Annandale, 3·vi·22).

Observatio. Species haec a *C. longirostris* Wasm. militis capitis margine antico sublaterali obtuso distinctissima est.

Capritermes obtusus Silv. var. **abbreviatus,** nov.

(Fig. VIII.)

Miles. Long. corp. 4·5 mm., long. capitis 1·70, ejusdem lat. 1·15, long. mandibulae laevae 1·70, antennarum 1·95, tibiae III, 1·15.

Antennae 14-articulatae, articulo tertio quam secundus parum breviore et quartum longitudine subaequante.

Operarius. Long. corp. 4 mm., long. capitis 0·80, ejusdem lat. 0·97, long. antennarum 1·35, tibiae III, 0·85.

Antennae 14-articulatae, articulo tertio quam secundus c. 1/3 breviore et quam quartus aliquantum longiore.

Habitat. Barkuda I., Chilka L., operarios nonnullos et militem.

Observatio. Varietas haec a forma typica statura distincte minore notanda est.

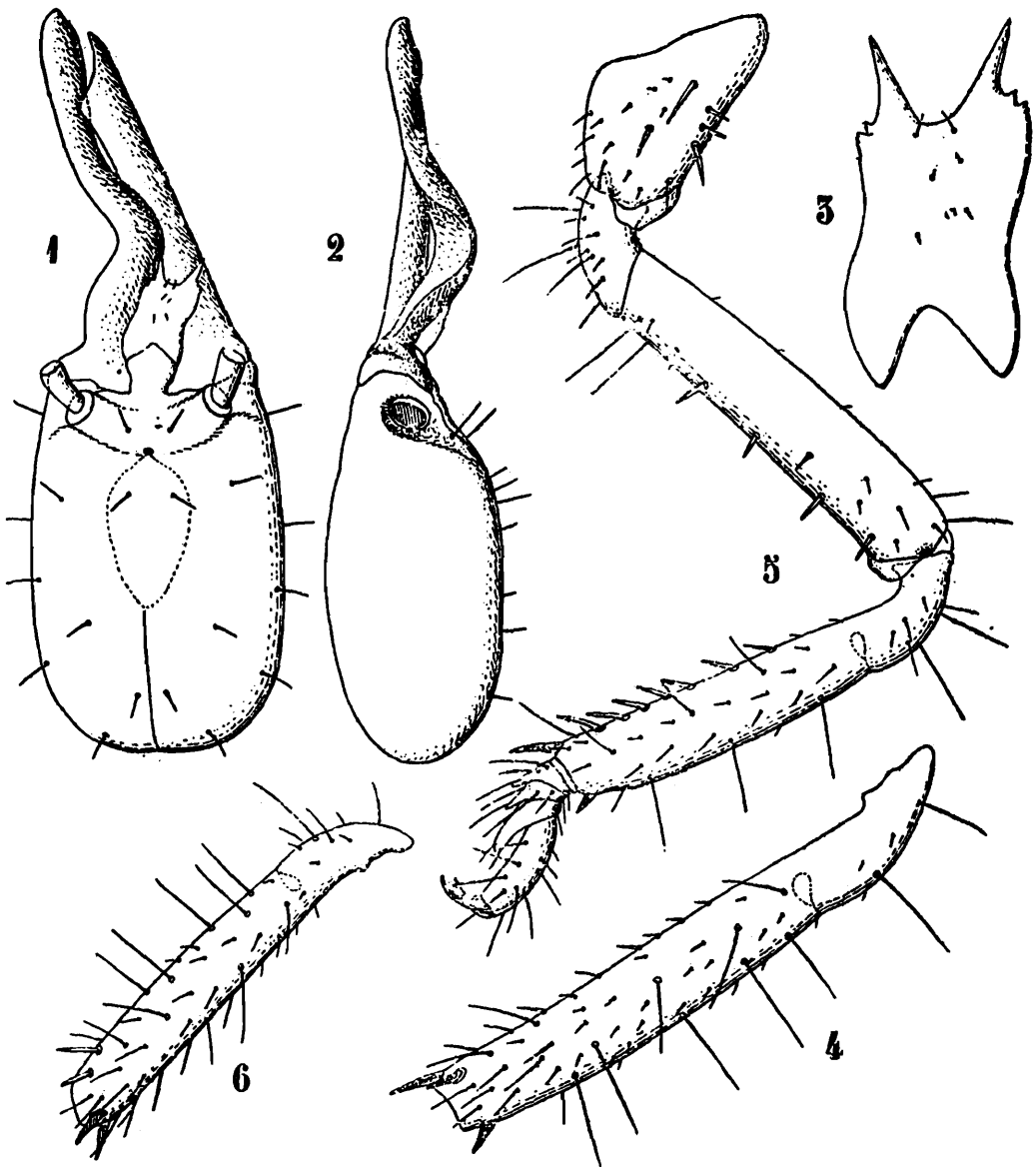

Fig. VIII.—*Capritermes obtusus* v. *abbreviatus*, miles: 1. caput pronum; 2. caput lateraliter inspectum; 3. labrum; 4. tibia primi paris; 5. operarii pes primi paris; 6. operarii tibia secundi paris.

THE HABITS OF THE TERMITES OF BARKUDA.

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(Plates V, VI.)

The following notes on the termites of Barkuda are based mainly on collections and observations made in the years 1919, 1920 and 1922, with a few in the early part of 1923. My visits to the island in these years were frequent but never prolonged. Previous to 1919 some specimens were collected, but no special observations were made. For the identification of species and varieties I am indebted to Professor Silvestri, who has described the collection in the preceding pages. Specimens have been examined by him in all doubtful cases.

The habits of the same species of termites living in different circumstances probably differ considerably. When, therefore, my observations differ from those made elsewhere by other observers [1], no actual discrepancy is necessarily implied. Termite ecology, like that of most other insects, can be discussed in a satisfactory manner only in reference to environment. On Barkuda there are several factors of importance in this connection. For a full account of these I must refer to my recent paper [2] on the island in the *Memoirs of the Asiatic Society of Bengal*, but one or two important facts may be mentioned here. In the first place, the rainfall on the island is small and is concentrated in the few months of the south-west monsoon; in the second, the soil is scanty and infertile, covering the underlying rocks in a thin layer. For the most part it is red and soft, but sandy areas exist. The vegetation is less impoverished than might perhaps be expected in these conditions, but practically all the dead wood on the island, on which it is fairly abundant, belongs to the genus *Ficus* and most of it to the Banyan (*F bengalensis*). These facts have certainly had a selective influence on the termite fauna of the island.

The termites of Barkuda may be classified biologically in accordance with the structure of their nests, in three categories, viz. (*i*) Burrowers, (*ii*) Mound-Builders, (*iii*) Log-Dwellers. Of the habits of two species, *Odontotermes* (*Euscaiotermes*) *primus* Silv. and *O. oblongatus* Holm., and of one variety, *Capritermes obtusus* var. *abbreviatus* Silv., I have no information. The remaining six species with their varieties fall into the three categories as follows :—

BURROWERS.	MOUND-BUILDERS.	LOG-DWELLERS.
Odontotermes (*Odontotermes*) *feae* (Wasm.)	*Odontotermes* (*Cyclotermes*) *obesus* Ramb.	*Coptotermes heimi*, Wasm.
Eurytermes assmuthi Wasm.	*O.* (*C.*) *obesus* var. *oculatus* Silv.	*Microcerotermes annandalei* Silv.
E. assmuthi var. *modestior* Silv.		
Microtermes anandi Holm.		
Coptotermes parvulus (Wasm.)		
Capritermes obtusus Silv.		

[1] I would refer here particularly to the valuable notes contributed by Father Assmuth to Holmgren's papers in vols. XXI and XXII of the *Journ. Bombay Nat. Hist. Soc.*, and to the former's own paper on wood-eating termites in the latter volume and vol. XXIII.

[2] *Mem. Asiat. Soc. Bengal* VII, pp. 257—287, pls. vii-xi (1922).

This biological classification does not correspond with any taxonomic one, for species of *Odontotermes* come under two headings; nor is it by any means absolute, for there is no fundamental distinction in habits between the mound-builders and the burrowers and both excavate galleries in logs as well as in the earth. I base the distinction entirely on the position of the royal chamber, or if there is no special royal chamber, on the part of the nest frequented by the queen or queens. With the mound-builders it is above ground, or at any rate almost at ground-level, in or immediately below the mound when the latter is fully constructed; with the burrowers it is under ground, while with the log-dwellers it is in dead logs of wood. I propose to discuss the nests of the three types separately, but before doing so to consider their comparative ecology in such important matters as swarming, the duration of life, the cultivation of fungi and the search for food.

SWARMING.

In most species swarming takes place on Barkuda at the beginning of the rainy season, *i.e.*, at some date in June. In 1920, in which year the rains began about the usual time, *Odontotermes obesus* [1] and *O. feae* swarmed on the night of June 12th-13th; in 1922, in which the rains commenced unusually early, this took place on the afternoon of June 2nd and in the succeeding night. In both years the event was practically simultaneous with the appearance of the south-west monsoon. On the afternoon of June 2nd in 1922 *Microcerotermes annandalei* and *Capritermes obtusus* also swarmed. Winged adults of *Microtermes annandalei* were found with workers and soldiers under the bark of a dead tree, apparently just about to emerge, in June, 1920. *Coptotermes heimi*, however, swarms earlier, in the dry season. Winged adults and a female which had just cast its wings were found in a nest on April 29th in 1922. Apparently *Eurytermes assmuthi* swarms in autumn, after the rainy season, for both young adults which had already cast their wings and winged nymphs apparently just about to undergo their final metamorphosis were taken in October, 1920. I have not observed the actual pairing of any species.

Probably the adults are ready to swarm in suitable climatic conditions some time before these usually occur. I have found male and female nymphs of *Microcerotermes annandalei* with the wings as long as the body but still teneral in February.

In this species, in *Coptotermes heimi* and in *Eurytermes assmuthi*, the communities of all of which are comparatively small, only a few winged adults are produced at a time and they probably issue forth singly or in small parties. The adults of *Capritermes obtusus* crawl out in large numbers from a small hole in the ground while rain is actually falling. They cease to do so when the rain stops and do not appear until it has become heavy. I have seen the process only in the afternoon between 4 and 6 P.M. This is also true of *Microcerotermes annandalei*, except that the hole is in the side of a dead tree-trunk. In the latter species the

[1] In Bombay this species swarms, according to Father Assmuth, *after* the rainy season.

winged adults issue unaccompanied, but in the former a few workers and one or two soldiers sometimes, but not always, come out of the hole with them. *O. obesus* and *O. feae* swarm only in wet weather and probably do not begin to do so until rain is falling, but they often continue to issue forth for a considerable time, sometimes for a whole night, after it has ceased to fall. In both species the flight is crepuscular or nocturnal, beginning about sunset or later and continuing until about 7 A.M.

Both in 1920 and in 1922 I was able to observe details of the swarming of *O. obesus* in the same nest, or at any rate in one in precisely the same position, at the base of a large tree of *Ficus infectoria* surrounded by brickwork that had fallen into decay. On both occasions the adults began to issue forth during the night and continued to do so until about 7-30 A.M. The numbers that appeared then became gradually less and the process was completed by 8 A.M. On the previous day the workers had been busy building up little hollow cones of irregular outline on the top of the mound. These were at first completely closed, but their wall was very thin. They varied in size but were never more than six or seven inches high. Before the adults came out, slit-like apertures were formed across the top of these cones on the side furthest from the tree-trunk. These were the vents of egress, and from them both winged forms, workers and soldiers issued in large numbers. As I did not observe the swarming till daylight I do not know whether the soldiers come out as early as the other castes, but they were mingled with them in considerable numbers at that time.

The adults as a rule took flight directly from the edge of the vents, but many fell over as they came out and had no difficulty in rising from the ground. The workers and soldiers wandered about in an apparently aimless way on the surface of the mound, where they were surrounded by hosts of black ants, which every now and then pounced on one of the workers and carried it off. The ants seemed to be wary of the soldiers, but these latter were not drawn up in any particular formation and did not occupy any particular position in reference to the workers and adults. Between 7-30 and 8 A.M. on both occasions all the adults had left the nest, which I opened later in the day; the workers and soldiers had retreated, and the former had in the course of a few minutes closed up the vents with pellets of clay brought from below.

As one of the objects of swarming is believed to be to allow cross-fertilization to take place between different communities, it is important to note how far this is permitted by actual events. On June 2nd, 1922, I observed swarming taking place simultaneously in two nests of *Capritermes obtusus* situated about 50 yards apart. On the night of June 12th-13th, 1920, and again on that of June 2nd-3rd, 1922, communities of both *Odontotermes obesus* and *O. feae* were swarming in different parts of Barkuda, while at Rambha, five miles away, *O. obesus* was swarming in the early morning of the 2nd. Possibly this occurred on Barkuda also on the night of the 1st-2nd, for one of my servants told me that he had seen winged termites in large numbers on that night; but I did not reach Rambha myself till about 6-30 A.M. on the 2nd.

An important question in this connection is that of the power of flight of the different species. In the larger forms such as *O. obesus*

it is certainly much greater than is usually realized. On the morning of June 2nd, 1922, between 7 and 8-30 A.M., I observed large numbers of winged adults of *O. obesus* flying over the surface of the Chilka Lake between Rambha and Barkuda. There was very little breeze at the time, but what there was blew from the S.W The majority of the termites were apparently attempting to cross the lake at right angles to the breeze or approximately so. In spite of their fluttering and seemingly ill-directed flight, the great majority were progressing steadily in one direction. Many fell by the way and were drowned, but many also persisted and reached land. Some that I saw fly ashore on the island must have flown for at least three miles.

The flight of the smaller species such as *Capritermes obtusus, Coptotermes heimi* and *Microcerotermes annandalei,* however, is less sustained. I have already noted that the first and the last of these species only issue forth while rain is actually falling. I find that adults taken direct from the mouth of the nest and kept in a dry cage were unable to co-ordinate the action of their wings or to rise from the ground. In issuing from the nest under natural conditions those of the *Capritermes* run about until they are wet before flying off.

There thus seem to be abundant opportunities for cross-fertilization among the commoner termites even on a small island such as Barkuda. On the one hand it is well within the range of flight of the larger species swarming on the mainland; on the other, some at any rate of the feebler species swarm simultaneously in different communities settled only a short distance apart.

All the communities of the same species do not, however, swarm on the same day, and probably some may produce more than one brood of winged adults in a year. So far as I can ascertain, *Odontotermes obesus* and *O. feae* swarm only once a year and all swarm on or about the same date; but this is not so with *Capritermes obtusus.* Two communities of this species, as I have already stated, swarmed in 1922 on the afternoon of June 2nd, but another in the same proximity swarmed on the 23rd of the same month, while in a fourth nest in another part of the island opened on June 27th, a few winged adults and a large number of sexual nymphs were found. The latter were not all in the same stage of development, some being much smaller and having the wing-pads less advanced than others; but the majority were clearly just about to undergo their final metamorphosis and the wing-pads had already assumed a brownish colour.

In the nest from which adults issued on June 23rd two young wingless queens and two wingless males were found, each pair in a separate chamber. The females had not yet increased in bulk to any appreciable extent, but one of them was already beginning to lay eggs. These young adults probably belonged to one or both of the swarms that appeared from adjacent nests on June 22nd.

DURATION OF LIFE.

My observations on the duration of life in the termites of Barkuda are very incomplete and my conclusions must be largely inferential. Some communities of *Odontotermes obesus* have existed to my knowledge

in the same place for at least five years, but how long any individual lived in them is of course beyond my knowledge. Speaking generally I am of the opinion that the sexual individuals of those species in which the winged adults are small live for a shorter period than those in which they are large, and, indeed, probably survive for only one year. I base this conclusion on the fact that in *Capritermes obtusus*, *Coptotermes heimi* and *Eurytermes assmuthi* only very young wingless males and females were found in nests examined shortly after swarming time. In all these species it is probable that more than one pair of adults inhabits each nest.

The only other termite for which I have any kind of data as regards the winged forms in *Odontotermes obesus*. In *O. obesus* there is only one sexual pair in each nest. This species, as I have already stated, swarms in June. A male and female, the latter already swollen to the full size, were taken from a nest of the typical form in July. In October, 1920, a nest of the var. *oculatus* was excavated very carefully. The royal chamber was removed almost intact and placed with a piece of cotton-wool saturated in chloroform under a bell-jar. When the inhabitants were dead it was removed, opened and examined. Only the female (60 mm. long in spirit) and some workers were found. The male had apparently already disappeared, and no eggs were found anywhere in the nest, though there were a few worker-nymphs. In a young mound of the same form which had only appeared above ground about the middle of June, 1922, a fertile pair was found, the female hard at work laying eggs, on July 24th. The female was only 52 mm. long alive and much less flabby than the one obtained in October. In December, 1922, and January, 1923, however, pairs were found in a nest of the same variety. The female was laying eggs, but was not of the full size in either case.

One large nest was examined on December 25th, and the king and queen removed. The nest, which was rapidly reconstructed on a much smaller scale, was again opened on February 18th. No queen was found and no young larvae were present. Larval workers, however, in their penultimate instar were fairly numerous.

As to the age of workers and soldiers I have little further information. That many die off in the latter part of the dry season I have no doubt. The communities of *O. obesus* and *O. feae* are much reduced in numbers at this season, despite the profuse production of young in early spring. In a nest of *Coptotermes heimi* opened in April I found many dead and shrivelled corpses of workers and soldiers in chambers somewhat remote from those occupied by living individuals.

CULTIVATION OF FUNGI AND SEARCH FOR FOOD.

At least four different forms of termites cultivate fungi on Barkuda. They are *Microtermes anandi*, *Eurytermes assmuthi*, *Odontotermes obesus*, and *O. obesus* var. *oculatus*. I have definite evidence that *Microcerotermes annandalei*, *Coptotermes heimi* and *Capritermes obtusus* are not cultivators, having made a full examination of their nests. The cultivating habit, therefore, is not correlated either with the taxonomic position of the species (except that all cultivating species belong to the family Metatermitidae) or with the nature of its

nest, except that the habit is apparently absent in log-dwellers. It is noteworthy that dead logs on Barkuda contain in the rainy season many species of uncultivated fungi.

Among the cultivating forms there is considerable diversity in the structure of the combs (pls. V, VI). It is, indeed, possible to discover an evolutionary series in those of the four forms, with the combs of *M. anandi* at the base and those of the typical form of *O. obesus* at the apex, those of *E. assmuthi* being a little more advanced in structure than those of the *Microtermes*, and those of the variety of *O. obesus* less advanced than those of the *forma typica* of the same species.

As Professor Bose is discussing the cultivation of fungi by the termites of Barkuda from a botanical point of view in another part of this report, I will merely describe the structure of the combs and of the chambers in which they are situated, with a few notes on other aspects of the culture.

Professor Bose has found that in artificial cultures the same fungus springs up from the combs of all the species, namely, *Xylaria nigripes*, a form only known from termite-mounds. This, however, is apparently only a weed, which the termites prevent from developing.

The communities of *Microtermes anandi* are small and are found in association with those of *Odontotermes*, or at any rate in deserted mounds of the latter. They are not, however, true parasites, for they excavate their own galleries in dead wood or in the earth, side by side with those of the larger species, and form their fungus-gardens in chambers dug out by themselves in the walls of the mound. In well-developed communities the fungus-combs are numerous but isolated and widely separated.

The combs of *Microtermes anandi* (pl. V, fig. 4) are perhaps the most simple in construction of any as yet described. Many of them consist merely of masses of pale yellow globular excretal pellets piled together and very imperfectly agglutinated. In others, which are still extremely fragile, the upper surface has a reticulate pattern of ridges with slight pointed elevations at the nodes, while incomplete cells, either vertical or horizontal are formed in the interior. These often take the form of deep, irregularly curved grooves on the surface. In the most perfect combs the cells are a little more definite, but they are rarely closed at both ends and always vary greatly in shape and size. The general form of the comb is flattened and cake-like. Its size is variable. The largest I have seen, which is not complete but nearly so, is 46 mm. long, 33 mm. broad and 26 mm. deep. Old combs are usually stained black in parts. The mycelia on the combs of this species are always rather scanty and the food-bodies few and less perfect in shape than in the combs of other species.

The largest and most flourishing combs of this species I have seen were dug out in June and July from the walls of deserted mounds of *O. obesus* and its variety *oculatus*. In October I once found a similar, but apparently less flourishing garden, tended by only a few workers, in a similar position. The workers of this species seem to have less con-

[1] For an excellent summary of all that is known on the subject see, Petch, *Ann: Roy. Bot. Gardens, Peradeniya* V, p. 303 (1913).

trol over their cultures than those of the species in which the habit is more highly developed.

In the nests of this species only workers were to be found as a rule in the garden chambers, but a few soldiers are occasionally there.

The fungus-combs (pl. VI, fig. 6) in the nest of *Eurytermes assmuthi* (the communities of which are also comparatively small) and of its variety *modestior*, in which they are still smaller, are very similar, but in some respects a little more complex in structure. In the only nest of the variety (which probably represents no more than a young or impoverished community) examined, only one garden was found, but in those of the *forma typica* there are usually two or three, separated by very narrow passage-ways. The masses of excrement in this species are a little more compact and less fragile than those of the *Microtermes* and they have the form of a comb in a pectinate sense. That is to say, the base is somewhat compressed and from it arise vertical finger-shaped projections, which may coalesce or anastomose in an irregular fashion to form vertical recesses or even partially closed cells. The gardens are not more than about 5 cm. in greatest diameter. They are enclosed in small rounded chambers dug out of the earth a few inches below the surface.

As in *M. anandi*, the soldiers apparently do not as a rule frequent the gardens. I have, however, seen one or two there on several occasions.

There is a considerable gap in complexity between the gardens of *E. assmuthi* and those of the great communities of *O. obesus* var. *oculatus* (pl. VI, figs. 4, 5). These gardens are extremely massive and must have a cubic capacity of many litres, for the whole of the basal part of the mound is occupied by a single large garden, incompletely divided by partitions that hang from the roof or rise from the floor of the large garden-chamber like stalagtites and stalagmites in a cave. The garden nearly fills the chamber, of which it is practically a cast. Sometimes there are two or more tiers of comb. The lower surface of the mass is fairly flat, while the upper surface is produced upwards into numerous little peaks, corresponding to elevations in the roof of the chamber.

The pellets of excreta in both this form and in *O. obesus typicus* remain less distinct than in the two smaller species and are more firmly welded together. Individually they are considerably larger.

It is in the internal structure of the garden that the greatest difference is to be found between the more primitive and the more complex cultures. In *O. obesus* var. *oculatus* there is also a considerable difference in this respect between the older and the younger parts of the garden. The latter are situated at the periphery of the mass. Their external surface is covered with irregular grooves and small circular apertures leading into internal cells or cavities of variable shape and size, but mostly orientated more or less distinctly with their major axis at right angles to that of the whole mass. There is little difference in external appearance between the younger and the older parts of the garden, except that the former are as a rule more rounded on the upper surface, occupying less elevated parts of the garden-chamber, and paler

in colour; but if a section be cut it at once becomes evident that the internal cells in the older parts are more vertical and considerably more regular in size and shape. On an average they are about 12 mm. high and 5 mm. broad. Some others are a little oblique or sinuous, but the vertical orientation of all is well marked.

Both the arrangement of the gardens and their internal structure are very different in the typical form of *O. obesus* (pl. V, figs. 1, 2; pl. VI, figs. 1-3). As we shall see later, the difference in arrangement is correlated with a difference in the form and structure of the nest. In the mounds of *O. obesus typicus* there is no single large fungus-garden, but there are many (sometimes as many as twenty or thirty) small gardens, each contained in a single chamber of almost spherical form. The largest chambers are rarely more than 9-10 cm. in diameter and the gardens in them a few centimetres less, but both vary considerably in size. In regularity of internal structure these gardens are almost comparable to honey-combs. They are never quite spherical but as a rule slightly convex above and flat or concave below. Occasionally they have the form of a mushroom with a bulbous head and a slightly narrower stem. I have found specimens in which the upper part was separated from the lower and fitted over it like a cap. Such combs were, however, abnormal and probably owed their peculiarity to some defect in the culture. The cap was always drier and of a darker colour than the remainder of the comb and bore comparatively few food-bodies. The upper part of normal combs often differs from the lower in the same way but to a less extent.

The upper surface of the comb of this termite as a rule contains a few large circular openings, which are approached by short, broad, irregular grooves. The lower surface also bears a few apertures, but they are smaller. Most of the entrances are on the sides.

The internal cells differ from those of the comb of the variety *oculatus* in their regularity, and in being transverse instead of vertical. They are also more uniform in size and are arranged in regular transverse rows in which the separate cells often alternate. Each cell is from 6 mm. to 15 mm. in length, from 3 mm. to 5 mm. in height, and from 10 mm. to 20 mm. in breadth.

The combs of this form thus closely resemble those of *O. redemanni* as figured by Petch.[1]

The combs of *O. obesus* are compact from the first and even when very small have a distinct "cellular" structure (pl. V, fig. 1).

In the four forms of fungus-garden here described we may note, as I have already pointed out, an evolutionary series. There is a gap between the structures produced by *Eurytermes assmuthi* and *Odontotermes obesus* var. *oculatus*, while the resemblance between the comb of the former species and that of *Microtermes anandi* is on the whole closer than that between those of the *forma typica* of *O. obesus* and its variety. Probably the latter's single big garden resembles the garden of *O. bangalorensis* as figured by Assmuth in Holmgren's paper.[2]

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[1] Petch, *Ann. Roy. Bot. Gardens, Peradeniya* III, pl. VII (1906).
[2] *Journ. Bombay Nat. Hist. Soc.* XXII, pl. E, fig. 3.

As to the actual culture of the fungi and their utilization by the termites I have few observations to offer, but there are one or two interesting facts of a collateral nature that have impressed themselves on me. First as to the removal of the combs by *O. obesus*. If a mound of that species be opened in February the upper garden-chambers, which are situated well above ground, will be found to be empty. If this is done in April or May, all the garden-chambers in the mound are empty. In both months the interior of the empty chambers is perfectly clean, and no trace of the gardens can be discovered. If, on the other hand, a mound be opened in which the termites have for some reason died out, as is often the case, dry and shrivelled remains of the gardens will be seen in abundance. I believe, therefore, that in the dry season, and especially when the weather is hot as well as dry, the workers remove the gardens bodily underground. In order to test their power to do so, I exposed three garden-chambers in a mound of *O. obesus typicus* on the evening of August 5th. By the next morning new roofs had been built over two of the chambers, but the third, which was very deep, remained open. The comb had completely disappeared. The passage leading to the chamber from the other parts of the nest had been blocked up.

There are probably two reasons for this removal, viz., (i) the impossibility of maintaining the correct temperature and moisture for the growth of the fungi above ground in hot and dry weather and (ii) the danger to the community if the upper parts of the nest are occupied too near the surface at such times. In descriptions of termite-mounds apertures in the walls, sometimes called "chimneys," are frequently mentioned, and it has even been suggested that these apertures are ventilation-shafts. They are common enough in the mounds of *O. obesus typicus* on Barkuda, but I believe that they are due entirely to accident and constitute a serious danger to the termites. They will always be found on examination to lead into unoccupied chambers or passages completely walled off from the nest. Most frequently they are due to the collapse of the roof of a garden-chamber. This comes about from several causes, both climatic and biological. In great heat, when the mound is dry, its walls are apt to crack, and naturally do so most readily where thinnest. A heavy rainfall then produces a funnel-shaped aperture in the roof of a hollow cavity. But the mound is weakened not only by heat and rain but also by the attacks of many boring or burrowing animals, ranging in size from the monitor lizard *Varanus bengalensis*, which is often as much as 4 feet long and sometimes hollows out the interior of a mound to form itself a safe retreat, to certain trap-door spiders [1] and the larva of a tiger-beetle (*Cicindela haemorrhoidalis*), which habitually construct their burrows in the mounds of *O. obesus*.

The danger to be apprehended (if they have the faculty of apprehension) by the termites when the mound is breached is not only that of flooding in heavy rain but also that of a massed attack by predaceous ants. Such ants are almost invariably to be found in the immediate vicinity of termite-mounds, and they lose no opportunity

[1] See Gravely, *Rec. Ind. Mus.* XXII, pl. xvii, figs. 4-6 (1921).

of carrying off workers and even, when larger species are the aggressors, soldiers. It is very common for empty garden-chambers which have accidentally received a "chimney," to be occupied by colonies of some Pomerine or Campanotine ant which would quickly depopulate even the great communities of such a termite as *O. obesus*, if an entry were given them.

If I am right in thinking that the workers of *O. obesus* remove their combs, the question naturally arises, how do they reconstruct them, for they must take them to pieces in order to remove them? In order to throw some light on this question I opened several mounds a few days after the rains had commenced in June, 1922. In all but one, which was apparently occupied by a young community just starting housekeeping, the combs were already fully formed in chambers in the upper part of the mound. They only differed from gardens examined later in the season in being extremely soft and friable. An artificial culture from them produced *Xylaria nigripes* in an exceptionally short time. It looked as though the combs had been hastily constructed or reconstructed and had not yet become consolidated or been completely weeded.

In one small mound which had just appeared above ground the comb-chambers were already constructed but void of comb. In one such chamber I found a little pile of minute fragments of wood and bark. Do the workers collect material for the formation of excrement and devour it to produce the excrement *in situ?* The point is worth investigating further.

As to the utilization of the food-bodies produced by the fungi in the combs, I have no direct observations to record; but I think it evident they do not provide the bulk of the food consumed by the workers and soldiers. Even in communities in which the garden-chambers are very large or numerous, they could hardly do this for the enormous number of individuals in each community; while in small communities such as those of *Eurytermes* or *Microtermes*, the gardens themselves are small. In the nests of *O. obesus* both soldiers, workers, and young of all castes are found in the gardens. The royal chamber is apart and if the adult males and females feed on fungus-products, they must be brought them by the workers. The eggs, however, are carried by the workers to the gardens, in which both they and the young are often found in large numbers, and I have little doubt that the young eat the food-bodies there produced. Possibly the workers and soldiers do so also in times of stress, but in damp weather they make long excursions outside the nest to feed on dead wood, dead leaves and other dead organic matter. I once traced a foraging party of *O. obesus* from a mound under a fig-tree for over 80 yards to a mass of dead weed thrown up by the lake on the shore. In whatever way the excrement [2] out of which

[1] See Annandale and Dover, *Rec. Ind. Mus.* XXII, p. 337 (1921) and Horn, *Deutsch. Ent. Zeits.*, 1899, pp. 234, 395. In April, 1922, I found the adults of this beetle abundant in burrows in termite-mounds on Barkuda. Their exuviae were also present and they were evidently waiting to emerge as soon as the rains began. At the beginning of June, after the first heavy showers, Dr. Kemp and I found only exuviae in the burrows, but the beetles were common outside.

[2] Petch, *Ann. Roy. Bot. Gardens, Peradeniya* III, p. 200 (1906).

the gardens are constructed be produced, it cannot be produced unless bulky food containing much woody matter be devoured.

In the gardens of *Eurytermes assmuthi* and *Microtermes anandi* only workers (young and adults) and young soldiers have as a rule been found. Eggs and newly hatched young are piled up together in empty chambers. The *Microtermes* accompanies its larger companion (*O. obesus*) on foraging expeditions in dead logs, in which it eats its own tunnels. They are smaller than those of the *Odontotermes*, too narrow, indeed, for the latter to penetrate. Both this species and *E. assmuthi* also keep their sexual adults apart from the fungus-gardens and even the winged nymphs are isolated in separate chambers. The habitual food of the *Eurytermes* workers is probably the rootlets of trees and other vegetable matter found in the soil. Conditions are, therefore, much the same as in the larger cultivating communities, and probably in the smaller communities also fungus-products are reserved mainly for the young and for adult sexual individuals. They certainly do not form the bulk of the food of the workers and soldiers, at any rate in damp weather.

In December, 1922, I excavated a large nest of *O. obesus* var. *oculatus* with the help of several friends. The ground was very hard and dry at the time. We found the general structure of the nest normal (see p. 245), but the fungus-garden was very bulky and in three tiers. It and its surrounding walls were still damp. The workers and soldiers, although apparently quite active, had almost deserted the galleries and were, indeed, quite absent from the upper vertical galleries, but were found in considerable numbers inside the combs and also in and around the royal chamber. Apparently excursions were not being made from the nest, and the only apparent source of food was the fungus gardens. The " food-bodies " in these were found to be less abundant in winter than in the wet season and to be practically absent from the inner part of the combs in which the workers and soldiers were congregated possibly because they were being devoured by the community at large as soon as they were formed.

THE NESTS OF THE BURROWERS.

Much the simplest and probably the most primitive nests are those of the burrowers. In many species the community is comparatively small and the amount of earth excavated in constructing the nest not of sufficient bulk to form a mound above ground. To this *Odontotermes feae* is an exception, but I will deal with that species last in this section, because its habits provide a transition to those of the mound-builders.

Simplest of all the Barkuda species in the construction of its nest is *Microtermes anandi*, the communities of which are also probably the smallest. It excavates a number of small rounded chambers connected by very narrow passages in the walls of a mound of *Odontotermes obesus*.

The chambers are numerous and each contains either a fungus-garden or a mass of eggs. They are widely separated one from another, Those that contain eggs have an arched roof and a flat floor, while the fungus-garden are more irregular in shape. I have not found a royal chamber. The sexually mature adults probably only live a short time. They have certainly been absent in several nests I have examined both

in the rainy season and after its conclusion, while masses of eggs were found in February. The number of soldiers present is small. Large or elaborate excavations are, therefore, unnecessary in the nest.

Although this species, so far as I know, always makes its nest in the mounds of *O. obesus*, it does not confine its excavations to the walls of the mounds, for I have found it, as already stated, constructing very narrow galleries in dead wood side by side with those of *O. obesus*. Such galleries, however, can hardly be regarded as part of the real nest. The workers, accompanied by a few soldiers, make their way underground to dead logs lying prone and enter them from below to feed on the decaying wood. Neither sexual individuals nor nymphs are found there.

The nests of *Eurytermes assmuthi* are not more extensive, but perhaps a little more complex. They are formed in vegetable mould at the base of trees and take the form of narrow horizontal passages a few inches below the surface of the soil and of small rounded chambers not more than 5 cm. in diameter and situated at the same level as the passages. The latter branch and anastomose sparingly over an area of many square feet and the chambers, which contain the fungus-gardens or provide accommodation for a royal pair or for groups of sexual nymphs, are situated toward the periphery of the whole. It is difficult to follow the exact arrangement of the complex as it is formed in soft earth which collapses at a touch; but there appears to be no exit to the outer air and I have never seen workers or soldiers above ground.

The nest of the variety *modestior* of this species is just like that of the *forma typica* but of less extent and perhaps less complex. The only community observed lived in close proximity to one of the latter form under a tree of *Hemigyrosa canescens*.

The communities of *Capritermes obtusus* are larger than those of either of the two preceding species, but in order to realize the fact it is necessary to excavate the whole nest. This it is by no means easy to do in the scanty soil of Barkuda, for the excavation is usually found among stones or rocks and penetrates downwards for a considerable distance. The species, therefore, though common, is very liable to escape notice. The only nest of which I succeeded in exploring the greater part was dug in a somewhat exceptional position, namely, in the wall of a deserted mound of *O. obesus*, and even in this nest I did not find the royal chamber, though eggs were observed in abundance. The nest consisted of narrow passage-ways and comparatively large but very flat round or oval chambers 10 cm. or more in diameter. These were situated at different levels. The total depth of space occupied by the whole nest must have been about 3 feet and the superficial area about the same. The upper chambers were occupied by large numbers of workers with a much smaller number of soldiers. Those lower down, at about ground-level, contained workers, immature workers and soldiers, sexual nymphs and eggs all together. A few winged individuals were also discovered in the same position. This was on the 29th of June.

The only external orifices I have seen are those through which swarming was taking place.

Odontotermes feae lives in still larger communities and probably excavates much larger and more complex underground passages and

chambers ; but I have never succeeded in exploring a nest of this species. The amount of earth it excavates is certainly considerable. Sometimes this earth is piled up in an amorphous mass among the roots of trees, more often it is utilized in filling up the cavities eaten in dead tree-trunks. In these cavities a complicated series of oblong vertical chambers is often constructed, having thick earthen walls formed of small pellets carried up from underground by the workers. The bulk of these earthworks, which often fill the greater part of dead but still upright trunks, is sometimes almost as great as that of small mounds of *O. obesus*. *O. feae*, however, always works under cover, while the mounds of its congener are built more or less in the open.

The real nest of *O. feae* is always underground and even when the excavated earth is piled up among the roots of trees, the pile contains only passage-ways and small irregular chambers.

The habits of *Coptotermes parvulus* are apparently similar to those of *O. feae*, but I have only once taken this species, in an upright hollow trunk of *Ficus bengalensis*. It was in very hard, dry wood.

THE NESTS OF THE MOUND-BUILDERS.

The mounds constructed above ground by many species of termites (on Barkuda by two varieties of *Odontotermes obesus* only) are not mere rubbish heaps, as has been stated, but highly organised structures containing not only the gardens of the community but also its royal palace, its public nurseries and its communal dwelling-place. Nevertheless, they must be regarded as a development from the almost structureless rubbish heaps piled up by such species as *Odontotermes feae* outside their burrows, and are in some respects analogous to the coarse and irregular chambers constructed by the same species in hollow tree-trunks and such situations.

The two varieties of *O. obesus* (the *forma typica* and *oculatus*) that occur on the island construct very different mounds. This is curious, for the only anatomical difference that Professor Silvestri has been able to find between the two forms is that the eyes of the female are much larger in *oculatus* (*v.* fig. II, p. 224). There is apparently no difference between the workers which build the mounds. At one time I thought that the difference in the mounds was due to a difference in the earth out of which they were built and that the var. *oculatus* only lived in sandy soil ; but I have recently found mounds of just the same construction among bushes of *Glycosmis pentaphylla* in the red soil in which those of the *forma typica* are usually built, and also mounds of the typical *O. obesus* in sandy soil. The mound (fig. 1) in which the type female of *oculatus* was taken, was situated in a thicket growing on sandy soil on the east side of the island and was excavated completely by Dr. Baini Prashad and myself in October, 1920. It was about 6 feet high, as a whole nearly cylindrical and about 3 feet in diameter, but was rendered very irregular in cross-section by the fact that numerous laterally compressed buttresses projected all round, running up from the ground almost to the highest point and ending in separate little peaks. There was no external aperture. What appears like one on the figure was merely a depression. Several dead leaves and a small fragment of dead wood were attached to the surface.

In this mound, as I have already stated, almost the whole of the basal part at and a little above and below ground-level was occupied by a single large, incompletely divided chamber enclosing the single fungus-garden of the community. The incomplete partitions were mostly vertical, but others were horizontal. Their consistency was softer than that of the other parts of the nest, probably because they were kept in a continual state of moisture. A little to one side of the garden, at about ground-level, and communicating with it by means of complicated narrow galleries, occupied chiefly by soldiers, was the royal chamber, in which were a single fully developed queen and numerous

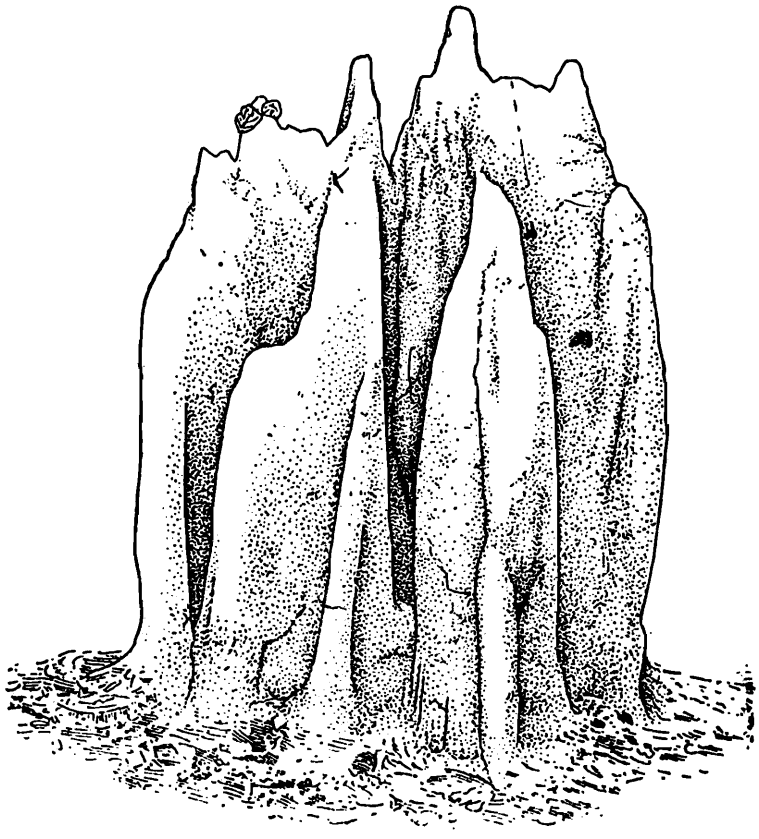

FIG. 1.—Mound of *Odontotermes obesus oculatus* from which type-specimens were obtained. From a Photograph.

workers. It was 17 cm. long, 7 cm. broad and 3 cm. high in the middle, the floor being flat and the roof somewhat irregularly arched. No male or eggs were found, but nymphs of both asexual castes were fairly abundant in the comb. The upper part of the mound consisted internally of compressed vertical galleries joined together by numerous narrow horizontal passages, the buttresses and narrow central core being hollow. These were occupied by a few workers and soldiers.

On June 24th, 1922, I opened a young nest of this form that had appeared above ground about six weeks before. It was situated in a *Glycosmis* thicket in red soil and had the shape of a sugar-loaf cone a little irregular at the base but without buttresses. It was about 2 feet high and slightly broader at the base. Internally the upper part consisted of vertical galleries of wide calibre joined together by rather narrower horizontal ones. These galleries seem useless to the community.

Possibly they assist in some way in regulating the temperature or moisture of the lower part of the mound, for they are always present. The whole of the base of the mound was occupied by a single large fungus-comb with relatively high vertical pinnacles, the largest of which was about 25 cm. high from base to apex. As in the older nest previously described, the comb was incompletely divided by clay partitions, but these all arose from the floor of the cavity. The royal chamber, containing a male and a mature but not fully swollen female, lay just under the comb a little to one side. This is its normal position.

In a third, very large nest of this form excavated in December, at least three large fungus-gardens, resembling those in the other nests, had been constructed one above the other. A fourth, much smaller nest, examined in January resembled the second.

The structure of the mound of *O. obesus* var. *oculatus* thus resembles that of *O. bangalorensis* as figured by Father Assmuth[1] in Holmgren's paper.

On Barkuda the mounds of the typical form of *O. obesus* (fig. 2) are usually built either in thickets of the shrub *Glycosmis pentaphylla* or

FIG. 2—Typical mounds of *Odontotermes obesus typicus*, showing artificial apertures. From a Photograph.

round the base of the trunks of fig-trees such as *Ficus infectoria*. They are usually constructed in groups the different members of which communicate underground and are as a rule only a foot or two apart but sometimes a yard or even more. Each mound is a small conical elevation, rarely more than 3 feet high and having about the same maximum diameter at the base. It is frequently compressed in one plane so as to be less than a foot thick and is as a rule pointed at the apex. The different mounds of each group are sometimes arranged in a straight line and sometimes scattered irregularly. I have not been able to correlate their orientation with any factor in the environment. When the surface is fresh and in good condition there is no external aperture, except the temporary slits made to permit of the exit of the adults and then closed after swarming has taken place; but in old mounds there are always large funnel-shaped openings due, as I have already pointed out, to

[1] In Holmgren, *Journ. Bombay Nat. Hist. Soc.* XXII, pl. F. There is some confusion about the name "bengalensis" on this plate, but I understand that it is really, despite the legend, a mistake for *bangalorensis*.

accidental causes. When a group of mounds is very flourishing the different mounds are sometimes enlarged to such an extent that they meet and coalesce, thus forming a single large mound of irregular shape. In very old mounds it is often only the central parts that are inhabited by *O. obesus*, with colonies of *Microtermes annandi* in the walls of the outer parts.

The internal structure of the nest is very different from that of the var. *oculatus*, the main differences being due to lack of buttresses and of an empty upper storey and to the fact that there are many fungus-gardens situated in separate chambers. These are contained both in the mounds and in the earth below them. The highest are often at the very top of the mound within a few inches of the surface. The chambers are almost spherical and perfectly smooth, almost polished internally. They are connected by narrow passage-ways and communicate in the same manner with vertical shafts that run down the mound. These are as a rule circular in cross-section instead of being compressed. In old mounds which have coalesced the royal chamber is situated near the centre some distance above ground. In younger nests, however, it is situated underground, at the base of one of the mounds. In form it resembles that of the var. *oculatus*.

The internal structure of old nests thus closely resembles that of those of the allied species *O. redemanni* as figured by Petch.[1]

The mound of *O. obesus* is built or repaired only in damp weather. If at other times it suffers any injury that causes a breach to be formed, a partition is as a rule hastily constructed, completely closing the internal galleries and chambers. If an accident of the kind occurs when the air is very dry a considerable part of the nest may be deserted and the partition formed well below ground, but even a slight shower is sufficient to encourage activity in building and if a nest is completely destroyed an attempt may be made to reconstruct it on a small scale even after a heavy dewfall. In the hot weather, *i.e.*, in the latter part of the dry season, the mounds are practically deserted in any case, the community having retired underground, and if the intact part of the mounds be opened, only an occasional patrol of workers and soldiers will be encountered. Immediately the rains commence, however, the workers become active and repairs and new constructions are started with great vigour. In 1922, after a prolonged drought, the first heavy rain fell on the evening of June 1st. Repairs were already in full swing on the 3rd, the work being done chiefly at night and in the early morning before the sun became hot. A few days later a break in the rains took place. The new half-built chambers were partitioned off and the working parties retreated underground to wait for more favourable conditions. As soon as rain fell again work recommenced.

A great deal of reconstruction evidently took place in the inner parts of the nest, but all that could be observed directly was the work on the outer parts. This consisted in re-roofing chambers in which breaches had been formed accidentally and in the construction of new pinnacles to the mound. The mode of operations was the same in both

[1] *Ann. Roy. Bot. Gardens, Peradeniya* III, p. vi (1906).

structures. A very thin, porous roof was first formed, its shape, whether flat, arched or conical, depending on the needs of the case. The workers surged up in large numbers and at the same time a line of soldiers took up their position, with their heads outwards, round the edge of the aperture, taking care that their soft bodies were well inside. When a new chamber was to be built, the workers ate away the roof of the old one below it. Each brought up from below a little pellet of clay, which it deposited, apparently haphazard, at the edge of the cavity, at the same time secreting a drop of saliva to cement it in place. There seemed to be no co-ordination between the work of different individuals and those which had deposited their pellets wandered about in an apparently aimless way, but the disorder was apparent rather than real, for when the chamber was too broad to be arched over in one span, other workers simultaneously built up pillars from the floor. These pillars were never too high to do more than just support the new roof.

I have said that the new roof when first constructed was porous. Beneath each little pore or aperture a soldier was on guard. If any object was brought within a couple of inches of the new roof, the soldier opposite it thrust out its head with a convulsive movement and widely opened its jaws, influenced, I suppose, either by movements in the air or by a change of temperature, for the soldiers of course are blind. If a hand was waved over the structure its movements were followed by a kind of shudder as each soldier in turn executed this manœuvre. The object of the guard was evidently to protect the workers against the attack of black predaceous ants, of which large numbers were always on the watch for an opportunity to carry off the workers. The soldiers they could not attack, for their soft bodies were protected by the wall and only their hard head and jaws were exposed. The ants, therefore, which ran about the surface of the mound, avoided those parts of it that were still porous. The little pits in which the sentries were on guard can often be seen on the inner surface of the wall in completed mounds (pl. V, fig. 3). These, except where the wall is very thick, provide evidence that the soldiers remain on guard while the wall is thickened round them and that it is only when it has reached its maximum thickness that the external holes are filled up. The stoppers are sometimes so thin as to be translucent.

No attempt was made to thicken the roof until the whole of the outer layer had been completed and the thickening was carried out entirely from within. The thin outer layer of the roofs of the new or reconstructed chambers was comparable to the temporary shelters made by the workers when on a foraging expedition, except that the latter are not porous. They are, however, extremely thin and fragile. The only occasions on which the workers of *O. obesus* appear in the open are when the adults are swarming and when they themselves are constructing the external parts of the mound, and these events only occur at night or in the early morning or late evening. When fungus-combs are removed from the nest with workers inside, the workers attempt to fill up the external apertures of the combs with their excrement. Food-supplies outside the nest are usually approached from underground and the burrows for this purpose may be many yards in length. In the

instance I have mentioned in which a party made its way for over eighty yards to a mass of dead water-weed, the stony nature of the soil rendered this method of approach impossible in places, and the termites had also apparently come up to the surface from time to time to devour dead twigs that lay in their way on the ground. At such places they had constructed temporary galleries of clay pellets consisting of an arched unpaved passageway. Such lengthy excursions, however, only take place in damp weather. In the hot season foraging rarely extends beyond the immediate vicinity of the nest. When actually feeding, even in the interior of a mass of dead leaves, the workers make a fragile roof of the same kind but of irregular shape to shelter themselves, while under the bark of dead trees they construct irregular chambers of the same substance but much less massive than those constructed by *O. feae*. These temporary earthworks, however, can hardly be regarded as part of the nest. Their object probably is to conserve the moisture of the air as well as to protect the workers from ants and other enemies.

The amount both of "original works" and of repairs undertaken in the mounds of both forms of *O. obesus* varies greatly in different years, apparently in correlation with the rainfall. In the wet season of 1922, in which the rainfall was abnormally low at Barkuda, hardly any new mounds were built on the island, while the repairs executed in old mounds were reduced to the minimum compatible with security.

NESTS OF THE LOG-DWELLERS.

Comparatively few species of termites, on Barkuda at any rate, live exclusively on dead wood. Indeed, *Coptotermes heimi* and *Microcerotermes annadalei* seem to be the only species that do so. The only wood in which I have found these log-dwellers was that of the Banyan (*Ficus bengalensis*). They occur most frequently in rotten trunks lying prone on the ground. In one such trunk I have taken no less than five species of termites, namely, *Odontotermes feae*, *O. obesus*, *Microcerotermes annandalei*, *Microtermes anandi* and *Coptotermes heimi*. Only the two species previously mentioned, however, were true log-dwellers.

The nests of the *Coptotermes*, of which there were many in this log, are confined to those parts of it that remain damp. During the hot weather the insects retire to the heart of the trunk, where this condition persists, but in the rains they may be found immediately under the bark. The real nest can be readily distinguished from the "filings", as Father Assmuth calls them, produced where the termites are feeding on wood. Although the species does not cultivate fungi, it produces for its dwelling-place a structure superficially not unlike the fungus-comb of some species. This structure, of a fragment of which a good photograph is reproduced by Father Assmuth,[1] is formed of wood covered with the excrement of the workers (pl. V, fig. 5). It has as a rule a bluish black colour and varies in size with the numbers of the community. In a large nest it has a capacity of several litres. The cells are narrowly oval with their long axis in the same direction as that of the fibres of the wood, *i.e.* parallel to the length of the trunk.

[1] Assmuth, *Journ. Bombay Nat. Hist. Soc.* XXII, p. 382, pl. iii, fig. 1, pl. iv, fig. 1.

Their walls consist of very thin layers of wood strengthened by the covering of excrement. Occasionally, where the tree-trunk is in contact with the earth, they are further strengthened by a thin layer of clay. They can, however, always be distinguished readily both from the thick-walled, irregular chambers of *O. feae* in a similar position and from the temporary and much more fragile galleries of *O. obesus*.

The chambers in this nest are eaten out from the wood by little bodies of workers, which crowd together for the purpose and are apparently so intent on their work that they can be dissipated only by violence. As they eat away the wood they secrete some substance that dyes it black to a depth of about a millimetre. Possibly this substance may guide another body working independently to form the other side of the partition, by means of some flavour or of a peculiar consistency it imparts to the wood. The excrement must be spread on the walls in a liquid or semiliquid condition after they are completed. The flattened pellets can be distinguished by the naked eye. Father Assmuth points out that the workers of this species spread their excrement on any body over which they crawl. He figures a bottle thus adorned and suggests that it may form an easy path-way for the workers, but I am convinced that my interpretation of its original function is correct, for the partitions between the cells are often so fragile, especially where the wood is rotten, that they would collapse unless strengthened.

In a nest opened in April I found some of the cells, always at a considerable distance from those occupied by living individuals, filled with the dead and shrivelled bodies of workers and soldiers. The occupied cells always contain large numbers of soldiers and workers. Immature individuals of the neuter castes are often found with them and I have not been able to distinguish any particular royal chamber.

The nests of *Microcerotermes annadalei* seem to me precisely like those of *C. heimi*. Indeed, it is possible that the former species merely occupies deserted nests of the latter.

The foregoing observations, incomplete and imperfect as they are, may, I hope, provide suggestions for those who are in a position to investigate the habits of termites more fully than I have been able to do. My notes are based, except where it is otherwise stated, on the examination of many nests of each species and on such field observations as I had time to carry out in the midst of much other work and on short visits to the island. They have been put together as a supplement to Professor Silvestri's systematic description of my collection and to Professor Bose's account of the fungi cultivated by certain species. Both these papers are published simultaneously with my own and in the same part of this volume.

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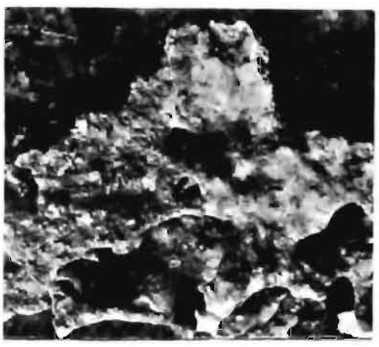

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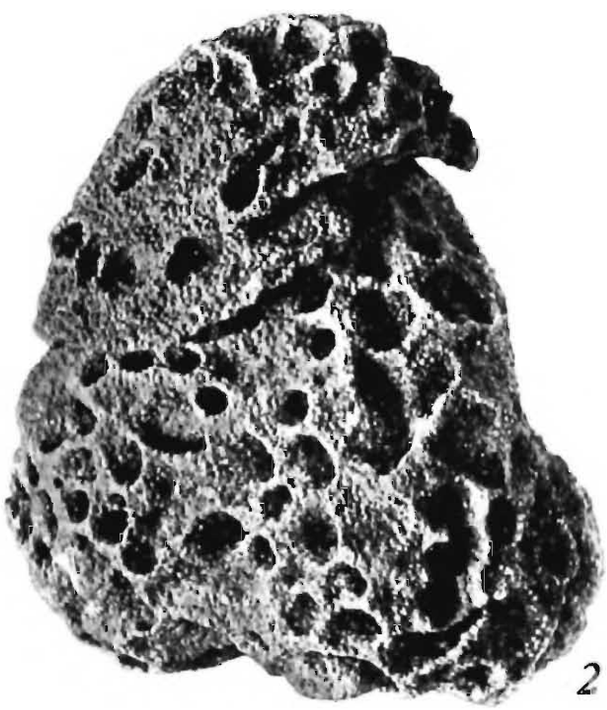

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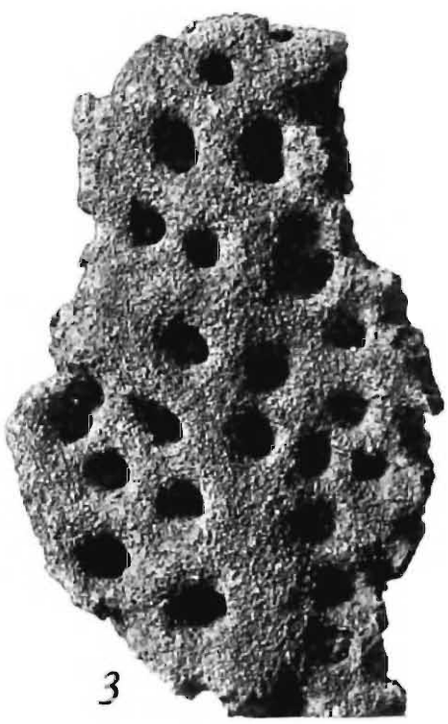

3

NESTS AND FUNGUS-COMBS OF TERMITES.

EXPLANATION OF PLATE V.

(All the figures, which are direct photographs, except fig. 5*a* are reproduced of the natural size.)

Odontotermes obesus typicus.

FIGS. 1, 1*a*.—A very young fungus-comb in two views.
FIG. 2.—An abnormal fungus-comb with a separate cap above.

O. obesus oculatus.

FIG. 3.—Inner view of a fragment of the outer wall of a superficial vertical gallery in the mound, showing the cavities in which soldiers are stationed during the construction of the wall.

Microtermes anandi.

FIGS. 4, 4*a*.—Two views of a large fungus-comb (slightly broken).

Coptotermes heimi.

FIG. 5.—Fragment of a nest from a log of *Ficus bengalensis*.
FIG. 5*a*.—Part of one of the partitions in the same nest enlarged.

EXPLANATION OF PLATE VI.

(All the figures, which are direct photographs, are reproduced of the natural size.)

Odontotermes obesus typicus.

FIG. 1.—A half-formed fungus-comb in lateral view.
„ 2.—A small but fully formed fungus-comb in lateral view.
„ 3.—Vertical section through a small fungus-comb.

O. obesus oculatus.

FIG. 4.—Vertical section through the young, peripheral part of a fungus-comb from the type-nest.
„ 5.—Fragment of the older, more central part of the same comb in lateral view.

Eurytermes assmuthi.

FIG. 6.—A complete fungus-comb in lateral view.

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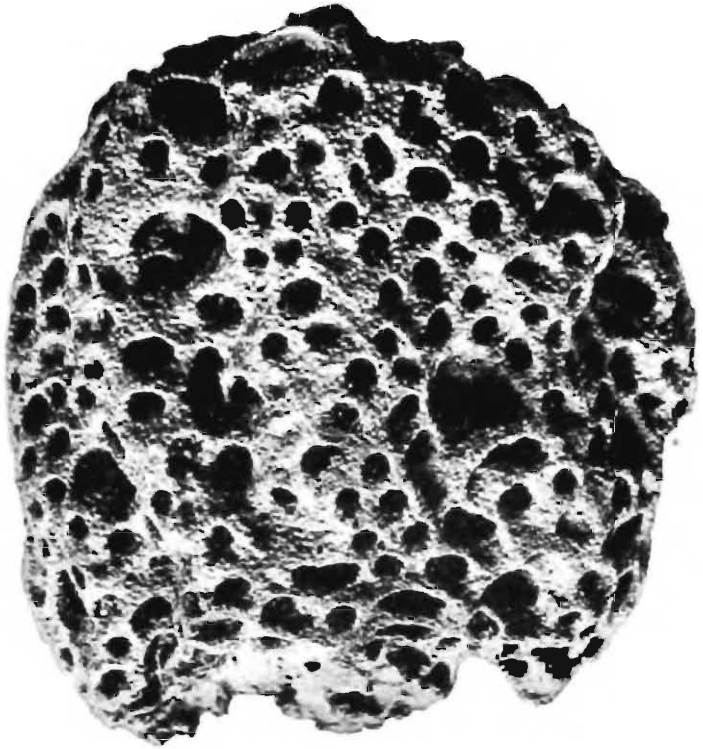

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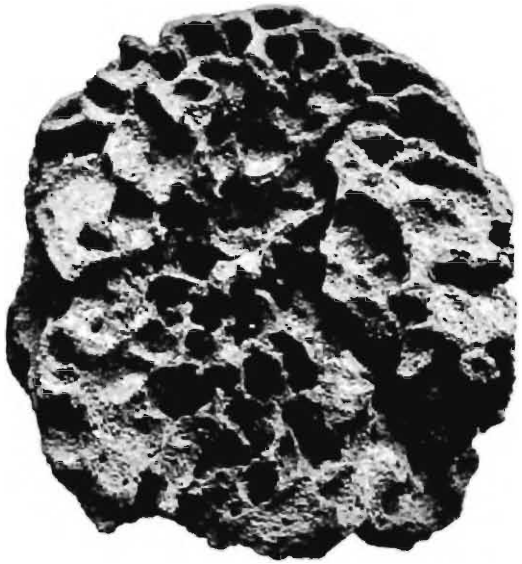

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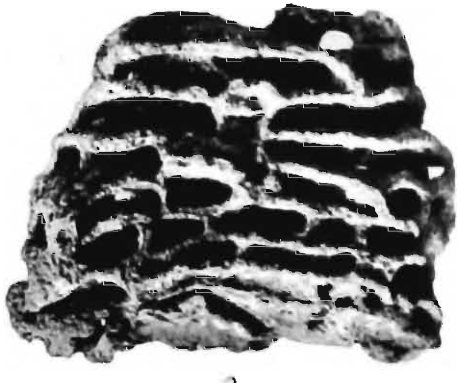

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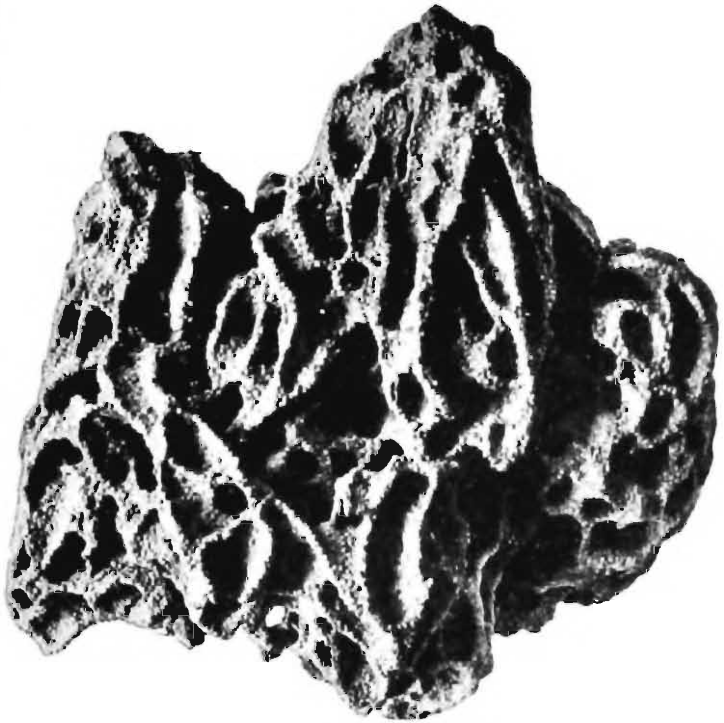


5

S.C.Mondul. photo:

FUNGUS-COMBS OF TERMITES.

ZINCO COLLOTYPE CO. EDINBURGH

THE FUNGI CULTIVATED BY THE TERMITES OF BARKUDA.

By S. R. Bose, *M.A., Ph.D., F.L.S., Professor of Botany, Carmichael Medical College, Belgachia.*

(Plate VII.)

A good number of combs of termite-nests from Barkuda I., Chilka Lake, were very kindly presented to me by Dr. N. Annandale, Director of the Zoological Survey of India. He has made an elaborate study of the habits of the termites in those nests, which has been recorded in the foregoing paper; the termites themselves have been identified by Prof. Silvestri of Portici. I am specially indebted to Dr. Annandale for the critical study of the combs and the nests and for the names of the termites used in this paper and other zoological details in it. During the latter part of July, 1922 I accompanied Dr. Annandale to the island of Barkuda and stayed there for about a week in order to study the fungi of the termite nests.

In the island of Barkuda, as Dr. Annandale observes, there are at least four forms of termites which cultivate fungi for food.

Mound-builders:—

1. *Odontotermes* (*Cyclotermes*) *obesus* (Ramb).
2. *O.* (*C*). *obesus* var. *oculatus* Silvestri.

Burrowers:—

3. *Eurytermes assmuthi* Wassmann.
4. *Microtermes anandi* Holmgren.

As Dr. Annandale has described in detail the structure of the combs of the different species of termites and of the chambers in which they are situated, in his part of the report, I will only allude to them briefly here.

Dr. Annandale notes that the four forms of combs are interesting as illustrating progressive development from those of *Microtermes anandi* to those of *Odontotermes obesus*. *Microtermes anandi* does little more than cultivate its mushrooms on a manure bed just as we do; there are hardly any definite cells on the comb, the irregular holes on the surface of the mass representing the rudiments of the cells. In the case of *Eurytermes assmuthi* the combs are a little more complex in structure, the masses of excrement are a little more compact and less fragile than those of *Microtermes* and they have the form of a comb in a pectinate sense. *Odontotermes obesus* var. *oculatus* forms elongated irregular vertical cells in a massive comb and there is one large fungus-garden contained in a single chamber. Finally the typical form of *O. obesus* adopts a more orderly arrangement of cells in the comb. There is a wide gap in the complexity of fungus-gardens between those of *Euryterms assmuthi* and of *Odontotermes obesus* var. *oculatus*.

A comb consists entirely of excreta of termites. Under the microscope wood-vessels of vegetable substance which have been eaten and have

passed almost unaffected through the digestive tract can be detected. It shows also spores of fungi and in one case at least I could find one distinct teleutospore. The comb is probably partially sterilized by its passage through the alimentary canal of the termites. Outwardly the more elaborate combs resemble a coarse bath sponge, and the colour varies from yellow-brown to dark brown. The upper part of the comb is often of a harder substance and of a darker colour than the lower.

Some fresh combs of *Odontotermes obesus* from red soil were cleared of termites by putting them in the track of a colony of black ants for some time. They were then wetted with water and on 16th September, 1920 three or four of the wet combs were placed upon water-soaked blotting-paper under the cover of a bell-jar. The next day the combs, which were almost bare before, were fully covered by a thin layer of dense white cottony mycelium. On 18th September there arose from the mycelium a large number of white upright stalks from 10 to 20 cm. long—the stromata of *Xylaria nigripes* (a photograph taken on the 2nd day of growth is shown in pl. VII, fig. 1). Some became attached to the sides of the bell-jar and some almost reached the top. These stalks of *Xylaria* are strongly heliotropic. They were at first white and looked like loosely-twisted strands of wool. In the course of two days, *i.e.*, on the 20th, the lower parts of the stalks turned black, and this black colour travelled from the base upwards, till in the course of a week or so everything turned black except the white apices and the stalks became solid with a white core of parallel hyphae enclosed by a black epidermal layer. The elongated stromata anastomosed in various ways in contact with the walls of the jar (a photo taken on the 12th day of growth is shown in pl. VII, fig. 2).

Some of the stalks had a white coating of conidia towards the lower parts. Water was added to the comb almost every day. Most of the stromata grew thicker, showed dichotomous branching (sometimes 4 to 6 divisions were found at the apices) and became conidioferous. A section of the apex under the microscope showed the conidial layer on the outside, but no perithecia were seen except in the case of *Xylaria* from *O. obesus* var. *oculatus* which was grown for a very long period. Most of the cultures of *Xylaria nigripes* were kept under observation for more than two and a half months.

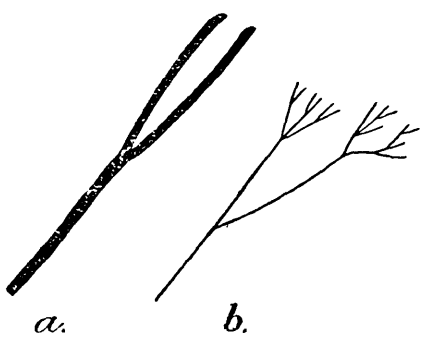
In the course of 12 to 14 days, the long stalks began to collapse and the majority of the looser stromata drooped down on the combs, which had by this time lost the regular character of their cells and had dissolved into an almost homogeneous black mass as shown in fig. 2, pl. VII; only a few remained attached to the sides of the bell-jar. During this time the bell-jar was opened for about a minute and this hastened the collapse of the stromata.

The drooping stalks were now attacked externally by white and yellowish rounded patches of parasitic *Mucor* and by yellow tufts of some *Discomycetes*, while small white sluggish mites also appeared on the tips of the stromata. The tips of some of the stromata still showed signs of branching and became flat and ultimately conidioferous. Fresh loose white stromata again developed here and there from the black stalks on 11th October (*i.e.*, on the 25th day), and ultimately became black and

firm like the original ones. Their white tips likewise became branched and conidioferous and these scanty fresh growths with single and branched conidioferous tips were observed on dying stromata on 20th October, 31st October, and finally on 20th November and following days. The more complex much-branched stalks ultimately assumed the form called *furcata* by some mycologists.

During this period, the maximum temperature of the room in which the jar was kept ranged from 81° to 88° F., and the minimum from 68° to 74°F. About half a dozen cultures of *Xylaria* from different termite-combs were grown, and the ultimate results were almost the same in all cases whether the termites were removed or not.

In two cases after about two weeks there was a sudden growth from the side of the jar of a very short-lived Agaric—*Coprinus niveus*, which is very common in Bengal in dung and heaps of rotten straw. A full description with a plate has been published in the Proceedings of the Science Convention of the Indian Association for the Cultivation of Science for 1918.



a. Branching of typical *Xylaria nigripes.*
b. Branching of the form *furcata.*

Possibly the spores of *Coprinus* had somehow travelled with the combs after their removal from the nest, though ordinary precautions were taken. In one of the two cases one of the combs did not produce *Xylaria* stromata ; but was first of all fully covered with a thick white mycelial mass of sessile spheres which, in the course of a week, turned green like green moulds on decomposed wood. The mass remained the same colour throughout, and eventually produced a number of rounded sporangia consisting of green spores.

The following notes show the minor differences observed in cultures of *Xylaria* from different combs. In the case of typical *O. obesus* from red soil, the *Xylaria* stromata were as long as 20 cm. and many of them were rather thick. In the case of a comb of *O. obesus* var. *oculatus* which contained one large fungus-garden in a single chamber, the stromata on the other hand were shorter (4-5 cm.) and the majority of them much thicker. Subsequent cultures of *Xylaria* from the combs of *O. obesus* and *O. obesus* var. *oculatus* in July, 1922 did not show any difference in the length or thickness of the stromata. In the case of *Microtermes anandi* the growth of *Xylaria* stromata was very scanty and the stalks long, about 10-14 cm., and very thin. These *Xylaria* from the different combs are the same species, all representing forms of *Xylaria nigripes*, which is exclusively confined to abandoned termite-

nests (*cf. Xylaria* Notes, no. 1, by C. G. Lloyd, September, 1918, pp. 10-11). If cultivated sufficiently long in a very moist atmosphere they assume, as I have stated, the form *furcata* (see text-fig.). These *Xylaria* have been kindly identified by Mr. C. G. Lloyd and Mr. T. Petch of the Peradeniya Botanical Gardens.

When the combs of *Eurytermes assmuthi* were put under bell-jars with living termites in them, the stalks of *Xylaria* grew up after a long time —5 or 6 days after the first day of culture. During this time most of the termites had died under the bell-jar. The growth was not abundant, and the stalks were very feeble and short, only about 3 cm. long. Some few remained unbranched, and most of them showed after a month regular but feeble dichotomous branching and in the form *furcata*, feebler sub-branching. Most of the *Xylaria* artificially grown in cultures were in conidial stages, but in the case of *Xylaria nigripes* from the comb of *O. obesus* var. *oculatus* in sandy soil, which was kept for a longer time, I succeeded in getting a number of rounded perithecia with asci and black oval spores, about 4×2 μ in longer and shorter diameter.

The nests of *O. obesus* form continuous series on the island of Barkuda, as can be seen from text-fig. 2, p. 247. They are mostly under-ground, throwing up a mound here and there above the surface.

From the part of the nest of *O. obesus* above ground were collected on 23rd June, 1920 during the rainy season a number of edible mushrooms (*Collybia albuminosa* (Berk) Petch),—some fully developed and others in a state of bud. In this fungus the stalk is about 16 cm. long with a spreading umbonate cap; its spores are pink, oval, and in measurement 8×4 μ. The specimens had long rooting stalks going down to the combs. The caps of some were partly eaten by beetles. These white *Collybia* were the only fungi which appeared, though only for a short time, from the mounds, which were full of living termites (*O. obesus*). These Agarics, however, appear but rarely at Barkuda. None were observed in 1922, which was a comparatively dry year, although Dr. Annandalemade a careful search for them on many occasions.

In no case observed were *Xylaria* stromata produced from combs *in situ* within the mounds. Some short (about 3 cm. long) firm black stalks of *Xylaria aemulans* Starb. (determined by Mr. Lloyd) were, however, collected from a piece of dead wood sticking to the outer earthen wall of the tall cylindrical mound of *O. obesus* var. *oculatus*, and from the dead prostrate trunks of *Ficus bengalensis* and from logs here and there close to these mounds. *Xylaria aemulans* is very common at Barkuda on prostrate logs.

Another Agaric, *Entoloma microcarpum* B. S. Br., was found in a big mound deserted by *O. obesus* but occupied by small colonies of *Microtermes anandi*. It had no connection with the comb of *Microtermes anandi*, but was simply growing out of the moist wall of the mound. The species was also found growing in clusters in the red soil covering the old roots of a *Ficus* tree. It is commonly eaten by the villagers in Bengal. I have collected it also from Hughli District, growing in close proximity to a termite-nest, in fact from the external surface of it, as well as from various places on the roadside and cultivated fields, and grassy walks, quite independent of termite-nests.

A number of sections of intestines of different species of fresh termites and of their different forms as workers, soldiers, sexual nymphs, larvae, etc., were made in the months of July and August to examine their contents. In the case of *O. obesus* and *O. obesus* var. *oculatus*, sections of the intestines of workers and soldiers showed the presence of fragments of fungal hyphae and some oval black spores, whereas in the case of *Microtermes anandi*, sections of intestines of workers and soldiers showed the presence of oval spores, fragments of some fungal hyphae and some wood vessels (spiral, reticulate, etc). But when I examined a number of sections of intestines of workers and soldiers of *Odontotermes obesus* during the months of May and June, I could not find any fungal spores in any of them; this might be due to the fact that fungi are scarce during the extreme hot weather. One of the sections showed a white pollen grain with a number of small warts on the upper surface. From the spores and fragmentary hyphae it cannot be determined exactly if they belong to the *Collybia* or to the *Xylaria*, because most fungi have oval spores. They only show how both or either fungus may be propagated from nest to nest.

Mr. Petch, the distinguished worker of Ceylon fungi, has contributed a masterly and elaborate account of the fungi of termite-nests in Ceylon to the *Ann. Roy. Bot. Gardens, Ceylon*, Vol. III, page 185 to 270 with seventeen plates. In this he states that the combs ultimately produce an Agaric—which has been assigned by various mycologists to *Lentinus*, *Collybia*, *Pluteus*, *Pholiota*, *Flammula* and *Armillaria* (now settled as *Collybia albuminosa*) which forms the chief edible mushroom amongst the Cingalese. The termites, he notes, regularly cultivate this agaric for food; they eat its mycelium and spheres and though the growth of *Xylaria nigripes* has never been found on combs *in situ*, it takes place regularly in deserted combs after continued rains and after two days in bell-glass cultivations of termite-free combs. Later on, it is succeeded by patches of *Mucor*, *Aspergillus*, yellow and red moulds, and some yellow *Discomycetes* (*Peziza*). From this, Prof. Petch concludes that the termites maintain a pure culture, that they weed out all foreign fungi except the edible one, but that *Xylaria nigripes* defies their efforts to exterminate it, that it is only kept under, that its mycelium somehow vegetates in the comb-substance and that all the other fungi which develop in cultures are probably due to infection after removal from the nest.

Later on, in 1913, in vol. V of the *Ann. Roy. Bot. Gardens, Ceylon*, pp. 303—341, Mr. Petch has brought out a complete and excellent summary of all that is known on the fungus-cultivation by termites in different parts of the world.

The long-stalked white mushrooms (*Collybia albuminosa*) from the termite nests are edible; they are found in different parts of Bengal, often associated with termite nests: some I got from the Holkar State through the divisional forest officer, with a note that it always grows in connection with ant-hills there. I have published a description of this *Collybia* with a plate in *Journ. As. Soc. Bengal*, Vol. XVI, no. 8, 1920. The fungus has been carefully analysed by Mr. C. B. Roy, B.Sc., M.B., of the Chemical Physiology Department of the Calcutta Medical

College, to whom my sincere thanks are due. It is found to contain 12·8% proteids, 14·8% carbohydrates, and a trace of fats (ether extractives) almost in the same proportion as in case of the local edible mushrooms. This edible mushroom is collected and sometimes sold during the rainy season in Bengal, and sometimes at the end of the rains. The rainfall[1] at Barkuda island is small, much smaller than that recorded for Peradeniya (Ceylon) by Mr. Petch, or than that of most parts of Bengal. Moreover, it is practically confined to a few months in the year.

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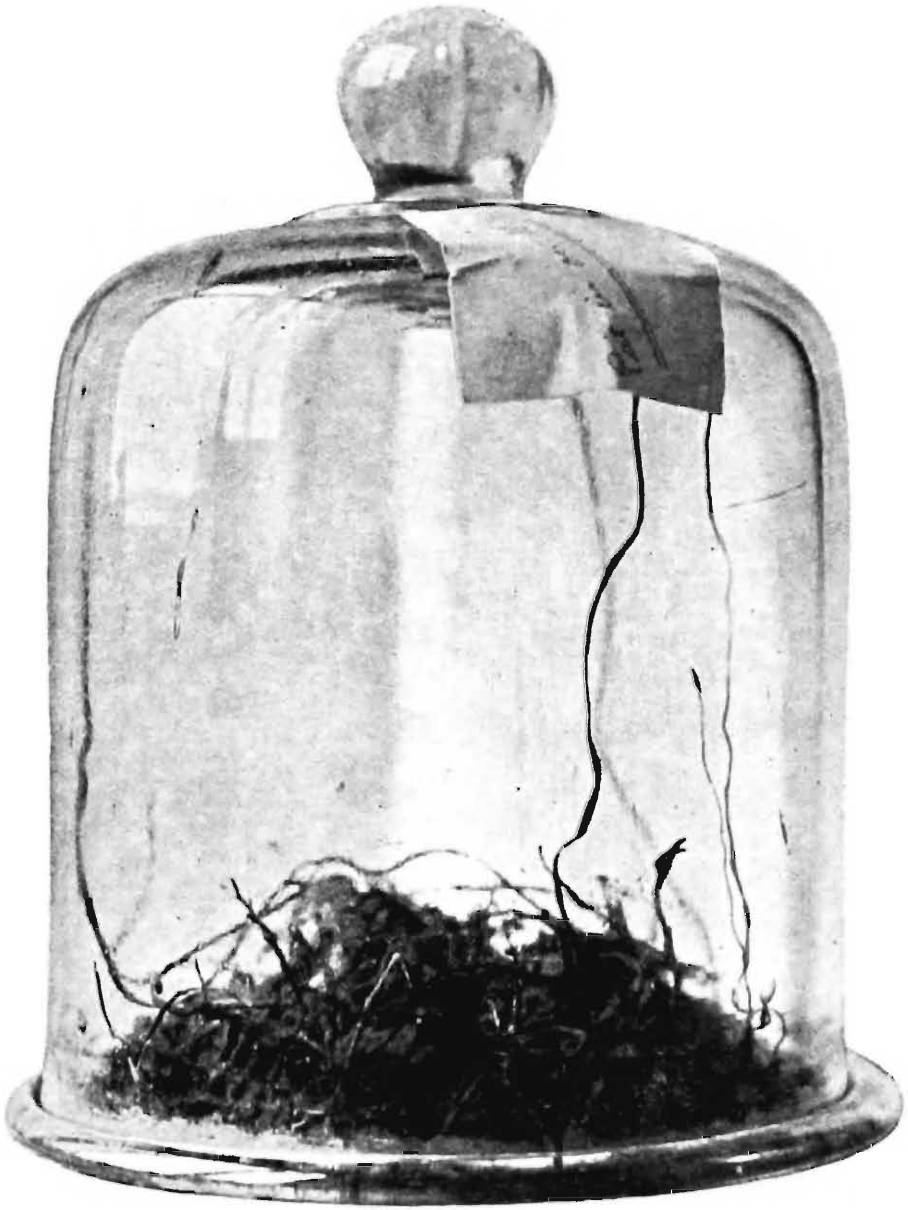
[1] See Annandale, *Mem. Asiatic Soc., Bengal*, Vol. VII, No. 4, pp. 259—260.

EXPLANATION OF PLATE VII.

FIG. 1.—*Xylaria nigripes* on the second day of culture from termite-free comb of *Odontotermes obesus*.

FIG. 2.—The same culture ten days later.

1



2

Culture of *Xylaria nigripes*.

CERTAIN COLEOPTERA OF BARKUDA.

By GILBERT J. ARROW, *F.Z.S.*, *F.E.S.*

SCARABAEIDAE.

COPRINAE.

Sisyphus indicus Hope. A single specimen was found in July. It is a common insect in most parts of India.

S. minutus F. Dr. Gravely found this species abundant during July and August. Dr. Annandale found a specimen beneath a dead bat in September and in February, one was taken from a nest of an ant, *Phidole rhombinoda*, under a stone. The species is common in many parts of India and in Ceylon.

Scarabaeus erichsoni Har. Found in Ceylon and Southern India.

Gymnopleurus cyaneus F. Distributed throughout India.

G. miliaris F. This is also generally distributed in India.

Catharsius pithecius F. A very common species throughout India and Ceylon.

Copris fricator F. Inhabits Ceylon and South India.

Phalops divisus Wiede. This is widely distributed in India.

Onthophagus ramosus Wiede. Bangalore, Nilgiri Hills, Punjab, etc.

Onthophagus quadricornis F. Ceylon, Nilgiri Hills, Malabar, Berhampur.

O. miliaris Boucomont. Inhabits Ceylon and Southern India.

O. tritinctus Bouc. South India.

Caccobius hystrix Bouc. South India and Ceylon.

C. furculus F. Malabar and Ceylon.

C. indicus Har. South India.

CHIRONINAE.

Chiron digitatus F. A widely distributed insect in Madras, Bombay and Bengal.

APHODIINAE.

Aphodius ovatulus Har. Travancore, Malabar, Dacca.

Rhyssemus sp. A single specimen of a species unknown to me.

HYBOSORINAE.

Phaeochrous emarginatus Cast. This is an extremely abundant species found throughout the East and as far as Australia.

ORPHNINAE.

Orphnus mysoriensis Westw. A very abundant species in Ceylon and Southern India.

O. parvus Wiede. This has a similar distribution to the last species and is frequently found in the same localities. *O. nanus* Westw. is a later name for the same insect.

GEOTRUPINAE.

Bolboceras trisulcatum Klug. A single specimen. The species has been found in the Deccan, Bombay, Gwalior, etc.

MELOLONTHINAE.

Neoserica bombycina Karsch. A single specimen of a species only previously known from Ceylon.

Autoserica iridescens Blanch. Two specimens. This has previously occurred in Malabar, Nilgiri Hills and Coimbatore.

Autoserica sp. A single specimen of a species unknown to me.

Mericserica chilkensis, sp. nov.

Chestnut red, smooth, shining and strongly punctured above and beneath, ovate and very convex; the clypeus broad and flat, coarsely and confluently punctured, its margin feebly elevated and very gently excised in front, the forehead finely and sparsely punctured; the pronotum strongly and evenly punctured, with its sides gently curved, the front angles acutely produced and the hind angles bluntly rectangular, the scutellum strongly punctured and acutely pointed; the elytra lightly striated and strongly and irregularly punctured; the pygidium moderately closely and not very strongly punctured and the lower surface strongly at the sides and very sparsely in the middle; the front tibiae bidentate, the hind femora and tibiae very broad, the antennae short, the 3rd joint equal to the two succeeding, the 6th produced into a short lamina.

Length 7—8 mm. : breadth 4—5 mm.

Numerous specimens were taken at light during June, July and August.

The joint preceding the club, *i.e.*, the 6th, is produced to about a fourth of the length of the club in the female, and in the male is about half as long as the club. The latter is little longer in the male than in the female and the length of the 6th joint is therefore the chief sexual distinction.

The genus *Mericserica* contained hitherto a single species, *M. oberthuri* Brenske, known only from the female, which, like the new species, has the rather unusual feature in that sex of a 4-jointed antennal club, as in the male.

M. oberthuri is much larger and the surface is opaque, instead of shining. The two species of *Chrysoserica* have a rather similar antennal structure, but the hind tibiae and tarsi are of a different character.

Apogonia ferruginea F. Four specimens came to light in June. The species seems to be generally distributed from Sikkim to Ceylon.

A. nigricans Hope. This came to light in numbers from June to October. The type, in the British Museum, is from Nepal.

Schizonycha ruficollis F. Two female examples were found. The species is a common one in Ceylon and Southern India and is also found at Nagpur and Belgaum.

RUTELINAE.

Adoretus lasiopygus Burm. A single specimen was taken at light. This is one of the commonest of Indian insects, ranging from Sikkim to Ceylon.

DYNASTINAE.

Eophileurus platypterus Wiede. A series of specimens was taken in June, July and August. The species has been found in Bombay and Madras.

Alissonotum piceum F. This insect was found under a mat of dried weeds on the shore of the island. Specimens occurred in April, June, October and December. The species is an abundant one throughout India.

CETONIINAE.

Clinteria klugi Hope. One specimen was found in August. The species is widely distributed from Nepal to Mysore.

Anthracophora crucifera Oliv. A single specimen. This is abundant and generally distributed throughout India and Ceylon.

HISTERIDAE.

Hister encaustus Mars. Found with termites (*Odontotermes obesus*) under dead leaves on foot-path.

DYTISCIDAE.

Eretes sticticus L. This water-beetle has a practically world-wide range.

Hydroporus sp. A single specimen of an unknown species.

HYDROPHILIDAE.

Philhydrus esuriens Walk. A single individual, which, although rather large, appears inseparable from this Ceylon species.

Hydrochus sp. Several specimens.

NITIDULIDAE.

Lasiodactylus chevrolati Reitt. This insect was abundant in July and August. It is found both in India and East Africa.

Circopes indicus Mots. One specimen was found on *Datura* flowers in August. The species has a wide distribution in India and Ceylon.

COLYDIIDAE.

Trachypholis hispidus Weber. Very common throughout the East. Several specimens were found in July.

HETEROCERIDAE.

Heterocerus feae Grouv. Two specimens of a small species apparently belonging to this species, which was described from Burma.

H. maindroni Grouv. Three specimens possibly belonging to this South Indian species.

EROTYLIDAE.

Amblyopus cinctipennis Lacord. A series of specimens.

COCCINELLIDAE.

Chilomenes sexmaculata F. This was taken in July, August and September. The species is a very abundant one in India, Southern China and the Malayan Region.

Brumus suturalis B. Generally distributed in India and Ceylon. There is also a specimen in the British Museum from Madagascar.

Scymnus sp. A single specimen.

Novius roseipennis Muls. One specimen was taken on *Glycosmis pentaphylla* in September and others at light during June and July. The species is widely distributed in India and Ceylon.

Epilachna 28-punctata F. An extremely abundant species throughout India, South China, the Malayan Region and also found in Australia.

E. dumerili Muls. Also a very common insect in India, Burma and Siam.

DRILIDAE.

Pachytarsus sp. A single specimen.

CIOIDAE.

Cis sp. Several specimens were found in a nest of *Xylocopa*.

ELATERIDAE.

About twenty species were found, of which the following have been identified.

Campsosternus splendidus Hbst. A common insect in India and Ceylon.

Agrypnus fuscipes F. Abundant from Bengal to Ceylon and found also in Mauritius.

Lacon. Several species.

Melanotus hirticornis Hbst. An abundant insect from Sikkim to Ceylon.

Cardiophorus stolatus Er. Found in Bombay, Malabar, etc.

Heteroderes brachmana Cand. Distributed throughout the Indo-Malayan Region.

CERAMBYCIDAE.

Cerambycinae

Rhaphuma fallax Chevr. Described from Bengal.

Lamiinae

Olenecamptus bilobus F. A very common insect throughout the Indo-Malayan Region.

Celosterna scabrator F. Found throughout India and in Ceylon.

Batocera rubus L. This is a well-known pest of rubber-plantations in India and has been introduced with very serious results into various other parts of the world.

Myagrus hynesi Pasc. Found in August and October. This species has only been recorded from Bombay.

Leprodera lecta Gahan. One specimen found in August. Also known from Sikkim, Burma, Siam, etc.

Sybra praeusta Pasc. One specimen. Previously known from Ceylon and Poona.

Pothyne sp. A single specimen.

Sthenias sp. Two specimens.

Pterolophia sp. One example.

(*The Longicornia have been determined by Dr. C. J. Gahan.*)

ANTHRIBIDAE.

Eucorynus crassicornis F. Six specimens. A widely distributed species in the Oriental region.

Basitropis nitidiscutis Jekel. A single male specimen. The species inhabits India and Ceylon.

Phloeobius gigas F., var. *nigroungulatus* Gyll. A single female. *P. gigas* is generally distributed in the East.

Araecerus suturalis Boh. One male.

(*The Anthribidae have been determined by Dr. K. Jordan.*)

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