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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

CATALOGUE

OF

RECENTLY DESCRIBED COCCIDÆ.

By J. G. SANDERS, M. A.,

Assistant.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 16, 1906.

Sir: I have the honor to transmit herewith the manuscript of a Catalogue of Recently Described Coccidæ (Scale Insects), prepared by Mr. J. G. Sanders, of this Bureau. Owing to the economic importance of this group of insects and the scientific interest attached thereto, I recommend that it be published as Technical Series No. 12, Part I, of the Bureau of Entomology.

Respectfully,

C. L. Marlatt,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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MISCELLANEOUS PAPERS.

CATALOGUE OF RECENTLY DESCRIBED COCCIDÆ.

By J. G. SANDERS, M. A., *Assistant.*

Since the publication, in March, 1903, of Mrs. Fernald's Catalogue[a] many new genera, species, and varieties of Coccidæ from various regions have been described by enthusiastic entomologists. Nine genera, 6 subgenera, 137 species, and 22 varieties comprise the following catalogue, which is fairly complete to date. The majority of the references are to publications which have appeared since March, 1903; however, a few previous to this date are cited, which were overlooked by Mrs. Fernald in the stupendous task of preparing her most useful contribution to coccidology.

The Bureau of Entomology maintains a complete bibliography, by the card-index system, of all publications pertaining to Coccidæ, both economic and systematic. At the suggestion of Prof. T. D. A. Cockerell, and with his valuable assistance, the writer has prepared a supplementary catalogue of new species only, which he hopes to publish *annually* hereafter. In this work the writer respectfully begs the assistance of all authors by the sending of separates or notices of publication, and specimens, if possible, to this Bureau, where they will be properly cared for and recorded.

The large national collection of Coccidæ, containing 1,038 identified species, of which number 660 are types and cotypes—besides much unidentified material from Australia, India, China, and Japan—has been carefully arranged alphabetically in cases built especially for the purpose. Each specimen is carefully wrapped in lens paper and put into a small telescopic pasteboard box, 50 by 75 mm. and varying from 10 to 50 mm. in depth, properly labeled on the edge. Five rows of these boxes, card-index style, fill the regulation insect drawer; and, with the drawers labeled, but a moment is necessary to find any specimen desired. Locality cards, giving all known data for each specimen, are also filed in alphabetical order.

The writer once more begs the assistance of all workers on Coccidæ in publishing annually a complete bibliography of all new species and in the maintenance of a complete bibliographical card index of all publications relating to scale insects.

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[a] Bul. 88, Hatch Exp. Sta., Mass. Agric. Coll. A Catalogue of the Coccidæ of the World. By Mrs. Maria E. Fernald.

Subfamily **MONOPHLEBINÆ.**

Monophlebus stebbingii mangiferæ Green.

Monophlebus stebbingii mangiferæ "Green," Stebbing, Jn. Linn. Soc. Lond., XXIX, p. 142 (1904).
Habitat—Lahore, India.
On Mango.

Monophlebulus townsendi Ckll.

Monophlebulus townsendi Ckll., Proc. Dav. Ac. Sci., x, p. 127 (1905).
Habitat—Philippine Islands.

Mimosicerya, new section of *Icerya*; Ckll., The Entom., xxxv, p. 233 (1902). Type, *hempeli.*

Icerya candida Ckll.

Icerya candida Ckll., Proc. Dav. Ac. Sci., x, p. 128 (1905).
Habitat—Philippine Islands.
"On cultivated tree with large oblong-ovate rough leaves."

Icerya colimensis Ckll.

Icerya colimensis Ckll., Mem. Soc. Cient. Ant. Alz., XIX, p. 81 (1902).
Habitat—Mexico.
On undetermined shrub.

Icerya littoralis tonilensis Ckll.

Icerya littoralis var. *tonilensis* Ckll., Mem. Soc. Cient. Ant. Alz., XIX, p. 80 (1902).
The Entom., xxxv, p. 318 (1902).
Habitat—Mexico.

Icerya rileyi larreæ Ckll.

Icerya rileyi var. *larreæ* Ckll., Mem. Soc. Cient. Ant. Alz., XIX, p. 82 (1902).
Habitat—Mexico.
On Larrea.

Subfamily **MARGARODINÆ.**

Ultracœlostoma, n. subg. of *Cœlostomidia;* Ckll., The Entom., xxxv, pp. 114, 258 (1902). Type, *assimilis.*

Xylococcus matumuræ Kuwana.

Xylococcus matumuræ Kuwana, Insect World, IX, 3, March (1905). Fig.

Subfamily **ORTHEZIINÆ.**

Polyocellaria[a] n. gen., Imhof, Biol. Centralblatt, xx, p. 527 (1900).
Kirkaldy, Can. Ent., XXXVIII, p. 10 (1906).

Arctorthezia, n. sect. of *Orthezia;* Ckll., The Entom., xxxv, pp. 114, 259 (1902). Type, *occidentalis.*

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[a] Described from Switzerland as a two-winged insect with hooked halteres, 10-jointed antennæ, 8 and 12 eyes and single-jointed tarsi. It is without much doubt a male Orthezia, but can not be an aphide, as considered by Kirkaldy.

Orthezia galapagoensis Kuwana.

Orthezia galapagoensis Kuwana. Jn. N. Y. Ent. Soc., x, p. 28 (1902). Fig.
Habitat—Galapagos Islands.
On *Cordea lutea; Scalesia microcephala.*

Orthezia olivacea Ckll.

Orthezia olivacea Ckll., Can. Ent., xxxvii, p. 136 (1905).
Habitat—Colorado.
In nests of *Lasius* sp. under rocks.

Orthezia solidaginis Sanders.

Orthezia solidaginis Sanders, Ohio Naturalist, iv, p. 94 (1904). Fig.
Pr. Ohio Ac. Sci., iv, sp. papers No. 8, Coccidæ of Ohio, p. 32 (1904). Fig.
Habitat—Ohio.
On *Solidago canadensis; Solidago* sp.

Subfamily **CONCHASPINÆ.**

Conchaspis fluminensis Hempel.

Conchaspis fluminensis Hemp., Bol. Agr. Sao Paulo, v, p. 312 (1904).
Habitat—Rio de Janeiro.
On an unknown shrub.

Subfamily **DACTYLOPIINÆ.**

Bambusaspis, n. sect. of *Asterolecanium;* Ckll., The Entom., xxxv, p. 114 (1902). Type, *miliaris.*

Asterolecanium greeni Marchal.

Asterolecanium greeni Marchal, Bul. Mus. d'Hist. Nat., vii, p. 455 (1904). Fig.
Habitat—France (in greenhouse); Ceylon.
On *Rheedia lateriflora.*

Asterolecanium pustulans sambuci Ckll.

Asterolecanium pustulans var. *sambuci* Ckll., The Entom., xxxvi, p. 112 (1903).
Habitat—Egypt.
On *Sambucus.*

Asterolecanium rehi Rübsaamen.

Asterolecanium rehi Rübs., Marcellia, i, p. 62 (1902).
Habitat—Madeira Islands.
On *Globularia salicina.*

Phenacobryum Ckll., The Entom., xxxv, p. 114 (1902).
Synonym of *Antecerococcus* Green (1900).

Eriococcus sordidus Green.

Eriococcus sordidus Green, Victorian Naturalist, xxi, p. 68 (1904). Fig.
Habitat—Australia.
On *Helichrysum ferrugineum.*

Eriococcus tricarinatus Fuller.

Eriococcus tricarinatus Fuller, Notes on Coccidæ W. Austr., p. 8 (1897).
Trans. Ent. Soc. Lond., p. 442 (1899). Fig.
Eriococcus simplex dealbata Fernald, Catalogue of Coccidæ, p. 78 (1903).
Habitat—Western Australia.
"On *Eucalyptus gomphocephala*, on galls of *Maskellia globosa* Fuller."

Genus **AMELOCOCCUS** Marchal. Type, *alluaudi*.

Amelococcus Marchal, Ann. Soc. Ent. France, LXXIII, p. 557 (1904).

Amelococcus alluaudi Marchal.

Amelococcus alluaudi Marchal, Ann. Soc. Ent. Fr., LXXIII, p. 557 (1904).
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).

Habitat—Madagascar.
On branches of *Euphorbia intisy*.

Sphærococcus pustulans Green.

Sphærococcus pustulans Green, Victorian Naturalist, XXII, p. 7 (1905). Fig.
Habitat—Australia.
On *Eucalyptus goniocalyx*.

Phenacoccus cockerelli King.

Phenacoccus cockerelli King, Can. Ent., XXXV, p. 195 (1903).
Habitat—Colorado.
On *Amelanchier*.

Phenacoccus kuwanæ Coleman.

Phenacoccus kuwanæ Coleman, Jn. N. Y. Ent. Soc., II, p. 62 (1903). Fig.
Habitat—California.
On lichen on *Picea breweriana*.

Phenacoccus ripersioides W. & T. Ckll.

Phenacoccus ripersioides W. & T. Ckll., Tr. Am. Ent. Soc., XXIX, p. 112 (1903).
Habitat—New Mexico.
With *Lasius niger* (8,000 feet altitude).

Genus **TRABUTINA** Marchal. Type, *elastica*.

Trabutina Marchal, Bul. Mus. d'Hist. Nat., VII, p. 448 (1904).

Trabutina elastica Marchal.

Trabutina elastica Marchal, Bul. Mus. d'Hist. Nat., VII, p. 448 (1904). Fig.
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).
Habitat—Algeria.
On *Tamarix articulata*.

Trionymus hordei Lindeman.

Westwoodia hordei Lindeman, ——— ———.
Korbuly, Csanad: Banhegyes (Kaszaper) (1886).
Horvath, Magyar, K. A. Rov. A. Koz., Jelentes, (1) 8, p. 96 (1892).
Sajo, Zeitschr. f. Pflanzenkr., IV, p. 151 (1894).
Trionymus hordei Ckll., Ent. News, XV, p. 40 (1904).

Trionymus nanus Ckll.

Trionymus nanus Ckll., Can. Ent., XXXVII, p. 136 (1905).
Habitat—Colorado.
On roots of grass under stones.

Pseudococcus andersoni (Coleman).

Dactylopius andersoni Coleman, Jn. N. Y. Ent. Soc., XI, p. 62 (1903). Fig.
Habitat—California.
On *Cupressus goveniana; Libocedrus decurrens.*

Pseudococcus crotonis (Green).

Dactylopius crotonis Green (sine descr.), Tropic. Agric., XXIV, p. 44 (1905).
Habitat—Ceylon.
On *Castilloa* sp.

Pseudococcus dudleyi (Coleman).

Dactylopius dudleyi Coleman, Jn. N. Y. Ent. Soc., XI, p. 63 (1903). Fig.
Habitat—California.
On *Cupressus macnabiana.*

Pseudococcus elongatus (Reuter).

Dactylopius elongatus Reut., Medd. Soc. Faun. Fennicæ, 66, 251 (1903).

Pseudococcus ephedræ var., Ckll.

Pseudococcus ephedræ var., Ckll., Mem. Soc. Cient. Ant. Alz., XVII, p. 145 (1902).
Habitat—Mexico.
On agave.

Pseudococcus lilacinus Ckll.

Pseudococcus lilacinus Ckll., Pr. Dav. Ac. Sci., X, p. 128 (1905).
Habitat—Philippine Islands.
On cultivated orange.

Pseudococcus tayabanus Ckll.

Pseudococcus tayabanus Ckll., Pr. Dav. Ac. Sci., X, p. 129 (1905).
Habitat—Philippine Islands.
On cultivated cacao.

Pseudococcus vagabundus (Von Schilling).

Dactylopius vagabundus Von Schill., Allg. Zeits. f. Ent., VIII, p. 305 (1903).
Giard, Bul. Soc. Ent. France, pp. 232, 233 (1903).
Reh, Allg. Zeits. f. Ent., IX, p. 36 (1904).
"=a mixture of *Pulvinaria camellicola. Phenacoccus aceris, P. æsculi*, and *P. mespili=pruni.*"—Giard.

Pseudococcus virgatus var., Ckll.

Pseudococcus virgatus (Ckll.) var., Pr. Dav. Ac. Sci., X, p. 128 (1905).
Habitat—Philippine Islands.
On cultivated Croton.

Antonina australis Green.

Antonina australis Green, Proc. Linn. Soc. N. S. W., pt. 3, p. 463 (1904). Fig.
Habitat—Australia.
On *Cyperus rotundatus.*

Subfamily **TACHARDIINÆ**

Tachardia albizziæ Green.

Tachardia albizziæ Green (sine descr.), Ind. Mus. Notes, v, p. 98 (1903).
Habitat—Ceylon.

Tachardia aurantiaca Ckll.

Tachardia aurantiaca Ckll., Can. Ent., xxxv, p. 65 (1903).
Habitat—Java.
On grape fruit (*Citrus*).

Tachardia cærulea Hempel.

Tachardia cærulea Hemp., Bol. Agr. Sao Paulo, v, p. 314 (1904).
Habitat—Rio de Janeiro.

Tachardia fici Green.

Tachardia fici Green, Ind. Mus. Notes, v, p. 97 (1903). Fig.
Habitat—India.
On *Ficus religiosa; F. bengalensis.*

Tachardia glomerella Ckll.

Tachardia glomerella Ckll., Ent. News, xvi, p. 52 (1905).
Habitat—New Mexico.
On *Gutierrezia glomerella.*

Subfamily **COCCINÆ.**

Pulvinaria coulteri Ckll.

Pulvinaria coulteri Ckll., Zool. Anzeiger, xxix, p. 514 (1905).
Habitat—Colorado.
On *Rosa* sp. (wild).

Pulvinaria goethei King.

Pulvinaria goethei King (sine descr.), Allg. Zeits. f. Ent., viii, p. 460 (1903).
Habitat—Germany.
On *Alnus glutinosa.*

Pulvinaria grabhami Ckll.

Pulvinaria grabhami Ckll., The Entom., xxxvi, p. 261 (1903).
Habitat—Madeira.
On leaves of *Jossinia tinifolia*, attended by *Iridomyrmex humilis.*

Pulvinaria innumerabilis betheli King.

Pulvinaria innumerabilis var. *betheli* King, Can. Ent., xxxv, p. 195 (1903).
Habitat—Colorado.
On *Alnus.*

Pulvinaria maxima Green.

Pulvinaria maxima Green, Ent. Mo. Mag., xl, p. 206 (1904). Fig.
Habitat—Java.
On stems of *Erythrina lithosperma.*

Pulvinaria polygonata Ckll.

Pulvinaria polygonata Ckll., Pr. Dav. Ac. Sci., x, p. 131 (1905).
Habitat—Philippine Islands.
"On a cultivated shade tree."

Pulvinaria psidii philippina Ckll.

Pulvinaria psidii philippina Ckll., Pr. Dav. Ac. Sci., x, p. 132 (1905).
Habitat—Philippine Islands.
On a cultivated *Ficus*.

Pulvinaria rehi King.

Pulvinaria rehi King (sine descr.), Allg. Zeits. f. Ent., VIII, p. 460 (1903).
Habitat—Germany.

Pulvinaria tyleri Ckll.

Pulvinaria tyleri Ckll., Pr. Dav. Ac. Sci., x, p. 132 (1905).
Habitat—Philippine Islands.
On "cadena de amor."

Pulvinaria vitis opacus King.

Pulvinaria vitis var. *opacus* King (sine descr.), Allg. Zeits. f. Ent., VIII, p. 461 (1903).
Habitat—Germany.

Pulvinaria vitis sorbusæ King.

Pulvinaria vitis var. *sorbusæ* King (sine descr.), Allg. Zeits. f. Ent., VIII, p. 461 (1903).
Habitat—Germany.

Pulvinaria vitis verrucosæ King.

Pulvinaria vitis var. *verrucosæ* King (sine descr.), Allg. Zeits. f. Ent., VIII, p. 461 (1903).
Habitat—Germany.

Eriopeltis coloradensis Ckll.

Eriopeltis coloradensis Ckll., Can. Ent., XXXVII, p. 136 (1905).
Habitat—Colorado.
On stems of grass.

Ceroplastes sanguineus Ckll.

Ceroplastes sanguineus Ckll., Ent. News., XVI, p. 162 (1905).
Habitat—Paraguay.
On *Maytenus* sp.

Ceroplastes schrottkyi Ckll.

Ceroplastes schrottkyi Ckll., Ent. News, XVI, p. 162 (1905).
Habitat—Paraguay.
On *Salix chilensis*.

Ctenochiton serratus Green.

Ctenochiton serratus Green, Victorian Nat., XXI, p. 67 (1904). Fig.
Habitat—Australia.
On *Styphelia* sp.

Eucalymnatus subtessellatus (Green).

Lecanium subtessellatum Green, Cocc. Ceylon, pt. III, p. 206 (1904). Fig.
Habitat—Ceylon.
On leaves of undetermined tree.

Genus **STICTOCOCCUS** Ckll. Type, *sjostedti*.

Stictococcus T. D. A. Ckll., Can. Ent., XXXV, p. 64 (1903).

Stictococcus sjostedti T. & W. Ckll.

Stictococcus sjostedti T. & W. Ckll., Can. Ent., xxxv, p. 64 (1903).
Habitat—Cameroons, Western Africa.

Coccus arundinariæ (Green).

Lecanium arundinariæ Green, Cocc. Ceylon, pt. III, p. 220 (1904). Fig.
Habitat—Ceylon.
On *Arundinaria* sp.

Coccus bicruciatus (Green).

Lecanium bicruciatum Green, Cocc. Ceylon, pt. III, p. 214 (1904). Fig.
Habitat—Ceylon.
On *Memecyclon umbellatum; Nothopegia colebrookiana; Eleagnus latifolia; Calophyllum* sp.; *Eugenia* sp.

Coccus capparidis (Green).

Lecanium capparidis Green, Cocc. Ceylon, pt. III, p. 187 (1904). Fig.
Habitat—Ceylon.
On *Capparis moonii.*

Coccus diversipes Ckll.

Coccus diversipes Ckll., Pr. Dav. Ac. Sci. x, p. 130 (1905).
Habitat—Philippine Islands.
"On cultivated fern 'parasite.'"

Coccus frontalis (Green).

Lecanium frontale Green, Cocc. Ceylon, pt. III, p. 192 (1904). Fig.
Habitat—Ceylon.
On leaves of "kina" (*Calophyllum* sp.).

Coccus incisus King.

Calymnatus incisus King, Rev. Chil. Hist. Nat., VI, p. 255 (1902).
Habitat—South America.
On nutmeg.

Coccus marsupialis (Green).

Lecanium marsupiale Green, Cocc. of Ceylon, pt. III, p. 212 (1904). Fig.
Habitat—Ceylon.
On *Piper nigrum; Pothos scandens; Anona* sp.

Coccus signiferus (Green).

Lecanium signiferum Green, Cocc. of Ceylon, pt. III, p. 197 (1904). Fig.
Habitat—Ceylon.
On *Caryota urens; Alpinia nutans; Begonia* sp. (cult.).

Mesolecanium inflatum Hempel.

Mesolecanium inflatum Hemp., Bol. Agr. Sao Paulo, v, p. 316 (1904).
Habitat—Rio de Janeiro.
On Myrtaceæ.

Eulecanium curtisi Kirkaldy. (Not valid.)

Eulecanium curtisi Kirkaldy, The Entom., XXXVII, p. 257 (1904).

Eulecanium folsomi Ckll.

Eulecanium folsomi Ckll., Can. Ent., xxxv, p. 193 (1903).
Proc. Ent. Soc. Wash., vii, p. 129 (1905).
Habitat—Illinois.
On Paw-paw (*Asimina triloba*).

Eulecanium lüstneri (King).

Lecanium lüstneri King, Allg. Zeits. f. Ent., viii, p. 409 (1903) (sine descr.).

Eulecanium pulchrum (King).

Lecanium pulchrum King, Allg. Zeits. f. Ent., viii, p. 410 (1903) (sine descr.).

Paralecanium calophylli (Green).

Lecanium (*Paralecanium*) *calophylli* Green, Cocc. Ceylon, pt. iii, p. 240 (1904). Fig
Habitat—Ceylon.
On *Calophyllum* sp.

Paralecanium expansum javanicum (Green).

Lecanium expansum var. *javanicum* Green, Ent. Mo. Mag., xl, p. 205 (1904).
Habitat—Java.
On *Anomianthus heterocarpus*.

Paralecanium expansum metallicum (Green).

Lecanium expansum var. *metallicum* Green, Ent. Mo. Mag., xl, p. 205 (1904).
Ann. Mag. Nat. Hist., (7), xiv, p. 377 (1904).
Habitat—Java; Malay Peninsula.
On *Myristica fragrans*.

Paralecanium expansum quadratum (Green).

Lecanium expansum var. *quadratum* Green, Cocc. of Ceylon, pt. iii, p. 236 (1904). Fig.
Habitat—Ceylon.
On cultivated nutmeg; undetermined tree.

Paralecanium expansum rotundum (Green).

Lecanium expansum var. *rotundum* Green, Ent. Mo. Mag., xl, p. 206 (1904).
Habitat—Java.
On *Rhizophora mucronata*.

Paralecanium peradeniyense (Green).

Lecanium (*Paralecanium*) *peradeniyense* Green, Cocc. Ceylon, pt. iii, p. 241 (1904). Fig.
Habitat—Ceylon.
On *Piper nigrum* (cult.).

Paralecanium zonatum (Green).

Lecanium (*Paralecanium*) *zonatum* Green, Cocc. Ceylon, pt. iii, p. 245 (1904). Fig.
Habitat—Ceylon.
On *Garcinia spicata*.

Saissetia discrepans (Green).

Lecanium discrepans Green, Cocc. Ceylon, pt. iii, p. 204 (1904). Fig.
Habitat—Ceylon.
On tea plant, in nest of *Cremastogaster dohrni* or exposed.

Saissetia psidii (Green).

Lecanium psidii Green, Cocc. Ceylon, pt. III, p. 225 (1904). Fig.
Habitat—Ceylon.
On *Psidium guava; Mangifera indica; Artocarpus integrifolia; Eugenia* sp.; *Fagrex; Myristica moschata.* Often inclosed in nests of *Œcophylla smaragdina.*

Saissetia punctulifera (Green).

Lecanium punctuliferum Green, Cocc. Ceylon, pt. III, p. 205 (1904). Fig.
Habitat—Ceylon.
On *Michelia champaca; Ærna lanata.*

Physokermes concolor Coleman.

Physokermes concolor Coleman, Jn. N. Y. Ent. Soc., XI, pp. 72, 77 (1903).
Habitat—California
On *Abies concolor.*

Physokermes taxifoliæ Coleman.

Physokermes taxifoliæ Coleman, Jn. N. Y. Ent. Soc., XI, pp. 73, 77 (1903).
Habitat—California.
On *Pseudotsuga taxifolia.*

"Lecanium" insolens King.

Lecanium insolens King, Rev. Chil. Hist. Nat., VI, p. 255 (1902).
Habitat—Brazil.
On *Philodendron.*

"Lecanium" limnanthemi Goury.[a]

Lecanium limnanthemi Goury, Feuille des Jeunes Nat., Feb., p. 62 (1905).
Habitat—France.
On submerged petiole of *Limnanthemum nymphoides.*

"Lecanium" tenebricophilum Green.

Lecanium tenebricophilum Green, Ent. Mo. Mag., XL, p. 204 (1904). Fig.
Habitat—Java.
Within tunnels in branches of *Erythrina lithosperma.*

Subfamily **DIASPINÆ**.

Chionaspis angustata Green.

Chionaspis angustata Green, Victorian Nat., XXI, p. 67 (1904). Fig.
Habitat—Australia.
On *Leptospermum lævigatum.*

Chionaspis candida Green.

Chionaspis candida Green, Victorian Nat., XXII, p. 6 (1905). Fig.
Habitat—Australia.
On *Callistemon salignus.*

Chionaspis cinnamomi Green.

Chionaspis cinnamomi Green, Jn. Bomb. N. H. Soc., XVI, p. 354 (1905). Fig.
Habitat—Ceylon.
On leaves of *Cinnamomum.*

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[a] No description was given. It is very improbable that it is a Coccid.

Chionaspis coronifera Green.

Chionaspis coronifera Green, Jn. Bomb. N. H. Soc., XVI, p. 353 (1905). Fig.
Habitat—Ceylon.
On undetermined tree.

Chionaspis decurvata Green.

Chionaspis decurvata Green, Ind. Mus. Notes, V, p. 63 (1903). Fig.
Habitat—India.
On rice (*Oryza sativa*).

Chionaspis formosa Green.

Chionaspis formosa Green, Pr. Linn. Soc. N. S. W., pt. III, p. 462 (1904). Fig.
Habitat—Australia.
On leaves of *Eucalyptus tereticornis*.

Chionaspis gleditsiæ Sanders.

Chionaspis gleditsiæ Sanders, Ohio Naturalist, III, p. 413 (1902). Fig.
Pr. Ohio Ac. Sci., IV, sp. papers No. 8, p. 46 (1904). Fig.
Habitat—Ohio, Pennsylvania, West Virginia, Maryland, Virginia, District of Columbia.
On *Gleditsia triacanthos*.

Chionaspis ortholobis bruneri Ckll.

Chionaspis ortholobis bruneri Ckll., Can. Ent., XXX, p. 133 (1898).
A synonym of *Chionaspis salicis-nigræ* (Walsh).

Chionaspis subcorticalis Green.

Chionaspis subcorticalis Green, Jn. Bomb. N. H. Soc., XVI, p. 351 (1905). Fig.
Habitat—Ceylon.
Under loose bark of *Artocarpus integrifolia*.

Chionaspis sylvatica Sanders.

Chionaspis sylvatica Sanders, Ohio Naturalist, IV, p. 95 (1904). Fig.
Pr. Ohio Ac. Sci., IV, sp. papers No. 8, p. 46 (1904). Fig.
Habitat—Ohio, Pennsylvania, West Virginia, Maryland, Virginia, District of Columbia.
On *Nyssa sylvatica*.

Howardia lobulata Del Guercio.

Howardia lobulata Del Guercio, Bul. Ent. Soc. Ital., XXXIV, pp. 179, 185 (1902).
Leonardi, Ann. R. Scuola Sup. Agr. Portici, V, pp. 1–5 (1903).
Synonym of *Rhopaloaspis riccæ* (Targ.).

Diaspis cordiæ Rübsaamen.

Diaspis cordiæ Rübs., Marcellia, IV, 5, p. 122 (1905).
Habitat—Rio de Janeiro.
On *Cordia curassavica*.

Diaspis squamosus Newst. & Theobald.

Diaspis squamosus Newst. & Theob., 2d Rep. Ec. Ent. Br. Mus., p. 185 (1904). Fig.
Habitat—Egypt.
On peach and pear.

Phenacaspis bupleuri (Marchal).

Chionaspis (*Phenacaspis*) *bupleuri* Marchal, Bul. Mus. d'Hist. Nat., VII, p. 454 (1904).
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).

Habitat—Algeria.

On *Bupleurum gibraltaricum.*

Phenacaspis ceratoniæ (Marchal).

Chionaspis (*Phenacaspis*) *ceratoniæ* Marchal, Bul. Mus. d'Hist. Nat. VII, p. 452 (1904). Fig.
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).

Habitat—Algeria.

On *Ceratonia siliqua.*

Phenacaspis strobilanthi (Green).

Chionaspis strobilanthi Green, Jn. Bomb. N. H. Soc., XVI, p. 352 (1905). Fig.

Habitat—Ceylon.

On *Strobilanthus* sp.

Hemichionaspis theæ ceylonica (Green).

Chionaspis theæ var. *ceylonica* Green, Jn. Bomb. N. H. Soc., XVI, p. 354 (1905). Fig.

Habitat—Ceylon.

Hemichionaspis townsendi Ckll.

Hemichionaspis townsendi Ckll., Pr. Dav. Ac. Sci., x, p. 135 (1905).

Habitat—Philippine Islands.

On bark of *Gossypium* sp.

Leucaspis corsa Lindinger.

Leucaspis (*Euleucaspis*) *corsa* Lind., Zool. Anzeiger, XXIX, 8, p. 252 (1904).
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).

Habitat—Corsica.

On *Pinus laricio.*

Leucaspis cupressi Coleman.

Leucaspis cupressi Coleman, Jn. N. Y. Ent. Soc., XI, p. 71 (1903). Fig.

Habitat—California.

On *Cupressus goveniana.*

Leucaspis kelloggi Coleman.

Leucaspis kelloggi Coleman, Jn. N. Y. Ent. Soc., XI, p. 68 (1903). Fig.

Habitat—California.

On *Pseudotsuga taxifolia; Abies magnifica; A. grandis; A. concolor; A. shastensis.*

Leucaspis kermanensis Lindinger.

Leucaspis (*Salicicola*) *kermanensis* Lind., Zool. Anz., XXIX, 8, p. 253 (1904).
Speiser, Zeits. f. wiss. Insekt., I, 12, p. 520 (1905).

Habitat—Corsica.

On *Salix persica; S. zygostemon; Populus euphratica.*

Leucaspis leonardi Ckll.

Leucaspis pini Berl. & Leon., Cherm. Ital., Fasc. I, No. 19 (1895).
Leucaspis leonardi Ckll., Jn. N. Y. Ent. Soc., XI, p. 84 (1903).

Habitat—Italy.

On *Pinus picea.*

Fiorinia bidens Green.

Fiorinia bidens Green, Jn. Bomb. N. H. Soc., XVI, p. 351 (1905). Fig.
Habitat—Ceylon.
"On leaves of undetermined tree."

Genus **RHOPALOASPIS** Del Guercio. Type, *riccæ*.

Rhopaloaspis Del Guercio, Bul. Soc. Ent. Ital., XXXIV, pp. 185–188 (1902).

Rhopaloaspis riccæ (Targ.) = *Leucaspis riccæ* Targ.

Aspidiotus californicus Coleman.

Aspidiotus californicus Coleman, Jn. N. Y. Ent. Soc., XI, p. 64 (1903). Fig.
Habitat—California.
On *Pinus sabiniana; P. ponderosa; P. lambertiana; P. attenuata.*

Aspidiotus capensis Walker.

Aspidiotus capensis Green, Ann. Mag. Nat. Hist. (7), XIV, p. 375 (1904). Fig.
Habitat—Cape Colony.
On undetermined plant.

This species, which is in the British Museum, has been redescribed and restored to science by Mr. E. E. Green.

Aspidiotus capsulatus Green.

Aspidiotus capsulatus Green (sine descr.), Jn. Bomb. N. H. Soc., XVI, p. 343 (1905).
Habitat—Java.
On *Piper nigrum.*

Aspidiotus coniferarum shastæ Coleman.

Aspidiotus coniferarum var. *shastæ* Coleman, Jn. N. Y. Ent. Soc., XI, p. 67 (1903). Fig.
Habitat—California.
On *Cupressus macnabiana.*

Aspidiotus cuculus Green.

Aspidiotus cuculus Green, Jn. Bomb. N. H. Soc., XVI, p. 341 (1905). Fig.
Habitat—Ceylon.
In abandoned galls of *Amorphococcus mesuæ* Green.

Aspidiotus ehrhorni Coleman.

Aspidiotus (Diaspidiotus) ehrhorni Coleman, Jn. N. Y. Ent. Soc., XI, p. 68 (1903). Fig.
Habitat—California.
Under lichens on *Abies concolor; Libocedrus decurrens.*

Aspidiotus florenciæ Coleman.

Aspidiotus florenciæ Coleman, Jn. N. Y. Ent. Soc., XI, p. 66 (1903). Fig.
Habitat—California.
On *Pinus ponderosa.*

Aspidiotus immaculatus Green.

Aspidiotus (Hemiberlesia) immaculatus Green, Victorian Nat., XXI, p. 65 (1904). Fig.
Habitat—Australia.
On *Styphelia virgata.*

Aspidiotus moreirai Hempel.

Aspidiotus moreirai Hemp., Bol. Agr. São Paulo, v, p. 320 (1904).
Habitat—Rio de Janeiro.
On leaves of *Drymus* sp.

Aspidiotus ohioensis York.

Aspidiotus (Diaspidiotus) ohioensis York, Ohio Naturalist, v, p. 325 (1905). Fig.
Habitat—Ohio.
On *Æsculus glabra*.

Aspidiotus oxycoccus Woglum.

Aspidiotus oxycoccus Woglum, Can Ent., xxxviii, p. 73 (1906). Fig.
Habitat—New Jersey.
On Cranberry (*Oxycoccus*).

Aspidiotus piceus Sanders.

Aspidiotus piceus Sanders, Ohio Naturalist, iv, p. 96 (1904). Fig.
Pr. Ohio Ac. Sci., iv, sp. papers No. 8, p. 66 (1904). Fig.
Habitat—Ohio.
On *Liriodendron tulipifera*.

Aspidiotus pisai Hempel.

Aspidiotus pisai Hemp., Bol. Agr. São Paulo, v, p. 320 (1904).
Habitat—Rio de Janeiro.
On leaves of *Drymus* sp.

Aspidiotus pseudospinosus Woglum.

Aspidiotus pseudospinosus Woglum, Can. Ent., xxxviii, p. 75 (1906). Fig.
Habitat—Florida.
On saw-palmetto.

Aspidiotus pustulans Green.

Aspidiotus pustulans Green, Ent. Mo. Mag., xli, p. 31 (1905). Fig.
Habitat—Java.
On *Erythrina lithosperma*.

Aspidiotus riveræ Ckll.

Aspidiotus riveræ Ckll., Ent. News, xvi, p. 161 (1904).
Habitat—Chile.
On stems of *Chusquea*.

Aspidiotus subfervens Green.

Aspidiotus (Targionia) subfervens Green, Victorian Nat., xxi, p. 66 (1904). Fig.
Habitat—Australia.
On *Acacia* sp.; *Pomaderris* sp.

Aspidiotus subrubescens corticoides Green.

Aspidiotus (Evaspidiotus) subrubescens var. *corticoides* Green, Victorian Nat., xxii, p. 3, (1905). Fig.
Habitat—Australia.
On *Eucalyptus globosus*.

Aspidiotus tayabanus Ckll.

Aspidiotus tayabanus Ckll., Pr. Dav. Ac. Sci., x, p. 133 (1905).
Habitat—Philippine Islands.
"On cultivated plant called 'rosal' or 'campopot.'"

Cryptophyllaspis bornmülleri Rübsaamen.

Cryptophyllaspis bornmülleri Rübs., Marcellia, I, fasc. i-ii, p, 62 (1902).
Habitat—Canary Islands; Madeira.
On *Globularia salicina.*

Cryptophyllaspis occultus elongatus (Green).

Aspidiotus (*Cryptophyllaspis*) *occultus* var. *elongatus* Green, Jn. Bomb. N. H. Soc., XVI, p. 345 (1905). Fig.
Habitat—Ceylon.
On leaves of *Grewia* sp.

Pseudaonidia curculiginis (Green).

Aspidiotus (*Pseudaonidia*) *curculiginis* Green, Ent. Mo. Mag., XL, p. 208 (1904). Fig.
Habitat—Java.
On leaves of *Curculigo recurvata.*

Chrysomphalus cistuloides (Green).

Aspidiotus (*Chrysomphalus*) *cistuloides* Green, Jn. Bomb. N. H. Soc., XVI, p. 342 (1905). Fig.
Habitat—Ceylon.
On leaves of *Cinnamomum.*

Chrysomphalus malleolus (Green).

Aspidiotus (*Chrysomphalus*) *malleolus* Green, Jn. Bomb. N. H. Soc., XVI, p. 342 (1905). Fig.
Habitat—Ceylon.
On leaves of *Mimusops hexandra.*

Chrysomphalus pedronis (Green).

Aspidiotus (*Chrysomphalus*) *pedronis* Green, Jn. Bomb. N. H. Soc., XVI, p. 341 (1905). Fig.
Habitat—Ceylon.
"On leaves of undetermined tree."

Chrysomphalus quadriclavatus (Green).

Aspidiotus (*Chrysomphalus*) *quadriclavatus* Green, Jn. Bomb. N. H. Soc., XVI, p. 343 (1905). Fig.
Habitat—Ceylon.
On leaves of *Murraya exotica.*

Chrysomphalus taprobanus (Green).

Aspidiotus (*Aonidiella*) *taprobanus* Green, Jn. Bomb. N. H. Soc., XVI, p. 344 (1905). Fig.
Habitat—Ceylon.
On leaves of *Phyllanthus myrtifolius.*

Targionia phyllanthi (Green).

Aspidiotus (*Targionia*) *phyllanthi* Green, Jn. Bomb. N. H. Soc., XVI, p. 344 (1905). Fig.
Habitat—Ceylon.
On stems and twigs of *Phyllanthus myrtifolius*.

Odonaspis penicillata Green.

Odonaspis penicillata Green, Jn. Bomb. N. H. Soc., XVI, p. 346 (1905). Fig.
Habitat—Ceylon.
On a large bamboo (*Gigantochloa aspera*).

Aonidia ebeni "Green" Leonardi=*Aonidia crenulata* Green. Green in litt., July 6, 1905.

Aonidia echinata Green.

Aonidia echinata Green, Jn. Bomb. N. H. Soc., XVI, p. 347 (1905). Fig.
Habitat—Ceylon.
On *Hemicyclia sepiaria*.

Aonidia javanensis Green.

Aonidia javanensis Green, Ent. Mo. Mag., XLI, p. 31 (1905). Fig.
Habitat—Java.
On leaves of *Myristica fragrans*.

Aonidia pulchra Green.

Aonidia (*Greeniella*) *pulchra* Green, Victorian Nat., XXII, p. 4 (1905). Fig.
Habitat—Australia.
On leaves of *Callistemon salignus*.

Aonidia pusilla Green.

Aonidia pusilla Green, Jn. Bomb. N. H. Soc., XVI, p. 347 (1905). Fig.
Habitat—Ceylon.
On leaves of *Carissa spinarum*.

Gymnaspis spinomarginata Green.

Gymnaspis spinomarginata Green, Jn. Bomb. N. H. Soc., XVI, p. 348 (1905). Fig.
Habitat—Ceylon.
On leaves of *Mesua ferrea*.

Genus **MYTILELLA** Leonardi. Type, *carinata*.

Mytilella Leonardi, Annali di Agr., V, p. 120 (1903).

Genus **AONIDOMYTILUS** Leonardi. Type, *concolor*.

Aonidomytilus Leonardi, Annali di Agr., V, p. 102 (1903).

Genus **FERNALDIELLA** Leonardi. Type, *indentata*.

Fernaldiella Leonardi, Annali di Agr., V, p. 105 (1903).

Lepidosaphes cockerelliana Kirkaldy. (Not valid.)

Lepidosaphes cockerelliana Kldy., The Entom., XXXVII, p. 257 (1904).
Synonym of *L. alba* Ckll.

Lepidosaphes bicornis (Green & Lidg.).

Mytilaspis bicornis Green & Lidg., Victorian Nat., XVII, p. 9 (1900). Fig.
Leonardi, Annali di Agr., V, p. 85 (1903). Fig.
Habitat—Victoria, Australia.
On *Eucalyptus globulus*.

Lepidosaphes cassiniæ Green.

Mytilaspis cassiniæ Green, Victorian Nat., XXII, p. 4 (1905). Fig.
Habitat—Victoria, Australia.
On *Cassinia aculeata*.

Lepidosaphes corrugata Green.

Lepidosaphes corrugata Green, Ent. Mo. Mag., XL, p. 209 (1904).
Habitat—Java.
On stems of *Coffea arabica*.

Lepidosaphes ficifolii (Berlese).

Mytilaspis ficifolii Berlese, Atti del R. Inst. d'Incorrag. (5), V (1903). Fig.
Habitat—Italy.
On leaves of *Ficus carica*.

Lepidosaphes hymenantheræ (Green).

Mytilaspis (*Coccomytilus*) *hymenantheræ* Green, Victorian Nat., XXII, p. 5 (1905). Fig.
Habitat—Victoria, Australia.
On *Hymenanthera banksii*.

Lepidosaphes intermedia victoriæ (Green).

Mytilaspis intermedia var. *victoriæ* Green, Victorian Nat., XXII, p. 5 (1905).
Habitat—Victoria, Australia.
On *Acacia montana*.

Lepidosaphes multipora (Leonardi).

Mytilaspis multipora Leon., Annali di Agr., V, p. 87 (1903). Fig.
Green, Victorian Nat., XXII, p. 6 (1903).
Habitat—New Zealand.
On *Pittosporum undulatum*.

Lepidosaphes rubrovittatus Ckll.

Lepidosaphes rubrovittatus Ckll., Pr. Dav. Ac. Sci., X, p. 135 (1905).
Habitat—Philippine Islands.
On cultivated *Eugenia malaccensis*.

Lepidosaphes ungulata Green.

Lepidosaphes ungulata Green, Ent. Mo. Mag., XLI, p. 30 (1905). Fig.
Habitat—Java.
On *Syzygium pseudo-jambolanum*.

Lepidosaphes wilga (Green).

Mytilaspis wilga "Green" Leonardi, Annali di Agr., V, p. 43 (1903). Fig.
Habitat—Australia.
On "*Wilga*."

Opuntiaspis javanensis Green.

Opuntiaspis javanensis Green, Ent. Mo. Mag., XLI, p. 28 (1905). Fig.
Habitat—Java.
On *Agave mexicana.*

Euparlatoria Leonardi, Ann. R. Sc. Sup. di Agr. Portici, V, p. 15 (1903).
To include *banksiæ, calianthina, cingala, myrtus, parlatoriæ, pergandii, proteus,* and *theæ.*

Parlatoria atalantiæ Green.

Parlatoria (*Websteriella*) *atalantiæ* Green, Jn. Bomb. N. H. Soc., XVI, p. 350 (1905). Fig.
Habitat—Ceylon.
On leaves of *Atalantia zeylanica.*

Parlatoria pergandii phyllanthi Green.

Parlatoria pergandii var. *phyllanthi* Green, Jn. Bomb. N. H. Soc., XVI, p. 350 (1905). Fig.
Habitat—Ceylon.
On leaves of *Phyllanthus myrtifolius.*

Parlatoria pseudaspidiotus Lindinger.

Parlatoria pseudaspidiotus Lindgr., Insekten Börse, XXII, 33, p. 131 (1905).
Habitat—India.
On orchids (*Vanda hookeriana* and *V. teres*).

Genus **CRYPTOPARLATOREA** Lindinger. Type, *leucaspis.*

Cryptoparlatorea Lindgr., Insekten Börse, XXII, 33, p. 132 (1905).

Cryptoparlatorea leucaspis Lindinger.

Cryptoparlatorea leucaspis Lindgr., Insekten Börse, XXII, 33, p. 132 (1905).
Habitat—Japan.
On needles of *Juniperus* sp.

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TECHNICAL SERIES No. 12, PART II.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

HABITS AND LIFE HISTORIES

OF SOME

FLIES OF THE FAMILY TABANIDÆ.

By JAMES S. HINE,
Of the Ohio State University, Columbus, Ohio.

ISSUED AUGUST 29, 1906.

WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 11, 1906.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled "Habits and Life Histories of some Flies of the Family Tabanidæ" (horseflies), prepared by Prof. James S. Hine, of the Ohio State University, Columbus, Ohio. As is well known, the insects of this family are injurious and annoying to human beings, and especially to horses and cattle, from their bites; but aside from this, and what is of much greater importance from an economic view-point, there is reason to believe that they sometimes act as agents in the transmission of infectious diseases. Every contribution to a knowledge of their habits and life histories is, therefore, of especial value. The present paper embodies the results of original investigations begun by Professor Hine during the summer of 1904 while a special field agent of this Bureau, and I recommend its publication as Part II of Technical Series bulletin No. 12.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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U. S. D. A., B. E. Tech. Ser. 12, Pt. II. August 29, 1906.

MISCELLANEOUS PAPERS.

HABITS AND LIFE HISTORIES OF SOME FLIES OF THE FAMILY TABANIDÆ.

By James S. Hine, *Columbus, Ohio.*

THE BLACK-STRIPED HORSEFLY.

(*Tabanus lasiophthalmus* Macquart.)

This species was reared from the egg to the adult. The fly is one of the earliest of its genus to appear in the spring, adults having been taken at Columbus, Ohio, as early as May 20, and it is common during the first half of June. The eggs are placed in masses on various plants that grow in low, wet ground, but I have not observed them over water. The masses are pure shining black when fully colored, rather small for members of the genus, only slightly convex, and accompanied with an unusual amount of cementing material, which nearly obscures the form and arrangement of the individual eggs. The mass in place suggests somewhat a drop of tar or other black substance fastened to the surface of a leaf of the common cattail reed (*Typha latifolia*), a sedge, or some other plant.

The eggs are usually deposited after the 10th of June, and the specimens from which larvæ for rearing hatched were taken in Medina County, Ohio, on a common sedge found growing near the outlet of a small spring. They were collected June 28 and hatched the next day and the day after. As I had not been successful up to this time in keeping very young larvæ for any length of time, it was decided to try different methods of treatment in order to find out, if possible, which is best suited to their requirements. Some were placed in a jar containing water only; others in a jar containing water with a couple of inches of sand in the bottom. A third jar in which larvæ were placed contained wet muck, while the fourth lot were placed in a jar containing moist sand to the depth of about 3 inches, covered over the top with a quantity of fine leaves of water plants. In all the breeding jars were placed plenty of small crustaceans and other minute invertebrates procured from water by means of a fine-meshed sieve.

It was soon observed that the larvæ in breeding jar No. 4 fed on the crustaceans and at the end of a few days showed a distinct increase in size. Those in the jars containing water soon died, and jar No. 3 did not appear to be a success, so all but No. 4 were abandoned. The larvæ in this last, however, were separated and placed in similar jars, one specimen in each, and reared to full size, the adult fly being procured the following spring.

Since, as stated, three of the four jars started with were soon abandoned, what is said hereafter regarding the method used in rearing pertains to the single one retained. A glass jar was selected so that the actions of the larvæ could be observed through it; a small jar seemed desirable because the larvæ are predaceous and eat their own kind as readily as anything else, for which reason it is necessary after a short time to place only a single specimen in a jar; also, even a small receptacle furnishes plenty of room, and the long series, which it is desirable to have, takes as much space in the insectary as one cares to give to a single species. Only the quantity of sand and other material necessary to success should be placed in the breeding jar, as it is desirable once in a while to look this material over carefully in order to locate the very small specimens and find out what they are doing.

All things considered, half-pint jelly glasses were found to be well suited for the purpose and easily obtainable. Covers proved to be desirable in order to prevent too rapid evaporation of moisture, but a small perforation or two in them was necessary to furnish ventilation. As the muck which was tested as soil for the jars grew much mold, clean lake sand was chosen as decidedly preferable for the purpose. The covering of plant material mentioned furnished a resting place for the small crustaceans offered for food, and the larvæ themselves seemed to choose to remain in it in preference to burrowing into the sand, although they were apt to be found in any part of the jar. Algæ made good material for covering, but only a small amount could be used, and too much water was detrimental, as either in excess tended to develop decay, and consequently a bad odor, which was observed to be unfavorable to the insects. The principal point in favor of the algæ, as compared with some other things, was that they contained no hollow stems or large pieces into which the larvæ could crawl, but still, because composed of small soft particles, furnished a mat in which they could hide. When it was desired to locate these larvæ it was easily done by picking the mass to pieces. As odors, which are often fatal to the larvæ, were likely to develop from the material put in for food and also from other sources, it was found necessary to watch the jars continually, giving them a thorough cleansing once in a while, and perhaps putting in fresh sand and plant material occasionally.

Larvæ when first hatched were about 2 mm. in length; they grew rather slowly, but in fifteen days after hatching had doubled their length. They fed readily on the small crustaceans which were given them. It was impossible to give these small crustaceans their proper surroundings, so many of them died, and it was observed that the young larvæ fed on these as well as on the specimens which they killed themselves. The larvæ could be seen crawling about in the jars; they appeared to remain very near the upper surface of the sand most of the time, and when food was scarce did much crawling, but when food was plentiful satisfied their appetites and hid among the plant material, where they remained quiet.

A difference in size in the various larvæ soon became apparent, and the older they became the greater this difference. On July 23, twenty-five days after hatching, some specimens measured as much as 7 mm., while others measured only 3 mm. At this date angleworms were given for food and were accepted readily, and appeared to be as satisfactory as the crustaceans, but it would seem that the latter are preferable for the stage just after hatching.

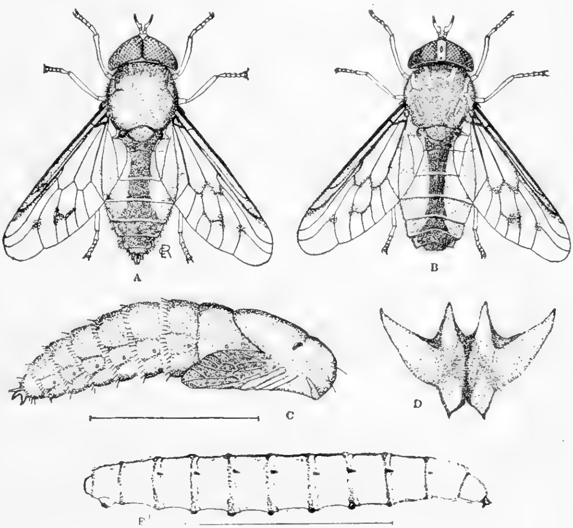

FIG. 1.—*Tabanus lasiophthalmus:* A, male; B, female; C, pupa; D, terminal abdominal teeth of pupa; E, undersized larva. All enlarged (original).

July 27 some of the larvæ were 10 mm. in length, and August 2 the same specimens measured 12 mm.; thus at this stage they grew more rapidly than when they were younger. They fed actively till about the middle of September, when they had become apparently full grown, or 25 mm. long. Length in the larvæ of tabanids is not a satisfactory means of indicating the size, for the segments telescope on one another in such a way that it is difficult to take two measurements exactly alike, but an endeavor was made in this case to make the different measurements similar, so I am satisfied that those given are sufficient to indicate the comparative sizes of the different ages. After the 15th of September the few specimens remaining alive buried themselves in the sand of the breeding jars and were quiet most of the time until the 10th of March, when one pupated, the adult emerging on the 25th of the same month; the others died before the pupal stage was reached. I have noted that larvæ of various species of tabanids taken from their natural habitats during the winter did not produce adults in spring much before the same species appeared naturally, but in this case, where the specimen was kept under artificial conditions during its entire life, the adult appeared almost two months earlier than is normal in nature.

The mature larva (fig. 1, E) is not notably different from those of other species of Tabanus so far as form and appearance are concerned. The color is a dirty white with a pinkish shade over most of the body; the prolegs are not so prominent as in many species, and on this account specimens appear somewhat maggot-like. On either side of the body is a longitudinal row of very small black spots or specks, one to each segment and located just above the ventral prolegs; these spots are lacking on some of the anterior and some of the posterior segments; their presence appears to be characteristic of the species, at least so far as my acquaintance with different larvæ goes. Mature specimens are about 25 mm. in length.

I have not taken the larva of this species in its natural habitat, therefore can not say anything as to where it is to be found, but suspect it lives in débris, or in the ground around low places near where the eggs are laid.

The pupa (fig. 1, C) is somewhat dusky in coloration, the thorax being almost black. The terminal teeth of the abdomen (fig. 1, D) are quite different from those of any species studied so far, and these differences alone make its determination easy. The dorsal and lateral teeth are much larger than the ventral, the lateral being much larger than any of the others; the ventral teeth point almost directly backward, while the direction of the others is largely upward. The thoracic spiracle is rather small and nearly longitudinal, its rima is curved, but no distinct hook is formed at the posterior end. Length, 18 mm.

The adult (fig. 1, A, B) measures from 13 to 15 mm. Eyes pilose, ocelligerous tubercle present, wings hyaline, cross-veins and furcation of the third vein margined with brown, abdomen broadly red on the sides; female subcallus denuded and shining black, frontal callosity also shining black, as wide as the front and separated from a denuded spot above by a pollinose interval, front slightly widened above; male subcallus not denuded, eyes very plainly pilose, head about equal in size to that of the female.

THE AUTUMN HORSEFLY.

(*Tabanus sulcifrons* Macquart.)

This is one of the common species of its family over a wide range. It is not so generally distributed as some of the other species, but where it occurs is apt to be abundant and very injurious to all kinds of stock. I have studied the species in several localities, but most of my knowledge of its habits was gained in Summit and Medina counties, Ohio, where it is a pest of the first magnitude. This country, where the ground is highest, has an elevation of 1,000 to 1,200 feet, and is more or less broken by gullies crossing here and there, and through each flows a stream of clear water of larger or smaller dimensions. These streams are fed by small springs and therefore contain water the year round, forming in their beds pools and riffles over which the sexes of *sulcifrons* may be seen flying much of the time.

I am not fully prepared to say why this particular species is so abundant in these counties and entirely absent in other counties of the same latitude in the western part of the same State; but it appears that there is present some condition which is necessary to its successful existence. The statement may be made in this connection that the autumn horsefly appears to prefer high ground, such as described,

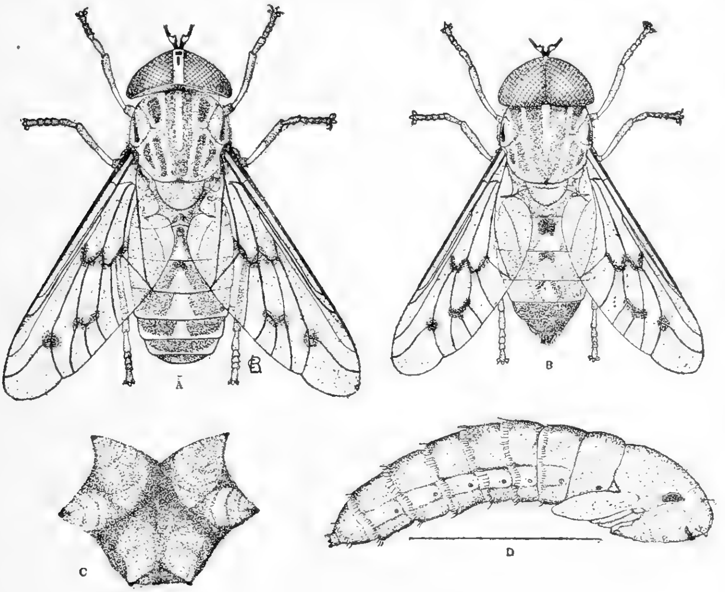

FIG. 2.—*Tabanus sulcifrons:* A, female; B, male; C, terminal abdominal teeth of pupa; D, pupa. All enlarged (original).

to low bottom land where many other horseflies find conditions exactly to their liking.

The adult (fig. 2, A, B) is a large brown fly 18 to 21 mm. in length. Palpi brownish, antennæ nearly black, with each third segment brownish at the base; legs dark, bases of the tibiæ lighter, the front pair black with the exception of the bases of the tibiæ and therefore much darker in general coloration than the others; wings with a distinct brownish tinge, cross-veins at the end of the discal cell, and the furcation of the third vein plainly margined with dark brown, first posterior cell open.

Female: Front of moderate width, sides parallel, frontal callosity shining brown, not quite as wide as the front, nearly square and with a linear prolongation above. Segments of the abdomen above with prominent, gray hind margins which expand into large gray triangles at the middle; usually a black marking on the anterior part of each of the second and third segments at the apex of the gray triangle.

Male: Division between the large and small facets of the eye prominent; head somewhat more convex than in the female, but of nearly the same size. Coloration in its entirety as in the other sex.

In Ohio the first specimens of the species usually appear about July 20 and specimens have been taken as late as the middle of September, but the period of greatest abundance is the first three weeks of August.

The adults are most in evidence when the sun is shining most brightly. As evening approaches they become less active and seek a resting place among foliage, on some tree trunk, on a fence or post, or in some similar place, where they remain quiet until the sun appears the following morning. These flies have a tendency to collect in certain favorable places in large numbers at evening, and if the collector or observer finds such a place, a visit to it by 7 o'clock in the morning will give an opportunity to procure plenty of specimens of both sexes, or abundance of notes on habits. When the sun has warmed the atmosphere somewhat, the flies begin to run over the objects on which they passed the night, or to fly from one perch to another. Both sexes are plentiful, the males often more plentiful than the females, and there is no difference in habits that makes it possible to readily distinguish the sexes. Specimens are easily taken, for by using care they may be picked up with the thumb and fingers, or if it is desired to use a net, it is not difficult to procure large numbers in a few minutes.

The only times I have observed copulation in the Tabanidæ were in places similar to the one just described and always about 8 o'clock in the morning. In a paper by the writer on the "Tabanidæ of Ohio"[a] it is recorded (p. 8) that on the 18th of August, between 8 o'clock and half past 8, several pairs of *T. sulcifrons* were observed in couple on the fence, and several pairs taken. The male in instances observed clung to the edge of a rail, and the female, with legs and wings motionless and touching nothing, hung suspended. My observations at this time led me to think that the opportunity for studying the mating habits of the species in question, and also of some others of its family, is confined to a particular time of day, and subsequent observations have not made it necessary to alter this opinion. On August 17 of the following year, about the same hour and near the place where the observations mentioned above were made, I captured nine pairs of the species, most of which were on the fence. At this time an effort was made to add to the data obtained before. It was then observed that when pairs were disturbed sufficiently to cause them to leave, the male did all the flying and proceeded only a short distance before alighting, either on the ground or on low-growing foliage, or it flew in a curve and soon returned to the fence. Coition in no case observed lasted over ten minutes, and all the pairs were taken within a quarter of an hour, after which time no more could be found.

As the hour became later fewer and fewer specimens were to be seen, and long before noon nearly all of the flies had left the places

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[a] Ohio State Academy of Science, Special Papers, No. 5, May 1, 1903.

where they were so abundant earlier in the day. Either they had gone in search of food—the females to different animals for the purpose of sucking blood and the males to various places where they could find nectar and other liquid substances to their liking—or else they had gone to the water, over which could be seen both sexes flying in abundance, now and then striking the surface with their abdomens, but flying so rapidly that the observer had difficulty in determining the nature of their actions or what was accomplished by them. However, if the day was dark and cloudy there was not much activity among them, and on some of the cooler days or when it was raining they were hardly ever seen at all. An acquaintance with their habits at such times revealed the fact that they were passing the time among the foliage, usually on the underside of a leaf, where they remained quiet until pleasant weather appeared again.

The habits of the sexes while flying over water have been investigated a great deal, but after all there are some points not fully understood. There appears to be no choice as to the kind of water, for running brooks are chosen as well as stagnant ponds. At first there was some question in my mind as to whether both sexes have the habit of striking the surface in their gyrations over water, but observation soon proved that one sex as well as the other visits ponds and streams regularly, and so far as I could see there is no difference in their habits so far as the dipping is concerned, and specimens taken in the act bear out this statement. Over a small pond in which there was an abundance of aquatic vegetation in parts and open water in other parts, I observed many of the insects flying. Specimens, after flying about for a time, often came to rest on the foliage and sometimes on the surface of the open water. Under such circumstances the sex could be determined readily. Along swiftly flowing streams specimens found favorite resting places on the stones that protruded above the water, or else on the bank near the water's edge.

The food habits of the adults are of especial interest, and every opportunity for studying these was utilized. I am thoroughly convinced that the females take much other food than blood and do not believe it would be overstating the facts to say that specimens of this sex may pass the period of adult life without taking blood at all. Both sexes of *sulcifrons* run over foliage a great deal and often have been observed sipping up water that forms on the leaves as dew. This dew in many cases carries nourishment in solution, and on trees infested by aphides, scale insects, and various other species, especially of the order Hemiptera, much food material is included. Many leaves become coated with honeydew dried to a semisolid state. The water that collects on these leaves during clear nights dissolves some of this material and makes it available as food for horseflies. I have watched many specimens on wet stones and damp sand along brooks.

They move from one place to another, stopping now and then to sip up any small amount of liquid that they find, and if one watches closely he may see this liquid disappear from small depressions where they have introduced their sucking mouth parts. I have examined many specimens of both males and females and found their alimentary tracts filled with a liquid slightly yellowish in coloration, indicating that it contained something besides clear water. In Summit County, Ohio, some cucumber trees (*Magnolia acuminata*) were found to be thoroughly infested with a species of scale of the genus Eulecanium. Male and female flies visited these trees in numbers and fed on the honeydew excreted by the scale insects.

A number of species of the family Tabanidæ, aside from the one under consideration, have been observed feeding on the excretions of insects. At Sandusky, Ohio, within a few minutes I took the sexes of no less than six species of the genera Chrysops and Tabanus feeding on honeydew from an aphis, which was abundant on Phragmites, a large species of aquatic grass.

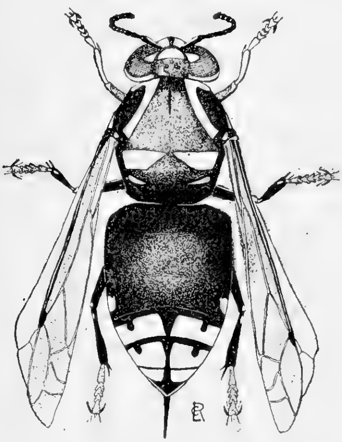


FIG. 3.—*Vespa maculata*, enlarged (original).

The various species of Tabanidæ have a great many natural enemies and *sulcifrons* is no exception in this regard. Aside from certain species of birds which are known to devour the flies occasionally, I have observed that the common bald-faced hornet (*Vespa maculata* L., fig. 3) is very active in capturing both sexes, either for food for itself or for its young. Around the cucumber trees mentioned above the flies were abundant, and while located under one of these one afternoon I saw something come tumbling down through the branches to the ground. When in position to see what it was, I found it to be a horsefly which was being held by a hornet. The matter was interesting, and I watched to see what transpired. The fly was too heavy for the hornet to carry, but the latter, equal to the occasion, immediately began to dismember the former, cutting off such parts as were not wanted. With its scissor-like mandibles, and otherwise well prepared for what was to follow, the hornet soon got into position and first clipped the slender neck of its victim, thus separating the head from the rest of the body. Legs and wings came next in order, and finally the abdomen; so that nothing was retained but the thorax. After lacerating this somewhat and disposing of some of the outer chitinous covering, it rolled the remainder into a sort of a ball and flew away with it—I suppose to its nest.

After one example of this kind had been observed, watch was made for others, and it was found that the occurrence was common. The hornets could be heard buzzing in all parts of the tree, and when one had the opportunity it pounced upon a fly and, holding on with its feet, came down with its prey to the ground, both insects making an abundance of noise with their wings.

August 6 under a single tree I saw the hornets kill three males and a female of the tabanid within the space of half an hour. At other times during succeeding days the occurrence was watched until it was proven that the habit is a natural one for this particular species of hornet.

Some variations in the actions of the hymenopteron were noted. In some cases, after cutting off the head and some of the appendages of the fly, it flew to one of the lower branches of the tree with the remains and finished the trimming while clinging to a twig by one hind leg and using the other legs to hold and manipulate its victim.

The possibility that the hornet stung its prey, when it first pounced upon it, was considered, and although there was no definite way of proving that such is not the fact, results of observation do not seem to indicate such a procedure. In one or two instances observed the pair came down into the water of a brook that flowed beneath the tree. Under these conditions the hornet became confused and released its hold on the fly, the latter flying away apparently unharmed.

Various species of spiders occasionally catch flies of this species, either by netting them in their webs or by jumping upon them from concealment.

The use of insecticides against adult horseflies has been more or less unsatisfactory, and whatever good has been accomplished has come almost entirely as a result of using some substance that acted as a repellent to the flies; for they are so retiring in their habits that as soon as anyone approaches with a sprayer an animal they are troubling, they are apt to leave and consequently do not usually receive a direct application. Effort on the part of different investigators to bring out an effective repellent has resulted in the testing of many substances which have penetrating odors. I have used a mixture prepared in the proportion of 1 pint of carbolic acid and 1 quart of pine tar to 3 gallons of kerosene. Application was made with a hand sprayer or atomizer, with the view of testing its effects on the adults of *Tabanus sulcifrons*. It was satisfactorily demonstrated that the mixture has properties as a repellent, but of such short duration that it could hardly receive practical consideration. When specimens were given a direct application they were readily affected and as a first result flew away a short distance and then dropped to the ground.

I have spent much time in an endeavor to work out the life history of this species, but my efforts have not been fully rewarded.

Although the eggs have been procured in many stages of development by dissecting the females, the habits of oviposition have not been observed. The form of the eggs and the number produced by a single female are as in other species of its size. Specimens containing eggs almost fully developed were taken in various places, but I could not get any clue as to where oviposition occurred by dissecting the females where they were collected, as I had hoped to do; therefore all that can be said at this time is, we hope to be able to obtain full information on the life history of the autumn horsefly in the future.

The pupa case (fig. 2, D) of the species was procured by locating a female which had just emerged. The place where this pupa case was taken is on a side hill, about 75 feet above the bed of a small stream. The description follows:

Length 26 mm., diameter 6 mm. Color yellowish brown, the thorax being nearly the same color as the abdomen. Tubercles of the head region well marked and distinctly darker than the surrounding parts. Prothoracic spiracular tubercle brown in color, elevated, narrow, ventral half oblique, dorsal half turned directly forward, thus forming a distinct bend near the middle of the length; rima nearly straight from outer end to the middle and evenly curved for the remainder of its length, inner tip curved backward, thus forming a well-defined hook. First abdominal spiracle nearly round; its rima following the posterior curvature, very narrow, but a little widened above; remaining abdominal spiracles a little smaller than the first one, each with a short, slightly curved or straight rima. Terminal abdominal segment with several small spines near the middle of its length and six larger spines at its apex (fig. 2, C). These spines are all brown in color, with the apex of each approaching black. Six apical spines of nearly the same size; the dorsal pair point upward, outward, and slightly backward, the lateral one on each side outward and backward, while the ventral pair extend almost directly backward. These six spines mark the corners of a hexagon with nearly equal sides, but the ventral pair are a little nearer together than the dorsal pair.

THE BLACK AND WHITE HORSEFLY.

(*Tabanus stygius* Say.)

This horsefly is very common in the vicinity of the Lake Laboratory, at Sandusky, Ohio, where most of my observations on the species were made. The adults appear about the 1st of July each season, and are on the wing for several weeks thereafter. The females were often observed biting cattle and horses, and are known to be important stock pests. The males were often seen in the marshes, on grasses infested by aphides, and it is known that this sex, and occasionally the females also, feed on honeydew which these insects excrete. The species oviposits principally on the leaves of Sagittaria standing in shallow water, habitually placing the eggs just above the point where the petiole meets the expanded part of the leaf (fig. 4). The precision with which this habit is followed becomes a matter of much interest. Out of hundreds of masses of eggs observed, only a very few were placed on other species of plants or in a different position on the leaf (fig. 5). The female (fig. 6) is occupied for a half hour or more in placing the several hundred eggs composing a single mass, and during this time the observer can take a position close by and watch the proceedings without frightening her away, but species of Tabanus are more particular about the approach of intruders than are various Chrysops.

The egg mass (figs. 4, 5) is white when first placed but turns brown shortly; it is very convex, and is composed of about five layers, one above the other. Individual eggs are of nearly the same size as those

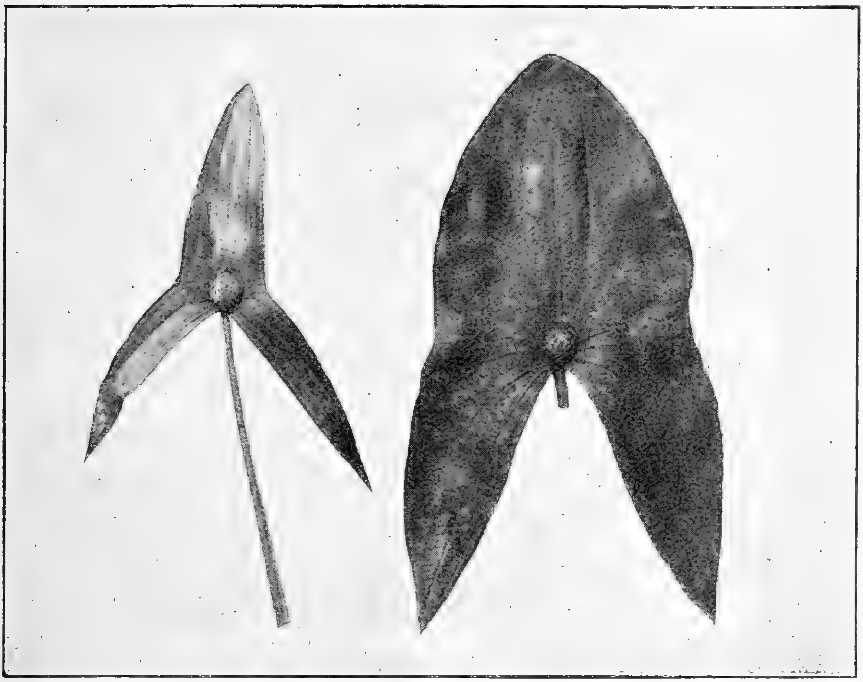


FIG. 4.—Eggs of *Tabanus stygius*, showing the location, with reference to the leaf, in which they are usually found. From a photograph; reduced (original).

of the black horsefly (*Tabanus atratus* Fab.), and are similar to them in form. Hatching, as observed, occurred in seven days after oviposition. From a careful study of microscopic sections of eggs killed as soon as laid it was concluded that development does not begin until after oviposition, consequently the time given is the entire incubation period.

When first hatched the larvæ contain a considerable amount of unused yolk, which furnishes them food for a time; it is therefore unnecessary for them to eat anything for a few days. This is advantageous no doubt, for food is not always just at hand, and in case it is not, the fact that nourishment is furnished naturally gives them an opportunity to investigate their surroundings.

At hatching time nearly all the larvæ that come from a single mass of eggs appear at the same time and when they have freed themselves from the shells go tumbling down into the water, scattering more or less and sinking to the bottom, where it is difficult to observe their further actions.

FIG. 5.—Eggs of *Tabanus stygius*, showing a position in which they are not often found. From a photograph (original).

I proved to my satisfaction that horsefly larvæ are palatable to the small catfish (*Amiurus melas*), although I am not fully informed of how much value the fish is in destroying them under natural conditions. From a large number of these larvæ, hatched July 21, 200 were counted out on the morning of the 23d, and placed in a quart jar of water containing two young fishes slightly more than an inch in length. Before noon of the same day all the larvæ had been devoured. At another time 300 larvæ were put into an aquarium with 12 of the catfish, with the result that the former disappeared within the space of an hour or two.

July 21 a number of larvæ just hatched were placed in a breeding jar containing damp sand covered over the top with fine plant material, and small crustaceans were put in for food. The larvæ took kindly to the surroundings, accepted the food offered, and began to grow from the start. After a couple of weeks, as angleworms were much easier to obtain, these were substituted for the crustaceans, with no bad effects on the larvæ, which continued to grow, though rather slowly. The largest attained a length of about 10 mm. by the beginning of winter, when they ceased eating. They appeared to be in good condition in the spring, but for some reason died without further increase in size.

August 2, of the same year, I took a large larva of this species in Summit County, Ohio, from under a flat stone along a brook that ran from a spring. When taken this specimen measured over 40 mm. in length and had every appearance of being mature, but it continued to eat the angleworms given it until late in the fall. It then ceased feeding until the following spring, when it took a small amount of food and entered the pupal stage about the middle of May, the adult, a male, issuing June 14.

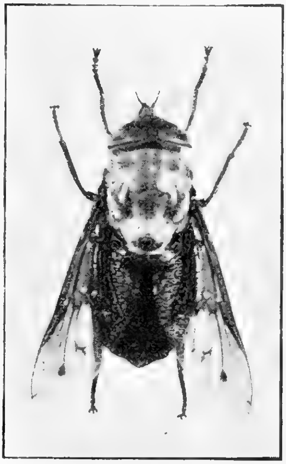


FIG. 6.—Adult female of *Tabanus stygius*. From a photograph; enlarged (original).

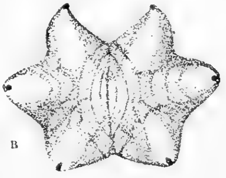
From what I have learned of the life cycle of the species it seems hardly possible that it passes all its transformations in a single year, for the larvæ reared from eggs were not over 8 mm. long when the specimen over 40 mm. long was collected; and as the latter did not produce the adult until about the normal time for adults to appear under natural conditions, it does not seem possible that the first-mentioned larvæ could have reached maturity and produced adults before the second year.

Larva, when first hatched, 4 mm. long; entirely light colored; form as in older specimens. As growth continues size is the only noticeable change.

The mature larva has been figured and described in detail by Hart in his paper, "On The Entomology of the Illinois River and Adjacent Waters."[a]

Pupa (fig. 7, A) 29 mm. long; color dark, approaching fuscous; prothoracic spiracle strongly bent at the middle; rima oblique and straight for the outer half of its length, remainder gradually curved, with a broad hook at the inner end. Teeth at the end of the abdomen (fig. 7, B) six in number, nearly equidistant from one another, of nearly the same size, with the extreme tips slightly turned inward.

A



B

FIG. 7.—*Tabanus stygius*: A, pupa; B, terminal abdominal teeth of same. Enlarged (original).

The pupa of *stygius* is much like that of *sulcifrons*, but there is some difference in the prothoracic spiracles and in the abdominal teeth.

[a] Bul. Ill. State Lab. Nat. Hist., Vol. IV, Art. VI, pp. 239–240, Pl. XI, figs. 47, 48, 1895.

Adult 20 to 22 mm. in length. Third segment of the antenna reddish at the base, blackish at the apex; legs black, the front tibiæ reddish at base; wings yellowish brown, cross veins and furcation of the third vein margined with darker; abdomen uniformly black. Female, thorax plainly white pollinose; male, thorax uniformly grayish brown.

The species is nearly related to *T. nigrescens*, which has the thorax of the female almost uniformly black.

THE RIVER HORSEFLY.

(*Tabanus rivax* Osten Sacken.)

I have never observed this species to be especially common, but it is widely distributed, having been taken in a number of the Eastern

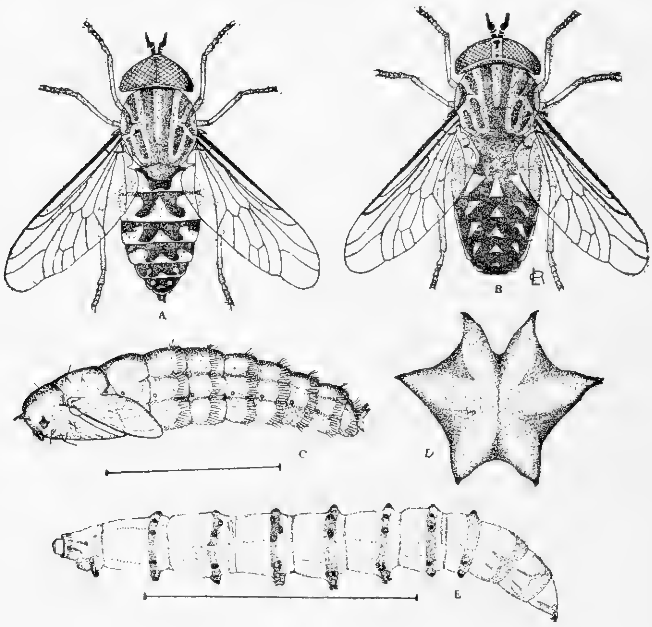


FIG. 8.—*Tabanus rivax:* A, male; B, female; C, pupa; D, terminal abdominal teeth of pupa; E, larva. All enlarged (original).

States. Since specimens are not plentiful they are not often observed around stock, but it is known that they have the same habits in this regard as the other members of the family. The male has been taken fully as often as the female, on protruding stones in swift-flowing streams, and in sunny spots in woods near such streams. The species is on the wing during the last half of June.

Adult (fig. 8, A, B) from 14 to 16 mm. in length, slightly elongate; antennæ black, first segment partially reddish in the female; thorax with five gray stripes separated by black; wings hyaline; legs black in general color, with the basal part of each tibia yellowish; abdomen with a prominent middorsal row of gray triangles and gray spots on each side.

Female: Palpi light yellow; front wider above than below, frontal callosity shining black, almost as wide as the front and with a narrow extension above. Abdomen with three rows of gray spots extending for its whole length; in this sex the gray spots are small but well defined.

Male: Palpi nearly black, much darker than in the female. The general arrangement of colors on the abdomen is the same as in the other sex, but the lateral gray spots are larger.

Eggs are placed on stones that project above the water in riffles of streams. They do not differ in particular from the eggs of other species of the genus, but the masses observed were not so convex as those of the black horsefly, and being placed on stones of a color similar to themselves are rather difficult to see. Females have been observed ovipositing as early as June 8, but most often eggs are deposited after this date.

Larvæ occur in the streams in the fall. In September and October each year we collect the larvæ of the dobson fly (*Corydalis cornuta* L.) for study in the laboratory. Whether we obtain these larvæ by turning stones at the edge of swift riffles, or by means of a net stretched across the riffles to catch such specimens as are dislodged by turning stones behind the net in the stream, we find plenty of the larvæ of this horsefly. I have collected much in streams, but the larva of the river horsefly is the only tabanid larva taken in riffles so far. I have not found it difficult to rear these larvæ, when taken at the season mentioned, by placing them in damp sand and feeding them on angleworms. As winter approaches they refuse to eat and take up a position in the sand and remain quiet until the following spring; then they feed actively for a few days and change to the pupa. Like other tabanid larvæ they are not particular as to their food; all that appears to be necessary is that they obtain small, soft-bodied animals. Crustaceans serve them as well as insects and their own species as well as some other species—whatever, in fact, is in the sand of the breeding cage.

Larva (fig. 8, E), when full grown, about 25 mm. long. General color yellowish white, anterior margin of each thoracic segment and a narrow band, including the prolegs, on the anterior half of the first seven abdominal segments opaque, and appearing darker than the other parts, which are more or less shining and usually finely striate longitudinally. Prothoracic segment divided by longitudinal grooves into four nearly equal parts, which may be called the dorsal, ventral, and lateral areas. The lateral areas are shining and finely striated on the posterior third and opaque on the anterior two-thirds; the dorsal and ventral areas are opaque on about the anterior fourth and distinctly shining on the remaining parts. The ventral space is plainly divided into two equal parts by a longitudinal groove. In order to see the character of this segment, it must be fully extended. The mesothoracic and metathoracic segments have a number of longitudinal grooves, some of which are very narrowly bordered by opaque darker coloring, which proceeds backward from the narrow anterior border of these segments. Each of the first seven abdominal segments has on its anterior part a transverse row of eight tubercles which encircle the segment. These all bear short spines or claws at the apex, excepting a dorsal pair on each of the first three or four segments. They may be called prolegs, since they have the parts necessary to such organs and, what is more, are used as prolegs. On the posterior dorsal border of most of the abdominal segments there may be a narrow, irregular, opaque marking of the same color of the narrow band in the region of the prolegs; eighth segment on each side with two narrow, curved markings which have the appearance of being composed of contiguous punctures. These markings are of the same shade of color as the other darker areas, and the lower one is more than twice as long as the upper.

Pupa (fig. 8, C) 18 mm. long and 4 mm. in diameter. Light brown in color, thorax somewhat paler than the abdomen. Antennal and other tubercles of the head and thorax prominent and darker than the surrounding parts. Prothoracic spiracular tubercle slightly elevated, reniform, oblique; rima uniformly curved for nearly its whole length; but just before the anterior end the curvature is stronger, although no hook is formed. First abdominal spiracle nearly round; rima almost uniformly curved, posteriorly very slightly widened just at the end, anteriorly slightly narrowed and curved so as to form a short hook. The other abdominal spiracles agree with the first one in general, but there is slight variation in the enlargement and curvature of the extreme ends. Terminal teeth (fig. 8, D) prominent, shining brown in color, darkest at the extreme tips. Dorsal pair of teeth smallest and closer together than the ventral, lateral teeth longer and larger than the ventral and located much beneath the dorsal, in fact they are nearly midway between the dorsal and ventral.

THE BLACK HORSEFLY.

(*Tabanus atratus* Fabricius.)

The eggs of this horsefly—male and female adults of which are shown in figure 9—are placed in masses of various sizes on the leaves and stems of grasses and sedges and other plants growing in marshy or wet ground, but not necessarily in the water. A single mass may contain as many as 500 eggs, but often they are smaller and they may be larger; they are white when first placed, but soon turn brownish. The mass is very convex and composed of several layers, one above the other, the bottom layer being attached to the surface of the leaf or stem and the other layers each to the one that was placed before it. Each egg is elongate spindle shaped, between 2 and 3 mm. in length and narrowed at each end. A female was observed ovipositing June 23 at 11 o'clock. The eggs were taken and kept in a room out of the sun, where they hatched on the morning of July 2 before 6 o'clock, thus requiring an incubation period of nearly nine full days. It has been proven that the eggs of tabanids hatch more quickly when exposed to the sun during the day, as where they are usually deposited; therefore, the time given is probably too long for eggs under natural conditions.

There is no definite way, so far as observed, of telling the eggs of the black horsefly from those of other species of its genus, but being a large species the masses are much larger than in some others, and are more convex than usual. The particular place of oviposition is in a measure characteristic.

Larvæ, when first hatched, are about 3 mm. in length, white, and with a narrow darker shade at the union of each two segments. As soon as they drop to the ground they begin to burrow and are soon beneath the surface, where they can not be seen. At first these larvæ are very hard to see on account of their small size; consequently not much has been learned of their habits under natural conditions; but when nearly grown they are to be found in a variety of places. Walsh was the first to make reference in writing to this species in the larval stage. He found specimens in floating débris and rotten logs and on one occasion under a log on dry land. I have taken them while digging in the ground in the vicinity of ponds, from under stones on ditch banks, from the water with dip nets, and occasionally in most unexpected places. However, if one is looking for them he is likely to meet with more or less disappointment, as the finding of one specimen does not indicate necessarily that others may be taken under the same conditions.

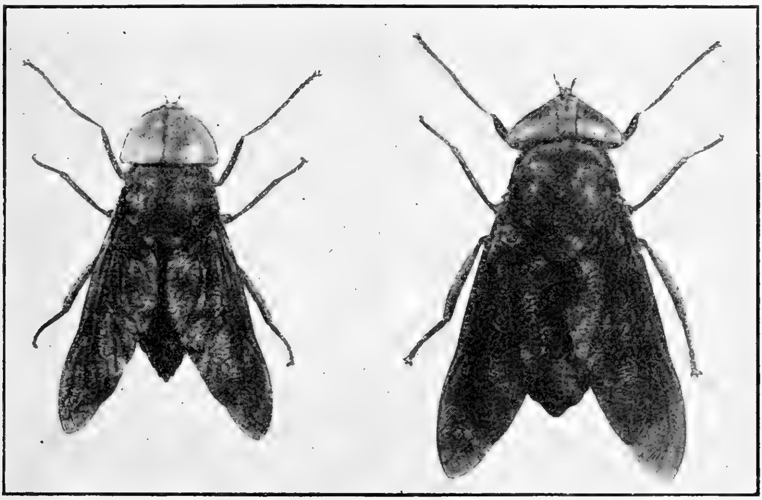


FIG. 9.—*Tabanus atratus:* Adult male at left, female at right. From a photograph; enlarged (original).

The fact that specimens have been taken from floating logs and débris suggests that they may be transported for longer or shorter distances in this way, and during high water stranded upon ground which, when the flood subsides, is high and dry and far removed from the bed of the stream. Since the species in all its habits is closely associated with water and wet ground, this seems to be the only way of explaining the appearance of larvæ in dry soil and in places remote from where the eggs are laid.

Full-grown larva nearly 2 inches in length. General color yellowish white, with wide dark brown bands at the union of each two segments. Prothoracic segment on each side with two lateral grooves, which do not quite reach the posterior border of the segment, and a dorsal groove continued for the entire length. These grooves and a number of irregular dots on the posterior part are dark colored, while the remainder of the segment is light. Mesothoracic segment, on each side, with four longitudinal grooves, which reach nearly the entire length. The dark markings on this segment include a narrow anterior border, the lateral grooves, and a number of irregular dots near the posterior margin. The metathoracic segment is like the last, except that the dark color on the anterior margin is wider and the posterior, instead of being dotted, is uniformly brown. The abdominal segments are each similar to the metathoracic, but the dark markings in the region of the lateral grooves are more or less abbreviated. Last abdominal segment with two pairs of dark markings; the ventral pair extend the whole length of the segment and are connected just behind the anal prominence by a cross-band; the dorsal pair are oblong, somewhat irregular in outline, and extend from the anterior margin to beyond the middle of the length. At the anterior ventral border of each of the first seven abdominal segments is a transverse series of prolegs, three on either side of the midventral line. These prolegs are located within the dark transverse bands, but are lighter in color than these and prominent enough to be seen easily. Above the prolegs on either side of the middorsal line is a small swelling which appears as a rudimentary proleg; before the two is a distinct transverse light spot still within the dark area.

The head of the larva is very small for so large an insect and the mouth parts are minute. The mandibles consist of two strongly chitinized pieces, and work by being pushed endwise backward and forward. When drawn in, the anterior ends point directly forward, but when protruded, these same ends point downward and backward, thus forming a pair of hooks by means of which the prey is held. The larva is able to protrude its mandibles very quickly and to use them very effectively on soft-bodied invertebrates on which it is known to feed.

Pupa (fig. 10, B) about $1\frac{1}{4}$ inches in length. Color brownish yellow. Antennal and other tubercles of the head darker than the surrounding parts. Prothoracic spiracle

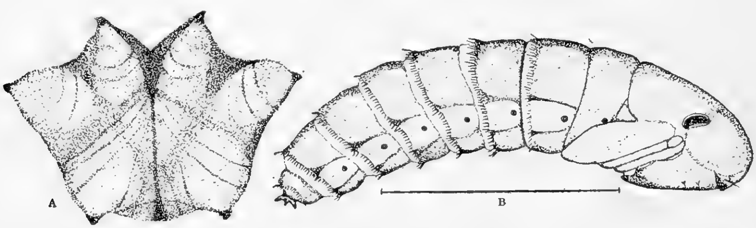


FIG. 10.—*Tabanus atratus:* B, pupa; A, terminal abdominal teeth of same. Enlarged (original).

slightly elevated, clear brown in color, reniform and oblique, rima gradually curved to near the dorsal end, where a distinct hook is formed by a sharp bend. Abdominal spiracles nearly round; rima of the first short and gradually curved and with a slight hook at the dorsal end. Terminal teeth (fig. 10, A) arranged in pairs, a ventral pair and a pair on each side formed by a dorsal and a lateral tooth. The distances between these teeth is variable; the two dorsal are nearest together, then follows the distance between a dorsal and a lateral, the distance between the two ventral, while the distance between a ventral and a lateral on each side is greatest of any.

THE MARSH EARFLY.

(*Chrysops mœrens* Walker.)

The marsh earfly is a common species in the marshes near the Lake Laboratory, at Sandusky, Ohio. The adults appear each year during the latter part of June and are abundant by the 10th of July. They continue to be common all through the latter month and August, and a few are to be found in September. Eggs were first observed during the first days of July and were present in varying numbers during the following two months.

During the time the female is ovipositing she is not easily disturbed;

consequently one has an excellent opportunity to watch the procedure. The accompanying illustration (fig. 11) was made from a photograph of a living specimen which was found in the act of egg-laying and carried, with the leaf, to the laboratory where the picture was taken. During the whole time she continued ovipositing without showing any signs that she was aware of what was going on or that she had any concern for the welfare of her eggs.

The method of placing the eggs is similar to that recorded for *C. callidus* in my paper on "The Tabanidæ of Ohio,"[a] pages 4 and 5. The female alights on the leaf with her head downward and begins the process by pushing the tip of her abdomen forward toward the under part of the thorax and placing the protruding end of an egg against the leaf. The end sticks fast in consequence of the glue-like substance which accompanies it, and she then moves the tip of her abdomen back to its normal position, thus freeing the egg. By similar movements one or two eggs are placed to one side of the first, and two or three to the other side of it. The unfinished end soon becomes V-shaped; she moves slowly forward and lifts the tip of her abdomen to one arm of the V and places eggs along down until the apex is reached; then changes to the other arm of the V and places eggs along down to the apex on this side. It was noted in specimens of this species observed that sometimes a female would place as many as three rows of eggs on one side, one after the other, before changing to the opposite side. It is only necessary to study a mass of these eggs in order to see the precision, in reference to one another, with which the different specimens are arranged.

FIG. 11.—*Chrysops mœrens* ovipositing. From a living specimen (original).

The eggs (fig. 12) are placed on various aquatic plants, oftentimes standing in rather deep water and at times as much as 20 rods from shore. I have always found them on scattering plants around the edges of grassy areas and not back among the dense growth; consequently they are easily seen, not only on account of conspicuous location, but also because of their shining black color, which contrasts strongly with the green leaves to which they are attached.

It has occurred to me that, on account of the uniform methods of placing the eggs followed by various species and the strong contrast of these eggs with their surroundings, there are times when hand

[a] Ohio State Academy of Science, Special Papers, No. 5, May 1, 1903.

picking might be of consequence, although I realize that in most cases such procedure would not be practicable. In order to demonstrate what could be done in the way of gathering eggs of this species, on the morning of July 17 I went out in a small rowboat and collected for an hour. At the end of this time a count showed 433 masses, and an average of 250 specimens to each mass—a result obtained by counting several and striking the average—gives a total of 108,250 single eggs taken as a result of the hour's work.

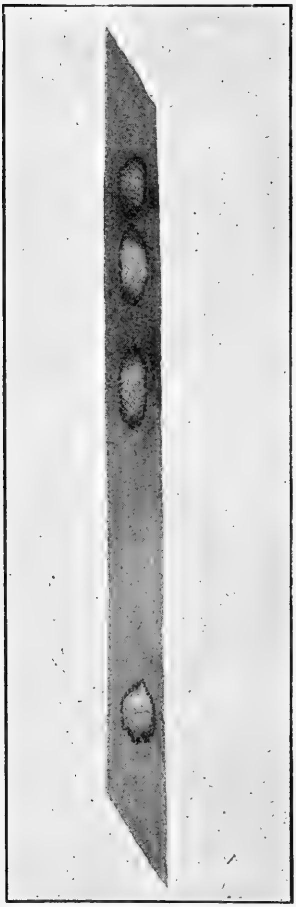


FIG. 12.—Eggs of *Chrysops mœrens*: Four masses on short section of leaf of Spharganium. From a photograph (original).

Eggs laid from 8.45 to 9.30 o'clock on the morning of July 13 hatched before noon of July 19, thus making the incubation period six days in length. This is the shortest incubation period I have observed for any of the species of the family.

In a previous paper I suggested that kerosene might be of consequence if used on the surface of stagnant water over which eggs are in place, in order that the larvæ when they hatch and drop to the water must pass through a film of the oil. Data on this point are very difficult to obtain in the natural breeding grounds of the flies, for it is almost impossible to find the very small larvæ after they have dropped from the eggs and have become more or less scattered among the débris which is usually plentiful in these places. I undertook to test the matter by the use of a tank of water on the surface of which kerosene was placed at the rate of half a pint to each square yard of surface. Spharganium leaves to which eggs were attached were brought in from the marsh and put into a bottle, as one would arrange a bouquet, and this placed on the bottom of the tank so that the parts of the leaves to which the eggs were attached were a foot or more above the surface of the water which contained the layer of kerosene. Even under these conditions an exact count could not be obtained, because the kerosene appeared to affect different specimens differently. Some were killed very quickly, some died after an hour or more, while others did not appear to suffer particular inconvenience from the treatment. Further observation is necessary in order to be able to give conclusive statements regarding the matter.

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TECHNICAL SERIES, No. 12, PART III.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE THYSANOPTERA OF CALIFORNIA.

By DUDLEY MOULTON,

Engaged in Deciduous-Fruit Insect Investigations.

ISSUED APRIL 5, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., February 5, 1907.

Sir: I have the honor to transmit herewith the manuscript of a paper by Mr. Dudley Moulton, special agent in this Bureau, entitled "A Contribution to our Knowledge of the Thysanoptera of California." This paper embodies the results of some work carried on by Mr. Moulton while a student at the Leland Stanford Junior University, Palo Alto, Cal., and forms part of a thesis for the degree of Master of Arts in the Department of Entomology at that institution. It contains keys and descriptions for the identification of the various species of thrips found to occur in California. The group of insects treated is one of economic importance, containing, as it does, species which are injurious to various field crops, fruit trees, and ornamental plants. I recommend the publication of the paper as Technical Series. No. 12, Part III, of this Bureau.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The systematic treatment of the Thysanoptera of California, which is presented in this paper, is the direct outgrowth of an investigation of the pear thrips (*Euthrips pyri* Daniel) which was undertaken in the Santa Clara Valley of California during the period from January, 1905, to April, 1906. This insect has become a serious fruit-tree pest in the deciduous-fruit sections around the San Francisco Bay. An important phase of the investigation was to learn the insect's distribution and the number of its food plants, both wild and cultivated. In looking for *Euthrips pyri* on various plants, naturally many other species of thrips were found, and much of interest learned regarding the life habits of several of them. It is the object of this paper to bring together these various observations and also the results of the more technical part of the work, leaving the economic treatment of the pear thrips for a separate paper.

The investigation of the pear-thrips problem in the Santa Clara Valley, as also the collecting of specimens described herein, was made possible by the very liberal attitude of the Santa Clara County board of supervisors, who granted everything necessary for a thorough and scientific study. The very careful and efficient work of the writer's two assistants, Mr. Earl L. Morris and Mr. C. T. Paine, must also be acknowledged. To Prof. Vernon L. Kellogg, professor of entomology in the Leland Stanford Junior University, the writer wishes to express his gratitude for encouragement, helpful suggestions, and friendly criticism.

D. M.

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MISCELLANEOUS PAPERS.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE THYSANOPTERA OF CALIFORNIA.

By Dudley Moulton, *Special Agent.*

INTRODUCTION.

Upon undertaking a study of the life history of the pear thrips (*Euthrips pyri*), and incidentally of other thrips as they came to notice, the writer was impressed by the great deficiency in our knowledge of these insects. In California it seemed, indeed, that new species could be collected on almost every side, and when trying to classify these specimens it was found that the individuals possessed most of the characteristics which would place them readily in any certain genus, but that there would often be found striking though minor differences. In several cases it has been necessary to extend the original generic descriptions to include California forms.

In a short published account of California thrips,[a] Miss Daniel states that previous to that time (1904) four species of thrips were known to exist in California. To this number her paper would add five. The writer finds, however, that one of her species, *Caliothrips woodworthi*, is the already described *Heliothrips fasciatus* of Pergande. Thus only eight were known previous to 1906. The writer has been able to gather abundant specimens of all of these thrips and now adds sixteen more new species and two varieties, making a total of twenty-six. It has been necessary to erect a new genus to include the species *Orothrips kelloggii*. The genus *Megalothrips*, represented by *Megalothrips hesperus*, has not before been recorded as found in America.

Economically considered, the thrips constitute an important group in California, because of the ravages of several species. Growers of deciduous and citrus fruits and of garden truck and nurserymen and florists have suffered at times very considerably, but not until

[a] New California Thysanoptera. By S. M. Daniel. Ent. News, Vol. XV, No. 9, pp. 293–297, November, 1904.

the conditions in the Santa Clara Valley became so grave that something had to be done was any very serious study given to these insects.

Orange growers in southern California were made very apprehensive a few years ago by the appearance of small brown spots on their oranges, caused by the feeding of the grass thrips (*Euthrips tritici* Fitch). The injury was, however, superficial, as a spot only was produced on the orange peel, the quality of the fruit being in no way injured nor its qualities of keeping affected. Yet because of the spots many of the best oranges had to be passed out as culls. This same thrips has been reported injuring alfalfa by its feeding within the blossoms. The damage was hardly noticed when the alfalfa was cut for hay, but for seed purposes the crop was an almost absolute failure. The grass thrips is everywhere present in wild and cultivated flowers and in blossoms of most of the indigenous trees. The writer has often been able to collect hundreds of specimens of this thrips with a single sweep of the net from the blossoms of the California sage (*Artemisia californica*), and from the manzanitas, especially *Arctostaphylos tomentosa*. This thrips is perhaps seen most commonly in our garden flowers—roses, lilacs, etc.—and does little or no apparent injury. Often, however, one finds ill-shaped and partly dead outer petals of rose buds or even full-blown roses. This injury, when not caused by mildew, can be quite easily traced to the grass thrips, which feeds in the tip of the bud on the outer end of the petals, just before or while the petals are spreading. This injury is common, but as roses unfold rapidly, the larger, inner petals are not injured, and the outer, smaller, imperfect ones may be picked off and the rose left apparently perfect. This species is perhaps the most widespread of all the thrips. Only at intervals does its injury render it a pest. Its appearance is very like that of the pear thrips (*Euthrips pyri*), and to the casual observer either species could easily be mistaken for the other.

The feeding injuries of *Heliothrips hæmorrhoidalis* are limited largely to azaleas, cherry laurel, and laurestina, and to greenhouse and other ornamental shrubs. The writer has found in greenhouses azalea plants which have been completely killed by these insects. Affected laurestina plants produce contorted, ragged, and pale leaves.

The injury of *Trichothrips ilex* on the Christmas berry (*Heteromeles arbutifolia* is noticeable wherever that plant grows. This insect has been found only on the one plant, and it is interesting to note that the plant is indigenous only to limited areas in the Coast Range region near San Francisco Bay. The Christmas berry is one of the showiest of California shrubs when, from November to January, it displays its fine clusters of crimson berries. When the plants are badly infested with thrips the leaves are deformed and ragged and the weakened blossoms produce small and imperfect berries. The berries have no special value commercially, but in their perfect state are used extensively for Christmas decorations.

The onion thrips (*Thrips tabaci* Lind.) finds an almost ideal habitat in the extensive onion-seed farms in California, and its injury to this plant in some sections and during some years is almost prohibitive of onion growing.

Especially to be mentioned, however, is the injury caused by the pear thrips (*Euthrips pyri* Daniel). This is strictly a fruit-tree pest, attacking as it does nearly all varieties of deciduous fruits. No other thrips is recorded as having done so much damage as has this one, and the problem for its control is a difficult one to solve. The writer's experience has been that, outside of purely cultural methods, we have no effective artificial means for checking it. Its natural insect enemies are few, and from the very nature of the pest's life habits it can not be controlled effectively by those beneficial forms which are already present. A parasitic fungus has for the time being proved a quite effective check, but the weather conditions, moist and warm for two years past (during 1905 and 1906), have been almost ideal for the growth of such fungi, and it is extremely doubtful if this check would prove at all effective under other conditions. The pear thrips is limited in its distribution to the deciduous-fruit areas around San Francisco Bay.

It is interesting to note the relations of some of the California thrips to their food plants. *Orothrips kelloggii* is found only in blossoms of manzanita and madroña—both trees peculiarly Californian—whose cup-shaped blossoms afford an ideal home for this striking thrips. *Æolothrips kuwanaii* is common only in the wild California lilac. *Trichothrips ilex* is peculiar to the Christmas berry, and has thus far been collected from no other plant. *Euthrips pyri* is limited in its feeding to cultivated fruits. *Cryptothrips californicus* is most often found under the old shells of the brown apricot scale (*Lecanium armeniacum*) and the black scale (*Saissetia oleæ*). It has been taken from these places mostly during the winter, and it may be that it is under the old shells only for protection, but the writer suspects that it may be a scavenger.

In preparing this paper the writer has introduced descriptions of genera only when it has been necessary to extend the characters to include California species. For other generic descriptions the reader is referred to Hinds's monograph of the North American forms.[a]

The already recognized characters of ovipositor, wings, antennæ, and mouth appendages are the principal ones here used in the keys for classifying the species. In describing new thrips the writer has made

[a] Contribution to a Monograph of the Insects of the Order Thysanoptera Inhabiting North America. By Warren Elmer Hinds. Proc. U. S. Nat. Mus., Vol. XXVI, No. 1310, pp. 79–242, Pls. I–XI, December 20, 1902.

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the customary measurements, and, in addition, has reduced the lengths of antennal segments to microns. In most other respects the plan adopted by Hinds has been followed. The writer has redescribed the three species of Miss Daniel (*Cryptothrips californicus*, *Euthrips pyri*, and *Sericothrips apteris*) to make their descriptions conform with the others.

CLASSIFICATION OF CALIFORNIA THYSANOPTERA.

KEY TO THE SUBORDERS AND FAMILIES.

I. Female with a saw-like ovipositor. Terminal abdominal segment of female conical, of male usually broadly rounded. Wings usually present; fore pair strongest, with more or less well-developed veins; double fringed behind. Membrane of wings with microscopic hairs.......Suborder TEREBRANTIA.

A. Antennæ with nine segments. Fore wings broad and rounded, with prominent ring vein and cross veins. Ovipositor upcurved................................(A) Family ÆOLOTHRIPIDÆ.

B. Antennæ with six to eight (nine?) segments. Wings present or absent; when present usually narrow and pointed at tips. Ovipositor downcurved.......................(B) Family THRIPIDÆ.

II. Female without ovipositor. Terminal abdominal segment tubular in both sexes. Wings usually present, both pairs similar; front pair with only a rudimentary, median, longitudinal vein; wings with simple fringe on both margins except fore wing, which is double fringed on posterior edge near tip by a few hairs; membrane of wings without microscopic hairs. Antennæ eight-segmented..........................Suborder TUBULIFERA.

(C) Family PHLŒOTHRIPIDÆ.

KEY TO THE GENERA.

(A) Family ÆOLOTHRIPIDÆ.

1. All segments of antennæ freely movable and diminishing in size gradually at tip. Maxillary palpi seven-segmented, labial palpi four-segmented.....................................(1) *Orothrips*, new genus.
2. Last four segments of antennæ closely united and together shorter than the fifth. Maxillary palpi three-segmented, labial palpi four-segmented.

(2) *Æolothrips* Haliday.

3. *Caliothrips* Daniel.[a]

(B) Family THRIPIDÆ.

1. Antennæ with eight segments (nine?).

a. Wings wanting; prothorax almost as large as pterthorax; body with or without reticulated structure.........(3) Genus *Sericothrips* Haliday.

a′. Wings fully developed.

b. Body with markedly reticulate surface; last segment of antenna drawn out and very much longer than the seventh.

(4) Genus *Heliothrips* Haliday.

b′. Body without reticulate structure; eighth antennal segment only a little longer than the seventh.

(5) Genus *Euthrips* Targione-Tozzetti.

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[a] *Caliothrips woodworthi*, new genus and species, was described in Entomological News for November, 1904 (Vol. XV, No. 9, pp. 296–297). The writer of the present paper has been unable to see the type specimen, but from the description believes that it will prove to be none other than the male of *Heliothrips fasciatus* Pergande, or a closely related species.

(B) Family Thripidæ—Continued.

2. Antennæ with seven segments.

a. Fore wings broad, reticulated and without front fringe. (6) Genus *Parthenothrips* Uzel.

a′. Fore wings narrowed near tip; fringe present on anterior margin. (7) Genus *Thrips* Linnæus.

(C) Family Phlœothripidæ.

1. Head about as long as broad ....(8) Genus *Trichothrips* Uzel.

2. Head markedly longer than broad.

a. Fore femora armed with tooth at tip....(9) Genus *Acanthothrips* Uzel.

a′. Fore femora without such tooth.

b. Head more than twice as long as wide; males with prominent clasping organs projecting from the side of sixth segment; very large thrips......................(10) Genus *Megalothrips* Uzel.

b′. Head about one and one-half times as long as wide; males without such clasping organs..............(11) Genus *Cryptothrips* Uzel.

KEY TO THE SPECIES.

1. Genus *Orothrips*, new genus.
Represented by one species ....(1) *O. kelloggii*, new species.

2. Genus *Æolothrips* Haliday.
Represented by one species and a variety..........(2) *A. kuwanaii*, new species.
(3) *A. kuwanaii robustus*, new variety.

3. Genus *Sericothrips* Haliday.

a. Body very dark brown, nearly black; pterthorax yellow; legs brown. (4) *S. apteris* Daniel.

b. Body uniform brown; surface of body strongly reticulated; legs yellow. (5) *S. reticulatus*, new species.

c. Body and legs uniform brown; four stout spines on the dorsal side of segment 9 ....(6) *S. stanfordii*, new species.

4. Genus *Heliothrips* Haliday.

a. All legs yellow; antennæ twice as long as head; wings slender, with one distinct longitudinal vein in center; small darkened area near base. Food plants are azaleas, laurestinas, dahlias, etc. (7) *H. hæmorrhoidalis* Bouché.

b. Legs brown, with tips of femora, both ends of tibiæ, and tarsi light-brown to yellow; antennæ one and one-half times as long as head; wings gray-brown with two transparent-white cross-bands, one at base and one at three-fourths the wings' length; two longitudinal veins, the second branching from the first near the broadened base of the wing, the first uniting with the costa to form the fore part of a strong ring vein. (8) *H. fasciatus* Pergande.

5. Genus *Euthrips* Targioni-Tozzetti.

a. Without prominent spines on fore angles of prothorax; longitudinal veins not regularly set with spines.

b. Head noticeably wider than long; sense cones on segments of antennæ very long and slender; general color of body light lemon-yellow. (9) *E. orchidii*, new species.

b′. Head about as wide as long; general color of body brown.

c. Basal segment of antenna concolorous with head and with segment 2; postocular spines wanting; two spines on posterior part of thorax dividing the hind margin into equal portions; about sixteen spines on hind vein of fore wing; general color brown to dark brown ....(10) *E. pyri* Daniel.

5. Genus *Euthrips* Targioni-Tozzetti—Continued.

c′. First segment of antenna of a lighter color than head and lighter than segment 2; postocular spines present and of medium length; three small spines bordering hind margin of prothorax on either side; posterior vein of wing with about twelve spines.
(11) *E. ehrhornii*, new species.

a′. With spines on fore angles of prothorax; longitudinal veins set regularly with spines.

b. Fore tibia armed at end with tooth..(12) *E. ulicis californicus*, new species.

b′. Fore tibia without such tooth.

c. General color of body brown to dark brown; individuals small, total length less than 1 mm.; with several quite long spines but with no short ones along posterior margin of prothorax.
(13) *E. minutus*, new species.

c′. General color of body yellow to brown; with a circlet of several large and several small spines bordering posterior margin of prothorax.

d. Fifth antennal segment about five-sixths as long as 4.
[a](14) *E. occidentalis* Pergande.

d′. Fifth antennal segment about two-thirds as long as 4.
[a](15) *E. tritici* Fitch.

6. Genus *Parthenothrips* Uzel.

Represented by one species .... (16) *P. dracænæ* Heeger.

7. Genus *Thrips* Linnæus.

a. Head noticeably wider than long.

b. Body color dark brown, thorax and other parts often orange tinted, inner crescents bordering ocelli orange-red; wings light brown with lighter colored area near base; body length about 1.25 mm.
(17) *T. madronii*, new species.

b′. Body color light yellow to light brown, inner crescents of ocelli light brown; wings uniform light colored; body length about 1 mm.
(18) *T. tabaci* Lindeman.

a′. Head as long or longer than wide; body long and slender; color almost transparent, sometimes shaded light brown.
(19) *T. bremnerii*, new species.

8. Genus *Trichothrips* Uzel.

a. Postocular spines wanting; all prominent spines on thorax and abdomen with blunt tips; antennæ about two and one-half times as long as head; each fore tarsus armed with a large tooth.
(20) *T. dens*, new species.

a′. Postocular spines prominent; body spines normal; antennæ not over twice as long as head; each fore tarsus armed with a small tooth.

b. Sides of head almost straight; fore femora of males greatly enlarged; fore tibiæ and tarsi and segments 3 to 6 of antennæ yellow.
(21) *T. femoralis*, new species.

b′. Sides of head slightly arched; fore femora of males not more than twice as broad as tibiæ; all tarsi and segment 3 of antennæ yellow.
(22) *T. ilex*, new species.

b″. All tarsi gray-brown and only base of segment 3 of antennæ yellow.
(23) *T. ilex dumosa*, new variety.

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[a] Many specimens of these two species have been examined and the variations in size, color, and relative lengths of antennal segments are so great that no sharp dividing line between the two species can be drawn.

9. Genus *Acanthothrips* Reuter.
   Represented by a single species ....(24) *A. doaneii*, new species.
10. Genus *Megalothrips* Uzel.
   Represented by a single species....................(25) *M. hesperus*, new species.
11. Genus *Cryptothrips* Uzel.
   Represented by a single species ....(26) *C. californicus* Daniel.

Family ÆOLOTHRIPIDÆ.[a]

The antennæ are nine-segmented. Ocelli are present in both sexes. The maxillary palpi are three to seven segmented; labial palpi are four or five segmented (sometimes two segmented in European forms). The wings are large, broad, and rounded at the outer ends. Each fore wing has a heavy ring vein and two longitudinal veins extending from base to near tip; each fore wing has from three to five cross-veins; the fore wings are without a fringe on the front margin. Both sexes bear a peculiar thumb and fore-finger-like hook on the outer side of the second segment of each fore tarsus. The ovipositor of the female is upturned. Males have the first abdominal segment much longer than the second. The members of this family have very long legs.

1. Genus OROTHRIPS, new genus.

Head wider than long. Ocelli present in both sexes. Antennæ nine-segmented, all sutures freely movable; third and fourth about equal in length. Maxillary palpi geniculate, seven-segmented; labial palpi five-segmented. Prothorax about one-third wider than long, its hind margin bordered with several quite strong spines on either side. Legs long and slender; fore femora thickened in both sexes; all tibiæ armed. Second fore tarsal segment in both sexes with hook-like appendage. Wings present in both sexes, broader in distal third, narrower near base. Anterior part of ring vein and two longitudinal veins thickly set with stout spines. Fore wing with two broad, darkened cross-bands near center and tip respectively, also darkened area near base.

(1) **Orothrips kelloggii**, new species. (Pl. I, figs. 1–4.)

Measurements: Head, length 0.16 mm., width 0.22 mm.; prothorax, length 0.16 mm., width 0.28 mm.; mesothorax, width 0.43 mm.; abdomen, width 0.41 to 0.50 mm.; total body, length 1.80 mm. Antennæ: 1, 36μ; 2, 54μ; 3, 114μ; 4, 108μ; 5, 60μ; 6, 45μ; 7, 42μ; 8, 24μ; 9, 33μ; total, 0.51 mm. General *color* dark brown, sometimes light brown, prothorax and abdomen shaded with orange.

Head about one-fifth wider than long and about as long as and retracted into prothorax; cheeks strongly arched; back of head transversely striated and clothed with small spines, a single pair posterior to ocelli, largest. *Eyes* large, black, with light posterior margin,

[a] It has been necessary to extend the characters of the family Æolothripidæ as given by both Uzel and Hinds in order to include California forms.

pilose, with large prominent facets. *Ocelli* orange colored, granulated, separated, and margined inwardly with dark orange-brown crescents; posterior ocelli approximate to but not bordering inner margin of eyes. *Mouth-cone* short, reaching about halfway across the prothorax, maxillary palpi geniculate, seven-segmented, first segment very large and almost as long as the other six; labial palpi five-segmented. *Antennæ* nine-segmented, uniform dark brown except tip of segment 2, which is light brown, and base of 3, which is yellow; all segments quite uniformly clothed with short dark hairs; segments 3 and 4 each with two elongated, light-colored, membranous sense areas on outer side, one dorsal and one ventral; segments 5 and 6 each with a simple sense cone on under side near tip.

Prothorax about one-third wider than long, constricted in the center of sides, very faintly cross-striated, uniformly covered with numerous spines; circle of twelve quite stout spines on posterior margin. *Mesonotum* striate-reticulate; with several stout spines, two on each side, two near center, and two on posterior margin. Mesothorax largest, quite smoothly and evenly rounded at union with metathorax; sides converge gradually toward the posterior. *Legs* unicolorous with body, except trochanters, tips of fore tibiæ, and fore tarsi, which shade to yellow; fore coxæ and femora thickened, other legs long and slender, legs thickly covered with short spines; fore tarsi each with thumb and forefinger-like hook; all tibiæ armed with spines near tip, hind tibiæ with several and a double row on inner side. Fore *wings* broadest near tip, narrower near base; anterior margin broadly rounded at tip, posterior margin nearly straight outward from scale; fore wings with a ring vein, two longitudinal and five cross veins; longitudinal veins and anterior part of ring vein thickly and regularly set with short spines. These spines are dark except on inner light area, where they are white. Fore *wings* without anterior fringe and with hairs on the posterior margin which do not average as long as the width of the wing; wings clear white with three darkened areas, one at base, one at tip, and a large irregular area near center. All cross veins are included in or margin on this central darkened area. Scales at base long and slender, each bears seven spines. Hind wings clear white and without veins; margined in front with short and behind with long simple fringe.

Abdomen ovate, or strongly spindle-shaped when distended; fourth and fifth segments largest, tapering gradually from fifth to the tip; segments 1 to 7 with a few short inconspicuous hairs on prominent angles; segment 8 with a single pair of stout spines; segment 9 with three long and several short pairs.

Males are similar, but with long, slender bodies.

Described from nine females and six males.

Food plants: Manzanita and madroña blossoms.

Habitat: Santa Clara Valley, California.

2. Genus ÆOLOTHRIPS Haliday.[a]

Head about as broad as long. Ocelli present in both sexes. Antennæ nine-segmented, the last four segments closely joined and together shorter than the one preceding; the third segment longest. Maxillary palpi three-segmented and geniculate. Prothorax about as long or a little longer than the head, without large bristles. Legs very long and slender; fore femora somewhat thickened in both sexes; fore tibiæ usually unarmed, although sometimes armed; second fore tarsal segment in both sexes with hooklike appendage. Wings usually present in both sexes; fore wing somewhat narrowed before the middle; fore part of ring vein furnished with very short hairs, which hardly overreach the edge of the wing and which increase in length toward the tip. Fore wings white, with dark cross or longitudinal bands. First abdominal segment in the males is much longer than the second, and the ninth is drawn out at the hind angles into short clasping organs or hooks.

(2) **Æolothrips kuwanaii**, new species. (Pl. I, figs. 5–8.)

Measurements: Head, length 0.13 mm. (varying to 0.16 mm.), width 0.17 mm. (to 0.18 mm.); prothorax, length 0.16 mm., width 0.20 mm.; mesothorax, width 0.30 mm.; total body, length 1.66 mm. Antennæ: 1, 36μ; 2, 51μ; 3, 84μ; 4, 81μ; 5, 69μ; 6, 7, 8, and 9, 51μ; total, 0.37 mm. *Color* of insect brown—sometimes dark brown—with conspicuous red pigment blotches, this red showing especially vivid through the membranous parts between the segments.

Head about as wide or only a little wider than long, rounded in front and only slightly elevated between basal segments of antennæ; cheeks arched; back of head faintly cross-striate with one especially prominent line near posterior margin; with several not prominent spines. *Eyes* prominent, black; with large facets, pilose. *Ocelli* present, placed well forward on anterior part of head, posterior ocelli contiguous with inner margin of eyes, orange-yellow and margined inwardly with deep orange crescents. *Mouth-cone* long, reaching to posterior margin of prothorax, pointed bluntly; maxillary palpi three-segmented, basal segment large, terminal one very small. *Antennæ* nine-segmented, two and one-half times as long as head; brown, unicolorous with body except segment 3, which is lemon-yellow shaded light-brown at tip; all segments except basal one thickly and uniformly clothed with short spines, those on tip of 2 are stoutest, spines on segments 1, 2, 4, and 5 are brown, those on 3 and style are white; sense area on 3 long and slender, on 4 a similar larger area; a simple sense cone on lower side of segment 6 near tip.

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[a] Genus modified to include California forms. *Æolothrips kuwanaii* differs only in minor details from the *Æolothrips* of other writers, so that it seems best to extend this genus rather than to create a new one.

Prothorax a little wider than long, and only slightly larger than head, with an emargination and thickening of the wall near center of each side; clothed with numerous small spines. *Mesothorax* largest; *metathorax* with sides almost straight and parallel except near posterior edge, where they turn abruptly inward. *Legs* dark brown, fore femora thickened, fore and second tibiæ armed at tip with two strong spines, last tibiæ with several spines at tip, and with two rows of smaller ones on inner side; each fore tarsus armed with a stout hook and tooth; all legs thickly set with small spines. Fore *wings* broadly rounded at tips, with two longitudinal veins which unite with ring vein near tip; with three cross veins and the vestige of a fourth; second longitudinal vein set with about twenty-six short, dark spines; spines also present on first longitudinal vein, but white and not conspicuous. Anterior margin of wing without fringe; hind margin with long, double fringe. Wings clear white, with dark brown longitudinal band covering posterior half from near base to near tip. Microscopic hairs on light-colored area white, those on darkened area brown. Hind pair of wings clear white, excepting a small, light brown longitudinal area near base; without veins: margined in front with short and on hind edge with long simple fringe.

Abdomen elongate-ovate, about one-third as wide as long. All segments uniform brown, with light brown intersegmental membrane, splashed conspicuously with red pigment; segments 2 to 7, inclusive, each with a dark cross line near anterior margin. Segments 1 to 8 without conspicuous hairs or spines; segment 9 bears eight long and several smaller spines along posterior margin. The three last segments form the sheath for the large upturned ovipositor.

Males are much smaller, with antennæ almost uniform brown and abdomen furnished with large clasping organs at tip.

Described from nine females and three males.

Food plant: California lilac (*Ceanothus thyrsiflorus*).

Habitat: Saratoga, Santa Clara County, Cal.

(3) **Æolothrips kuwanaii**, variety **robustus**.

Measurements: Head, length 0.16 mm, width 0.20 mm; prothorax, length 0.20 mm, width 0.23 mm; width of mesothorax 0.38 mm; total body length 2.4 mm. Antennæ: 1, 36μ; 2, 60μ; 3, 114μ; 4, 69μ; 5, 69μ; 6, 7, 8, and 9, 51μ; total 0.38 mm. *Color* quite uniform dark brown, with conspicuous red pigment blotches; the third antennal segment is light brown, with a touch of purple pigment at its base.

A single specimen of this insect, which is about one-third larger than *A. kuwanaii*, has been taken from an apricot tree near Cupertino, Cal.

Family THRIPIDÆ.

(3) Genus SERICOTHRIPS Haliday.

Body broad and having a silky luster, due to the presence of numerous minute spines on the abdominal segments. Head fully one and one-half times as wide as long. Eyes large and protruding; ocelli present in both sexes. Antennæ eight-segmented. Maxillary palpi three-segmented. Prothorax much longer than the head, without long spines at hind angles. Legs, especially hind pair, quite slender. Wings either reduced or fully developed; when present the fore wing is broad at basal fourth, the remainder being very narrow; only one longitudinal vein developed; fore fringe long; spines on veins numerous and moderately developed; abdomen in some species strongly arched and its segments broad and short; tip of abdomen conical in both sexes; abdomen of male much more slender throughout. (After Hinds.)

To include California forms this genus must be extended as follows: Head may be almost as long as wide; ocelli wanting; maxillary palpi two or three segmented; head may be as long as prothorax; legs medium stout. The three California forms now recognized are wingless.

(4) **Sericothrips apteris** Daniel.

Measurements: Head, length 0.13 mm., width 0.16 mm.; prothorax, length 0.13 mm., width 0.2 mm.; length of pterthorax 0.08 mm., width 0.26 mm.; width of abdomen 0.40 mm.; total body length 0.65 to 1.0 mm. Antennæ: 1, 18μ; 2, 39μ; 3, 45μ; 4, 39μ; 5, 36μ; 6, 54μ; 7, 15μ; 8, 18μ; total, 0.25 mm. General *color* very dark brown, pterthorax lighter, abdomen almost black.

Head rounded in front, elevated between bases of antennæ; back of head cross-striate, with a spine on each side just inward from each eye and several posterior to eyes; cheeks arched, sides roughened. *Eyes* prominent, not pilose; together they occupy about one-half the width of the head. *Ocelli* wanting. *Mouth cone* long, extending to mesothorax, tipped with black; maxillary palpi three-segmented. *Antennæ* eight-segmented, basal joints widely separated; first two segments broadest; suture near tip of segment 6, which often makes the antennæ appear nine-segmented; spines prominent; color quite uniform brown.

Prothorax of even length with head, sides evenly arched, with a few not prominent spines; pronotum faintly reticulate-striate; color dark brown. *Pterthorax* not nearly so long as head, narrow in front, diverging posteriorly; color orange-yellow to light brown; surface marked with transverse reticulating wrinkles; wings wanting. *Legs* moderately stout; hind femora with spines at tip; color brown, tibia and tarsi shading yellow.

Abdomen broadly oval; segments 2 to 7, with an irregular row of about twelve spines along posterior margin; spines on last two segments short but quite strong; color very dark brown to almost black.

Redescribed from numerous specimens including several cotypes kindly furnished by Miss Daniel.

Food plant: Grass.

Habitat: Counties about San Francisco Bay, California.

This species is described in Entomological News for November, 1904, page 295. I have taken specimens from grass on the campus of the University of California, at Berkeley, Cal., where it was first found, and from the same food plant in the Niles Canyon, Alameda County, and on the campus of the Leland Stanford, Jr., University, Palo Alto, Cal. It is easily distinguished from the other species of the genus in that the pterthorax is decidedly lighter colored than the rest of the body, which is very dark brown to brown-black.

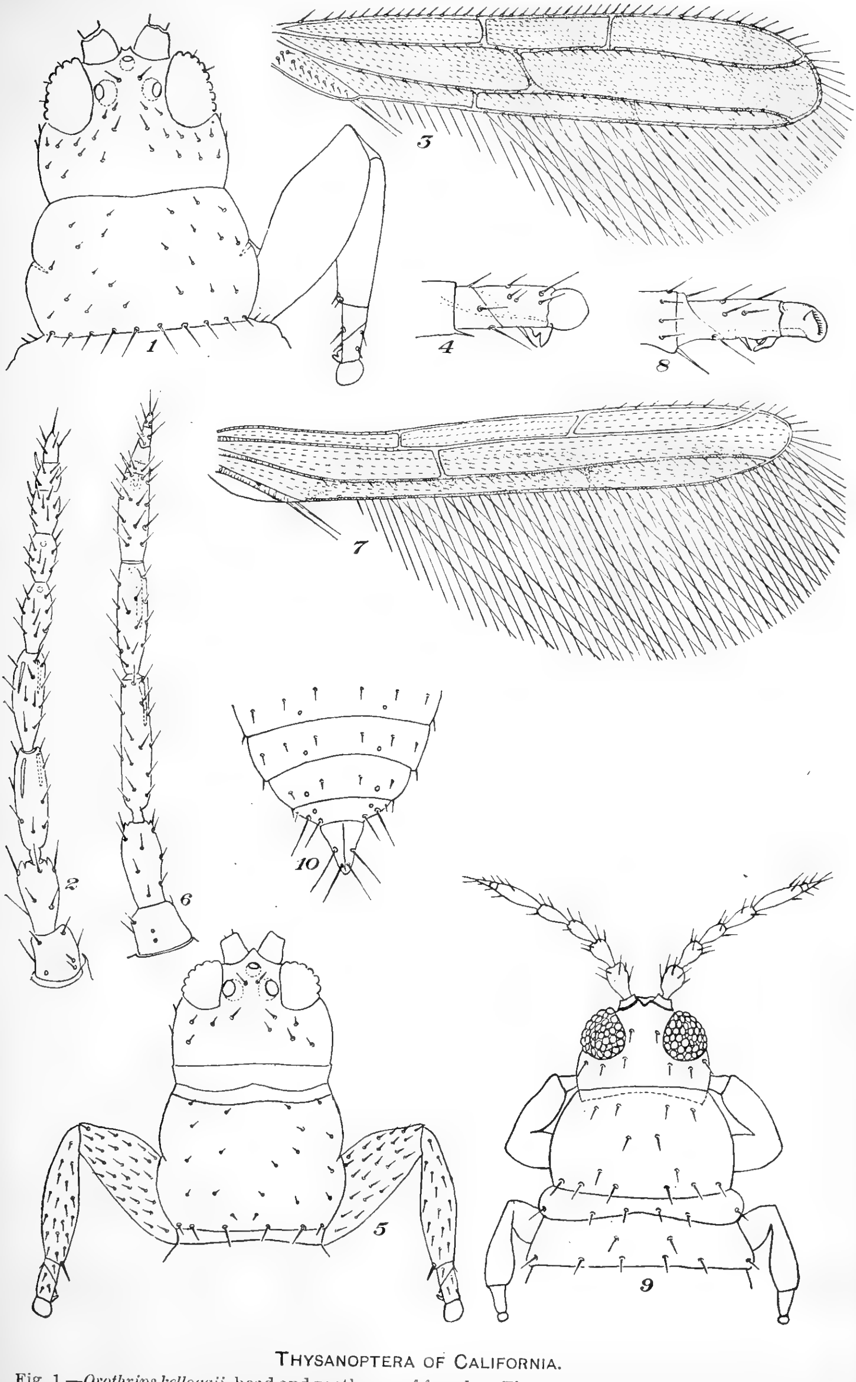
(5) **Sericothrips reticulatus**, new species. (Pl. I, figs. 9, 10.)

Measurements: Head, length 0.16 mm., width 0.20 mm.; prothorax, length 0.18 mm., width 0.26 mm.; abdomen, width 0.48 mm.; total body length 1.41 mm. Antennæ: 1, 21μ; 2, 48μ; 3, 54μ; 4, 54μ; 5, 51μ, 6, 69μ; 7, 12μ; 8, 21μ; total, 0.336 mm. *Color* brown, head and thorax lighter, and abdomen shading to dark brown at tip; legs yellow. Body increasing in size gradually from head to sixth abdominal segment, from where it tapers abruptly to the small ninth and conical tenth.

Head small as compared with other segments of body; cheeks arched, edges roughened; frons with two prominent darkened angles directly above basal segments of antennæ and with an intermediate angular depression. Head surface strongly reticulate, with no conspicuous spines and with but few very small hairs. *Eyes* large, prominent, with coarse facets, not pilose, with light-colored outer borders, pigment very dark purple. *Ocelli* absent. *Mouth cone* broad, pointed bluntly at tip; maxillary palpi two-segmented. *Antennæ* eight-segmented, slightly more than twice as long as head, segments almost uniform brown, sense hairs light colored and inconspicuous.

Prothorax but slightly longer than head. It bears a few very small hairs, but no spines. *Mesothorax* smallest segment of body excepting the last two of the abdomen, with *metathorax* only a little larger, and together they are wider, although not so large, as the prothorax. They bear no conspicuous hairs or spines. *No wings* or wing-pads are present. All *legs* are medium stout, unarmed, and with only a few inconspicuous hairs; color yellow, tarsi tipped with brown.

Abdomen brown, shading darker toward the tip; broadly oval; segments 1 to 4 increasing in size gradually; segments 4, 5, and 6 about equal, segment 7 tapering, 8 abruptly tapering to meet the very small ninth and conical tenth. Entire upper surface of abdomen reticulate.



THYSANOPTERA OF CALIFORNIA.

Fig. 1.—*Orothrips kelloggii*, head and prothorax of female. Fig. 2.—*Orothrips kelloggii*, left antenna of female. Fig. 3.—*Orothrips kelloggii*, right fore wing of female. Fig. 4.—*Orothrips kelloggii*, fore tarsus of female. Fig. 5.—*Æolothrips kuwanaii*, head and prothorax of female. Fig. 6.—*Æolothrips kuwanaii*, right antenna of female. Fig. 7.—*Æolothrips kuwanaii*, right fore wing of female. Fig. 8.—*Æolothrips kuwanaii*, fore tarsus of female. Fig. 9.—*Sericothrips reticulatus*, head, prothorax, and mesothorax of female. Fig. 10.—*Sericothrips reticulatus*, end of abdomen of female.

Segments 1 to 8 have each several very small hairs, segments 9 and 10 each with six or eight quite long, conspicuous spines.

Described from one female.

Food plant: Grass.

Habitat: Campus of the Leland Stanford Junior University, California.

This species has many characters in common with the *Prosopothrips vejdovskyi* described by Uzel.[a]

(6) **Sericothrips stanfordii**, new species. (Pl. II, fig. 11.)

Measurements: Head, length 0.12 mm., width 0.16 mm.; prothorax, length 0.13 mm., width 0.21 mm.; width of abdomen 0.36 mm; total body, length 1.25 mm. Antennæ: 1, 21μ; 2, 36μ; 3, 36μ; 4, 39μ; 5, 33μ; 6, 48μ; 7, 9μ; 8, 15μ; total, 0.24 mm. *Color* brown, tips of tibiæ yellow, tarsi yellow, with brown tips.

Head rounded in front, cheeks almost straight, roughened; surface of head cross-striate almost to a reticulation; a spine just inward from and two or three posterior to each eye; none, however, are prominent. *Eyes* medium, with light-colored inner and outer borders; slightly pilose, not protruding. *Ocelli* absent. *Mouth-cone* broad at base, blunt and dark-brown at tip; maxillary palpi three-segmented. *Antennæ* eight-segmented; twice as long as head; brown, segment 3 light brown.

Prothorax bears no prominent spines and but few short inconspicuous hairs; sides slightly arched; surface faintly cross-striate. *Mesothorax* and *metathorax* resemble abdominal segments; the mesothorax is the smaller; they bear no conspicuous spines or hairs; cross-striate on upper surface. Color uniform brown with rest of body. *No wings* are present. *Legs* medium stout, third pair armed with spines; tips of tibiæ yellow, tarsi yellow, each with a conspicuous brown spot at tip.

Abdomen dark brown, with light-colored bands on posterior edges of all segments excepting last two; these bands have small longitudinal, wavy thickenings; intersegmental membrane light brown or yellow. Body elongate-ovate; third, fourth, and fifth segments largest, tapering gradually to tip (segments cross-striate, especially on their anterior parts). Segments 1 to 7 each with several regularly placed small hairs; on last three segments, and especially on the last two, these hairs become quite strong, prominent spines.

Described from four females.

Food plant: Grass.

Habitat: Campus of the Leland Stanford Junior University, California.

4. Genus HELIOTHRIPS Haliday.

(7) **Heliothrips hæmorrhoidalis** Bouché and (8) **H. fasciatus** Pergande.

For descriptions of these two species see Hinds's Monograph of the Thysanoptera of North America, pages 168 and 174, respectively.

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[a] Monographie der Ordnung Thysanoptera, page 166.

Heliothrips hæmorrhoidalis is one of the commonest thrips in greenhouses, where it feeds on azaleas, ferns, and dahlias; out of doors it feeds and becomes very destructive on laurestinas.

Heliothrips fasciatus (Pl. II, figs. 12–14) has been taken from oranges in Colusa County by Mr. E. K. Carnes, from pea vines in Santa Rosa by Mr. O. E. Bremner, and the writer has taken it from wild vetch sweepings in the Santa Cruz Mountains, Santa Clara County, Cal.

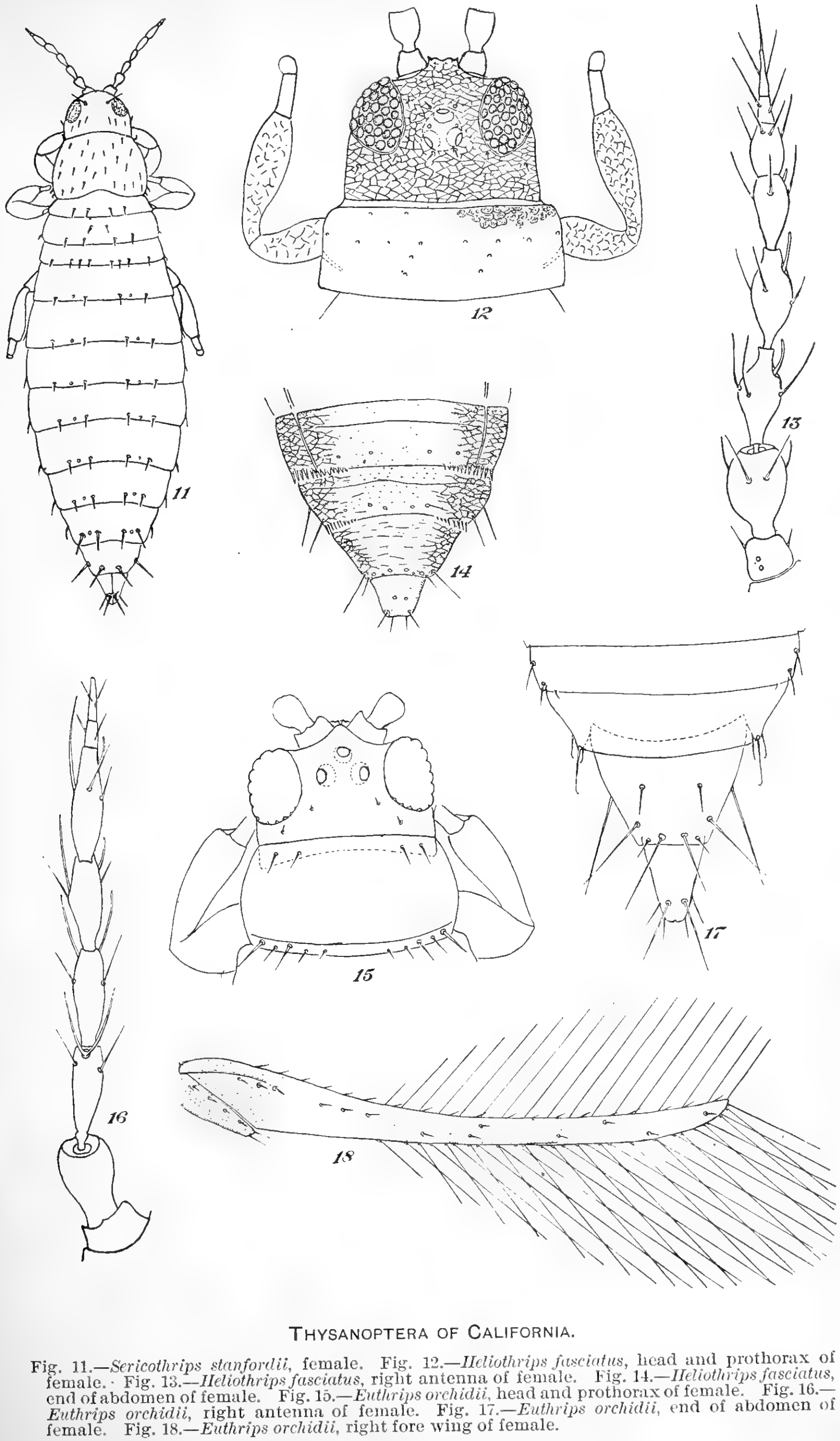
5. Genus EUTHRIPS Targione-Tozzetti.

Ocelli usually present, but sometimes more or less rudimentary. Antennæ eight-segmented. Maxillary palpi three-segmented. Prothorax as long or somewhat longer than head, with two long spines on each hind angle and one similar spine on each anterior angle in many species, but this is wanting in others. Legs usually unarmed, but in a few species with a stout tooth on the under side of fore tibia at end. Wings usually fully developed, but sometimes reduced; when present they are moderately broad, and in those species which have a spine at the fore angle of the pronotum both longitudinal veins are closely and regularly set with spines for their entire length. Spines on the abdomen are moderately stout, anal spines are long and slender. These species are usually active and most of them have the power of springing.

(9) **Euthrips orchidii**, new species. (Pl. II, figs. 15–18.)

Measurements: Head, length 0.10 mm., width 0.15 mm.; prothorax, length 0.10 mm., width 0.18 mm.; mesothorax, width 0.22 mm.; abdomen, width 0.25 mm.; total body, length 0.88 mm. Antennæ: 1, 18μ; 2, 30μ; 3, 48μ; 4, 48μ; 5, 48μ; 6, 54μ; 7, 12μ; 8, 21μ; total, 0.28 mm. *Color* yellow, head and all legs light lemon-yellow, wings light brown.

Head one-third wider than long, retracted into prothorax, angular in front, with concave depressions receiving basal joints of antennæ; spines inconspicuous: cheeks almost straight; head broadest across eyes. *Eyes* relatively large, occupying about one-half the length of the head, prominent; pigment granular and from deep red to purple; facets of eye as large as ocelli, eyes pilose. *Ocelli* subapproximate, margined inwardly with orange-red crescents. *Mouth-cone* short, reaching hardly beyond posterior margin of head, pointed and with a brown spot at tip; maxillary palpi three-segmented. *Antennæ* eight-segmented, light lemon-yellow, with tips of segments 4, 5, and 6 shading to light brown; segments 3, 4, and 5 of about the same length, segment 6 longest; forked sense cones on segments 3 and 4 long and slender, a short and a long simple sense cone near tip of segment 5, a similar pair on 6; on this latter segment the inner long cone is very long and reaches almost to tip of antennæ. All spines and sense cones are pale and inconspicuous.



THYSANOPTERA OF CALIFORNIA.

Fig. 11.—*Sericothrips stanfordii*, female. Fig. 12.—*Heliothrips fasciatus*, head and prothorax of female. Fig. 13.—*Heliothrips fasciatus*, right antenna of female. Fig. 14.—*Heliothrips fasciatus*, end of abdomen of female. Fig. 15.—*Euthrips orchidii*, head and prothorax of female. Fig. 16.—*Euthrips orchidii*, right antenna of female. Fig. 17.—*Euthrips orchidii*, end of abdomen of female. Fig. 18.—*Euthrips orchidii*, right fore wing of female.

Prothorax almost twice as wide as long, all angles broadly and evenly rounded; a prominent line across the posterior part which might easily be mistaken for the hind margin; with two short and quite stout spines on each posterior angle; all spines light colored and not readily seen. *Mesothorax* largest, sides of *metathorax* almost parallel and very slightly arched. *Legs* uniform light yellow; all tibiæ with a spine at tip, hind tibiæ with a row of regularly placed spines on upper inner side; all tarsi with a brown spot at tip. *Wings* present and fully developed; fore wings light brown, with two white areas, one near base and one at tip. A single rudimentary vein at base of each fore wing; spines of wing few and scattered, except two groups of three each near base and five on scale; wing broadest at base, anterior margin bowed, posterior margin straight from base to near tip, where it curves forward to form a scythe-like tip; both anterior and posterior fringes long and sparse.

Abdomen ovoid, tip conical, segments 9 and 10 drawn out, and spines on these last two are long and prominent.

Described from four females.

Specimens collected from orchids in greenhouse, Fruitvale, Alameda County, Cal., by Mr. O. E. Bremner.

(10) **Euthrips pyri** Daniel. (Pl. III, figs. 19–24.)

Measurements: Head, length 0.13 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.2 mm.; mesothorax, width 0.28 mm.; abdomen, width 0.31 mm.; total length 1.26 mm. Antennæ: 1, 33μ; 2, 45μ; 3, 63μ; 4, 54μ; 5, 33μ; 6, 66μ; 7, 9μ; 8, 12μ; total, 0.31 mm. *Color* dark brown, tarsi light brown to yellow.

Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. *Eyes* prominent, oval in outline, black with light borders, coarsely faceted and pilose. *Ocelli* are approximate, yellow, margined inwardly with orange-brown crescents, posterior ones approximate to but not contiguous with light inner borders of eyes. *Mouth-cone* pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. *Antennæ* eight-segmented, about two and one-half times as long as head, uniform brown except segment 3, which is light brown; spines pale; a forked sense cone on dorsal side of segment 3, with a similar one on ventral side of segment 4.

Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines are not conspicuous. *Mesothorax* with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate.

Legs moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. *Wings* present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of fore wings thickly set with from twenty-nine to thirty-three quite long spines; fore vein with twelve or fifteen arranged in two groups of three and six respectively on basal half of wing and a few scattering ones on distal part; hind vein with fifteen or sixteen regularly placed spines; costal fringe on fore wing about twice as long as costal spines.

Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow.

Redescribed from many specimens, including several cotypes from Miss Daniel.

Male unknown.

Food plants: Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts. The insect is found mostly on deciduous fruits.

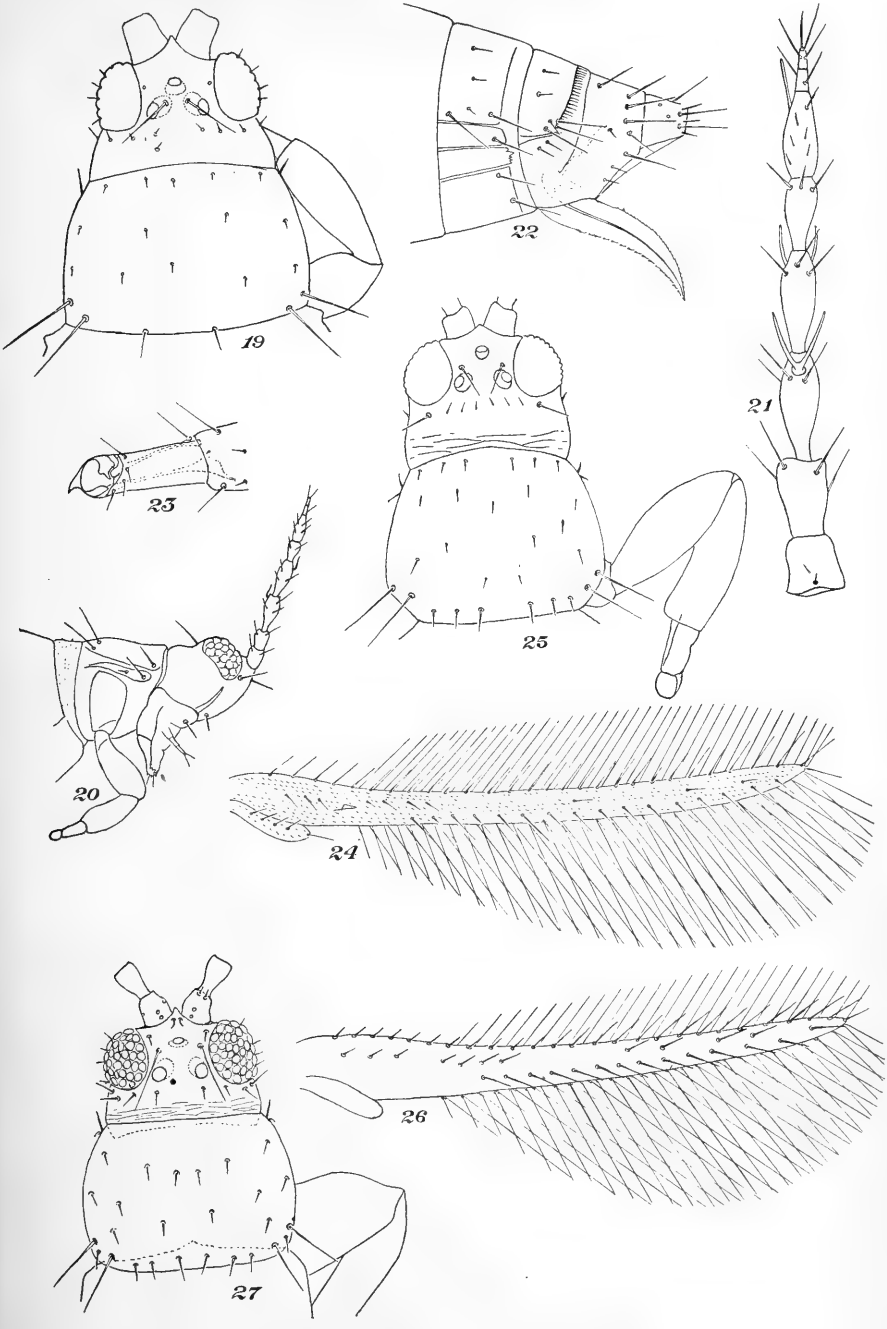
Habitat: San Francisco Bay region, California.

(11) **Euthrips ehrhornii**, new species. (Pl. III, figs. 25, 26.)

Measurements: Head, length 0.11 mm., width 0.13 mm.; prothorax, length 0.14 mm., width 0.18 mm.; mesothorax, width 0.23 mm.; abdomen, width 0.29 mm.; total body length 1.2 mm. Antennæ: 1, 24μ; 2, 39μ; 3, 48μ; 4, 45μ; 5, 36μ; 6, 54μ; 7, 6μ; 8, 9μ; total, 0.26 mm. General *color* brown, head light brown, thorax a little darker, abdomen brown to dark brown.

Head slightly longer than wide; front of head angular, and with concave depressions to receive basal segments of antennæ; cheeks roughened; posterior part of head faintly cross striate. Spines between ocelli prominent; postocular spines present but small. *Eyes* large, oval, slightly protruding, with an emargination on the side of the head between cheek and eye; pigment purple. *Ocelli* separated, margined inwardly with orange-red crescents. *Mouth cone* long and pointed; maxillary palpi three-segmented. *Antennæ* subapproximate; uniform brown except segment 1, basal half of 3, and tip of 4, which are gray-brown.

Prothorax widest across posterior part; all angles rounded. Two large spines on each posterior angle with several smaller ones along posterior margin; of these latter the inner ones are the larger; large spines on posterior angles are dark brown; no conspicuous spines on anterior angles. Sides of both *mesothorax* and *metathorax* slightly arched; pterthorax may be of a darker shade of brown than prothorax. *Legs* uniform brown, except all trochanters, which are white, and tibiæ,



THYSANOPTERA OF CALIFORNIA.

Fig. 19.—*Euthrips pyri*, head and prothorax of female. Fig. 20.—*Euthrips pyri*, head and prothorax of female from side. Fig. 21.—*Euthrips pyri*, right antenna of female. Fig. 22.—*Euthrips pyri*, end of abdomen of female from side. Fig. 23.—*Euthrips pyri*, fore tarsus of female. Fig. 24.—*Euthrips pyri*, right fore wing of female. Fig. 25.—*Euthrips ehrhornii*, head and prothorax of female. Fig. 26.—*Euthrips ehrhornii*, right fore wing of female. Fig. 27.—*Euthrips ulicis californicus*, head and prothorax of female.

which are light brown; each hind tibia armed at tip with a spine; all tarsi with a brown spot at tip. *Wings* fully developed, uniform light gray-brown, all veins weak. Fore margin and hind vein set regularly with conspicuous dark brown spines, about twenty-six on fore margin and thirteen on hind vein; fore vein with twelve spines arranged in two groups of three and four on basal half of wing and five scattered spines on distal half.

Abdomen elongate-ovate, pointed at tip. Spines at sides increasing in prominence toward tip, those on 9 and 10 largest and most conspicuous of any on body. Hairs in comb-like structure on posterior margin of segment 8 closely placed.

Described from two females.

Food plant: Grass.

Habitat: Alum Rock Canyon, Santa Clara County, Cal.

This species is very close to *Euthrips pyri.*

(12) **Euthrips ulicis californicus**, new variety. (Pl. III, fig. 27; Pl. IV, figs. 28–31.)

Measurements: Head, length 0.13 mm., width 0.17 mm.; prothorax, length 0.21 mm., width 0.25 mm.; mesothorax, width 0.36 mm.; abdomen, width 0.40 mm.; total body, length 1.33 mm. Antennæ: 1, 30μ; 2, 45μ; 3, 75μ; 4, 66μ; 5, 48μ; 6, 66μ; 7, 15μ; 8, 18μ; total, 0.36 mm. *Color* dark-brown, except tarsi and fore tibiæ, which are light brown or yellow.

Head slightly wider than long, deeply set in prothorax; cheeks straight, parallel; front of head broad and quite straight, having only a small elevation between bases of antennæ; head noticeably square in front; back of head transversely striate; large spine on back of head just inward from each eye and anterior to each posterior ocellus; a pair of small backwardly curved spines on apex of head; four or five spines posterior to each eye, the outer one of each group being prominent on the side of the cheek. *Eyes* medium, prominent, but not protruding; pilose; with light inner borders, pigment deep red to black. *Ocelli* large, separated, orange colored, with orange brown crescents, posterior ones almost contiguous with light borders around eyes. *Mouth cone* pointed, maxillary palpi three-segmented. *Antennæ* eight-segmented, about two and one-half times as long as head; brown, unicolorous with body except segment 3, which is yellow, and 4, which is light brown; forked sense cones are found on segments 3 and 4 and a pointed sense scale set in a transparent area near tip of segment 6. Segments 3 and 4 constricted near their tips.

Prothorax noticeably larger than head, sides convex; a short spine on each anterior angle and two long prominent spines on each posterior angle. *Mesothorax* largest, anterior angles broadly rounded, posterior ones slightly constricted to meet the smaller metathorax. Sides of *metathorax* almost straight and parallel posterior angles rounded. *Legs* brown, concolorous with body except fore tibiæ, which are yellow, shading to brown on sides, fore tarsi, which are yellow, and other tarsi which are yellow to light brown. Fore femora thickened. Fore tarsi armed each with a stout tooth, and near this is a protuberance on which is set a sharp spine. *Wings* present; fore wings brown, except basal fourth, which is white; costa and both longitudinal veins set with long, conspicuous brown spines, twenty-six on costa, twenty on fore vein, sixteen on hind vein, five on scale.

Abdomen ovate; third to sixth segments largest and about equal; the seventh to tenth tapering gradually to form the conical tip. A few quite prominent spines along sides of abdomen, but long and slender ones only on segments 9 and 10, a circlet of eight on segment 9 and six on segment 10.

Males smaller than females; antennæ, legs, and wings with similarly placed spines; fore femora thickened, fore tibiæ armed with teeth. Tip of abdomen with prominent spines, penis upturned; antennæ with segments 1 and 5 to 8 brown, and 2, 3, and 4 yellow.

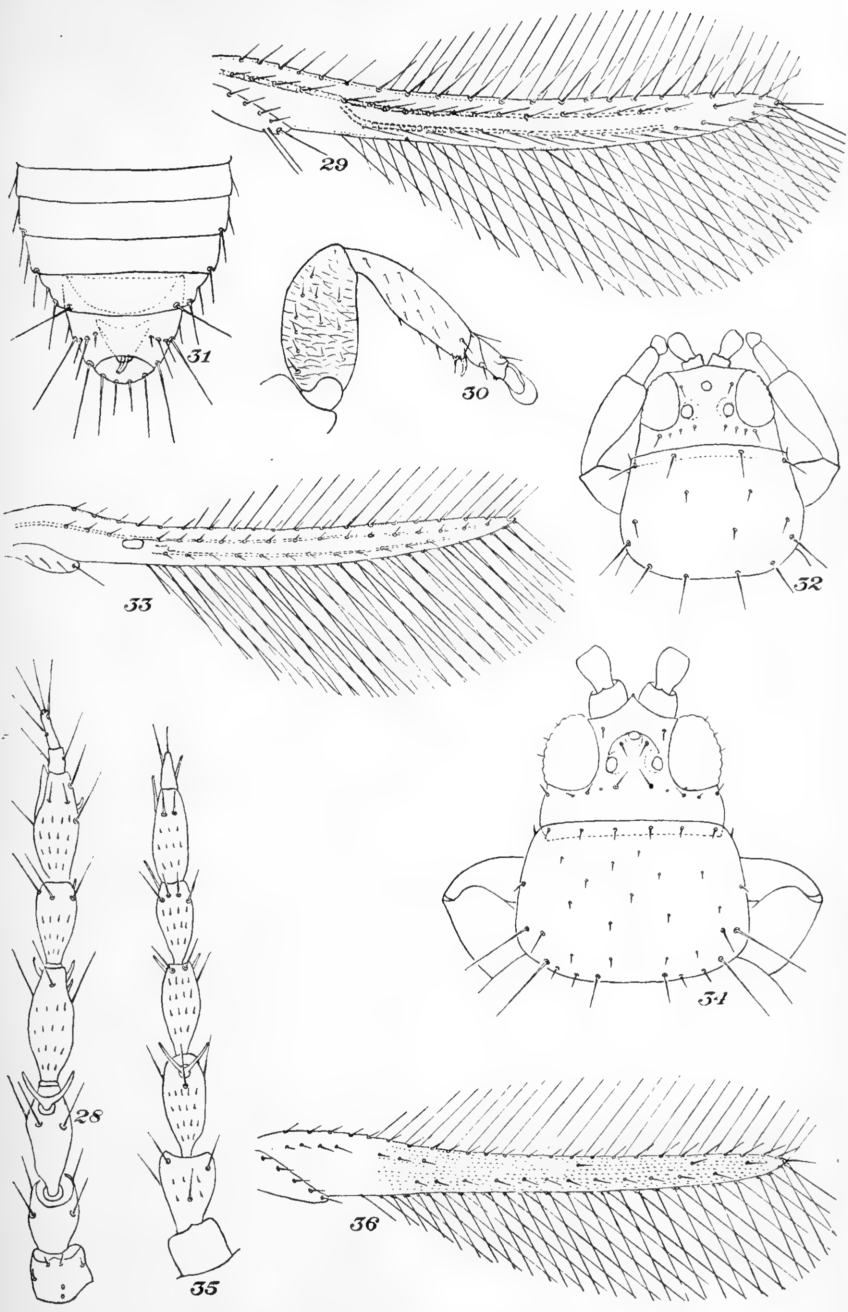
Described from three females and four males, specimens taken from vetch sweepings near Wrights Station, Santa Clara County, Cal.

The species here described corresponds in almost every respect to the *Physopus ulicis* Haliday, as described by Uzel in his Monographie der Ordnung Thysanoptera, page 115. The genus name *Physopus* has since been changed to *Euthrips* by Hinds in his Monograph of the Thysanoptera of North America. I therefore have called this species *Euthrips ulicis californicus*. The *Physopus ulicis* of Uzel is recorded as found in England (Haliday), in Finland (Reuter), and in Bohemia (Uzel).

(13) **Euthrips minutus**, new species. (Pl. IV, figs. 32, 33.)

Measurements: Head, length 0.096 mm., width 0.14 mm.; prothorax, length 0.105 mm., width 0.17 mm.; mesothorax, width 0.21 mm.; abdomen, width 0.24 mm.; total body, length 0.83 mm. Antennæ: 1, 21μ; 2, 30μ; 3, 39μ; 4, 36μ; 5, 30μ; 6, 42μ; 7, 9μ; 8, 12μ; total, 0.21 mm. *Color* uniform dark brown, wings gray-brown.

Head about one and one-half times as wide as long, retracted into thorax; anterior margin of head almost straight, being but slightly and smoothly elevated in front; cheeks straight, diverging posteriorly; no conspicuous markings on head. A weak spine close in front of each posterior ocellus and one behind each eye; other spines very inconspicuous. *Eyes* moderately large, not protruding, pigment of a deep red. *Ocelli* widely separated, posterior ones contiguous with light inner margins of eyes; considerably larger than facets of eyes; orange-yellow; margined inwardly with large orange crescents. *Mouth-cone* short; maxillary palpi three-segmented. *Antennæ* inserted a little below the margin, slightly more than twice as long as head, quite uniform brown.



THYSANOPTERA OF CALIFORNIA.

Fig. 28.—*Euthrips ulicis californicus*, left antenna of female. Fig. 29.—*Euthrips ulicis californicus*, right fore wing of female. Fig. 30.—*Euthrips ulicis californicus*, fore leg of female. Fig. 31.—*Euthrips ulicis californicus*, end of abdomen of male. Fig. 32.—*Euthrips minutus*, head and prothorax of female. Fig. 33.—*Euthrips minutus*, right fore wing of female. Fig. 34.—*Thrips madronii*, head and prothorax of female. Fig. 35.—*Thrips madronii*, right antenna of female. Fig. 36.—*Thrips madronii*, right fore wing of female.

Prothorax noticeably larger than head, without conspicuous markings; anterior angles straight, posterior broadly rounded. A large spine on each anterior angle and a second on anterior margin on either side about half way between the first spine and the median line; three large spines on posterior margin on either side about equidistant apart, the outer one being the conspicuous spine on the posterior angle; other spines extremely small. *Mesothorax* widest, sides arched, evenly united with metathorax; sides of *metathorax* almost straight, but widening toward the abdomen. Thorax slightly orange colored. *Legs* medium, brown, except fore tibiæ and all tarsi, which are light brown. Hind tibiæ and tarsi armed each with a sharp spine. *Wings* present, reaching to tip of abdomen; gray-brown, each with a small, white, transparent area about one-fifth the wing's length from its base. Two longitudinal veins, fore vein extending from base to near tip, hind vein appears close after the white area and fades before the end. Fore margin of wing and longitudinal veins set regularly with short, sharp-pointed brown spines, twenty-three on fore margin, eighteen on fore vein, twelve on hind vein.

Abdomen with prominent spines only on last few segments; a weak comb-like arrangement of spines on the posterior margin of segment 8.

Described from one female.

Food plant: Grass.

Habitat: Berkeley, Cal.

(14) **Euthrips occidentalis** Pergande, and (15) **Euthrips tritici** Fitch.

For descriptions of these species see Hinds's Monograph of the Thysanoptera of North America, pages 152 and 148, respectively.[a]

6. Genus PARTHENOTHRIPS Uzel.

(16) **Parthenothrips dracænæ** Heeger.

For description see Hinds's Monograph, page 176. Specimens taken from dracæna in greenhouse in San Francisco, by Mr. E. M. Ehrhorn.

7. Genus THRIPS Linnæus.

(17) **Thrips madronii**, new species. (Pl. IV, figs. 34–36.)

Measurements: Head, length 0.11 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.20 mm.; mesothorax, width 0.33 mm.; abdomen, width 0.33 mm.; total body, length 1.25 mm. Antennæ: 1, 27μ; 2, 39μ; 3, 60μ; 4, 54μ; 5, 45μ; 6, 54μ; 7, 21μ; total, 0.3 mm. *Color*

[a] The writer has taken specimens of these two species of *Euthrips* (*occidentalis* and *tritici*) from the most of our wild and cultivated flowers. They are commonly found together. The variations in size, color, and in the relative lengths of segments of the antennæ (in each of the two species) are so great that the writer has been unable to draw a sharp line of distinction between them.

uniform brown, usually dark brown; wings gray-brown, lighter at base; tibiæ and tarsi sometimes light brown.

Head almost as long as wide, front of head angular, basal segments of antennæ set in concave depressions in front of head; cheeks arched, sides roughened; posterior part of head cross-striate. No prominent spines on head, although there is a row of small spines on each side immediately back of the eyes, the inner ones of which are the larger. *Eyes* prominent, slightly protruding, pilose, margined inwardly with light borders; pigment black. *Ocelli* subapproximate, separated from inner margin of eyes; light orange colored and margined inwardly with deep orange-red crescents; usually with circular thickening connecting anterior ocellus with outside of posterior ones, and included within this, on either side of the anterior ocellus, is a small spine. *Mouth cone* long, pointed; maxillary palpi three-segmented; labial palpi two-segmented, first very short, second very long and slender. *Antennæ* with all segments of uniform width and color, except 2, which is somewhat wider and a little darker brown; sometimes segment 3 is also a little lighter brown.

Prothorax about as long as head but somewhat wider; all angles rounded; a pair of prominent spines on each posterior angle, with a smaller pair on posterior margin near center; sometimes a third quite prominent spine is present near larger ones on posterior angles. *Mesothorax* largest; *metathorax* smaller with sides almost straight, hind angles rounded. All segments uniform brown. *Legs* medium, concolorous with body; hind tibiæ armed with several stout spines. *Wings* fully developed, noticeably broader at base and gradually narrowing toward the tip, light brown, except basal one-fourth, which is light gray-brown. Costal and longitudinal veins prominent only on basal half of wing; costa with about twenty-six regularly placed spines; fore longitudinal vein with two groups on basal half, first group of four and second of three; three other spines on distal half; hind vein with twelve regularly placed spines.

Abdomen uniform dark-brown, with a darker brown line across anterior margins of segments 2 to 7; connective tissue brown; stout spines on sides of all segments, these becoming longer near the tip with the longest on segments 9 and 10. Comb-like arrangement of spines on posterior margin of segment 8.

Males much smaller than females and with large light-colored oval areas on ventral sides of segments 3 to 6.

Described from twenty-one females and three males.

Food plants: Blossoms of madroña, California laurel, and California lilac.

Habitat: Santa Clara Valley, California.

This species in a general way resembles *Euthrips pyri*, and either one at a casual glance could be easily mistaken for the other.

(18) **Thrips tabaci** Lindeman.

For description see Hinds's Monograph, page 179.

Thrips tabaci is common everywhere in wild and cultivated flowers, but its principal food plant is the onion. It has been very destructive on several large seed farms where onions are grown for seed purposes. It is commonly known as the onion thrips.

(19) **Thrips bremnerii**, new species. (Pl. V, figs. 37–39.)

Measurements: Head, length 0.1 mm., width 0.10 mm.; prothorax, length 0.12 mm., width 0.14 mm.; mesothorax, width 0.18 mm.; abdomen, width 0.21 mm.; total body, length 1.08 mm. Antennæ: 1, 21μ; 2, 33μ; 3, 42μ; 4, 36μ; 5, 33μ; 6, 39μ; 7, 15μ; total, 0.21 mm. *Color* uniform light lemon-yellow, shading to light brown; abdominal segments often shaded brown on dorsal side. Body long and slender.

Head about as long as wide, angular in front, basal segments of antennæ received in concave depressions on upper front side, back of head faintly cross-striate; cheeks arched but little. A spine on either side of anterior ocellus and one immediately behind each posterior ocellus, the spines light, concolorous with head and not conspicuous. *Eyes* prominent, protruding, pilose, black or deep purple by transmitted light, red by reflected light. *Ocelli* subapproximate, very light and margined inwardly with light-brown crescents. *Mouth cone* shading dark brown toward the end and tipped with black; maxillary palpi three-segmented, labial palpi two-segmented, terminal one very long. *Antennæ* quite uniform light brown, basal segment often lighter or second segment darker.

Prothorax but little larger than the head; all angles rounded, and if the body is distended, together with the light colored intersegmental membrane, the prothorax is quite round; two large brown spines on each posterior angle, with a row of three on each side along the hind margin, the inner one being the larger. *Pterthorax* somewhat darker than prothorax; sides of mesothorax rounded, sides of metathorax narrowed in front, forming a quite noticeable concave depression on either side. *Legs* medium, concolorous with or somewhat lighter than body, hind tibiæ alone armed with spines, a dark-brown spot on the tip of each tarsus. *Wings* fully developed, though not reaching to tip of abdomen, broad at base; uniform white with brown spines. Veins are either very rudimentary or, as in some specimens, highly developed. In these latter the two longitudinal veins may be seen extending to and joining the margin on either side of the tip; also there are two cross veins, one at about one-third, and a second at about two-thirds the wing's length from the base; they connect costa and fore longitudinal vein. Costa with twenty-five spines; fore vein with twelve, arranged as follows: Two groups of four and three, respectively, on basal half of wing, and five others regularly placed on distal half; twelve on hind vein.

Abdomen long and slender; segments 3 to 8 with a brown line near anterior margin; spines on last segments not noticeably long.

Described from twenty-five females.

Food plant: Figs. Specimens taken from the inside of ripe figs.

Habitat: Santa Clara Valley, California.

Family PHLŒOTHRIPIDÆ.

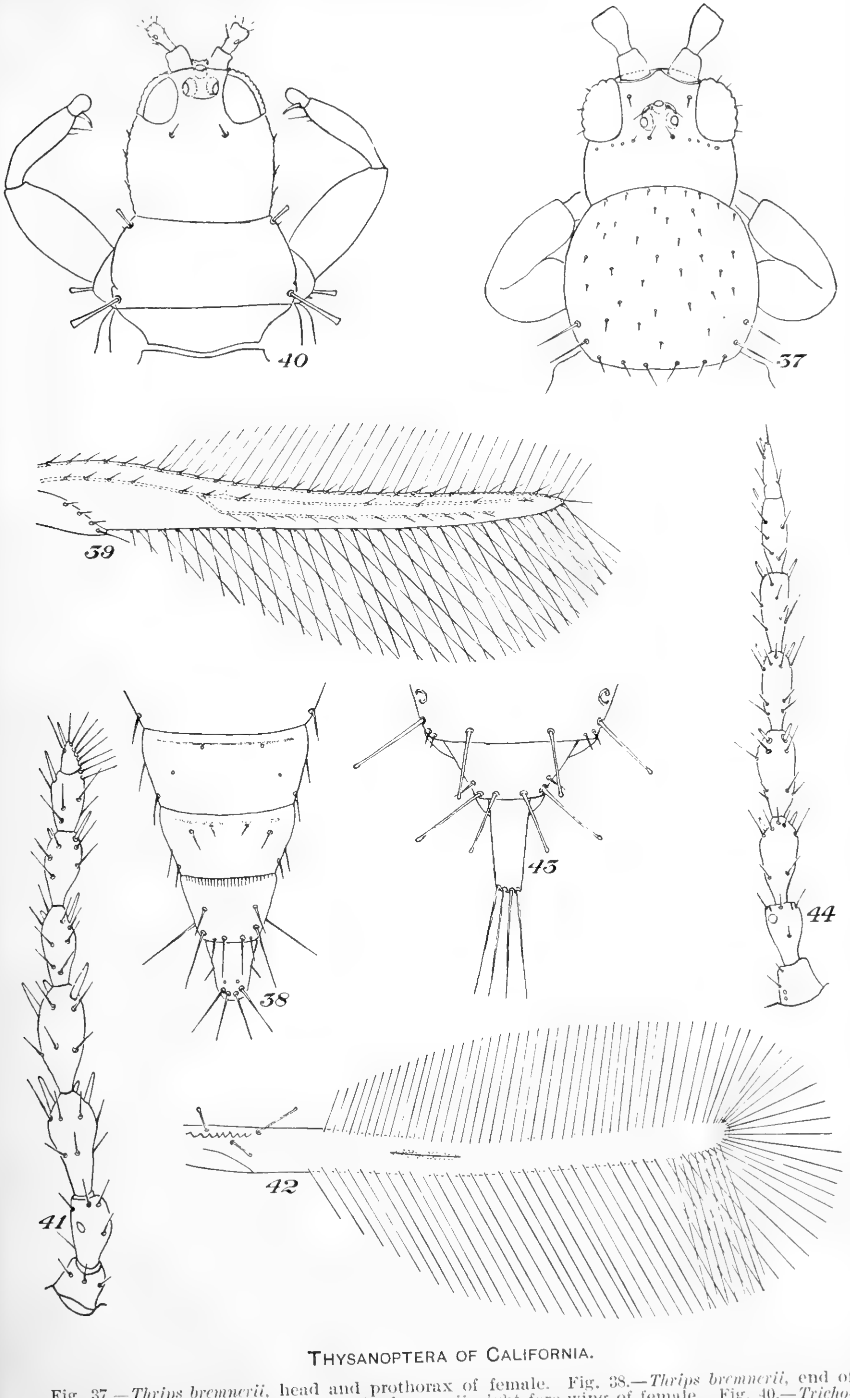
8. Genus TRICHOTHRIPS Uzel.

(20) **Trichothrips dens**, new species. (Pl. V, figs. 40–43.)

Measurements: Head, length 0.26 mm., width 0.25 mm.; prothorax, length 0.15 mm., width 0.31 mm.; mesothorax, width 0.35 mm., abdomen, width 0.40 mm.; tube, length 0.17 mm.; total body, length 1.5 mm. Antennæ: 1, 30μ; 2, 60μ; 3, 90μ; 4, 78μ 5, 54μ; 6, 54μ; 7, 48μ; 8, 24μ; total, 0.44 mm. *Color* brown, with conspicuous red pigment blotches on body and legs.

Head about as long as wide, broadly rounded in front; frons elevated only slightly between basal segments of antennæ. Cheeks arched, converging posteriorly; with edges roughened; bearing a few short, stout spines which are raised on small tubercles. Red pigment on head is conspicuous. A pair of short, inconspicuous, postocular spines are present. *Eyes* large, with small facets, black by transmitted light, with light inner borders and light lemon-yellow, transparent outer borders; not pilose. *Ocelli* present, subapproximate, margined inwardly with dark crescents, anterior one on apex of head. *Mouth cone* pointed, reaching beyond posterior margin of prothorax. *Antennæ* eight-segmented, one and two-thirds times as long as head; brown, unicolorous with body, except that the base and tip of segment 3 and bases of segments 4 and 5 shade to light brown or lemon-yellow. Segment 1 truncate; 2 constricted at base into a broad stalk and fitting ball-and-socket-like into a depression in segment 1; 3 to 6 inclusive each with a slender stalk at base, each also somewhat constricted at the distal end; 7 cylindrical-ovate and very closely and evenly united with 8, which is conical. A dark spot on segment 2 is probably a sense area; segments 3 to 6 inclusive each with three simple sense cones, with one cone on segments 5 and 6 rudimentary; 7 and 8 bear each a simple sense cone and a fringe of eight or nine sense hairs on their inner margin.

Prothorax about half as long as head but wider than head is long. It bears no hairs other than a single, stout, transparent, knobbed pair on the hind angles and a similar smaller pair on the anterior angles. *Mesothorax* and *metathorax* about equal in width and slightly wider than prothorax; with sides almost parallel; they bear no conspicuous spines or hairs. Each *fore coxa* projects considerably beyond margin at sides of prothorax and forms what appears to be the prominent angle; each bears a short, stout, transparent, knobbed hair on prominent angle.



THYSANOPTERA OF CALIFORNIA.

Fig. 37.—*Thrips bremnerii*, head and prothorax of female. Fig. 38.—*Thrips bremnerii*, end of abdomen of female. Fig. 39.—*Thrips bremnerii*, right fore wing of female. Fig. 40.—*Trichothrips dens*, head and prothorax of female. Fig. 41.—*Trichothrips dens*, left antenna of female. Fig. 42.—*Trichothrips dens*, right fore wing of female. Fig. 43.—*Trichothrips dens*, end of abdomen of female. Fig. 44.—*Trichothrips femoralis*, right antenna of female.

Fore femora enlarged; fore tarsi stout and each armed with a stout tooth. Other than a single row of stout spines on the hind tibiæ, the legs bear no conspicuous spines and only a few small hairs. *Wings* reach to base of tube; both pairs equal; edges parallel; with simple fringe of long, straight hairs on both margins. Fore wings double fringed on posterior margin near tip by seven or eight hairs. Membrane of wings transparent, shaded gray-brown near base. Fore wings each with a single median rudimentary vein and center of wing along vein shaded light brown. Base of wing bears three knobbed hairs, one long and two short ones; costal margin near base with wavy thickenings.

Abdomen about as wide as thorax, last three segments tapering abruptly; tube slender and about two-thirds as long as head; terminal hairs as long as tube. The abdomen is brown and red, unicolorous with the thorax and head. Each posterior angle of all segments except the first bears a stout, transparent, knobbed hair, these increasing in length from the second to and including the ninth. Other smaller hairs are also found on the prominent angles.

Described from one female; male unknown.

Food plant: Apricot.

Habitat: Santa Clara Valley, California.

(21) **Trichothrips femoralis**, new species. (Pl. V, fig. 44; Pl. VI, figs. 45, 46.)

Measurements: Head, length 0.21 mm., width 19 mm., prothorax, length 0.20 mm., width 0.33 mm. (including coxa); mesothorax width 0.38 mm.; abdomen, width 0.40 mm.; tube, length 0.16 mm.; total body, length 1.7 mm. Antennæ: 1, 33μ; 2, 48μ; 3, 66μ; 4, 66μ; 5, 66μ; 6, 63μ; 7, 63μ; 8, 48μ; total, 0.52 mm. *Color* uniform dark-brown, except fore tibiæ and tarsi and segments of antennæ, 3 to 6 inclusive, which are yellow; middle and hind tarsi light brown. Orange-colored pigment may be seen in lighter colored specimens.

Head slightly longer than wide, rounded in front; frons elevated between basal segments of antennæ; cheeks almost straight and parallel; margins roughened; back of head with cross striations. Postocular spines prominent; other small spines not conspicuous. *Eyes* occupying about one-third the length of the head, with small facets, not pilose; with light, irregular, orange-tinted inner borders and light lemon-yellow narrower outer borders. *Ocelli* present, anterior one on apex of head, posterior ones orange-tinted and contiguous, with light inner borders of eyes. *Mouth cone* small, no longer than width at base, tip bluntly pointed; rudimentary chitinous thickening on either side about halfway between base of cone and eyes, equally well developed on both sides. *Antennæ* eight-segmented, slightly more than twice as long as head; basal segment brown; 2 brown, shading to yellow; 3 to 6 inclusive are yellow, with 5 and 6 shading to gray-brown at tips; 7 and 8 brown. Dark-brown area on inner margin of segment 2 probably a sense area; simple sense cones on segments 3 to 8.

Prothorax almost as long as head and about one-third wider than long; it bears ten prominent spines, a pair on anterior margin, one on each anterior angle, one midway on each side, and two on each posterior angle. Sides of *mesothorax* almost parallel and united evenly with the sides of the metathorax, which latter converge posteriorly. The *fore coxæ* are protruding and form what appear to be the prominent sides of the prothorax; each is tipped with a long spine. Fore femora enlarged; fore tarsi each armed with a very small tooth. *Wings* reaching nearly to base of tube, both pairs similar, clear white, with a long simple fringe on both anterior and posterior margins.

Abdomen about equal or slightly wider than the mesothorax; segments 2 to 7 inclusive taper uniformly, with hind angles prominent. Abdomen uniform brown with the thorax and head; red pigment conspicuous. Segments 1 to 7 each with two long spines on each side near posterior margin, the outer ones in each case appearing as the spine on the outer prominent angle; the spines approach each other and the margin on segments 7, 8, and 9 to form a pair on the prominent angles. Segments 1 to 7 have each two pairs of strong, incurved spines at about one-fourth the width of the abdomen from the margin and in each case the hinder pair is the stouter; these spines function in holding the wings when at rest. Tip of tube bears six long spines about as long as the tube itself, and several shorter ones. Scales present on last segments of females.

Males are similar to females in most respects, but possess the very greatly enlarged fore femora and do not have scales on the last abdominal segments.

Described from one female and two males.

Food plant: Wild mullein.

Habitat: Newcastle, Cal.

(22) **Trichothrips ilex**, new species. (Pl. VI, figs. 47–49.)

Measurements: Head, length 0.21 mm., width 0.20 mm.; prothorax, length 0.13 mm., width, including coxa, 0.32 mm.; mesothorax, width 0.38 mm.; abdomen, width 0.50 mm., length of tube 0.16 mm.; total length of body 1.70 mm. Antennæ: 1, 30μ; 2, 51μ; 3, 60μ; 4, 60μ; 5, 60μ; 6, 54μ; 7, 54μ; 8, 30μ; total, 0.35 mm. *Color* very dark brown, almost black; all tarsi and tips of fore tibiæ and segments 3 and 4 of antennæ shading to yellow.

Head about as long as wide, broadly rounded in front, frons projecting between basal segments of antennæ; cheeks slightly convex, and with edges roughened, back of head with transverse striations. Postocular spines prominent. *Eyes* medium, with small facets, not protruding, not pilose, with light-yellow outer margin and a light, irregular inner border. *Ocelli* present, granulated, anterior one on apex and posterior ones bordering inner margins of eyes. *Mouth cone* about as broad as long, reaching nearly to posterior margin of prosternum, pointed at tip; chitinous thickenings between base of mouth-cone and eyes very rudimentary and about equally well developed. Maxillary palpi two-segmented; basal segment very small, second segment long. Labial palpi two-segmented, basal segment shortest. *Antennæ* eight-segmented, about twice as long as head; color brown, except segment 3 and basal parts of segments 4, 5, and 6, which are yellow. Segment 2 with darkened sense area on dorsal surface; 3 to 7 have simple sense cones; 7 and 8 have a row of sense hairs.

Prothorax about twice as wide as long; it bears ten long spines, two on anterior margin, one on each anterior angle, one near middle of each side, and two at each posterior angle. Sides of *pterthorax* slightly convex, converging both anteriorly and posteriorly. Fore coxæ apparently immovably set and forming the outer angles of the prothorax; fore femora somewhat enlarged; all tarsi with a brown spot at tip and armed with a small tooth. *Wings* reaching nearly to tip of eighth segment, both pairs similar; first pair light brown, hind pair gray; each with a long, simple fringe on both margins; tip of fore wing double fringed behind by about twelve hairs; with three prominent spines at base and a wavy thickening near anterior margin at base; wings without veins.

Abdomen broadly ovate, segments 1 to 7 inclusive about equal; eighth tapering abruptly to meet the smaller ninth and very narrow tenth; segments with two long and several shorter spines on prominent angles, these spines increasing in length toward the tip. Segments 1 to 7 each with two pairs of inwardly curved spines about one-fourth the width of the abdomen from the margin; the posterior pair in each case is the larger. Tip of tube bears six long and several short hairs. Females with scales on last segments of abdomen.

Described from numerous specimens.

Male similar to female, but without scales on abdomen.

Food plant: Christmas berry (*Heteromeles arbutifolia*).

Habitat: Coast region of California.

(23) **Trichothrips ilex dumosa**, new variety.

The members of this variety are very similar to the species, differing only in minor details. The two insects are about equal in size; the head is somewhat longer in *T. ilex dumosa*, the antennæ are brown, with only the base of segment 3 yellow; all tarsi are gray-brown to brown. The food plant is the scrub oak, *Quercus dumosa*.

Habitat.—Saratoga, Santa Clara County, Cal.

9. Genus ACANTHOTHRIPS Uzel.

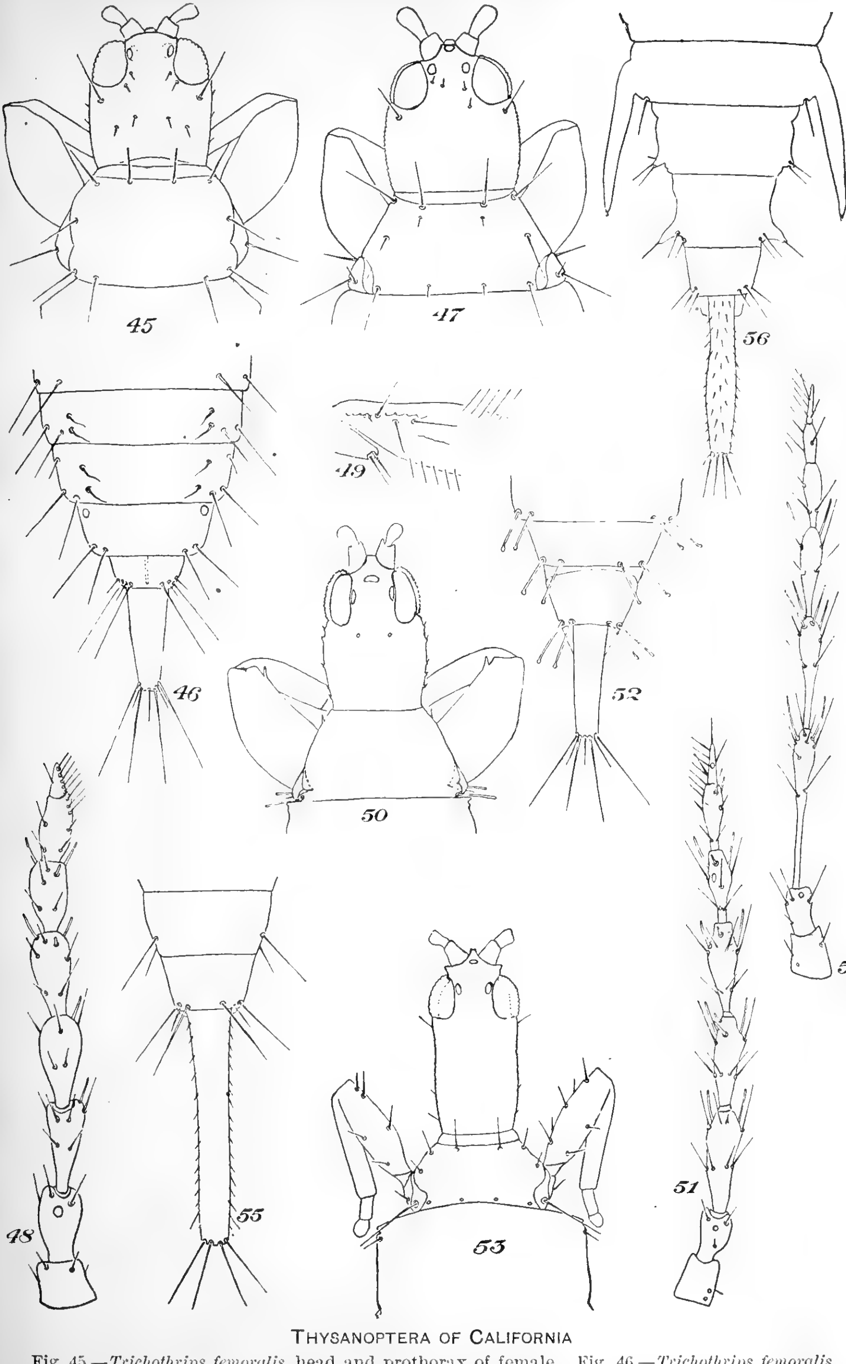
(24) **Acanthothrips doaneii**, new species (Pl. VI, figs. 50–52.)

Measurements.—Head, length 0.37 mm., width 0.25 mm.; prothorax, length 0.20 mm., width, including protruding coxa, 0.45 mm.; mesothorax, width 0.50 mm.; abdomen, width 0.50 mm.; tube, length 0.28 mm.; total body, length 2.4 mm. Antennæ: 1, 48μ; 2, 69μ; 3, 126μ; 4, 120μ; 5, 114μ; 6, 81μ; 7, 78μ; 8, 45μ; total, 0.633 mm. *Color* very dark brown, except tips of tibiæ, tarsi, and basal and distal parts of segments 3 to 6, inclusive of antennæ, these parts shading to yellow.

Head about one-third longer than wide; cheeks converging posteriorly; frons elevated between basal segments of antennæ; back of head with cross striations, roughened and set with small spines raised on conspicuous tubercles. *Eyes* large, slightly bean-shaped, not pilose, finely faceted, each with an orange-colored inner border and a light lemon-yellow, uniform outer border. *Ocelli* present, anterior one near apex of head, posterior ones contiguous with central concave portions of inner margins of eyes. *Mouth cone* pointed, reaching almost to posterior margin of prosternum. *Antennæ* eight-segmented, scarcely twice as long as head; segments 1, 2, 7, and 8 dark brown, 3 to 6 inclusive brown, shading light brown or yellow at either end; segment 1 cylindrical; 2 subclavate, 3 to 6 inclusive constricted to broad stalks at base, and constricted abruptly at their distal ends where they receive sense cones, two on segments 3 and 7, three (one rudimentary) on 5 and 6, four (two rudimentary) on segment 4.

Prothorax about twice as wide as long, reticulate, bearing a single pair of short spines on anterior angles and a long pair of knobbed hairs on posterior angles; surface faintly covered with short inconspicuous hairs. *Mesothorax* with front margin almost straight, projecting beyond sides to form a short, rounded shelf where the segment is widest; sides almost parallel, constricted after the middle, posterior angles rounded. *Metathorax* with sides evenly convexed, roughened, and reticulate; mesonota and metanota also reticulate. *Fore coxæ* protruding beyond and not readily distinguished from sides of prothorax; fore femora greatly enlarged and armed on inner margin of distal part with a stout tooth, each fore tarsus also armed with a tooth; other legs long and slender. *Wings* fully developed, both pairs alike, with regular fringe of long, closely arranged hairs on either margin; a wavy thickening along anterior margin at base of fore wing, upon which stand one long and two short knobbed hairs; distal anal wing margin double fringed with about twenty-four hairs.

Abdomen about as wide as mesothorax and slightly wider than the metathorax. Sides of segments 1 to 5 almost equal and parallel, other segments tapering gradually to meet the tube; a pair of knobbed hairs on each prominent angle; tip of tube bears six long and several short hairs.



THYSANOPTERA OF CALIFORNIA

Fig. 45.—*Trichothrips femoralis*, head and prothorax of female. Fig. 46.—*Trichothrips femoralis*, end of abdomen of female. Fig. 47.—*Trichothrips ilex*, head and prothorax of female. Fig 48.—*Trichothrips ilex*, left antenna of female. Fig. 49.—*Trichothrips ilex*, base of right fore wing of female. Fig. 50.—*Acanthothrips doaneii*, head and prothorax of male. Fig. 51.—*Acanthothrips doaneii*, left antenna of male. Fig. 52.—*Acanthothrips doaneii*, end of abdomen of male. Fig. 53.—*Megalothrips hesperus*, head and prothorax of female. Fig. 54.—*Megalothrips hesperus*, right antenna of female. Fig. 55.—*Megalothrips hesperus*, end of abdomen of female. Fig. 56.—*Megalothrips hesperus*, end of abdomen of male.

Described from one male.
Food plant: Grass.
Habitat: Alum Rock Canyon, Cal.

10. Genus MEGALOTHRIPS Heeger.

(25) **Megalothrips hesperus,** new species. (Pl. VI, figs. 53–56.)

Measurements: Head, length 0.58 mm., width 0.26 mm.; prothorax, length 0.25 mm., width 0.46 mm.; metathorax, width 0.83 mm.; abdomen, width 1 mm.; tube, length 0.83 mm., width 0.11 mm.; total body, length 4.66 mm. Antennæ: 1, 75μ; 2, 84μ; 3, 315μ; 4, 234μ; 5, 195μ; 6, 102μ; 7, 75μ; 8, 90μ; total, 1.17 mm. *Color* dark brown, with orange or red pigment; all tibiæ and tarsi shaded to yellow; bases of antennal segments 3, 4, 5, and 6 are lemon-yellow.

Head more than twice as long as wide, greatest width across eyes; cheeks roughened, almost parallel, slightly concave close behind eyes, constricted at union with prothorax; frons elevated between bases of first segments of antennæ; back of head transversely striate and with a few short spines set on very small tubercles. *Eyes* large, with conspicuous light-yellow outer borders; with small facets and very faintly pilose. *Ocelli* present, anterior one on apex of head, posterior ones contiguous, with indistinct, light inner margins of eyes. *Mouth cone* broad and short, with blunt tip, and reaching hardly halfway across prosternum. Maxillary palpi two-segmented, basal segment very short; labial palpi very small. *Antennæ* eight-segmented, about twice as long as head; segments 1, 2, 7, and 8, and tips of 4, 5, and 6 brown; tip of 3 light-brown; segment 3 with a long, narrow stalk; segments 4 and 5 similar, but with shorter stalks. Darkened sense area on segment 2; one sense cone on segment 6, two on segments 3 and 5, four on 4, and a row of sense hairs on segment 8.

Prothorax about one-half wider than long, transversely striate; it bears six prominent spines, two on anterior margin, a pair on anterior angles, and a larger pair on the posterior angles. *Mesothorax* with prominent, square, anterior angles; sides almost straight and parallel, with edges roughened, united evenly with metathorax. *Metathorax* with posterior angles broadly rounded. *Legs* long and slender; all femora dark-brown; tibiæ yellow, shaded with brown near the middle; tarsi yellow tipped with brown; trochanters with red pigment. All legs armed with long, stout, yellow spines; these are especially prominent on femora; fore coxæ protruding, forming the prominent angles of the prothorax. *Wings* present, reaching to tip of fourth abdominal segment; membrane white; both pairs with long, simple anterior and posterior fringes of closely arranged hairs; anterior wings double fringed along their posterior distal margin for about half their length; each wing with a single rudimentary vein.

Abdomen with segments 2, 3, and 4 widest and about equal; other segments tapering evenly to base of tube. Tube long and slender and about seven times as long as wide. Segments 2 to 7, inclusive, each closely transversely striate, with a dark transverse line near anterior border. Intersegmental membrane brown, with net structure. When the abdomen is distended the connecting tissue is almost as wide as the segment itself. Segments each with two or three prominent spines on angles.

Male: Head, length 0.58 mm., width 0.23 mm.; prothorax, length 0.23 mm., width 0.42.; metathorax, width 0.73 mm.; abdomen, width 0.72 mm.; tube, length 0.63 mm., width 0.10 mm.; clasper, length 0.66 mm.; total body, length 4.66 mm. As long but somewhat smaller than female. Wings present. A long tube-like clasper projects from either side of segment 6; this is black at the base and shades to yellow-brown, and on the tip it bears a short bulb-like hair. Segments 7 and 8 each have a similar though smaller side projection near the posterior edge; the pair on segment 8 is the larger and is thumb-shaped. Scales present, tube tipped with eight long, clear lemon-yellow hairs and several smaller ones. Posterior half of abdomen and the tubes are very dark brown.

Described from two females and one male.

Food plant: Unknown.

Habitat: Stanford University, Cal.

11. Genus CRYPTOTHRIPS Uzel.

(26) **Cryptothrips californicus** Daniel.

Measurements: Head, length 0.26 mm., width 0.16 mm.; prothorax, length 0.15 mm., width, including prominent coxa, 0.25 mm.; mesothorax, width 0.33 mm.; abdomen, width 0.38 mm.; total body, length 1.7 mm. Antennæ: 1, 24μ; 2, 51μ; 3, 75μ; 4, 69μ; 5, 51μ; 6, 45μ; 7, 42μ; 8, 27μ; total, 0.35 mm. General *color* black, often dark brown under the microscope, with purple pigment.

Head cylindrical, one and one-half times as long as wide; front of head strongly prominent between basal segments of antennæ; sides almost straight and parallel, roughened, converging only slightly posteriorly; back of head transversely striate; head without conspicuous spines, except a single one posterior to each eye. *Eyes* large, prominent, but not protruding, with rather small facets; not pilose. *Ocelli* situated far forward, anterior one on tip of prominent apex. *Mouth cone* broad at base, short, reaching only a little past the middle of the pronotum; maxillary palpi three-segmented and quite long and slender. *Antennæ* with eight segments, separated at base by prominent prolonged vertex; segments 1 and 2 dark brown, unicolorous with head, 3 and base of 4 yellow, others shading brown toward the tip.

Prothorax small, about as long as width of head; sides straight, but extending outward posteriorly, with a prominent blunt spine on each hind angle; the protruding fore coxæ form what appear to be the prominent angles. *Pterthorax* hardly as wide as abdomen, sides almost straight, narrowed abruptly in front, gradually behind. *Legs* long and slender and unicolorous with body; fore coxæ greatly enlarged. *Wings* extending to seventh abdominal segment; both pairs alike, clear white and with long simple fringe on both anterior and posterior margins, excepting fore wings at tips, which are double fringed behind by about six hairs.

Abdomen long and slender; it tapers gradually from second to eighth segments; the ninth segment is small; the tenth, the tube, is very small and slender. Hairs on prominent angles of segments 7, 8, and 9 long and slender; several long and several shorter ones on end of tube. Protruding scales on last abdominal segments of males.

Males similar to but usually somewhat smaller than the females.

Redescribed from many specimens. For original description see Entomological News, 1904, page 293.

This thrips has been found almost exclusively under the old shells of the brown apricot scale (*Lecanium armeniacum* Craw) and the black scale (*Saissetia oleæ* Bern.) and probably feeds on the remains of the old scales.

Habitat: Central and southern California.

LIST OF CALIFORNIA THYSANOPTERA AND THEIR FOOD PLANTS.

Species.	Food plants.
(1) *Orothrips kelloggii*, new species	Manzanita and madroña blossoms.
(2) *Æolothrips kuwanaii*, new species	California lilac (*Ceanothus thyrsiflorus*).
(3) *Æolothrips kuwanaii*, variety *robustus*	(Found on apricot tree.)
(4) *Sericothrips apteris* Daniel	Grass.
(5) *Sericothrips reticulatus*, new species	Grass.
(6) *Sericothrips stanfordii*, new species	Grass.
(7) *Heliothrips hæmorrhoidalis* Bouché	Azaleas, ferns, dahlias, cherry laurel, laurestina.
(8) *Heliothrips fasciatus* Pergande	Oranges, pea vines, wild vetch.
(9) *Euthrips orchidii*, new species	Orchids.
(10) *Euthrips pyri* Daniel	Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts.
(11) *Euthrips ehrhornii*, new species	Grass.
(12) *Euthrips ulicis californicus*, new variety	Vetch.
(13) *Euthrips minutus*, new species	Grass.
(14) *Euthrips occidentalis* Pergande	Most wild and cultivated flowers.
(15) *Euthrips tritici* Fitch	Grass, alfalfa, California sage (*Artemisia californica*), manzanitas (especially *Arctostaphylos tomentosa*), oranges, roses, lilacs, etc.
(16) *Parthenothrips dracænæ* Heeger	Dracæna.
(17) *Thrips madronii*, new species	Blossoms of madroña, California laurel, and California lilac.

Species.	Food plants.
(18) *Thrips tabaci* Lindeman	Wild and cultivated flowers, onion.
(19) *Thrips bremnerii*, new species	Figs.
(20) *Trichothrips dens*, new species	Apricot.
(21) *Trichothrips femoralis*, new species	Wild mullein.
(22) *Trichothrips ilex*, new species	Christmas berry (*Heteromeles arbutifolia*).
(23) *Trichothrips ilex dumosa*, new variety	Scrub oak (*Quercus dumosa*).
(24) *Acanthothrips doaneii*, new species	Grass.
(25) *Megalothrips hesperus*, new species	Unknown.
(26) *Cryptothrips californicus* Daniel	Unknown (This species has been found under the old shells of the brown apricot scale (*Lecanium armeniacum* Craw) and the black scale (*Saissetia oleæ* Bern.) and probably feeds on the remains of the old scales.)

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TECHNICAL SERIES No. 12, PART IV. (Supplement to Technical Series No. 1.)

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

NEW GENERA AND SPECIES OF APHELININÆ,

WITH A

REVISED TABLE OF GENERA.

By L. O. HOWARD, PH. D.

ISSUED JULY 12, 1907.

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1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 9, 1907.

Sir: I have the honor to transmit the manuscript of a paper concerning certain important parasites of scale insects, which, on account of its technical character, I recommend for publication as Part IV of Technical Series No. 12 of this Bureau.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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U. S. D. A., B. E. Tech. Ser. 12, Pt. IV. Issued July 12, 1907.

MISCELLANEOUS PAPERS.

NEW GENERA AND SPECIES OF APHELININÆ, WITH A REVISED TABLE OF GENERA.

By L. O. Howard, Ph. D.

INTRODUCTION.

Technical Series, No. 1, published in June, 1895, comprised a consideration of the Aphelininæ of North America, together with some mention of the insects of this group found in other parts of the world. In that publication the species of thirteen genera were considered, and twenty-six species were described. The economic importance of the group was pointed out and tables of host relations were printed. It was shown that economically these minute parasites are by far the most important of the parasites of the Diaspinæ, and in the twelve years that have elapsed since the publication of the bulletin their economic importance has become even more evident. It is claimed in California that the San Jose scale is held in subjection by these creatures, and in point of fact observations by Johnson and others in the East have shown that under certain conditions *Aphelinus fuscipennis* How. may multiply to such an extent as to produce a very high percentage of parasitism of this scale insect. Whether these parasites in the eastern United States will ever become as effective as in California, however, seems doubtful, on account of the longer breeding season on the Pacific coast, and as a matter of fact the opportunity to test the question does not exist, so universal and so effective has become the use of the lime-sulphur sprays in the eastern States.

In the twelve years since the publication of Technical Series, No. 1, many different species of Aphelininæ have been reared in one part of the world or another, and most of them have been referred to the writer for study. Very few, however, have been described; these are as follows:

Myiocnema (n. g.) pallida Ashmead. Canadian Entomologist, XXXII, No. 11, Nov., 1900, p. 349. Reared by A. Craw from *Saissetia oleæ* Bernard (*Lecanium oleæ*), collected by Geo. Compere, Brisbane, Queensland.

Aphelinus simplex Zehntner. Med. v. h. Proefst. Oost-Java, n. s., No. 36, 1897, pp. 19–20, Pl. I, figs. 18, 19. Reared by L. Zehntner, Java, from *Chionaspis sacchari-folii* Zehntner.

Encarsia planchoniæ Howard. Proc. U. S. Nat. Mus., XVIII, No. 1092, 1896, pp. 635–636. Reared by E. Ernest Green, Punduloya, Ceylon, from *Asterolecanium delicatum* Green (*Planchonia delicata*).

Encarsia aonidiæ Howard. Ibid., p. 636. Reared by E. Ernest Green, Punduloya, Ceylon, from *Aonidia corniger* Green.

Encarsia flaviclava Howard. Journ. Linn. Soc. Lond., XXV, 1894, No. 97. Collected on St. Vincent, B. W. I., by H. H. Smith.

Coccophagus orientalis Howard. Proc. U. S. Nat. Mus., XVIII, No. 1092, 1896, pp. 633–634. Reared by E. Ernest Green, Punduloya, Ceylon, from *Ceroplastes actiniformis* Green, *Coccus viridis* Green (*Lecanium viride*), *Saissetia hemisphærica* Targioni Tozzetti (*Lecanium coffeæ* Signoret), and *Pseudococcus longispinus* Targioni Tozzetti (*Dactylopius adonidum*).

Coccophagus flavescens Howard. Ibid., p. 634. Reared by E. E. Green, Punduloya, Ceylon, from *Saissetia hemisphærica* Targioni Tozzetti (*Lecanium coffeæ* Signoret).

Coccophagus fletcheri Howard. Bul. 7, n. s., Div. Ent., U. S. Dept. Agric., 1897, p. 63. Reared by J. Fletcher from *Eulecanium fletcheri* Cockerell, Ottawa, Canada.

Prospalta tristis Zehntner. Med. v. h. Proefst. Oost-Java, n. s., No. 29, 1896, pp. 11–12, pl., figs. 17–21. Reared by L. Zehntner from *Aleyrodes bergi* on sugar cane.

Prospalta berlesei Howard. Ent. News, XVII, No. 8, Oct., 1906, pp. 291–293. Reared by A. Berlese, Florence, Italy, from *Diaspis pentagona* Targioni Tozzetti, received from Washington, D. C., U. S. A.

Ablerus aureonotus Howard. Journ. Linn. Soc. Lond., XXVI, 1896, p. 157. Captured by H. H. Smith, Balthazar, Grenada, B. W. I.

Ablerus (Azotus) pulchriceps Zehntner. De plantenluizen van het suikerriet op Java, VIII, IX. (Med. v. h. Proefst. West-Java, No. 38, 1899, pp. 10–11, Pl. II, figs. 15–17.) Reared by L. Zehntner on *Aleyrodes* on sugar cane, Java. Belongs to *Azotus* Howard.

Physcus flavidus Zehntner. De plantenluizen van het suikerriet op Java. (Med. v. h. Proefst. West-Java, No. 37, 1898, pp. 5–7, pl., figs. 11–16.) Reared by L. Zehntner, Java, from *Chionaspis madiunensis* Zehntner.

Aneristus (n. g.) ceroplastæ Howard. Can. Ent., XXVII, No. 12, 1895, p. 351. Reared by T. D. A. Cockerell, Jamaica, B. W. I., from *Ceroplastes* sp. on *Euphorbia hypericifolia*.

Azotus (n. g.) marchali Howard. Proc. Ent. Soc. Wash., IV, No. 2, 1898, pp. 138–139. Reared by Paul Marchal, at Paris, France, from *Epidiaspis piricola* Del Guercio (*Diaspis ostreæformis* Signoret); and by W. M. Maskell, from *Aspidiotus hederæ* Vallot (*Aspidiotus nerii* Bouché), Sidney, N. S. W.

Archenomus (n. g.) bicolor Howard. Ibid., pp. 137–138. Reared by Paul Marchal, Paris, France, from *Epidiaspis piricola* Del Guercio (*Diaspis ostreæformis* Signoret).

The present paper comprises a description of twenty new species and five new genera. Nearly all of these were received from other parts of the world, but some of them have no doubt already been established in this country. In fact, in looking over the material that has accumulated since the publication of Technical Series No. 1, it becomes obvious that the Aphelinine fauna of the United States, particularly of the eastern United States, has been undergoing a change. Species that were abundant eight or twelve years ago have become scarce, and introduced species have taken their places. It is indeed difficult to decide whether any of our Aphelininæ are natives of the United States. The introduction of plants from abroad, including very many different kinds of hothouse plants bearing scale insects, has resulted in the introduction not only of new scale insects, but of a number of species of scale-insect parasites. These parasites have undoubtedly in some instances attacked native scale insects and have increased in number. It seems very possible that *Coccophagus lecanii* Fitch and *Aphelinus mytilaspidis* Le Baron are native species. The same, too, is probably the case with *Eretmocerus corni* of Haldeman, but it seems probable that of the remaining species the great majority are of foreign origin.

In order to facilitate the recognition of genera, the descriptions of the new forms contained in this paper are prefaced by a catch table of genera. This table applies only to females. The males of many genera are not known, and as a rule females are reared in infinitely greater abundance than males, affording a strong suspicion that alternation of generations accompanied by parthenogenesis may hold with a number of the species. With the present paper and with Technical Series No. 1, and particularly where the observer has access to von Dalla Torre's catalogue, there should be no very great difficulty in recognizing described species and in deciding whether species reared have been described.

Subfamily APHELININÆ Howard.

Table of Tribes.

Tarsi 5-jointed [a] ________ Tribe I. *Aphelinini* Ashmead.
Tarsi 4-jointed ________ Tribe II. *Pteroptricini* Ashmead.

Tribe I. APHELININI.

Table of Genera

Females.

1. Fore wings with an obliquely transverse hairless line below stigma ______ 2
   Fore wings without such an oblique hairless line ______ 8
2. Antennæ 4-jointed ______ 3
   Antennæ 6-jointed ______ 4
   Antennæ 7-jointed ______ 7
3. Scape long, slender; pedicel swollen; funicle joint very minute; club long and broad ______ *Marlattiella*, new genus.
4. Ovipositor exserted to from one-fifth to one-third length of abdomen ______ 5
   Ovipositor not at all or but slightly exserted ______ 6

[a] In the middle tarsi of *Encarsia luteola* and *E. quaintancei* the 2 terminal segments of the middle tarsi have coalesced, making them appear 4-jointed.

5. Notal sclerites normal, wings hyaline ---------- *Centrodora* Foerster.
Mesopostscutellum acutely triangular, fore wings with an irregular pattern of dark lines or spots ---------- *Perissopterus* Howard.
6. Wings hyaline, or with a slight fuscous patch, eyes naked - *Aphelinus* Dalman
7. Antennal club 3-jointed, the 2 funicle joints longer than broad and subequal in length ---------- *Mesidia* Foerster.
8. Antennæ 6-jointed ---------- 9
Antennæ 7-jointed ---------- 10
Antennæ 8-jointed ---------- 13
9. Antennæ with a scape, pedicel, 3 ring joints (funicle), and a moderately long club ---------- *Thysanus* Haliday.
(*Plastocharis* Foerster.)
10. Club 1-jointed; ovipositor extruded to one-half length of abdomen ---------- 11
Club 2-jointed; ovipositor scarcely extruded ---------- 12
11. Stigmal vein squarely truncate at tip ---------- *Ablerus* Howard.
Stigmal vein with a swollen and rounded tip ---------- *Azotus* Howard.
12. First funicle joint shorter than second and third ---------- *Physcus* Howard.
13. Antennal club 2-jointed ---------- 14
Antennal club 3-jointed ---------- 15
14. Hind tibiæ armed with very stiff black bristles ---------- *Myiocnema* Ashmead.
Hind tibiæ not so armed ---------- *Encarsia* Foerster.
15. Stigmal vein lacking; wings with a very long fringe.
Aspidiotiphagus Howard.
Stigmal vein present; marginal cilia comparatively short ---------- 16
16. Marginal vein shorter than submarginal ---------- *Prospalta* Howard.
Marginal vein as long as or longer than submarginal ---------- 17
17. Antennal scape short, flagellum strongly flattened; hind tibiæ flattened and with a row of short bristles above ---------- *Aneristus* Howard.
Antennal scape not especially short, flagellum subcylindrical; hind tibiæ normal ---------- *Coccophagus* Westwood.

Tribe II. PTEROPTRICINI.

Table of Genera.

Females.

1. Antennæ 5-jointed ---------- 2
Antennæ with more than 5 joints ---------- 3
2. Funicle joints 1 and 2 ring joints ---------- *Eretmocerus* Haldeman.
Funicle joint 1 very short; joint 2 slender, four times as long as joint 1.
Cales, new genus.
3. Antennæ 7-jointed ---------- 4
Antennæ 6-jointed ---------- 5
Antennæ 8-jointed ---------- 6
4. Tarsal joints of middle leg short and subequal in length; middle tibial spur as long as first two tarsal joints together ---------- *Casca*, new genus.
First tarsal joint of middle leg as long as joints 2 and 3 together; middle tibial spur not quite as long as first tarsal joint ---------- *Bardylis*, new genus.
5. Club of antenna 3-jointed, joints subequal in length; only one funicle joint.
Artas, new genus.
Club of antenna 2-jointed; wings spotted ---------- *Marietta* Motschulsky.
6. Club 3-jointed; funicle joints 1 and 2 very short, 3 longer than 1 and 2 together and much wider than either ---------- *Pteroptrix* Westwood.
Club apparently 2-jointed; funicle joints 1 and 2 very short, 3 and 4 each longer than 1 and 2 together ---------- *Archenomus* Howard.

Genus **MARLATTIELLA**, new genus.

Female.—Tarsi 5-jointed. Wings with an oblique hairless streak extending from stigma backward to near base of wing; the disc otherwise uniformly and rather densely ciliate; marginal vein much longer than submarginal; stigmal evident and plainly furnished with a rounded knob at tip; fore wing obtusely rounded at tip. Antennæ 4-jointed; scape inserted near mouth border, long, slender, reaching to top of head; pedicel considerably swollen, longer than broad; the single funicle joint very small, almost like a ring joint and rather oblique; club long and broad, rather blunt at apex, longer than scape, pedicel, and funicle together, and with sparse longitudinal striations. Axillæ of mesoscutum very narrow. Middle tarsi with first joint nearly as long as second and third together; middle tibial spur about as long as corresponding first tarsal joint. Hind tarsi longer than middle tarsi. Ovipositor somewhat extruded. Eyes hairy.

Male.—Unknown.

Type.—The following species:

Marlattiella prima, new species. (Fig. 13.)

Female.—Length 0.84 mm.; expanse 1.54 mm.; greatest width of fore wing 0.24 mm. General color dull orange-yellow; eyes reddish brown; ocelli carmine; closed mandibles dusky; all legs uniformly light yellow. Wings hyaline, veins faintly dusky.

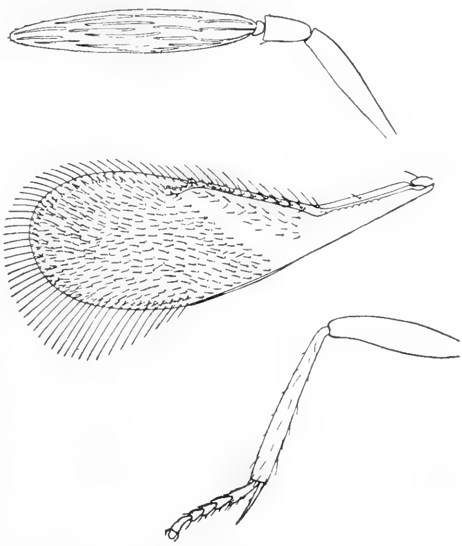

FIG. 13.—*Marlattiella prima:* Antenna, fore wing, and middle leg of female. Greatly enlarged (original).

Male.—Unknown.

Type.—No. 10297, U. S. National Museum. Described from 10 female specimens bred from *Leucaspis japonica* Cockerell, collected by C. L. Marlatt, October 11, 1901, at Tientsin, China, on a "bush with variegated foliage," possibly a *Croton*.

Genus **MESIDIA** Foerster.

Mesidia Foerster. Hymenopterologische Studien, Heft II, 1856, p. 30.

This genus, hitherto known only through Foerster's brief characterization, is intermediate between *Aphelinus* and *Coccophagus*, having the oblique hairless line on the fore wing, extending from stigma to near base of wing, of *Aphelinus* and having the three joints before the club of the antennæ of equal length, as with *Coccophagus*. Other female generic characters may be derived from the new species described below. The ovipositor is strong and well extruded. The femora are slightly swollen. The antennal club is ovate and flattened; funicle joints 1, 2, and 3 subequal in width and each somewhat shorter than the basal joint of the club; pedicel triangular, rather broader and longer than first funicle joint; club with sparse longitudinal striæ, as in *Coccophagus*. Eyes densely hairy, but with very

FIG. 14.—*Mesidia mexicana:* Female. Greatly enlarged (original).

short hairs. Marginal vein of fore wings as long as submarginal; stigmal obscure and almost lacking.

Type.—The following species:

Mesidia mexicana, new species. (Fig. 14.)

Female.—Length 0.68 mm.; expanse 1.4 mm.; greatest width of fore wing 0.24 mm. General color dark brown, nearly all of mesoscutellum except anterior border yellowish; all coxæ, femora, and antennæ brownish; tibiæ and tarsi whitish; wing veins dusky. All of mesonotum, except light portion of scutellum, finely and closely aciculate, as is also the mesoscutum.

Type.—No. 10298, U. S. National Museum. Described from 9 female specimens reared from an *Aleyrodes* collected on "Palo de Gusano" by C. H. T. Townsend at S. Francisco del Peal, Tabasco, Mexico, July 1, 1887.

Genus AZOTUS Howard.

Azotus Howard. Proc. Ent. Soc. Wash., Vol. IV, No. 2, 1898, pp. 138–139.

This interesting genus was described in the male sex only in the Proceedings of the Entomological Society of Washington, Vol. IV,

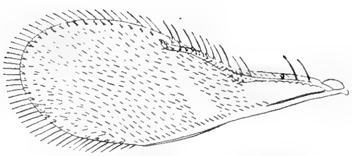

FIG. 14, correction.—The figure of *Mesidia mexicana* (entire insect) is incorrect in that it does not show the "oblique hairless line on the fore wing, extending from stigma to near base of wing." This is shown correctly in the above figure of the fore wing of the insect.

No. 2 (1898), pp. 138–139, the type species being *A. marchali* Howard reared by Dr. Paul Marchal at Paris from *Epidiaspis piricola* Del Guercio (*Diaspis ostreæformis* Signoret) and subsequently by W. M. Maskell from *Aspidiotus hederæ* Vallot (*Aspidiotus nerii* Bouché) received from Sydney, N. S. W.

Of the species described below a good series of females is before the writer and the following generic characterization of the female is therefore presented:

Female.—Ovipositor apparently normally extruded to from one-third to one-half the length of abdomen. Antennæ 7-jointed, there being no suture dividing the club into the two segments of which it is evidently homologically composed. (In the original description of the male antenna it was called 8-jointed, although no true suture

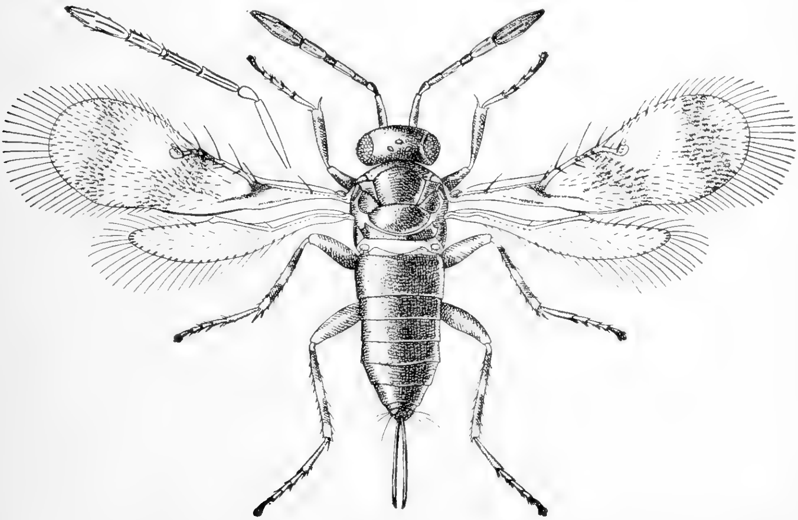

FIG. 15.—*Azotus capensis:* Female, and antenna of male. Greatly enlarged (original.)

occurs with the club in that sex.) Club nearly as long as last 3 funicle joints together; funicle joints 1, 2, and 4 nearly equal in length, 1 rather the shorter of the three; funicle joint 3 much shorter, although not so disproportionately short as in the male. All tarsi 5-jointed: joint 1 nearly as long as the others together; middle tibial spur about half as long as first tarsal joint. Marginal vein of fore wings not as long as submarginal; marginal cilia not especially long.

Azotus capensis, new species. (Fig. 15.)

Female.—Length 0.9 mm.; expanse 1.8 mm.; greatest width of fore wing 0.24 mm. General color black, with greenish metallic reflections on notum; antennæ brown, with base and tip of scape, tip of pedicel, and all of funicle joints 2 and 4 nearly white; all coxæ and femora brown, femora light at tips; trochanters white; front tibiæ brown, light at tips; middle and hind tibiæ nearly white, with two brown bands; front tarsi light brown, terminal joint dark brown; middle and hind tarsi nearly white, the last joint brown. Eyes crimson. Marginal vein of fore wings brown; wings hyaline, with a transverse brown patch below marginal vein and another one nearer tip of wing; an oblique shade at point where submarginal vein turns upward to costa.

Male.—Length 0.6 mm.; expanse 1.8 mm.; greatest width of fore wing 0.24 mm. Antennæ uniformly light brown. Legs as in female, except that middle and hind tibiæ are uniformly brown, light at extremities, and that all tarsi are brownish. In the fore wings the brown shade below the marginal vein is present, but the outer brown shade is much fainter.

Type.—No. 10299, U. S. National Museum. Described from 12 male and 17 female specimens bred from an *Asterolecanium* on *Euryops tenuissimus*, Cape of Good Hope, South Africa, by C. P. Lounsbury, October, 1898.

NOTE.—*Ablerus pulchriceps* Zehntner (De Plantenluizen van het suikerriet op Java, VIII, IX, pp. 10, 11, Plaat ii, figs. 15, 16, 17), reared from *Aleyrodes longicornis* Zehntner in Java, belongs to this genus and greatly resembles this species, judging from Zehntner's well-drawn figures.

Genus **ENCARSIA** Foerster.

Encarsia Foerster. Kleine Monographien, 1878, pp. 65–66. (Type, *Encarsia tricolor* Foerster.)

TABLE OF SPECIES.

Females.

1. Tarsi of middle legs 4-jointed; joints 4 and 5 apparently coalesced ------- 2
   Middle tarsi plainly 5-jointed ------- 3
2. Pedicel and first funicle joint subequal in length ------- *luteola* Howard.
   First funicle joint shorter than pedicel and than second funicle joint. *quaintancei*, new species.
3. Club flattened ------- *flaviclava* Howard.
   Not flattened ------- 4
4. First funicle joint swollen ------- *angelica* Howard.
   Not swollen ------- 5
5. Pedicel and first funicle joint subequal in length ------- 6
   Pedicel shorter than first funicle joint ------- 8
   Pedicel longer than first funicle joint, which is distinctly shorter than second ------- 10
6. Funicle joints 1 and 2 subequal in length; flagellar striations barely discernible ------- 7
   Funicle joint 2 considerably longer than 1; striations close and distinct. *planchoniæ* Howard.
7. Fore wings with disc closely and completely ciliate ------- *portoricensis*, new species.
   Fore wings with a round bare space below stigma ------- *pergandiella*, new species.

8. All funicle joints subequal and concolorous 9
Funicle joint 1 nearly as long as 2 and 3 together; the latter subequal and white; joint 1 and the club black .... *diaspidis*, new species.
9. Terminal joint of club shorter than basal joint .... *aonidiæ* Howard.
Club joints equal in length .... *coquillettii* Howard.
10. First funicle joint distinctly shorter than second .... *townsendi*, new species.

Encarsia diaspidis, new species.

Female.—Length 1.6 mm.; expanse 3.6 mm.; greatest width of fore wing 0.5 mm. Eyes markedly hairy. Antennal scape robust; pedicel somewhat longer than broad; 1st funicle joint twice as long as pedicel; joints 2 and 3 much shorter and subequal in length and width; club rather slender and pointed, longer than funicle joints 2 and 3 together; all joints, including scape, plainly hairy. General color orange-yellow; antennæ black, joints 2 and 3 of funicle white; eyes reddish; dorsum of abdomen and metanotum infuscated, except for tip of abdomen, which is yellow; all legs uniform honey-yellow; wing veins yellowish.

Male.—The male *Encarsia* has not been described; but I have a slide from Lounsbury containing male specimens reared from the same host, in the same locality, and at the same time as the female described above, and these are probably the males of *E. diaspidis*. They are described as follows, generic characters included: Length 1.08 mm.; expanse 2.4 mm.; greatest width of fore wing 0.44 mm. Antennæ 8-jointed; scape not long, slightly swollen in middle; pedicel short, only as long as broad; 1st funicle joint long, 6 times as long as broad; funicle joints 2 and 3 subequal in length and width and each about one-half as long as joint 1; club 3-jointed, the segments as distinct as those of funicle; club joints 1 and 2 about equal in length to funicle joints 2 and 3; terminal joints shorter and rather obtusely pointed at tip; all flagellar joints strongly longitudinally striate. First joint of middle tarsus longest; middle tibial spur about as long as first tarsal joint. General color very dark brown, nearly black; antennæ uniformly dark brown; femora brown, hind femora darker than front and middle femora; trochanters light yellow; all tibiæ dusky, lighter at tips; tarsi yellowish, with their terminal joints brown.

Type.—No. 10300, U. S. National Museum. Described from 6 female and 6 male specimens, reared July, 1897, from a *Diaspis* on *Acacia horrida* at Bathurst, Cape Colony, South Africa, by C. P. Lounsbury.

This species is probably not a true *Encarsia*.

Encarsia portoricensis, new species.

Female.—Length 1 mm.; expanse 1.84 mm.; greatest width of fore wings 0.28 mm. Antennæ rather stout, with flagellum uniformly hairy, longitudinal striation only faintly discernible; scape uniformly slender; pedicel very slightly longer than broad; 1st funicle joint about as long as pedicel; joint 2 very slightly longer than 1 and about equal to joints 3 and 4 and each of the two club joints. Submarginal and marginal veins about equal in length, stigmal very short and entering the wing at a small angle. Middle tarsi and tibial spur as with the preceding species. General color lemon-yellow; ocelli dark crimson, eyes very dark crimson; antennæ and legs dusky; abdomen with a brownish dorsal central patch. The specimen from Porto Rico has the abdomen entirely brown above and the pronotum and anterior portion of mesoscutum brownish.

Male.—Unknown.

Type.—No. 10301, U. S. National Museum. Described from 3 female specimens reared January, 1899, by Mr. A. Busck from *Aleyrodes* sp. on a climbing vine, Bayamon, Porto Rico (Bur. Entom. No. 8423°) and 1 female specimen received March, 1907, from Mr. E. K. Carnes of the California Board of Horticultural Commissioners, labeled "on *Aleyrodes* sp. Mexico."

Encarsia pergandiella, new species.

Female.—Length 0.58 mm.; expanse 1.46 mm.; greatest width of fore wing 0.14 mm. Antennæ long, slender, and faintly hairy; pedicel and first funicle joint subequal in length; remaining funicle joints increasing gradually in length; basal joint of club slightly longer than terminal joint and the preceding funicle joint. Ovipositor slightly extruded. First tarsal joint of middle legs long and slender, nearly as long as the remaining 4 joints together; middle tibial spur about one-half length of 1st tarsal joint. Front wings rather narrow, with a considerably longer fringe than usual; discal cilia rather sparse, and a round perfectly hairless spur below stigma. General color uniform honey-yellow; eyes and ocelli red.

Male.—Unknown.

Type.—No. 10302, U. S. National Museum. Described from 7 female specimens reared by Mr. Theo. Pergande from an Aleyrodes on *Xanthium strumarium*, Washington, D. C., September 25, 1900 (Bur. Entom. No. 9321°). Also reared by Mr. Pergande at Washington, D. C., November 20, 1894, from an *Aleyrodes* on blackberry (Bur. Ent., No. 6452).

Encarsia townsendi, new species.

Female.—Length 0.66 mm.; expanse 1.56 mm.; greatest width of fore wing 0.22 mm. Antennæ with numerous hairs, but with very faint striation; scape not especially long; pedicel longer than wide; first funicle joint about as long as wide, shorter than pedicel and only one-half as long as second funicle joint; second and remaining funicle joints subequal in length and width, as is also basal joint of club (terminal joint of club missing on all specimens).

Middle tarsi with joint 1 as long as 2 and 3 together; middle tibial spur as long as joint 1. Ovipositor considerably extended. Face and vertex orange-yellow; ocelli carmine; eyes dark red; mesoscutellum dull lemon-yellow; remainder of notum and dorsum of abdomen light brown; tip of abdomen yellowish; antennæ dusky; legs and antennal veins dusky; fore wings with a faint dusky shade below marginal vein.

Male.—Unknown.

Type.—No. 10303, U. S. National Museum. Described from 5 female specimens reared June 19, 1897, from an *Aleyrodes* on a coarse grass taken at Sangrillo del Chico, Tabasco, Mex. (Bur. Ent., No. 741), by C. H. T. Townsend.

Encarsia quaintancei, new species.

Female.—Length 0.66 mm.; expanse 1.4 mm.; greatest width of fore wing 0.18 mm. Middle tarsi 4-jointed as with *luteola*, the fourth and fifth segments apparently coalesced. Pedicel of antennæ twice as long as broad; joint 1 of funicle somewhat longer than broad, shorter than pedicel and shorter than second funicle joint; second, third, and fourth funicle joints increasing gradually in length; club joints subequal in length. Fore wings with a small rounded hairless space below and beyond stigma, not extending to one-half the wing breadth. Eyes hairy. Mesoscutum delicately hexagonally reticulated; axillæ delicately reticulate. General color brown; mesoscutellum wholly lemon-yellow; tips of abdomen and flagellum of antennæ yellowish; all legs faintly yellowish; wings hyaline.

Male.—Unknown.

Type.—No. 10304, U. S. National Museum. Described from 1 female specimen reared August 29, 1900, by Theo. Pergande from *Aleyrodes* sp. on *Polygonum*, Bladensburg road, D. C.

The species is named for Prof. A. L. Quaintance in recognition of his excellent work on the Aleyrodidæ.

Genus **PROSPALTA** Howard.

Prospalta Howard. Insect Life, Vol. VII, 1894, p. 6. (Type, *Prospalta aurantii* Howard.)

Prospalta maculata, new species. (Fig. 16.)

Female.—Length 1 mm.; expanse 2.24 mm.; greatest width of fore wing 0.31 mm. Comes rather close to *P. murtfeldtii* How., but the antennæ are not so strongly clubbed. The color is as follows: Antennal club brown, whitest at tip; scape and funicle joints 2 and 3 whitish; general color of body and legs light yellow; middle and hind tibiæ each with two brown bands; first tarsal joint of middle and hind legs brown; first, fourth, fifth, and sixth abdominal segments with a complete brown cross-band; second and third with a brown cross-band interrupted in the middle. Mesoscutum with two longitudinal brown bands; axillæ brown; mesoscutellum with two large brown spots. Wings hyaline.

FIG. 16.—*Prospalta maculata:* Female. Greatly enlarged (original).

Type.—No. 10305, U. S. National Museum. Described from 1 female specimen bred by Mr. E. K. Carnes from *Lepidosaphes beckii* Newman (*Mytilaspis citricola* Glover), sent to California from China by Mr. George Compere.

Genus COCCOPHAGUS Westwood.

Coccophagus Westwood. Philosoph. Mag., Vol. III, 1833. (Type, (*Entedon*) *scutellaris* Dalman.)

Coccophagus subochraceus, new species.

Female.—Length 1.1 mm.; expanse 2.6 mm.; greatest width of fore wing 0.48 mm. Differs from *C. ochraceus* in having the entire body, including the mesopleura and the terminal segments of the abdomen, ochraceous.

Male.—Differs from *C. ochraceus* in having the axillæ and the entire dorsal surface of the abdomen black and the metanotum dusky.

Type.—No. 10306, U. S. National Museum. Described from 5 female and 25 male specimens bred from a *Lecanium* on *Leucospermum attenuatum*, at Zuurberg, Cape Colony, South Africa, by C. P. Lounsbury, 1897.

Coccophagus longifasciatus, new species. (Fig. 17.)

Female.—Length 0.78 mm.; expanse 1.56 mm.; greatest width of fore wing 0.26 mm. Antennæ stout, moderately clavate, with plain longitudinal striæ. Surface of body smooth, impunctate. General color of body light lemon-yellow; eyes and ocelli bright carmine; all legs pallid; antennæ and wing veins slightly dusky; a broad lateral brown band extending down either side of the body from the pronotum to the tip of the abdomen.

Male.—In the male the brown band is not so perfect, but the pronotum, the anterior border of the mesoscutum, the axillæ, all of the metanotum, and the sides and tip of the abdomen are brown.

Type.—No. 10307, U. S. National Museum. Described from 4

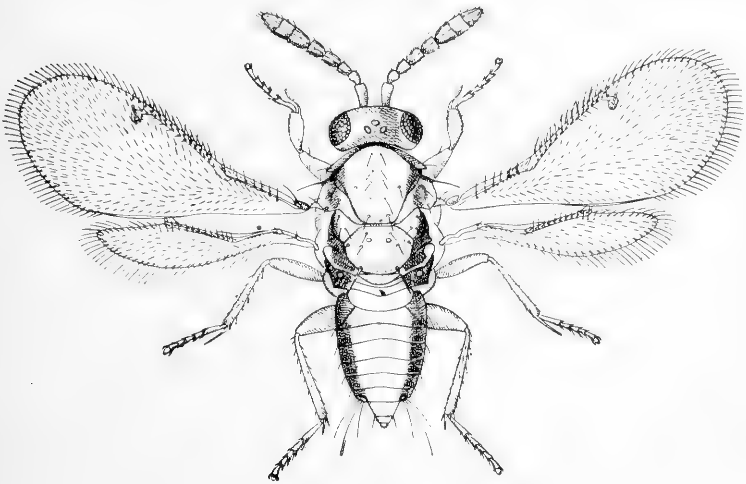

FIG. 17.—*Coccophagus longifasciatus:* Female. Greatly enlarged (original).

male and 4 female specimens bred from *Saissetia nigra* Nietner (*Lecanium nigrum*), at Manaar, Ceylon, by E. Ernest Green, 1897.

Coccophagus zebratus, new species. (Fig. 18.)

Female.—Length 1.34 mm.; expanse 2.4 mm.; greatest width of fore wing 0.32 mm. Body smooth, flat, impunctate; antennæ with only very slight indications of longitudinal striæ; hind femora and coxæ considerably swollen. Club of antennæ dark brown; scape, pedicel, and funicle joints 1 and 2 of a rather lighter brown; funicle joint 3 white. Vertex, occiput, pronotum, and mesonotum lemon-yellow, metascutum brown; face and remainder of thorax whitish; all femora and coxæ whitish and front tibiæ as well; middle and hind tibiæ slightly brownish at base; first joint of middle and hind tarsi brown. Abdomen whitish, with a broad brown transverse band on each segment. Wing veins dusky.

Male.—Unknown.

Type.—No. 10308, U. S. National Museum. Two female specimens bred from *Aclerda distorta* Green, MS., Punduloya, Ceylon, by E. Ernest Green.

Genus CALES, new genus.

Female.—Tarsi 4-jointed; first and last joints of middle tarsus much longer than second and third; middle tibial spur not as long as first tarsal joint; joints of hind tarsus subequal in length. Antennæ 5-jointed; bulla very long and slender, scape somewhat swollen; pedicel not greatly swollen, nearly three times as long as broad; funicle joint 1 short and slender, about as long as broad (this joint may possibly be found to be double on examination of additional specimens). Second funicle joint slender, more than four times as long as joint 1; club ovate, undivided, and longer than funicle and pedicel together. Eyes naked. Fore wings narrow, with subparallel fore and hind borders; marginal cilia long; discal cilia very sparse and placed in two long horizontal rows and part of a third; marginal

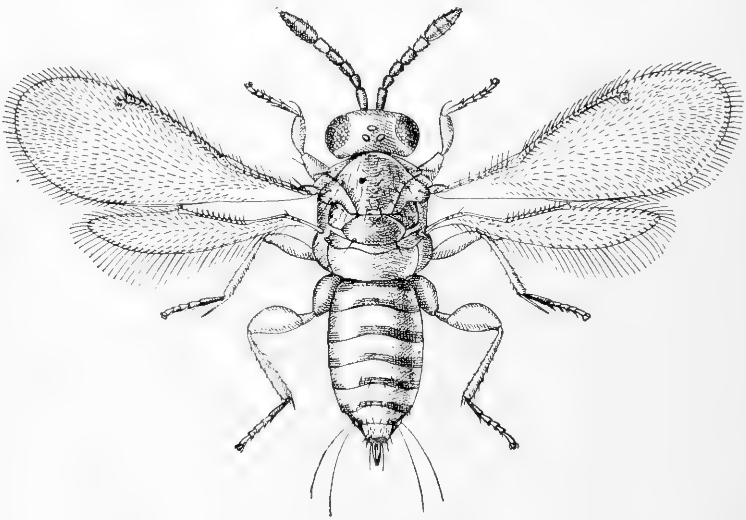

FIG. 18.—*Coccophagus zebratus:* Female. Greatly enlarged (original).

vein somewhat longer than submarginal; no differentiated stigmal. Ovipositor slightly extruded.

Male.—Unknown.

Type.—The following species:

Cales noacki, new species. (Fig. 19.)

Female.—Length 0.52; expanse 1.44 mm.; greatest width of fore wing 0.12 mm. General color lemon-yellow; eyes reddish brown; antennæ uniformly yellow; legs slightly dusky. Legs long and slender; body rather slender and graceful; abdomen rather short and triangular. Wings hyaline, veins dusky.

Type.—No. 10309, U. S. National Museum. Described from one female specimen reared by Fritz Noack, Campinas, Brazil, from an undetermined species of *Orthezia.* (Bureau of Entomology No. 818301.)

Genus CASCA, new genus.

Female.—Comes rather close to *Bardylis*, from which, however, it may be easily separated by tarsal, antennal, and wing characters. All tarsi 4-jointed, the tarsal joints of middle leg all short and subequal in length; apical spur of middle tibia as long as first two tarsal joints together; hind tarsi longer than middle tarsi, but the joints are subequal in length as with the middle. Marginal vein of fore wing rather shorter than submarginal; stigmal evident; disk uniformly ciliate, but more sparsely than with *Bardylis;* hind border of wing slightly excavate beyond anal angle, tip regularly rounded; marginal cilia long, longest at lower wing tip. Antennæ 7-jointed, somewhat clavate, the club rather long and but slightly swollen, tapering to a point and with the joints subequal in length; second funicle joint shorter than first, but of same width and only slightly longer than wide, much shorter and narrower than first club joint; first funicle joint about twice as long as wide, as long as, but narrower than pedicel. Flagellum hairy and club with longitudinal striæ. Eyes hairy.

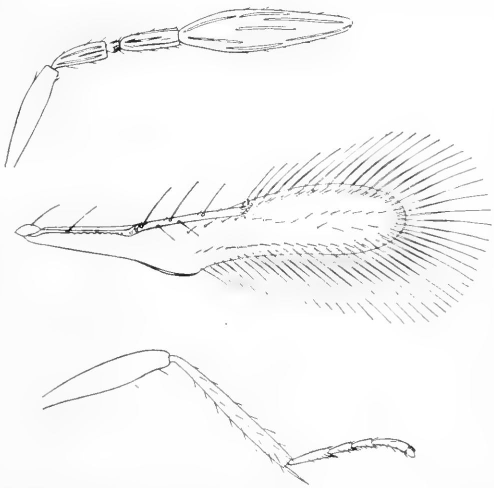

Fig. 19.—*Cales noacki:* Antenna, fore wing, and middle leg of female. Greatly enlarged (original).

Male.—Unknown.

Type.—The following species:

Casca chinensis, new species. (Fig. 20.)

Female.—Length 0.86 mm.; expanse 1.34 mm.; greatest width of fore wing 0.16 mm. Head and face orange-yellow, occiput dusky; ocelli and eyes carmine, the eyes darker than the ocelli; antennæ light dusky yellow; all legs pallid; pronotum, abdomen, and metascutum brown; mesoscutum also brownish at anterior border; remainder of mesoscutum yellowish and remainder of mesonotum and mesopleura pallid. Fore wing with a pronounced dusky cloud below marginal vein.

Male.—Unknown.

Type.—No. 10310, U. S. National Museum. Described from 2 female specimens reared in California by Mr. E. K. Carnes from

Lepidosaphes beckii Newman (*Mytilaspis citricola* Glover) collected in China by Mr. George Compere.

Genus BARDYLIS, new genus.

Female.—All tarsi 4-jointed; first tarsal joint of middle leg nearly as long as second and third joints together; middle tibial spur not quite as long as first tarsal joint. Marginal vein of fore wing a trifle shorter than submarginal; stigmal short but evident; wing disc very closely and evenly ciliate; margin with long cilia from stigma to anal angle, gradually lengthening from stigma to lower distal point and thence rapidly decreasing in length to anal angle; margin of wing evenly curved from anal angle to costa. Antennæ 7-jointed, pronouncedly clavate; club ovate, with its joints of subequal length; the two funicle joints about equal in length and width, each slightly shorter than pedicel and first club joint; the whole surface of the flagellum furnished with minute hairs. Eyes hairy.

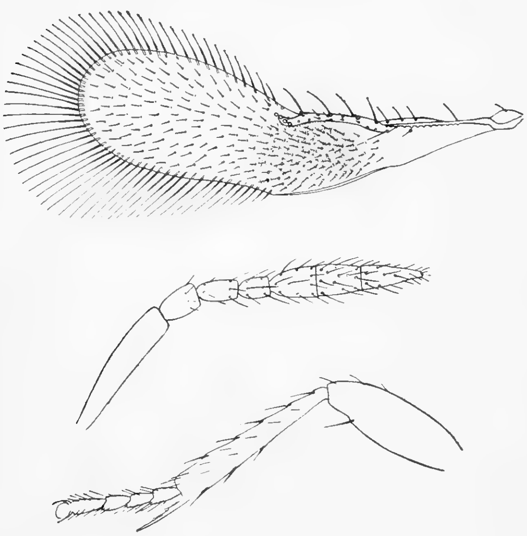

FIG. 20.—*Casca chinensis:* Fore wing, antenna, and middle leg of female. Greatly enlarged (original).

Male.—Antennæ more elongate, 8-jointed, all scape joints subequal in length and width, except terminal joint of club, which comes to a rounded point. The tarsi are longer than in the female and the first funicle joint is not as long as the second and third together.

Type.—The following species:

Bardylis australiensis, new species. (Fig. 21.)

Female.—Length 0.5 mm.; expanse 1.34 mm.; greatest width of fore wing 0.18 mm. Color: Head, pronotum, mesoscutum, tegulæ, and abdomen brown; mesoscutellum, metascutum, mesopleura, and metapleura dull orange-yellow; antennæ, coxæ, and femora light brown; wing veins dusky; fore wings with a dusky cloud below marginal vein; eyes dark red. Occiput closely and finely aciculate; mesoscutum faintly aciculate.

Male.—Differs from female only as pointed out in generic diagnosis, except that the clouded portion of the fore wing is lighter than in the female.

Type.—No. 10311, U. S. National Museum. Described from many male and female specimens reared by Mr. Geo. Compere, evidently from scale insects, at Swan River and Perth, West Australia. (Compere's numbers 774, 855, 871, 873, 923, 925, 944, and 1026.)

Also from a number of specimens reared by A. Koebele, September 29, 1899, from an *Aspidiotus* on *Hakea* sp., at Sydney, New South Wales. (Koebele's No. 1998.)

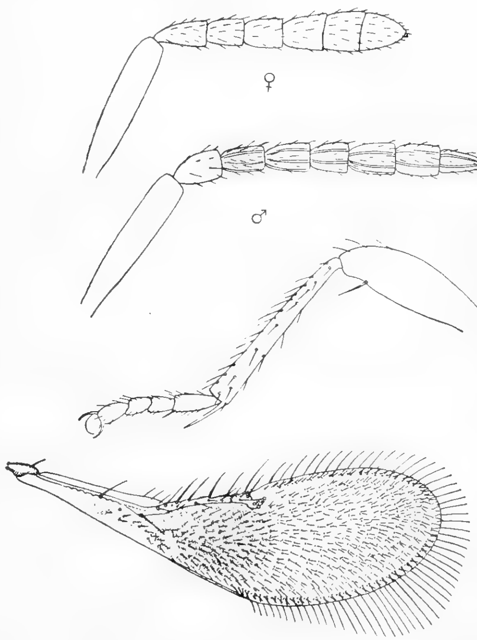

FIG. 21.—*Bardylis australiensis:* Antenna of female, and antenna, hind leg, and fore wing of male. Greatly enlarged (original).

Genus ARTAS, new genus.

Female.—Tarsi 4-jointed; antennæ 6-jointed; scape and pedicel normal, the single funicle joint about as long as the first club joint and slightly more slender; club joints subequal in length, the terminal joint tapering to a point. Fore wings very obtusely rounded and almost bare, having very few discal cilia; four long hairs arising from marginal vein, and a series of very long marginal hairs beginning at the tip of the marginal vein and extending around to the middle of the lower margin, slightly longer at lower tip; marginal vein equal in length to submarginal; stigmal lacking as in *Aspidiotiphagus.* Tarsal joints of middle tarsi subequal in length, tibial spur longer than the first two tarsal joints together.

Male.—Unknown.

Type.—The following species:

Artas koebelei, new species. (Fig. 22.)

Female.—Length 0.38 mm.; expanse 1 mm.; greatest width of fore wing 0.13 mm. General color dull yellow; mesoscutellum light lemon-yellow; eyes and ocelli dark red; wing veins dusky; pronotum, front of mesoscutum, axillæ, and sides of metanotum dark brown; dorsum of abdomen dusky.

Male.—Unknown.

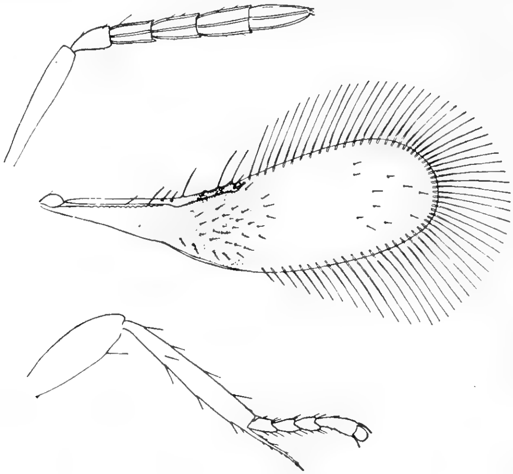

FIG. 22.—*Artas koebelei:* Antenna, fore wing, and hind leg of female. Greatly enlarged (original).

Type.—No. 10312, U. S. National Museum. Described from 11 male specimens reared from *Chionaspis vitis* Green, Hongkong, China, by A. Koebele.

Genus **PERISSOPTERUS** Howard.

Perissopterus Howard. Tech. Ser. 1, Div. Ent., U. S. Dept. Agric., 1895, pp. 20–21. (Type, *P. pulchellus* Howard.)

Male.—In the original description of this genus[a] the male is not described, the description of the male *P. pulchellus* having been made from a dry mount with shriveled antennæ. The important fact has since been discovered that with the male of *Perissopterus* the antennæ are only 5-jointed, viz, scape, pedicel, 2 ring joints, and club; the club being long, oval, and more or less flattened. With *P. pulchellus* the male in other respects resembles the female.

TABLE OF SPECIES.

1. Eyes hairy	2
Eyes naked	3
2. Antennal club black	*noumeænsis*, new species.
Antennal club pallid	*capillatus*, new species.

[a] Tech. Ser., No. 1, Div. Ent., U. S. Dept. Agric., pp. 21–22.

3. First four tarsal joints of middle leg white, including tibial coronet of spines .... *busckii*, new species.
   Not white, tibial coronet black 4
4. First and fifth tarsal joints black, rest white .... *javensis*, new species.
   First and fifth and at least part of the second tarsal joint black 5
5. General color white, tinged in spots with dark reddish orange, dotted with black .... *pulchellus* Howard.
   General color light orange-yellow, with black dots (no red or white). *mexicanus* Howard.

Perissopterus capillatus, new species.

Female.—Length 1 mm.; expanse 2.16 mm.; greatest width of fore wing 0.36. Eyes closely and plainly hairy. Eyes well separated; ocelli at angles of obtuse-angled triangle. Vertex and occiput faintly reticulate, thorax smooth. The fore wings appear spotted with patches of dark cilia, the spots not connected in a reticulate pattern as with *P. pulchellus* and *P. mexicanus.* Head uniform orange-yellow, eyes red; mesonotum lemon-yellow, metanotum darker; abdomen marked with alternating transverse bands of light yellow and honey-yellow; antennæ light yellowish; legs very light in color, femora dusky at tip; middle and hind tibiæ dusky at tips and with two other dusky spots on bands; first and fifth tarsal joints dusky.

Male.—Unknown.

Type.—No. 10313, U. S. National Museum. Described from 11 female specimens reared by Mr. Koebele from *Lepidosaphes pallens* Maskell (*Mytilaspis pallens*) on *Xanthorrhœa*, Sydney, New South Wales, December 20, 1895.

Perissopterus noumeænsis, new species.

Female.—Length 0.86 mm.; expanse 1.9 mm.; greatest width of fore wing 0.3 mm. Eyes with numerous fine black hairs. General color dingy yellowish white; antennal club dark brown, nearly black; scape, pedicel, and funicle lighter; lower face orange; sides of mesoscutum with a thin line of brown; abdomen with alternating dark brown and whitish bands; femora slightly brownish above, tibiæ brownish at tips; middle tarsi entirely brownish yellow; hind tarsi with first joint pallid, rest yellowish.

Type.—No. 10314, U. S. National Museum. Described from one female specimen, bred October, 1899, from *Aspidiotus* sp. on cocoa palm, Noumea, New Caledonia, by A. Koebele.

Perissopterus busckii, new species.

Male.—Length 0.76 mm.; expanse 1.7 mm.; greatest width of fore wing 0.3 mm. Eyes naked. Markings of fore wings reticulate, not arranged in spots. General color uniform orange-yellow; antennal club brownish, lighter at tip; scape whitish, pedicel dark above, light below; metascutellum darker at sides; legs pallid; all femora with two dark spots below; tibiæ with four equidistant brown spots on bands; terminal tarsal joints dusky; basal tarsal joint of hind leg also dusky.

Female.—Unknown.

Type.—No. 10315, U. S. National Museum. Described from one male reared from *Asterolecanium aureum* Boisduval, collected at San Juan, Porto Rico, February 21, 1899, by A. Busck.

Perissopterus javensis, new species.

Female.—Length 0.72 mm.; expanse 2.2 mm.; greatest width of fore wing 0.28 mm. Eyes naked. Pattern of fore wings of the reticulate type. Ovipositor well extruded. Mesoscutum and mesoscutellum delicately hexagonally reticulate-punctate. General color orange, sides of thorax and abdomen marked with whitish; abdomen with more or less perfect cross-bands of brownish. Legs pallid; femora with two narrow bands of brown; tibiæ with three broad brown bands, broader on middle than on hind tibia, and with a narrow brown tip; first and fifth tarsal joints brownish, others pallid. Antennæ with club brown, yellowish at tip; third funicle joint brown, white at tip; first and second funicle joints (ring joints) brown; pedicel brown at base, white at tip.

Male.—Smaller. Color about as with female, but with small white thorax. Entire club brown except somewhat lighter at tip; pedicel whitish at tip.

Type.—No. 10316, U. S. National Museum. Described from 7 male and 8 female specimens reared February, 1900, from a species of *Tachardia* on an ornamental plant at Singapore, Straits Settlements, by A. Koebele (Koebele's No. 2005).

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Technical Series, No. 12, Part V.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau

MISCELLANEOUS PAPERS.

THE MORE IMPORTANT ALEYRODIDÆ INFESTING ECONOMIC PLANTS.

WITH DESCRIPTION OF A NEW SPECIES INFESTING THE ORANGE.

By A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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In Charge of Deciduous Fruit Insect Investigations.

INTRODUCTION.

Systematically the Aleyrodidæ occupy a position between the Coccidæ and Aphididæ, two families of insects containing many serious pests of agricultural and horticultural crops. Species of Aleyrodidæ are, however, with a few exceptions, not at present of especial economic importance, though many of them occur in some numbers on useful plants. Also, with few exceptions, so far as known the injurious species of this family are not yet generally distributed over the world, as are so many scale insects and aphides, possibly from the fact that the Aleyrodidæ feed exclusively on the leaves of their host plants and are thus not so likely to be distributed in shipments of trees and plants as if occurring on the twigs and branches. When once established in a locality an introduced species, as compared with scale insects, would disseminate more rapidly, since the adults of both sexes are winged, though they are not strong fliers.

The Aleyrodidæ are most abundant in tropical or semitropical regions, though species of *Aleyrodes* in the United States are fairly abundant in the Transition zone. Species of *Aleurodicus*, however, are almost exclusively tropical, and with one exception are known thus far only from the Western Hemisphere, whence it is not improbable that this species was distributed.

The family contains only two genera—*Aleyrodes* and *Aleurodicus*—and 143 species have been described to date. The literature dealing with these insects is so widely scattered that it has seemed desirable to comment briefly on the species known to infest economic plants, so that their introduction or dissemination may be better guarded against.

ECONOMIC PLANTS AND THE MORE IMPORTANT ALEYRODIDÆ INFESTING THEM.

Tobacco.—Tobacco is attacked by two species of *Aleyrodes*—namely, *A. nicotianæ* Maskell, from Mexico, and *A. tabaci* Gennadius, from Greece. The former is apparently not of much economic importance, as shown by the condition of infested leaves from Mexico. *A. tabaci* is, however, more injurious, according to Targioni-Tozzetti, who gives a very full account of the species in his "Animali ed Ensetti del Tobacco." The insect was first noticed in 1889 on leaves from Araucania, where it was said to be spreading more and more. In the work just cited it is remarked that, save possibly for a decrease in dimensions, the leaves do not show signs of alterations, but from the quantity of insects which remain on the dry leaves the tobacco is rendered unfit for use. No method of treatment is suggested.

Sugar cane.—No aleyrodids have as yet been recorded from sugar cane in this country, but abroad certain species are pests of importance. *Aleyrodes bergii* Signoret was described in 1867 from the Isle of Mauritius, where it was found on sugar cane. In Java this same species is at present a serious pest of cane, and there it has been carefully studied by Dr. L. Zehntner and reported on in the Archief Java Suikerindustrie for 1896. Two other species infest sugar cane in Java—namely, *Aleyrodes longicornis* Zehntner and *A. lactea* Zehntner, the former being quite destructive. These species have also been fully treated by Zehntner in the "Archief" for 1899. The remedial measures practiced consist in cutting off and burning the infested leaves, and spraying with milk of lime, which is said to destroy the immature insects, but not the developed parasite within the pupa case—*Ablerus pulchriceps* Zehntner, which attacks *longicornis*. *Aleyrodes lactea* is also attacked by the fungus *Aschersonia aleyrodis* Webber, or a very similar species, which attacks *Aleyrodes citri* in this country. *Aleyrodes sacchari* Maskell occurs on sugar cane in Fiji, and *A. barodensis* Maskell was received by Maskell from Baroda, India, with the advice that the insects were rather damaging to sugar cane in those parts.

Orange.—Of the several aleyrodids attacking the orange, *Aleyrodes citri* Riley and Howard is much the most important. In Florida especially this species at the present time is doubtless the most important of all of the insect pests of this crop, and it is also the subject of frequent complaint from southern Louisiana and to a less extent from southeastern Texas. The literature of this species is considerable, and its life history has been carefully worked out. Some important papers are: "The Orange Aleyrodes," by Riley and Howard (Ins. Life, Vol. V, p. 219); "Sooty Mold of the Orange and its Treatment," by H. J. Webber (Bull. 13, Div. Veg. Phys. and Pathol., U. S. Dept. Agric.); "The White Fly," by H. A. Gossard (Bull. 67, Fla. Agric. Exp. Sta.), and "White Fly Conditions in 1906, etc.," by E. W. Berger (Bull. 88, Fla. Agric. Exp. Sta.). At the present time the insect is the subject of a special investigation by the Bureau of Entomology. *Aleyrodes floridensis* Quaintance, more common on guava in Florida, also occurs on the orange, but on this latter plant it has not yet proved to be of special economic importance. In Arizona Prof. T. D. A. Cockerell has found on orange a form of *Aleyrodes mori* Quaintance which he has given the varietal name *arizonensis*. *Aleyrodes aurantii* Maskell was described from specimens on orange from the northwest Himalayas, the leaves received by Maskell being thickly covered with the pupa cases. *Aleyrodes marlatti* Quaintance occurs on orange in Japan, and *A. spinifer* Quaintance on *Citrus* sp. and rose in Java.

For the past three or four years the Bureau of Entomology has received from Cuba orange leaves infested with an undescribed species of *Aleyrodes*, the description of which is given herewith:

Aleyrodes howardi n. sp.

(Plate VII; text figs. 23, 24.)

Egg.—Uniform brownish in color, without reticulations, curved; size about 0.18×0.09 mm. Stalk short, eggs lying prostrate on leaf, arranged more or less in circles or curves.

Larva.—Color and structure essentially as in pupa case.

Pupa case.—Size about 0.9×0.55 mm., subelliptical in shape. Many specimens with more or less evident indentures on cephalo-lateral margin of case, with cephalic end obtusely pointed. Color on leaf under hand lens with secretion removed, yellowish brown varying to blackish; under transmitted light yellowish to brownish yellow. There is a distinct marginal rim all around, with wax-tubes distinct, the incisions acute and tubes rounded distally. From margin of case all around arises a short rim of wax, composed of individual wax threads, serrated on margin as seen under a high power of microscope. Case usually quite covered by a very copious secretion of grayish, curling wax rods, which is very conspicuous on badly infested leaves, quite hiding the insects beneath (Pl. VII, fig. 1; text fig. 23). Denuded of secretion, pupa case is seen to be at first almost flat, but later becoming rather convex as the insect develops, with segments distinct.

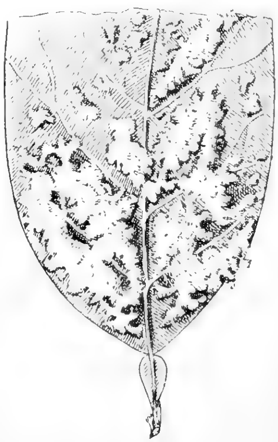


FIG. 23.—*Aleyrodes howardi*, showing copious secretion from pupæ, on lower surface of orange leaf. (Original.)

Dorsum with pair of strong setæ on first abdominal segment, a pair at vasiform orifice, and a pair at caudal margin extending some distance beyond margin of case. Vasiform orifice relatively small, subcordate, the rim dark brown, from 6 to 8 strong setæ or spines arising from caudal margin; operculum largely filling orifice, the distal margin with 2 faint notches; lingula not distinguishable (see fig. 24).

Adult female.—Usual; body yellow, wings immaculate; length of body about 0.84 mm.; hind tibiæ, 0.35 mm.; fore wing, 1 mm. long by 0.36 mm. wide. Hind tarsus, 0.16 mm.

Male.—Not seen.

Food plant.—Orange. Collected at Artamisa, Cuba, February 5, 1905, by C. L. Marlatt, and at Habana, Cuba, February 19, 1903, by E. A. Schwarz. Received from Dr. Mel. T. Cook, June 6, 1905, from Santiago de las Vegas, Cuba.

Judging from the abundance of this insect on orange leaves received from the above-mentioned sources, this is a very serious pest of the orange, perhaps rivaling the so-called white fly of Florida (*Aleyrodes citri* Riley and Howard).

Described from numerous infested leaves, pupa cases in balsam mounts, and two females.

Type.—No. 10821, U. S. National Museum. Named for Dr. L. O. Howard.

Cotton.—*Aleyrodes gossypii* Fitch, described in Fitch's Third Report, is known only from the single type specimen on *Gossypium religiosum* from Ningpo, China. The second species is *Aleyrodes abutilonea* Haldeman, of which *A. fitchi* Quaintance appears to be a synonym. This species has been found on cotton at Harrisville, Miss.; Selma, Ala., and Columbus, Tex. At the place first mentioned the insects were very abundant, the lower surface of the leaves being covered with the pupa cases. The insect was also taken by Riley on cotton growing in his garden at Washington, D. C., and in Delaware, Maryland, and Virginia it occurs very abundantly on *Abutilon abutilon*, probably its native food plant, which it greatly injures, and is thus beneficial, since this plant is a troublesome weed.

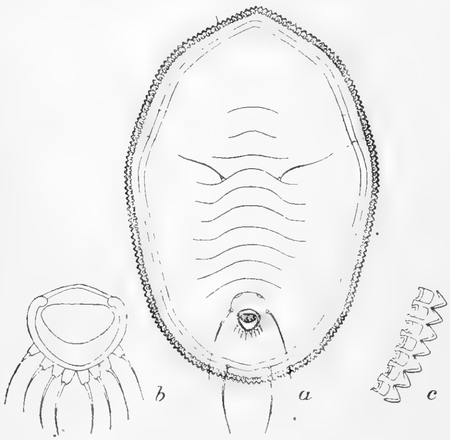
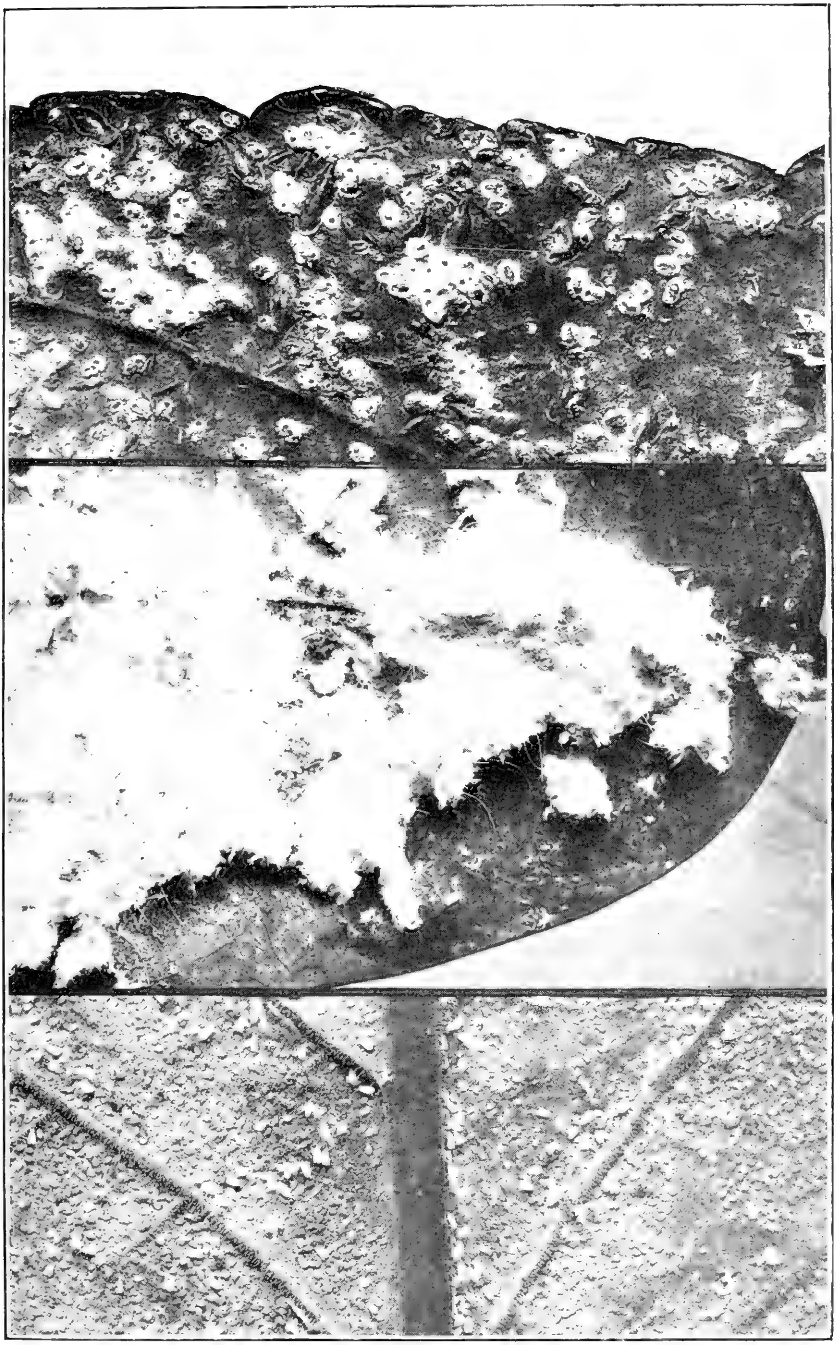


Fig. 24.—*Aleyrodes howardi:* Pupa case and details. Greatly enlarged (original).

Guava.—In Florida *Aleyrodes floridensis* Quaintance is quite common on the guava, the under surface of leaves sometimes being quite covered with the pupa cases. In Brazil *Aleyrodes horridus* Hempel and *A. goyabæ* Göldi occur on this plant, the latter often by hundreds, constituting a serious pest. *Aleurodicus cocois* Curtis infests guava in Trinidad, Venezuela, and Brazil. Guava is also infested by *A. cockerelli* in Brazil, and by *A. holmesii* Maskell in Fiji, which Cockerell thinks has there been introduced from America along with its food plant.

Cocoanut.—In Demerara and Barbados the cocoanut palm for many years has been seriously injured by *Aleurodicus cocois* Curtis, which, in company with a scale insect, was held responsible for a widespread disease of the trees on the latter island. This species was the subject of an article by Riley and Howard in Insect Life, Volume V, page 314 (1893). At the time this article was written, the introduction of this species into southern Florida on cocoanut, and guava, which it also infests, was considered only a matter of time, if not already accomplished. Thus far, however, nothing has been recorded of its occurrence in that State.



ECONOMIC ALEYRODIDÆ.

Fig. 1.—*Aleyrodes howardi*, on orange. Fig. 2.—*Aleyrodes anonæ*. Fig. 3.—*Aleyrodes vaporariorum*, on tobacco.

Custard apple (*Anona* spp.).—In Demerara *Anona muricata* and *A. squamosa*, and in Trinidad *A. reticulata*, are often seriously infested with *Aleurodicus anonæ* Morgan, and this same species has been reported on *Anona* from Pernambuco, Brazil. This species is remarkable from the large amount of cottony substance secreted, the under surface of badly infested leaves being thickly covered with it (see Pl. VII, fig. 2). *A. mirabilis* Cockerell occurs on *Anona* sp. in Mexico, and *Aleyrodes lacerdæ* Signoret is recorded from *Anona sylvatica*, the locality not being stated.

Strawberry.—*Aleyrodes packardi* Morrill is troublesome to strawberries, according to Morrill, and occurs in Ohio, Kentucky, southeastern New York, and Connecticut. Until the investigations of Doctor Morrill this species had been referred to *A. vaporariorum* Westwood, which it resembles. This and the greenhouse Aleyrodes (*A. vaporariorum*) are the subject of a valuable paper by Morrill published as Technical Bulletin No. 1 of the Massachusetts Hatch Experiment Station. *A. fernaldi* Morrill is also recorded from strawberry, though more abundant on Spireæ. In Europe *A. fragariæ* Walker occurs on strawberry, according to Walker, in myriads during July, but in France, as stated by Signoret, it is less numerous.

Cabbage.—In Europe *Aleyrodes brassicæ* Walker has long been known as more or less injurious to cabbage, kale, and other members of this family. According to C. W. Dale, and reported by J. W. Douglas, it is common on the indigenous wild cabbage which grows on the coast of the Isle of Purbeck, and the species is not to be regarded as imported and naturalized on cabbage cultivated in gardens. In Brazil, State of Sao Paulo, *Aleyrodes youngi* Hempel infests cabbage, the injury being considerable, as the infested leaves become yellow, wilted, and covered with a white powder, and are thus rendered unfit for use.

Greenhouse plants.—Several species of aleyrodids are known to infest plants in greenhouses, notably *Aleyrodes vaporariorum* Westwood, which in some sections of the North, as Massachusetts and Connecticut, constitutes a serious drawback to the growing under glass of such vegetables as tomatoes, cucumbers, and melons, and to such flowering plants as *Ageratum*, *Lantana*, and heliotrope. This species is a very general feeder, attacking plants representing several botanical families (see Pl. VII, fig. 3). An undetermined species having banded wings infests tomatoes and other vegetables under glass, and to some extent out of doors, in Florida. *Aleyrodes nephrolepidis* Quaintance occurs on a fern, *Nephrolepis*, thus far reported only from the conservatory of the Pennsylvania State College, where it evidently has been introduced. According to Professor Butz the adults were very abundant, flying around in the conservatory. Other aleyrodids occurring on ferns are *Aleyrodes filicium* Göldi, on *Asplenium cuneatum*, and other Brazilian ferns, in the botanic gardens at Rio de Janeiro; and the same species has been reported on *Oleander articulata* and *Pteris quadriolata* in the Fern House, Kew Gardens, in England. *Aleyrodes aspleni* Maskell occurs on *Asplenium lucidum* and other ferns in New Zealand, though whether in conservatories or not is not indicated. *Aleyrodes citri* Riley and Howard is fairly common on citrus plants in greenhouses, though rarely troublesome. In Florida *A. rolfsii* Quaintance infests geranium in injurious numbers out of doors, and might become a pest to this plant in greenhouses if there introduced.

Rubus spp.—*Aleyrodes ruborum* Cockerell seriously infests a cultivated *Rubus*, *R. trivialis*, in Florida, and occurs scatteringly on a wild blackberry, *R. cuneifolius*. In France, Signoret found a species occurring in numbers on *R. fruticosus*, which he described as *A. rubi*, and in England *A. rubicola* has been described by Douglas, infesting a *Rubus* growing in a sheltered situation.

Currant.—*Aleyrodes ribium* Douglas occurs on red and black currants in England. This is possibly the same species which infests *Vaccinium uliginosum* in Germany.

Prunus spp.—Peaches and plums are at times infested with *Aleyrodes pergandei* Quaintance, the only aleyrodid recorded from these plants. It also occurs on Cratægus and wild crab-apple, though it is never injurious so far as yet reported.

Fig.—No aleyrodids are recorded from the cultivated fig, *Ficus carica*, but in India *Aleyrodes alcocki* Peal occurs very abundantly, especially after the rainy season, on young plants of *Ficus indica* and *F. religiosa*. These plants, from the fact that they take root on old buildings and similar situations, become a nuisance, and the insects are therefore regarded as beneficial by Mr. Peal, who expresses regret that the pupæ are so badly parasitized by a small yellow chalcidid fly.

Bamboo.—Various species of bamboo in the vicinity of Calcutta are infested with *Aleyrodes bambusæ* Peal. As a rule, according to Mr. Peal, only a few leaves in a bamboo clump are attacked, but the insect sometimes occurs in large numbers, killing the leaves.

Indigo.—*Aleyrodes leakii* Peal occurs on *Indigofera tinctoria* and *I. arrecta*, Behar, India, being more common on the latter plant. Need for its control is considered likely with the increased cultivation of these plants for commercial purposes.

Betel.—*Piper betle*, a pepper, the leaves of which are chewed by natives of Eastern countries with the betel nut, is attacked in Bakarganj, India, by *Aleyrodes nubilans* of Buckton, by whom it is reported as doing considerable injury.

Grape.—An undetermined *Aleyrodes* has recently been received on vinifera grape from Fred. W. Maskew, Marysville, Cal.

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TECHNICAL SERIES, NO. 12, PART VI.

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BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

A RECORD OF RESULTS FROM REARINGS AND DISSECTIONS OF TACHINIDÆ.

By CHARLES H. T. TOWNSEND,
Expert in Charge of Dipterous Parasites, Gipsy Moth Laboratory.

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A RECORD OF RESULTS FROM REARINGS AND DISSECTIONS OF TACHINIDÆ.

By Charles H. T. Townsend,
Expert in Charge of Dipterous Parasites, Gipsy Moth Laboratory.

INTRODUCTION.

It seems opportune to present, for the benefit of those interested, a preliminary announcement of some of the results secured in the course of the work connected with the rearing of Tachinidæ, carried on under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, at the Gipsy Moth Laboratory, Melrose Highlands, Mass. Credit is due to assistants for carrying out the details of much of the work, as well as for some originality on certain points. Mr. W. R. Thompson has made all the dissections and prepared all the early-stage material for permanent preservation, both microscope slides and alcoholics, all of which work has been performed most admirably. He perfected the method of bleaching the puparia so as to show the anal stigmata to the best advantage in a slide mount. He has also done all the photographic work. Mr. D. H. Clemons has been continuously employed on the investigation of the reproductive habits of the various species in the outdoor cages, in which work he has shown much ability. He made the startling discovery of the leaf-larviposition habit of *Eupeleteria magnicornis.* Mr. T. L. Patterson has attended continuously to the Japanese Tachinas, and secured from them the maximum day's record of oviposition.

As this work was entirely new, practically nothing having ever before been attempted in the way of systematically rearing tachinids from egg to fly, it called for considerable ingenuity and much originality of method. It further developed, almost at the outset, that the various species were by no means uniform in their habits of reproduction; in fact, so greatly did they differ in this respect that a method adapted to one was by no means sure to succeed with another. The first two species studied furnish an apt illustration of this point. They were *Parexorista cheloniæ* Rond. and *Blepharipa scutellata* R.-D. The former is practically confined to *Euproctis chrysorrhœa* L. and the latter to *Porthetria dispar* L. Both are single brooded.

It was found necessary, in order to secure proper mating and oviposition in confinement, to devise a cage that would approximate natural conditions. Such an one was constructed out of doors, and consisted of just enough wooden framework to support a wire-screen inclosure 7 feet in three dimensions with a canvas top for protection

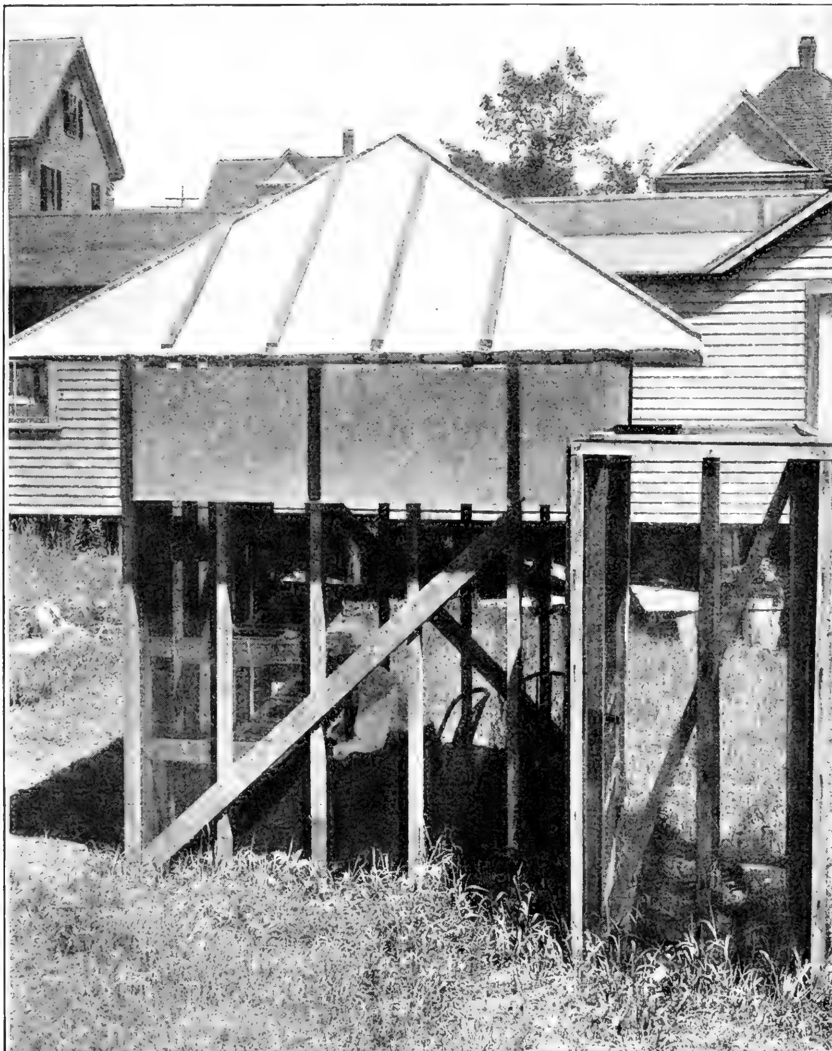

FIG. 25.—Outdoor cage for rearing Tachinidæ, with vestibule. (Original.)

against sun and rain. Into this cage (see figs. 25 and 26) were put several hundred flies of the above two species. The "tanglefooted" trays devised by Mr. W. F. Fiske, containing young caterpillars of *Euproctis chrysorrhœa* and *Porthetria dispar*, were strung on wires within. The caterpillars can not get out of these trays, which are open above, and the flies have free access to them. The invention of this tray is what made success possible with this cage. Food was provided for the flies in the shape of bananas and other fruit cut and sprinkled with sugar, and wet sponges supplied them with requisite moisture. This cage, thus furnished, proved to be a perfect success, although some supplementary devices were found necessary for certain species as the work progressed. The flies mated freely therein and were apparently as much at home as in the open.

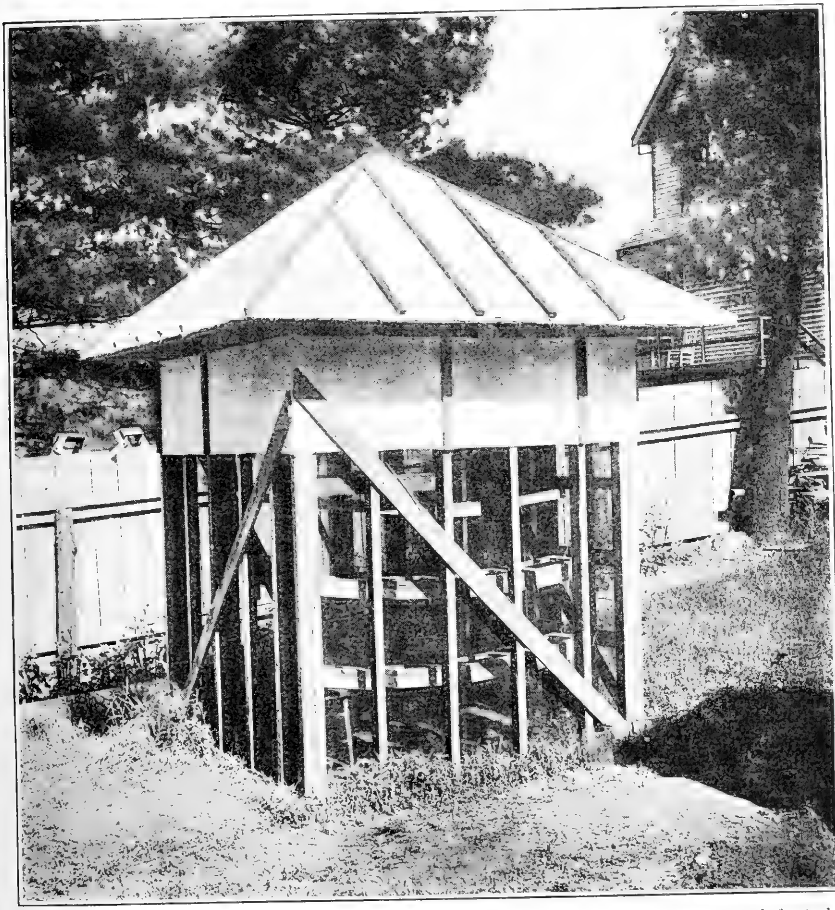

FIG. 26.—Outdoor cage for rearing Tachinidæ, showing disposition of "tanglefooted" trays within the cage. (Original.)

PAREXORISTA CHELONIÆ Rondani.

No difficulty was encountered in securing oviposition on the part of *Parexorista cheloniæ*, which deposited its elongate, cylindrical, whitish, thin-shelled, and pediceled eggs freely on the small caterpillars of *Euproctis chrysorrhœa* just out of the nests. The maggots, upon the hatching of the eggs, penetrated the caterpillars and a good number of them were reared to the puparium in the trays. The four stages of the maggot were secured by opening some of the caterpillars from time to time. Thus the entire life-history was worked out for the species, so that now the egg, any stage of the maggot, and the puparium as well as the fly can be identified. The entrance of the newly hatched *cheloniæ* maggot into the young *chrysorrhœa* caterpillar was observed through a binocular microscope.

It must be stated here that, as a preliminary to the rearing work, the puparia of the various species were carefully studied, and it was found possible to identify them by the characters of the anal stigmata, which are very constant in the same form and furnish a variety of design in the various species that was totally unlooked for. By this means the puparia were sorted into species before the issuance of the flies.

The last stage of the maggot of *Parexorista cheloniæ* can always be told by the similarity of its anal stigmata to those of the puparium. The first stage, newly hatched from the egg, is very similar in the various forms of the true tachinids in having the body segments furnished with rows of minute, posteriorly directed spines, which aid the maggot in progression over the skin of the caterpillar and in entrance through the same. Its anal stigmata are not the same as those of the last-stage maggot. The second stage is characterized by the absence of a large proportion of the spines, especially those of the middle segments, and its anal stigmata begin to look like those of the last stage. The penultimate stage is the most interesting of all, and develops an unusual feature, hitherto not understood. The maggot of the first two stages derives no air from the outside, but in the penultimate stage it protrudes the pointed anal end through the skin of the caterpillar. This anal end of the penultimate-stage maggot is highly chitinized by virtue of its exposure to the air, and terminates in a pointed tube, which is curved in some species, and within the base of which lie the anal stigmata. Through this extruded tube the maggot procures air. Certain observers had already noted that some tachinid maggots protrude the anal end through the skin of the host, but it was supposed that certain species had this habit in all stages of the maggot, while others had not, since maggots are often found free inside the host.

The truth, however, is that the penultimate stage of many tachinid maggots, and this stage only, possesses this peculiarity. The last-stage maggots of these species live free inside the hosts, their cast, penultimate-stage, chitinized anal skins remaining *in situ* in the skin of the caterpillar at the point where they passed that stage. We have repeatedly dissected these anal skins from caterpillars containing last-stage maggots. The description of the maggot stages given above applies well to *Parexorista cheloniæ*. A few species, which will be noted later on, not only remain as last-stage maggots within the chitinized anal skin of the preceding stage, but even transform to puparia therein, inside the caterpillar skin.

BLEPHARIPA SCUTELLATA Robineau-Desvoidy.

It was naturally inferred at this stage of the work that the reproduction of *Blepharipa scutellata* would be found as simple as that of *Parexorista cheloniæ*. Such inference was wide of the mark. All efforts to observe oviposition on the part of *scutellata* or to secure the deposited egg proved futile. The flies mated freely, remaining in copula four or five hours in some cases, but the females, unlike those of *cheloniæ*, paid no attention to the caterpillars. They even manifested alarm when the caterpillars were placed near them. In several instances they were observed to touch the ovipositor feebly to the surface or edge of the leaves upon which the caterpillars in the trays had been feeding. The supply of *scutellata* flies was limited, and it was not until this supply was exhausted that the truth dawned upon us. By dissecting dead females we secured the eggs, which were found to be minute and black, with a thin chitinized chorion, and about one-fortieth or one-fiftieth the size of those of *Parasetigena segregata* Rond., although the fly is ordinarily considerably larger than that species. The whole experiment recalled the observations of Sasaki[a] made twenty-two years ago on the Uji parasite (*Crossocosmia sericariæ* Corn.) of the silkworm in Japan. Sasaki's statements had been received with considerable incredulity by European students, but no longer seemed so improbable to us in the light of our investigation of *scutellata*, which, by the way, is extremely closely related to the Uji parasite. Every circumstance in connection with the strange behavior of the females of *scutellata* pointed directly to a habit of leaf-oviposition, the eggs to be swallowed by the caterpillars and hatched within their alimentary canal. When this conclusion had been definitely reached, no eggs of *scutellata* were on hand for experimental purposes. The conclusion had come very slowly, and was at first only doubtfully and reluctantly accepted.

PALES PAVIDA Meigen.

Soon after this, however, a similar case was encountered in *Pales pavida* Meig., a summer-issuing, two-brooded species, the flies of which began to emerge from the early-summer importations of puparia from Europe. The females of *pavida* acted in exactly the same way as did the females of *Blepharipa scutellata*. No deposited eggs could be secured, but the females were opened as they died and the eggs found

[a] Sasaki, C.—On the Life History of *Ugimya sericaria* Rondani. Journ. Coll. Sci. Imp. Univ. Japan, Vol. I, pp. 1–39, Pls. I–VI. Tokyo, 1887.

to be practically the same as those of *scutellata*. Some of these eggs, taken from a dead and dried female, were placed on pieces of leaf and fed to several species of caterpillars. The excrement of these caterpillars was carefully examined the next day and many of the eggs found therein, most of them empty, but two from the excrement of an arctian had passed through entire. The bits of leaf that this arctian (*Diacrisia virginica* Fab.) had swallowed with the eggs were in many cases six to eight times as large as the egg, conclusively demonstrating that these minute tachinid eggs can be swallowed entire by caterpillars with their food without injury to the egg. The arctian was opened nine days after, and a small *parida* maggot, probably in its second stage, was found in the midst of a fat body next the alimentary canal. Thus the first step was gained toward a verification of the existence of this remarkable and hitherto reluctantly credited leaf-ovipositing habit in certain tachinids, including the removal from Sasaki of the stigma under which his startling observations had placed him.

ZENILLIA LIBATRIX Panzer.

A second step, which, in our opinion, practically removes all lingering doubt of the truth of our conclusions, was taken when *Zenillia libatrix* Panz. was studied. This is another summer-issuing, double-brooded species, whose eggs are quite similar in all characters to those of *Pales parida* and *Blepharipa scutellata*. Although our supply of the flies was extremely limited, yet the very few females under observation, while they did not reach the point of actual oviposition, lived long enough to give us a decided insight into their habits.

We have found that female tachinids, when nearing their ovipositing period, will attempt oviposition and simulate with the ovipositor the action of an ovipositing female. In many instances we have observed ovipositing females make repeated attempts, thrusting the ovipositor at the caterpillars several times before actually depositing an egg. The last two of the *libatrix* females—which, by the way, had manifested the same alarm at the proximity of caterpillars as had the females of *P. parida* and *B. scutellata*—were seen to touch the ovipositor excitedly as many as thirteen successive times to the newly eaten edge of a leaf where caterpillars had just been feeding. No egg was deposited, but the action showed the intent and, in our opinion, conclusively indicates the habit. About 150 mature eggs of *Z. libatrix* were secured from the last two females, after these died, and were fed on pieces of leaf to caterpillars of *Euvanessa antiopa* L., *Melalopha inclusa* Hbn., and *Schizura concinna* S. & A. The result of this experiment remains to be seen, but I hazard the prediction that *Z. libatrix*, *P. parida*, and *B. scutellata* will all be found to possess the leaf-ovipositing habit.

Two other European species—as yet undetermined, but which I refer doubtfully to *Masicera* and *Phorocera*—both reared from *Euproctis chrysorrhœa*, have similar eggs and doubtless have the same habit.

PROBABILITY OF AN EXTRA MAGGOT STAGE IN LEAF-OVIPOSITING SPECIES.

It should be mentioned here that in all probability *Blepharipa scutellata*, *Pales parida*, *Zenillia libatrix*, and the other flies belonging to this group have an additional maggot stage over other tachinids, since the newly hatched maggot is so very much smaller in size than are those of the latter. It ranges from one-tenth to one-fiftieth the size of the newly hatched maggots of those species which deposit eggs or maggots on the caterpillars, or maggots on the leaves, and yet is often much larger in the last stage than are they. In such case its second stage would correspond to the first stage of the other tachinid maggots, and would not show the last-stage type of anal stigmata. This is the case with the maggot of *P. parida* above mentioned, which is evidently in its second stage and whose anal stigmata do not yet show the four slits of the last-stage maggot. Each anal stigma appears as a bifid plate with scalloped edge, indicating a further split of each half at the next molt, which would produce the last-stage type.

THE DEPOSITION OF LIVING MAGGOTS BY TACHINID FLIES.

We come now to another phase of tachinid reproduction. It has long been known that *Sarcophaga* and its immediate allies deposit living maggots. It was not definitely or generally understood, however, that many true tachinids do the same thing. A remark made by Lowne in his Anatomy of the Blowfly, to the effect that both *Sarcophaga* and *Tachina* (these names evidently used in the wide sense) deposit living maggots, and the records cited by Brauer in Die Zweiflügler des kaiserlichen Museums zu Wien, Volume III, that *Echinomyia grossa*, *Miltogramma conica*, and *Trixa* are larviparous, are the only references I have seen to this fact. We found before we had gone very far, however—in fact, this point developed with *Parexorista cheloniæ*—that female tachinids of certain species may deposit eggs practically undeveloped, or at any stage of the development of the embryo, or perhaps may even deposit living maggots.

It should be stated here that the eggs of muscoidean flies originate in tubes called the egg-tubes, a cluster of which forms an ovary. The egg-tubes of each ovary open through a single tube into the oviduct. The eggs, upon reaching full size, pass from the egg-tubes of an ovary through the single tube into the oviduct, at the lower end of which they are fertilized by the male element proceeding from the minute long tubules which lead to the three spermathecæ or seminal vesicles. The latter receive the male fluid at the time of union of the sexes. The point of opening of the spermatic tubules marks the termination of the oviduct, immediately below which begins the long, tube-like, coiled uterus.

Upon dissecting dead females of *Parexorista cheloniæ* the uterus of certain of them was found to be packed not only with eggs but also with living maggots. The latter occurred at the lower end of the uterus next the ovipositor. As many as three hundred such eggs and maggots were found in the uterus of one *cheloniæ*. This explained why no definite period of time could be ascertained for the hatching of the egg of *cheloniæ* after its date of deposition. Some of the eggs hatched almost immediately after being laid upon the caterpillars, while others did not hatch for a week. After making this observation we realized that some of our species might be expected to deposit living maggots.

DEXODES NIGRIPES Fallen and COMPSILURA CONCINNATA Meigen.

The expectation that some species of Tachinidæ would deposit living maggots was immediately realized in the next species taken up, *Dexodes nigripes* Fall., a common summer-issuing species reared from both *Euproctis chrysorrhœa* and *Porthetria dispar*. The uteri of the females of *nigripes* were commonly found to contain living maggots, and these were apparently deposited, not on, but inside the skin of caterpillars of both *E. chrysorrhœa* and *Hemerocampa leucostigma* S. & A., and reared to the puparium in both. A very similar species, *Compsilura concinnata* Meig., apparently has the same habit of depositing living whitish maggots inside the skin of the caterpillars, and was reared in small caterpillars of *chrysorrhœa* from cold storage, not only to the puparium, but to the fly as well, thus proving at least three broods in one season for this species. It should also be stated that the above puparia of *Dexodes nigripes* similarly gave issuance to the flies, thus proving that it also has at least three broods.

The very remarkable point brought out in the investigation of these two species is that the females of both are provided with a long curved sheath, into the base of which the ovipositor fits, and which tapers to a microscopically sharp point. With this organ the females evidently puncture the skin of the caterpillars at the moment of larviposition, introducing the living maggot within the skin of the host. Such a habit was never suspected in the Tachinidæ. We have examined native species which are furnished with the same sheath and must have the same habit.

EUPELETERIA MAGNICORNIS Zetterstedt.

One of the next species taken up was *Eupeleteria magnicornis* Zett., which proved to be most remarkable as regards startling deviations from the previously known manner of reproduction among tachinids. The females of this species were most carefully labored with for a week or more in the attempt to secure their oviposition, using all kinds of caterpillars available. All efforts were in vain. Some dead females had been dissected and found to contain elongate, whitish, slightly curved eggs. It was not realized at the time that these females were immature so far as the development of the eggs in the uterus was concerned, and thus it was inferred that the species would deposit large elongate eggs on the caterpillars. It seemed quite inexplicable, therefore, when the females proved to be as much alarmed at the close proximity of caterpillars as were the females of *Blepharipa scutellata*, *Pales pavida*, and *Zenillia libatrix*. From the nature of the eggs it was impossible that they could be deposited on the leaves and eaten by the caterpillars. But why, then, should the females be so alarmed when brought face to face with the caterpillars? After much patient observation and experiment this question was answered. The flies were found to deposit living maggots, not on or in the caterpillars, but, most remarkable to relate, on the green shoots, leaf-stems, leaf-ribs, and even sometimes on the surface of the leaves!

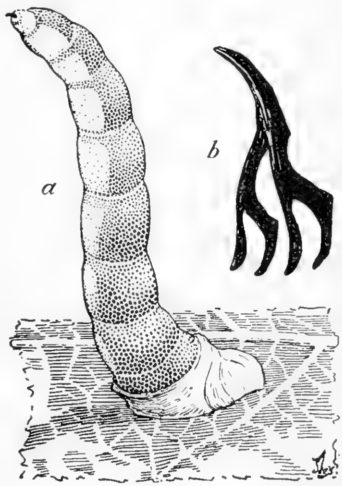

FIG. 27.—*Eupeleteria magnicornis*: *a*, First-stage maggot attached to leaf, awaiting approach of a caterpillar; *b*, enlarged mouth-hook of maggot. *a*, Greatly enlarged; *b*, highly magnified. (Original.)

The females would hover in the air about the shoots after the manner of syrphid flies, looking for caterpillars. They gave preference to the stems in depositing their maggots, and usually placed them where a silken thread had been left by a caterpillar as it climbed along a stem or over a leaf. Perhaps the sense of smell guided them in their larviposition on these silken threads. Several species of caterpillars were used with equal success, and it was found that the females would not deposit their maggots on shoots where caterpillars were not present. In fact it seemed necessary that caterpillars should have first crawled over the stems and leaves. The maggots are securely attached to the surface of the leaf or stem at the moment of deposition, by a thin membranous case, which is cup-shaped and surrounds the anal end of the body. Attached to the leaf or stem by this base, the maggot (see fig. 27) is able to reach out in all directions as far as its length will permit—and it is much more slender and elongate than those maggots which hatch from deposited eggs. It is constantly in motion when it feels the proximity of a host. As the maggot is deposited on the silken thread with which a webworm or caterpillar of *Euproctis chrysorrhœa* marks its trail as it leaves the nest, the caterpillar is sure to pick it up in following its thread back. Doubtless the flies larviposit only on freshly laid strands, which have not lost the odor of the caterpillar. When the maggot is left undisturbed for a time it appresses its body longitudinally to the surface of the stem or leaf-rib to which it is attached. But the moment it is touched by any object it immediately becomes extremely active, striving to attach itself to the looked-for host. As soon as it lays hold on a caterpillar the motion of the latter and the exertions of the maggot itself pull it loose from the membranous cup-shaped base, which remains where it was attached.

It is probable that this habit of larviposition in *Eupeleteria magnicornis* has been developed on account of the advantage gained thereby in the certainty of attachment of the maggot to a caterpillar. Being deposited where the caterpillar must pass over it, the maggot can attach itself with great ease to the legs or underside of the caterpillar, where the hairs are few and short. It would be much less certain of attachment if the female attempted to deposit it directly on the caterpillar. The fly is large and would unduly alarm the caterpillar, which would make frantic efforts to shake the maggot off. In this it would often succeed before the maggot could find its way through the barbed hairs that protect the upper and lateral surfaces of the caterpillar's body.

The maggot of *Eupeleteria magnicornis*, as might be expected, in view of its deviation in habit from the maggots of those species previously studied, has the integument quite different in character, since it must remain for a considerable time outside the host. The species which deposit living maggots on the caterpillars, as well as those which deposit eggs, have a whitish, thin-skinned maggot. The maggot of *magnicornis*, however, has a tougher skin and is quite dark in color. In the opinion of the writer, it is one of the most specialized tachinid maggots known, although the body shows 13 very distinct segments. The integument, both dorsal and ventral, is furnished with minute, slightly chitinized, scale-like plates, save only the median ventral region. Those of the dorsal region are distinctly larger and more chitinized than are those of the lateral ventral region, but the median ventral surface of each one of the body segments except the anal is entirely without them, being furnished instead with a band of minute black spines, which are entirely lacking on the dorsal surface. Thus it is readily seen that this maggot is especially well adapted both to remain a very considerable time in the air and to cling to and make its way over the skin of the caterpillar as soon as the latter presents itself.

This species possesses the further peculiarity of transforming to its last maggot stage inside the chitinized anal penultimate-stage skin, and also of changing to the pupa within the same, the whole remaining inclosed in the caterpillar skin. As a consequence the puparium is very thin and light colored, since it is protected from the action of both light and air by the caterpillar skin as well as by the penultimate-stage maggot skin.

ZYGOBOTHRIA NIDICOLA Townsend.

Zygobothria nidicola Towns. is another species which has exactly the same habit of last-stage maggot and puparium as that just described for *E. magnicornis.* It is an extremely interesting species in many ways. The two sexes are so different in appearance that they might be taken for distinct species or even genera. The males, in our experiments, began issuing from the puparia much in advance of the females. The species has been reared from *Euproctis chrysorrhœa* only, and then under such conditions as to indicate that the females oviposit on the young caterpillars in the fall, the young maggots hibernating in the *chrysorrhœa* nests with the young caterpillars. For this reason it was named *nidicola.* Though the sexes are so different, the fact that they belong together has been proved by their issuance from puparia having the same anal stigmata. No oviposition was secured, but by dissecting females the ovarian eggs were found to be elongate, whitish, and much like the unhatched uterine eggs of *Eupeleteria magnicornis.*

ZYGOBOTHRIA GILVA Hartig and CARCELIA GNAVA Meigen.

Zygobothria gilva Hartig is a close relative of the preceding species, but has been reared by us from *Porthetria dispar* only. Its egg, which has been found by dissecting the female, is quite similar to that of *Zygobothria nidicola.*

Of somewhat the same character is the egg of *Carcelia gnava* Meig., which has been reared from both *Euproctis chrysorrhœa* and *Porthetria dispar.* The deposited egg of *gnava* has been secured. The fly places its eggs on the caterpillar. The egg is not as slender as that of *gilva.*

PARASETIGENA SEGREGATA Rondani.

The last group of species with which we have to deal is characterized by depositing, on the caterpillars, eggs more or less oval in shape, of comparatively large size, with one exception whitish in color, and having a moderately or quite thick chorion. The first of these species that we took up was *Parasetigena segregata* Rond., which issued from hibernating puparia along with *Blepharipa scutellata.* For a time it was confused with the latter species, since only a dozen or so specimens issued and these were not at first examined with a lens. The radical difference in the behavior of the females soon attracted our attention to their distinctness from *scutellata.* The females were not alarmed at the close proximity of large caterpillars of *Porthetria dispar*, but, on the contrary, were highly excited to oviposition by them, repeatedly and most enthusiastically and energetically ovipositing upon them whenever the caterpillars were placed near. This is apparently a single-brooded species.

TACHINA AND ALLIES.

Tricholyga grandis Zetterstedt, *Tachina larvarum* Linnæus, and *Tachina utilis* Townsend are closely related to each other and all deposit very similar eggs, which are much like those of *Parasetigena segregata*, but somewhat narrower and more elongate in shape and with a thinner chorion. They are all deposited very freely upon caterpillars. The species of *Tachina* are at least double-brooded, and the second generation of *T. grandis* has been recently reared by us to the fly, showing it to be three-brooded.

The egg of an undetermined European species, which I refer doubtfully to *Hemimasicera*, is similar to these in all characters except that it is of a decidedly light-yellow color. The eggs of this group of species are normally deposited in a practically undeveloped stage of the embryo.

Two Japanese species of *Tachina*, representing in Japan the European *T. larvarum* and *T. utilis*, but specifically distinct from them, have the same character of eggs and belong in the group with *Parasetigena segregata*, just mentioned. What has been said of this group applies to them.

TACHINA CLISIOCAMPÆ Townsend.

An American species of *Tachina*, which I identify as *clisiocampæ*, also deposits the same kind of eggs. It has been reared from both *Euproctis chrysorrhœa* and *Porthetria dispar.* An interesting point has recently been determined in connection with it. It oviposits very freely on large caterpillars of *dispar* over the greater part of the *dispar*-infested area from Rhode Island to Maine. Last season great numbers of its eggs were found on the *dispar* caterpillars, a great many of which were brought into the laboratory for rearing. Not a single tachinid puparium was secured from them. The fact that no puparia could be reared from caterpillars covered with eggs seemed inexplicable. The explanation was found this season, when many more such caterpillars were collected for rearing. In repeated instances the newly hatched maggot was observed as it escaped from the eggshell, and in none of the observed cases was the young maggot able to penetrate the tough skin of these large *dispar* caterpillars; the maggots were watched repeatedly through a binocular in their vain efforts to do so. This species, being a native, has not yet adapted itself to *dispar*. It has been reared from it to a considerable extent, but it is quite certain that in most of the cases the egg was deposited upon the smaller and younger caterpillars, whose skins are not so tough as are those of the large ones. A very few puparia were secured this season from many thousands of *dispar* caterpillars collected, showing that hardly any of the deposited eggs of the species took hold, for these eggs were common and numerously deposited. When the species does become adapted to *dispar* as a host, which it undoubtedly will eventually, it will prove a most efficient help in checking the increase of the latter.

It is very interesting to note that the Japanese Tachinas greatly resemble *clisiocampæ*, the American form. Both differ from the European *larvarum* in having a very decided, general golden tinge to the body bloom, especially that of the head and thorax. This bloom is quite distinctly silvery in *larvarum*.

JAPANESE REPRESENTATIVES OF EUROPEAN SPECIES.

Several representatives in Japan of European species have been recognized in the puparia secured from Japanese specimens of *Porthetria dispar*, a considerable quantity of such puparia having been imported from Japan the present season. The Japanese Tachinas have been mentioned above. *Crossocosmia* sp. has been plentifully received from Japan, where it represents the European *Blepharipa scutellata* and has the same leaf-oviposition habit. The fly has been reared of a Japanese *Pales* near *pavida*, which greatly resembles the European form and has the same habit. A Japanese species corresponding to that doubtfully referred (p. 106) to *Hemimasicera* has issued from the puparium, and differs from the European form in its darker coloring and golden instead of silvery bloom. Species representing *Compsilura concinnata*, *Zygobothria gilva*, and *Carcelia gnava* have also been found in the Japanese puparia.

IMPORTANCE OF STUDYING THE UTERINE EGGS OF TACHINIDÆ.

It has developed during the progress of the work that a study of the uterine eggs of tachinids is of primary importance in the investigation of the various species. Certain very positive deductions may be drawn from them as to habit of reproduction. Before securing oviposition—and it has been seen that one is often baffled for a considerable time in effecting this—the females can be opened and the uterine eggs obtained. Those eggs contained in the upper extent of the uterus are of course the most recently fertilized and the least developed of the uterine eggs. If they have a very thin shell it is probable that they hatch within the uterus, and that the female therefore deposits living maggots. Such is the case with *Dexodes nigripes*, *Compsilura concinnata*, and *Eupeleteria magnicornis*, and with such dexiine and macronychiid flies as we have studied; and from the character of the eggs such is possibly the case with *Zygobothria gilva* and *Z. nidicola*, though only ovarian eggs of the last have as yet been secured. Furthermore, if the hatched uterine maggot is furnished with a membranous encasement of its anal end, it shows that this maggot is not to be deposited on the caterpillars, but is to be attached to the stems or leaves. Such is the case with *magnicornis*. The uterine maggots of *nigripes* and *concinnata* have no such anal membrane of attachment, and are introduced into the caterpillars. If the uterine eggs are slender and very elongate it is quite certain that they hatch in the uterus. Such is the case with the dexiine and macronychiid flies.

If, however, a thin-shelled egg is furnished with a pedicel, this is proof positive that the egg is intended to be deposited as such, but the thin shell indicates that it is normally deposited at an advanced stage of development of the embryo. Such is the case with *Parexorista chelonia*, whose eggs have a pedicel, and should normally hatch soon after deposition. The few occurrences of hatched maggots in the uterus of *chelonia* were doubtless due to an abnormal hatching of the eggs after the death of the females. No doubt, however, *chelonia* is in process of transition from an ovipositing to a larvipositing habit. It is greatly to the advantage of the species that the egg should hatch shortly after deposition, for this guards against its loss by molting. We have found that a large percentage of the eggs are molted off by the caterpillars. Those species which deposit living maggots derive a still greater advantage in this direction. Those eggs which have a thick shell are intended to withstand atmospheric conditions for some time, and may be deposited a week or more before the embryo is fully developed. Such is the case with *Parasetigena segregata*, *Hemimasicera* sp. (?), *Tricholyga grandis*, *Tachina larvarum*, *T. utilis*, *T. clisiocampæ*, and the Japanese Tachinas. That the eggs of these are large shows that they are to be deposited on the caterpillars.

Again, if the eggs are minute it is quite certain that when matured they will be black and highly chitinized, and each character points directly to a habit of leaf-oviposition. The chitinization indicates that the eggs are intended to withstand exposure to the elements and to be swallowed. Equally indicative is minuteness, for otherwise the eggs could not be swallowed entire. It is probable that such eggs, deposited on leaves and intended to be swallowed, remain unchanged without losing their vitality for a very considerable period of time, until they are swallowed by the caterpillars. It is equally probable that such eggs are not deposited until the embryo is nearly or quite fully developed, and that the digestive juices and conditions which the egg encounters in the alimentary canal of the caterpillar act upon the chitin and cause the shell to weaken so as to release the maggot. It is certain that such eggs must hatch within a very few hours after being swallowed, otherwise they will pass out with the excrement. One of the fed eggs of *Pales parida*, above noted, passed through a *dispar* caterpillar in about four hours. A minute egg can not have a thick chorion and is therefore provided with a chitinized thin one, which withstands atmospheric conditions equally as well as, or better than an unchitinized thick one. Furthermore, the chitinization strengthens the egg and thus lessens the chance of injury to it while being swallowed. Still further, we have found that the chorion of all these eggs possesses a minute raised reticulation, which we consider is intended as a framework to strengthen it so as to protect the egg still more fully from injury in being swallowed. Such are the eggs of the *Blepharipa scutellata* group above described, which includes *Pales parida* and *Zenillia libatrix*. The chorion reticulation of *cheloniæ* and other tachinid eggs is not so thickened and raised.

Enough has been said to show how very largely the reproductive history of the species may be read from the uterine eggs, which can be dissected from almost any female fly, collected or otherwise. It is only necessary that the female be fertilized. Even the ovarian eggs from unfertilized females show a great deal, for we have noted that the ovarian eggs of *Parexorista cheloniæ* show the pedicel while still enclosed within the egg-tubes.

REPRODUCTIVE CAPACITY OF TACHINIDÆ.

The capacity for reproduction in the females of the various species of Tachinidæ is another very interesting subject, of which surprisingly little is known. The greatest number of eggs that we have noted in the uterus of *Parexorista cheloniæ* is about 300, but this number may not represent the full capacity of the females for reproduction. After the uterus is well filled, further eggs may reach it from the ovaries until its extreme limit of distension is finally attained, and still more may follow as the contents are deposited. The uterus of a female of *Eupeleteria magnicornis* which had begun larviposition was found to contain, at a conservative estimate made from actual count of a portion, 3,200 eggs and maggots. This did not represent the full capacity of the female, for the egg-tubes in the ovaries still contained ova. The uterus in this specimen was very long and coiled, and greatly distended by its contents. This is a high record of reproductive capacity. It is quite probable, however, that *Blepharipa scutellata* exceeds even this record, for the fly is large and the egg minute. Besides, a habit of leaf-oviposition would presuppose a lavish productiveness of eggs. Sasaki estimates a capacity of over 5,000 for *Crossocosmia sericariæ*, and some of our native species having the same habit equal this estimate. *Tachina* and its close allies deposit a great many of their comparatively large eggs, but their capacity does not seem to much exceed 100, judging from those we have opened. The other species that we have so far studied have, upon dissection, shown from 100 to 5,000 uterine eggs. The uterus of a native macronychiid fly, *Microphthalma trifasciata* Say, which deposits living maggots, was found by us to contain some 2,000 eggs and maggots. Native species having the leaf-larviposition habit commonly show from 2,000 to 3,000 uterine eggs and maggots, and those having the leaf-oviposition habit run up to 5,000 uterine eggs. The genera of these are given farther on.

THE REARING OF TACHINIDÆ IN CONFINEMENT.

It had currently been supposed that the oviposition of tachinids in confinement was a most difficult thing to secure. With proper facilities at hand, such is by no means the case. The Riley rearing cage, large or small, is not at all adapted to the work, yet some species may be induced to oviposit in it, and even in the very restricted space under a jelly glass. The proper cage for this work is our large out-of-doors wire-screen cage, which is shown in figures 25 and 26. For indoor rearing of single caterpillars bearing eggs or containing maggots we have adopted the glass cylinders shown in figure 29. These have the top covered with cheesecloth, and are placed on a stand which consists of a simple cloth-covered frame 5 inches square. Two opposite sides of the frame are made higher than the other two, for the completed stand to rest on, so as to allow circulation of air beneath. Cheesecloth will not do for the covering of the frame, since the mesh will permit tachinid eggs and small maggots, or even small caterpillars, to escape. For the same reason cheesecloth will not do for the bottom of the "tanglefooted" trays. We have known full-grown maggots to work through it with ease. For both frames and trays a more closely-woven cloth should be used. Flies also can be placed in the glass cylinders, but a little dry sugar and a bit of wet sponge should be included with them. Many species will live for two or three weeks in this way. These cylinders are especially adapted to rearing tachinid maggots in single caterpillars, either indoors, or, during warm weather, in one of the large cages outdoors, which may advantageously be furnished with shelves for this purpose.

In our large outdoor cages we have been greatly struck with the extreme docility of the ovipositing female tachinids. They can be handled and caused to oviposit quite at the will of the operator in most cases.

AN IMPROVEMENT IN THE METHOD OF COLONIZING TACHINIDÆ.

The extreme ease with which oviposition was secured in the cases of *Tricholyga grandis* and the Japanese and European Tachinas in the outdoor cages suggested the feasibility of an improvement in the method of colonization hitherto practiced. Until this season only the flies themselves had been liberated, but recently the plan has been adopted of colonizing caterpillars upon which the tachinids have been induced to oviposit, in conjunction with the liberation of the flies. Egg colonization, or the colonization of the caterpillars with the eggs on them, is a step in advance of fly colonization, and thus gives greater assurance of success in the establishment of the species. It has proved very easy of accomplishment. Over 1,000 webworms were colonized in July with eggs of the Japanese Tachinas on them. Oviposition was secured in an outdoor cage by one assistant at the rate of 200 to 300 eggs per day during favorable weather, these being furnished by but little over a dozen ovipositing females. These flies were afterwards liberated. The cage used is shown in figure 28.

Early in August a new lot of Japanese Tachinas had become ready for oviposition in this cage, and one assistant in one day, working six hours, secured 335 eggs from them on young caterpillars of *Euproctis chrysorrhœa* from cold storage, one egg on a caterpillar. This lot of eggs came from not over 20 ovipositing females. This is a very high record of oviposition—almost an egg a minute—for it must be remembered that the caterpillars had to be exposed, one at a time, to the flies. These eggs, with others secured on other days, were colonized by placing the caterpillars on new oak growth near the laboratory, where defoliation by *Porthetria dispar* had occurred early in the season. This second lot of Japanese flies was afterwards liberated, over a thousand eggs having been secured from them on young *chrysorrhœa*, and colonized. Some of the advantages of egg colonization before liberation of the flies are the provision in the outdoor cages of food and caterpillars for oviposition, and protection from enemies preceding and during a part of the ovipositing period. Furthermore, after fly colonization, if we find eggs of the flies in question on caterpillars in the vicinity, we naturally consider the establishment of the species to be more or less assured. If, however, we colonize the caterpillars themselves with the eggs of the flies already on them, we have this assurance at the moment of colonization, which must be considered a very great advantage.

NEW ALTERNATE HOSTS FOR INTRODUCED TACHINID FLIES.

An important problem in the process of establishment of imported summer-issuing species of tachinids is that new alternate hosts must be found for them in this country. The caterpillars of *Porthetria dispar* and of *Euproctis chrysorrhœa* have mostly pupated by midsummer, both here and abroad, and are thus not available as hosts after that time. Therefore the late summer generations of these tachinids develop in certain alternate hosts which occur in their native country. Those alternates are not present here, and new alternates must be provided for them from our native species. Fortunately tachinids are quite amenable to a change of host. Gratifying results have been obtained in this direction. Tussock caterpillars (*Hemerocampa leucostigma* S. & A.), have proved very acceptable to *Dexodes nigripes*, *Compsilura concinnata*, *Tricholyga grandis*, and other species, but they are not sufficiently abundant after midsummer to be of use for egg colonization on a large scale. Caterpillars of *Datana*, *Basilarchia*, *Euvanessa*, *Anisota*, *Schizura*, *Melalopha*, and others have been found acceptable to the flies in most instances, but likewise none of these is sufficiently abundant at the right time. We were at first very much at a loss for suitable alternate host caterpillars in sufficient number. It was therefore most gratifying to find that the newly hatched fall webworms (*Hyphantria cunea* Dru.) just coming on, which were abundant and easily obtained, were admirably suited to the purpose. Profuse oviposition was secured on these from the Japanese Tachinas, and also from *Tricholyga grandis*, *Tachina larvarum*, and others. The webworms, as soon as they had been oviposited on, were put back in the webs in large colonies to insure their prosperity. The females of *Eupeleteria magnicornis* industriously deposited their maggots on webworm-infested shoots, placed with the flies inside the wire-screen receptacle shown in figure 29.

To make success more certain in the egg colonization of the Japanese and European Tachinas, oviposition was also secured on young *chrysorrhœa* caterpillars that had been kept in cold storage until about the 1st of August. Had it not been for the fact that a great amount of new and tender oak foliage was available, where complete defoliation by *dispar* had occurred during the early summer, these *chrysorrhœa* caterpillars could not have been used. The old and matured leaves are not suited to the young caterpillars just out of the nests, but the latter flourish on the new oak growth.

Thus the question of alternate hosts in this country was satisfactorily answered, not only for purposes of egg colonization, but also for the needs of the liberated flies. The flies of *Tricholyga grandis* and the first lot of flies of Japanese *Tachina*, all of which had, so to speak, been trained to webworms through much oviposition on them, were colonized in separate webworm localities. Thus it was certain not only that their wits had been sharpened for webworms but that they would find plenty of these on which to oviposit.

Similarly, the second lot of flies of Japanese *Tachina*, which had been trained to oviposition on *chrysorrhœa* entirely, was furnished at the time of liberation with a good supply of native cold-storage *chrysorrhœa* caterpillars of fair size, placed on new and tender oak growth, the *chrysorrhœa* of the vicinity being little more than hatched

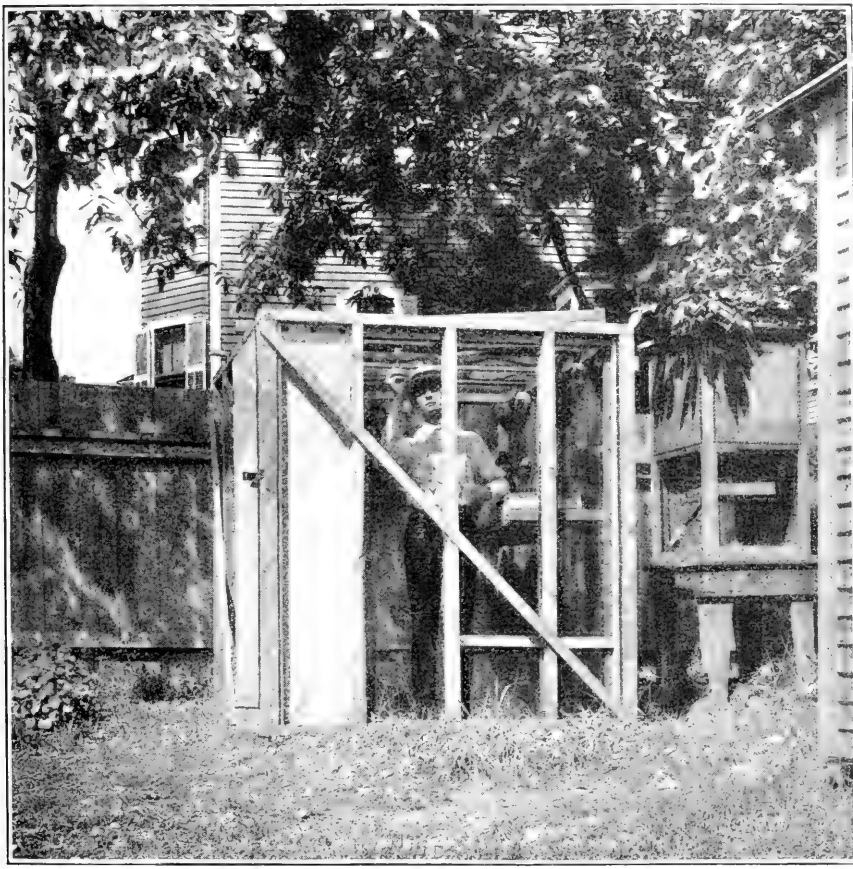

FIG. 28.—Outdoor cage for securing oviposition of Japanese *Tachina*, covered about door with paper to prevent the flies from congregating at that point. (Original.)

at the time and too small to furnish it with proper host material. Some of these caterpillars were dissected about a week later and 20 per cent of them showed living maggots of *Tachina*.

IMPROVEMENTS IN THE OUTDOOR REARING CAGE.

Experience with the outdoor cage described on page 96 has suggested two improvements, which will be put into practice the coming season. It is often highly desirable to be able to admit all the sunlight and warmth available in the Massachusetts climate. For this purpose the canvas roof should be capable of being shifted completely to one side, so as to admit the sun, and swung back over the cage again during bad weather and at night. The cage used for the Japanese *Tachina* was made without any roof, being open to the sky through the wire screening. Tarred roofing was placed over it when needed. This proved to be a very great advantage.

The second improvement will consist in a raised cement floor to extend a foot all around outside the wire screen, this outside portion to contain a shallow trench that should be kept constantly supplied with a little kerosene on water. This will obviate all difficulty from ants, carabids, and spiders, which will often kill the flies if not care-

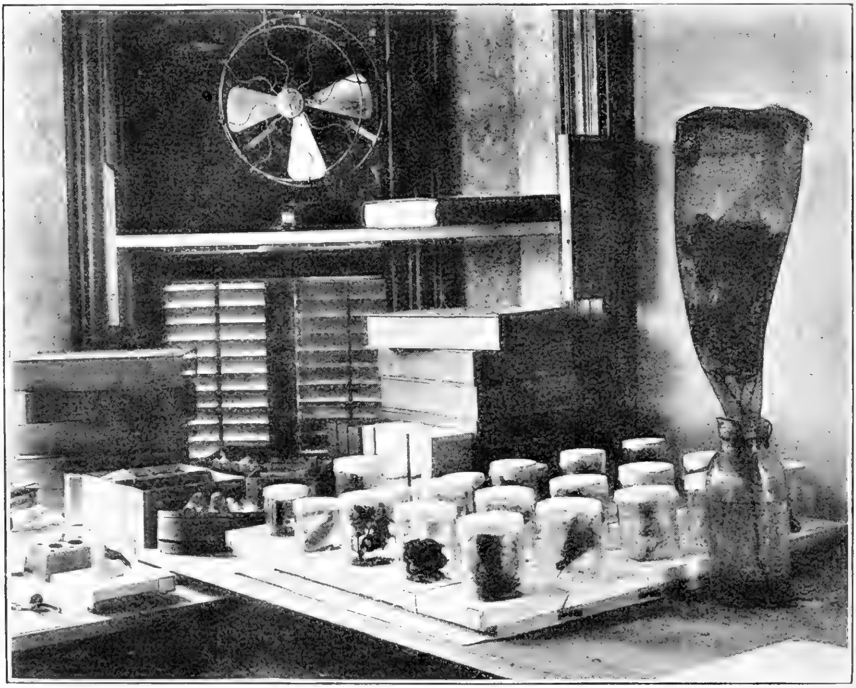

FIG. 29.—Glass cylinders in use in rearing Tachinidæ, and wire-screen receptacle for inclosing flies with caterpillars on foliage. (Original.)

fully watched. The floor can be sloped slightly inside the cage, so as to drain off through a pipe to be carried beneath the kerosene trench. Next season there will also be erected a separate cage of this description fitted with shelving to accommodate the numerous glass cylinder stands necessary for the rearing of the different stages of tachinids separately in caterpillars, which can be accomplished much better under out-of-door conditions.

Attention should be called to the wire-screen vestibule with which our first outdoor cage was furnished (shown in fig. 25). This was found quite necessary in order to prevent the flies from escaping while the experimenter is going in and out of the door, certain species being extremely active during warm, sunny weather. Figure 26 is introduced to show the disposition of the "tanglefooted" trays within this cage. Figure 28 shows the outdoor cage used in securing oviposition of Japanese *Tachina*, which, in default of a vestibule, was covered about the door with paper to prevent the flies from congregating there. Figure 29 shows the glass cylinders in use and the wire-screen receptacle for inclosing flies with caterpillars on foliage that can be kept green for a considerable time.

We further have in mind for next season a compound outdoor cage on these lines, 30 by 15 feet floor space, arranged with five compartments on each side of a passageway, each compartment to be 6 by 6 by 6 feet, so as to allow one experimenter to work separately with 10 species of flies at a time. The whole will be fitted with canvas roof and drop curtains, in sections, capable of being completely rolled up or lowered, as desired. A small table, with microscope and work materials for the use of the experimenter, will be placed at one end of the passageway. The other end of the latter will open outside by a screen door, and each compartment will open into the passageway only. The vestibule can thus be dispensed with, since the passageway will serve the purpose.

BLEACHING THE PUPARIA OF TACHINIDÆ.

One point connected with the preparation of early-stage tachinid material for permanent preservation deserves mention. It has already been stated that the anal stigmata of the puparia show excellent characters for the separation of the various forms. It is highly desirable to present photomicrographs of these along with the taxonomic results derived from a study of them, but no practical mounts for this purpose can be made of them in their natural condition. A series of bleaching experiments has therefore been instituted, and the puparia have been successfully bleached with chlorine water to any desired degree. The result is a slide mount from which either drawings or photographs may be made with ease.

RESULTS FROM DISSECTIONS OF NATIVE TACHINIDÆ.

I am able to include here some interesting results obtained from dissections of females of native tachinids. We have secured the uterine eggs of some seventy species, and the results are a revelation. *Bombyliomyia abrupta* Wiedemann, *Echinomyia algens* Wiedemann, 3 species of *Peleteria*, 3 species of *Archytas*, *Panzeria* sp., *Varichæta* sp., *Copecrypta* (*Trichophora*) *ruficauda* van der Wulp, and *Micropalpus* sp. show uterine maggots similar to those of *Eupeleteria magnicornis*, thus proving the abundant presence of the leaf-larviposition habit in our native fauna. The maggots of some of the forms differ in the details of the spines and plates. We now know thirteen species, therefore, that have this habit.

The great fecundity and consequent importance of *Blepharipa scutellata* and *Crossocosmia* sp. as parasites of *Porthetria dispar* is strongly suggested in a native species of *Parachæta*, whose uterus we found to contain some 5,000 minute black eggs similar to those of *scutellata*. Some of these uterine eggs, upon being slightly pressed beneath a cover glass, disclosed the fully formed maggots, which fact proves our supposition that eggs of the leaf-ovipositing species are ready to hatch at the time of deposition. Sasaki has shown this to be the case with the Uji parasite. Furthermore, the structure of the maggot itself, as well as that of the chorion, shows that the former may remain quiescent within the latter for a considerable period until the egg is swallowed by a caterpillar. The newly-hatched maggots of this group are quite as specialized as are those of the *magnicornis* group, but in a totally different direction. Those above mentioned were found to be broad-oval, considerably flattened, the anterior end slightly narrowed and pointed, and with the spines chiefly disposed on the anterior segments. There are 12 rows of spines, each segment except the last having a row, but the rows of the middle segments are very short. The first four rows, on segments 1 to 4, are complete and continuous on all sides; the next seven rows, on segments 5 to 11, are incomplete, showing from 4 to 8 spines in the middle on the ventral surface only, segments 6 to 9 having the least; the last row, on the preanal segment, is complete. The spines of the first three dorsal rows are especially strongly hooked and claw-like, the hook process of each pointing backward so as to hold the maggot in piercing the walls of the alimentary canal of the caterpillar. The spines of the other rows are also claw-like, but the hooks are less strongly developed. Last, but especially suggestive, is the fact that the lateral portions of the maggot show a row of large fat globules on each side just inside the skin, which are no doubt designed to sustain the maggot until the egg is swallowed. (See fig. 30.)

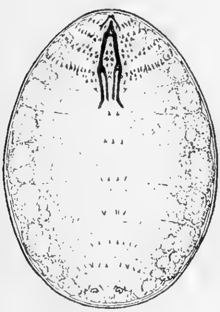

Fig. 30.—*Parachæta* sp.: Uterine egg with chorion removed, showing structure of the fully formed maggot from below. Highly magnified (original).

Gonia frontosa Say, *Pseudogermaria* sp., *Blepharipeza leucophrys* Wiedemann and a second species, *Parachæta* sp., *Latreillimyia* sp. (aberrant form from Pennsylvania), *Triachora unifasciata* Desvoidy, two species doubtfully referred to *Masicera*, *Exorista* sp., *Eusisyropa blanda* Osten Sacken, *Sisyropa* sp., and two species near *Eusisyropa* (Laboratory Nos. 1979, 2322) have all been found to have minute eggs similar in size to those of *Blepharipa scutellata*. Thus, at the very first examination of our native species we find fourteen different forms that we can say positively have the leaf-oviposition habit. Five of the two dozen European species that we have studied are to be added to these, making a total of nineteen American and European species now known to have this habit. It is therefore evident that, while European and American students were industriously engaged in criticising and discrediting Sasaki's statements, abundant proof of them was right at hand on both continents, had anyone stopped to look for it.

The uterine eggs of the other native forms dissected indicate a habit of oviposition on, or larviposition in or on the host. The dexiine flies appear so far to deposit living maggots, slender and pointed like those of the macronychiid flies. *Theresia tandrec* Coquillett (*non* Robineau-Desvoidy) deposits the same kind of a maggot, except that its anal end is bifid into two slender processes in which the tracheæ terminate. The pseudodexiine flies deposit a maggot somewhat less elongate, and some of the masiceratine and phoroceratine flies, one still more shortened. One species near *Masicera*, but with stout discal macrochætæ, was found to contain uterine maggots that were shortened and plump, with strongly marked complete rows of spines on the segments, greatly resembling certain œstrid maggots (*Œstrus* and *Gastrophilus*). *Hemyda aurata* Desvoidy gave us only ovarian eggs, which are elongate but do not seem to indicate larviposition. So far the leaf-oviposition habit seems confined to certain masiceratine, willistoniine and goniine flies and their near relatives, which seem to form two or three compact taxonomic groups. The habit of leaf-larviposition seems confined to the echinomyiine and hystriciine flies. An immense amount of this dissecting work must yet be done, however, before any generalizations can be made.

As might be expected, there is considerable diversity of type in the structure of the chorion of the minute eggs. This may, or may not, imply independence of origin. For example, the European species doubtfully referred to *Phorocera* (p. 101) has the exposed chorion (the part not attached to the leaf surface) limpet-shaped and showing concentric rings instead of the ordinary reticulation; and the exposed chorion of *Sisyropa* sp. (Laboratory No. 1975) is reticulate, but shows a remarkable, irregular, light-colored fringe around the edge, pierced with microscopic shot-holes. Both of these forms of egg, placed on the leaves, would greatly resemble extremely small miniatures of certain coccids!

SUMMARY OF REPRODUCTIVE HABITS NOW KNOWN IN THE TACHINIDÆ.

From what has been recorded in this paper it will be seen that we now know five different styles of reproductive habit in the Tachinidæ. These may be summarized as follows:

Reproductive habits.	Examples.
(1) Host-oviposition	*Tachina larvarum.*
(2) Leaf-oviposition	*Blepharipa scutellata.*
(3) Supracutaneous host-larviposition	Dexiine flies and allies.
(4) Subcutaneous host-larviposition	*Compsilura concinnata.*
(5) Leaf-larviposition	*Eupeleteria magnicornis.*

This is certainly an excellent showing for adaptation and variety of habit in a family as compact in character as the Tachinidæ, which does not include the macronychiids, muscids, or phasiids, and in which a certain unity of habit was long supposed to obtain. It may be further remarked that we have in one instance dissected two female specimens, separated with difficulty on slight external characters, and appearing at first to be the same species, and have found one to have the habit of leaf-oviposition and the other, a habit of either host-oviposition or host-larviposition. This aptly illustrates the necessity for a most careful study of external adult characters and a nice sense of discrimination—in other words, the zoological sense—in order to distinguish the many distinct but often closely similar forms of these flies. Slight differences in shade of pollinose covering, in width of front, in strength of frontal bristles, in hairiness of eyes, and in thoracic and abdominal lines—all of these easily overlooked—were the only external characters that enabled us to pronounce the two specimens distinct species. The character of the uterine eggs, however, at once demonstrated the very marked distinctness of the two forms, which can not be referred to the same genus, nor even to the same tribe, and perhaps not even to the same subfamily.

The five classes of reproductive habit mentioned above are arranged in the order of their probable antiquity, host-oviposition being considered the oldest and leaf-larviposition the most recent. This order not only seems natural from the reproductive standpoint, but is borne out by a study of the external characters of the flies themselves, principally the character of the facial plate.

CONCLUSION.

The results of all this work on European, Japanese, and American tachinids point to the very great importance of *Blepharipa scutellata* and *Crossocosmia* sp. as parasites of *Porthetria dispar*. The great capacity for reproduction, possessed by these species, and the fact that all of their eggs must be eaten by the caterpillars wherever *dispar* is abundant, place them in the lead of parasites.

No two species can be so relied upon as parasites of *Euproctis chrysorrhœa*, but the Japanese Tachinas, *Tricholyga grandis*, *Compsilura concinnata*, *Dexodes nigripes*, and *Parexorista cheloniæ* seem to be among the most important here.

All of the other imported species mentioned will prove of much importance as aids in the control of one or both of these moths. The great majority of them are parasitic on both hosts.

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TECHNICAL SERIES, No. 12, PART VII.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

THE ORANGE THRIPS.

By DUDLEY MOULTON,
Engaged in Deciduous Fruit Insect Investigations.

ISSUED FEBRUARY 11, 1909.

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1909.

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MISCELLANEOUS PAPERS.

THE ORANGE THRIPS.

By Dudley Moulton,

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTORY.

The orange thrips, *Euthrips citri*, a new species, described in this article, has become a very important orange-tree pest in the southern San Joaquin Valley of California and has been the subject of special investigation. The writer has been able to talk with many orange growers and packers, and with men who have developed extensive nurseries, and the following notes have been gathered largely from these sources.

DISTRIBUTION.

The San Joaquin orange belt extends along the western border of the Sierra foothills from a point about east from the city of Fresno, southward to a short distance below Porterville, with some orchards as far south as Bakersfield. The belt is not at all continuous, but is broken in many places because of improper soil conditions, frosts, and the lack of water for irrigation. The thrips is distributed everywhere throughout this belt, but is not found, so far as I have been able to learn, in any other orange section of California.

EXTENT AND NATURE OF INJURY.

The orange groves in the San Joaquin belt are wonderfully profitable, for as much as $2,000 per acre has been realized in a single year from full-bearing orchards. This thrips problem is, therefore, a very important one when we consider the large area which is planted and is being planted.

Curled and thickened leaves and marked oranges, the characteristic signs of the thrips, have been known for from ten to fifteen years, but only recently have these injuries been attributed to the thrips. The thrips has been increasing rapidly in numbers, until now the annual loss to the orange growers amounts to many thousands of dollars.

The writer recently visited a packing house where oranges from thrips-infested orchards were being graded and boxed, and found that about 30 per cent were passed from fancy (first grade) to choice (second grade), which means a difference in price of about 40 cents per box; and that about 5 per cent of the crop was being passed out as culls, due entirely to the scablike markings of the thrips. While the quality of the fruit is not noticeably impaired, as the injury is present only on the surface of the skin, oranges are graded and also sold largely on appearance, and this scab produces a very unpresentable fruit. (See Pl. VIII, figs. 3, 4.)

The thrips feeds also on the foliage and tender branches, and the damage to these is serious, although not so noticeable as on the fruit. Only newly unfolding and tender leaves and buds are attacked; as the feeding is mostly confined to the surface no part of the leaf tissue is killed outright, but there follows the "silvering," characteristic of thrips and other surface-feeding insects. The leaves become cup-shaped and wrinkled and the tissues noticeably thickened. (Pl. VIII, figs. 1, 2.) Orange trees in this section have four growths annually, so that there is always an abundance of new foliage present when the thrips is above ground.

LIFE-HISTORY NOTES.

There are apparently two broods of this species. Adults of the first brood appear just before the blossoms in February, March, and April, and a second brood appears in July, August, September, and October. Adults and larvæ of the first brood feed on the small oranges just as the petals are being thrown off, the larvæ usually under the protection of the sepals, and on the first growths of the foliage. The second brood feeds on the nearly mature oranges and on the third and fourth growths of the foliage. All varieties of oranges and lemons are attacked, but the very noticeable scabbing on the fruit is common only on the navel orange; it is less conspicuous on the Valencia.

SOIL CONDITIONS AS AFFECTING PREVALENCE.

It has been noticed that the thrips is not so prevalent on trees planted in sedimentary or loam soils as where the soil is of a clayey or adobe texture. This fact may be explained as follows: This thrips, like most others of its group, presumably spends the last of its larval, its pupal, and its early adult life in the soil underneath the trees, and would naturally, then, be more or less affected by the texture of the soil and by cultivation. Orange groves are usually irrigated several times during the summer and are cultivated throughout the year. Sedimentary soils break to pieces readily

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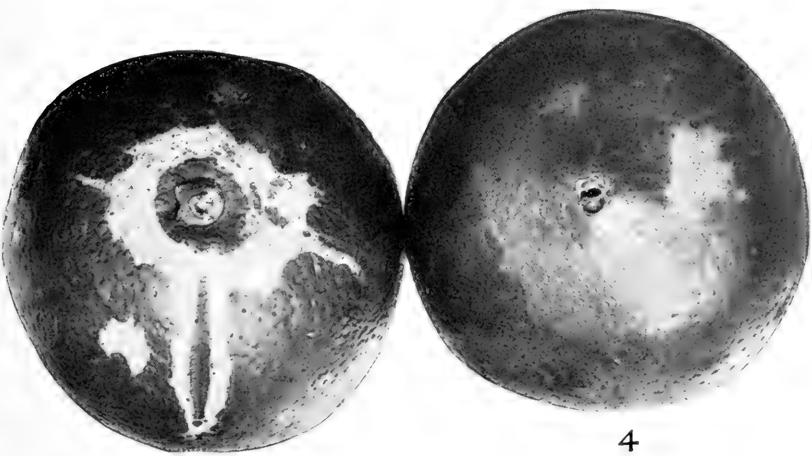

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WORK OF THE ORANGE THRIPS (EUTHRIPS CITRI, N. SP.).

Fig. 1.—Injury to tender orange shoot. Fig. 2.—Orange buds in axils of leaves killed back as fast as formed, preventing further growth. Fig. 3.—Scab injury at stem end of orange, due to work of thrips shortly after blossoms fell. Fig. 4.—Scab injury at distal end of orange, due to work of thrips late in season. (Original.)

when thus moistened and cultivated, and thrips in this ground would probably be broken from their small cells, if indeed they were able to make cells at all in this soil, and many of them would be killed by the cultivator and by the grinding together of the soil particles during cultivation. On the other hand, in clay lands the particles of soil pack closely together and form clods, and during cultivation any number of thrips within these clods might be repeatedly turned over and over without injury. In this soil, too, it would be possible for the thrips to make a strong, well-lined cell.

Another fact in the cultivation of orange groves should be mentioned in this connection. After the trees have become large and the fruit-laden limbs hang over and drag on the ground it seems impossible to cultivate thoroughly close up to the tree, and there may be an area of several square feet that is not disturbed during the entire summer. This offers an ideal breeding place for the thrips.

REMEDIES.

We are not able at this time to say what spray can be used to control this thrips, but a strong tobacco extract will doubtless prove effective and will not hurt the tree. Some of the cheaper soap washes ought also to be effective.

ENEMY.

It may be mentioned that a *Triphleps*, presumably *T. insidiosus* Say, is found everywhere feeding on the larvæ of this thrips.

DESCRIPTION.

The following description of the female of *E. citri* has been made after examination of many specimens. No males have yet been collected. The insect is called *citri* because, so far as we know, it feeds on citrus trees only.

Euthrips citri n. sp.

Measurements: Head, length 0.75 mm., width 0.15 mm.; prothorax, length 0.09 mm., width 0.18 mm.; mesothorax, width 0.24 mm.; abdomen, width 0.25 mm.; total body, length 0.86 mm. Antennæ: 1, 12μ: 2, 36μ; 3, 39μ; 4, 39μ; 5, 30μ; 6, 34μ; 7, 6μ; 8, 12μ; total, 0.205 mm. *Color*, yellow to orange-brown, with thorax and segment 2 of antennæ more noticeably orange-brown.

Head twice as wide as long, retracted considerably into the prothorax, broadly rounded in front, with only slight depressions to receive the basal joints of the antennæ; two spines on anterior margin, other spines not conspicuous; cheeks almost straight and parallel. *Eyes* large, occupying almost one-half the length of the head, prominent; pigment deep red to purple; facets of eyes large, eyes pilose. Ocelli subapproximate, margined inwardly with yellow-brown crescents. *Mouth-cone* short, reaching almost to posterior margin of prothorax, broadly rounded and with black stop at tip; maxillary palpi 3-segmented. *Antennæ* 8-segmented, with segment 2 orange-yellow, other segments uniformly light brown; segments 2, 4, 5, 6 almost equal in length; style about one-half the length of segment 6. All spines inconspicuous; sense cones transparent.

Prothorax about twice as wide as long, posterior angles broadly rounded; with long brown and outer small spine at each posterior angle, other spines not conspicuous. *Mesothorax* largest and with anterior angles broadly rounded. *Legs* light yellow-brown, with tarsi lighter but dark brown at the tips; spines on legs brown. *Wings* present and fully developed, fore-wings broadest near base and pointed at tips; with a ring vein and a single longitudinal vein which divides at about one-third the length of the wing from the base, the anterior part running parallel and approximate to the anterior part of the ring vein and ending abruptly near the tip, the posterior paralleling and approaching the posterior part of the ring vein and ending about one-half the wing's length from the end, each branch with a dark-brown marking immediately at its tip. The costa bears a row of about 29 regularly placed spines. Other spines placed as follows: A group of 5 near base of median longitudinal vein; 2 on either side of where second vein branches from the first, and 3 scattered spines about equidistant on each branch vein and in each case one of these spines immediately at the end of the vein; several rather long spines on scale. Veins of the fore-wing unusually strong and conspicuous, somewhat orange colored near base but fading to yellow near tip. Membrane of wings transparent.

Abdomen ovoid, tip conical, all spines, excepting a very few at tip, inconspicuous.

Described from many female specimens collected from orange foliage and fruit at Exeter, Tulare County, Cal.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

BIOLOGICAL STUDIES ON THREE SPECIES OF APHIDIDÆ.

By JOHN JUNE DAVIS,

Of the University of Illinois, Urbana, Ill.

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MISCELLANEOUS PAPERS.

BIOLOGICAL STUDIES ON THREE SPECIES OF APHIDIDÆ.

By John June Davis,

Of the University of Illinois, Urbana, Ill.

INTRODUCTION.

This paper deals principally with the biology of three of our commoner species of aphides, and includes descriptions of the different forms in all their various stages, as well as a complete bibliography of these species.

I have carried on these rearing experiments for the past two years in the insectary of the State entomologist of Illinois, Dr. S. A. Forbes. Practically all of the data here given, however, were obtained in 1906.

I am especially under obligations to Doctor Forbes, under whose direction I have made the experiments—those relating to *Aphis maidi-radicis* while serving as his assistant; to Dr. J. W. Folsom, who has aided me on all parts of this paper, and to Prof. F. M. Webster, who read the manuscript and made helpful suggestions.

THE CORN ROOT-APHIS.

(*Aphis maidi-radicis* Forbes.)

GENERAL ACCOUNT.

The corn root-aphis was first recognized by Benjamin Dann Walsh, who found it, in 1862, at Rock Island, Ill., where it was doing considerable damage to a small field of corn. At that time it was supposed by Mr. Walsh to be a root form of the common corn leaf-aphis (*Aphis maidis* Fitch), which lives on the upper parts of the corn plant, while the corn root-aphis, as the name would indicate, lives on the roots.

Dr. S. A. Forbes first began the study of this root-aphis in 1883, and most of the facts now known relating to its life history, ecology, and economic control have been obtained by him or under his supervision. When he began the study of this aphis, it was believed to be merely the root form of the corn leaf-aphis. Failing after many elaborate experiments to breed either from the other, and repeatedly tracing the complete life history of the root-aphis year after year with no appearance of the leaf-aphis at any time in the series, he regarded the corn root-aphis as a distinct species, and described it as such in 1891, in the Seventeenth Report of the State Entomologist of Illinois.

The insect has, of late years, become of great economic importance, not only in Illinois, but also in many other States of the corn belt. Outside of Illinois it has been reported as injuring corn in New York, New Jersey, Maryland, Virginia, West Virginia, Ohio, Indiana, Minnesota, Iowa, Missouri, Nebraska, Kentucky, Mississippi, Louisiana, and Colorado.

FOOD PLANTS.[a]

Although corn is its principal food plant, the corn root-aphis attacks also sorghum and broom corn; has been reported as attacking the roots of squash vines in Delaware and Ohio, and what is at present considered as this species has been found on the roots of numerous weeds and grasses, namely, smartweed (*Polygonum incarnatum*), knotweed (*P. persicaria*), crab grass (*Panicum*), purslane (*Portulaca oleracea*), dock (*Rumex crispus* and *R. altissimus*), *Setaria glauca*, *S. viridis*, *S. germanica*, fleabane (*Erigeron canadense*), mustard (*Brassica nigra*), sorrel (*Oxalis stricta*), plantain (*Plantago major* and *P. rugellii*), pigweed (*Amarantus hybridus*), and ragweed (*Ambrosia trifida*). In May, 1907, Mr. E. O. G. Kelly found it on wheat roots in a field which had been in corn the previous year. It has also been collected on the roots of cultivated aster, upon which I have found it to be of much economic importance in Illinois.

LIFE HISTORY.

Last year (1906) I obtained the complete life history of this corn root-aphis from the egg stage in spring to the egg in autumn. The vivaria which I used for the rearing and observation of this root aphis consisted of 8-dram or 10-dram glass vials, each containing a ball of moist cotton in the bottom and plugged at the top with a piece of cotton. In this cage a sprouting corn plant was placed, a reserve supply of these food plants being constantly kept for use. The first young and the last young of each generation were placed on corn roots in separate vials, and these vials were kept in closed boxes to exclude

[a] The scientific names of plants throughout this paper are given according to the nomenclature of Gray, in deference to the author's wishes.—Ed.

light, thus giving conditions probably most favorable to the optimum development of the aphis. As soon as the plant began to wilt it was replaced by a fresh one, the aphides being transferred thereto by means of a camel's-hair brush.

During the life cycle of this aphis there appear five different forms, namely, winged viviparous females, wingless viviparous females, oviparous females, males, and eggs. Briefly, the life history is as follows: From the eggs, which have been found hatching in the field between April 8 [a] and May 22, from 10 to 22 generations may follow. These generations are all viviparous from spring until the latter part of September or in October, according to conditions of temperature, etc. The last generation of the season is known as the oviparous generation, and consists of males—wingless only, so far as known—and oviparous wingless females. The males and females pair, and the females lay eggs, usually during the months of October and November, the eggs not hatching until the following spring.

Now follows a detailed account of the life history as worked out by me in 1906. Eggs collected at Elliott, Ill., April 12, 1906, in the nests of the common brown ant (*Lasius niger* L., var. *americanus* Emery) were placed in a cage in our insectary April 16. They were first noticed to be hatching April 17. Young aphides hatching April 18 and 19 were placed on corn roots in the previously-described vials, and two lines of generations were thus started, both of which were carried through to the egg in the fall. These stem mothers—that is, the aphides hatching from the egg—produced their first young May 1 and 4, respectively, and their last young May 18 and 14, respectively. Taking the *first young of the first young* all the way through the series, 22 generations were obtained, counting the oviparous generation as the last. (See Tables I and II.)

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[a] In 1906 Mr. E. O. G. Kelly, a field assistant of the State entomologist of Illinois, searched for eggs and young of *A. maidi-radicis* in the fields, beginning the 1st of April. He did not find eggs until April 12, and on April 17 he found the young stem mothers in the field. The following year Mr. Kelly first found eggs March 24 (these hatched in the insectary March 26), and young stem mothers were found in ants' nests as early as March 29. April 15 he found the young with their beaks inserted in old corn roots, this probably being occasioned by the fact that large numbers of the weeds upon which the aphis usually feeds at this season had been killed by the very cold weather of the preceding week.

TABLE I.—*Line of generations of Aphis maidi-radicis from egg to oviparous generation, 1906.*

Generation (from egg).	Date of birth.	Date it became adult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	Number of young.	Average young per day of productive period.	Largest number of young in one day.	Date of death or disappearance.	Total length of life.
				Days.		*Days.*	*Days.*					*Days.*
1	Apr. 18	Apr. 30	May 1	13	May 18	17	2	96	5.6	10	May 20	32
2	May 1	May 12	May 13	12	May 27	14	6	74	5.3	10	June 2	32
3	May 13	May 19	May 21	8	May 30	9	1	53	6.6	9	May 31	18
4	May 21	May 27	May 29	8	June 4	6	0	31	5.3	7	June 6	14
5	May 29	June 5	June 6	8	June 24	18	8	89	4.9	9	July 2	34
6	June 6	June 14	June 15	9	July 2	17	9	76	4.4	7	July 11	35
7	June 15	June 22	June 23	8	July 25	2	0	7	3.5	4	June 25	10
8	June 23	....	June 30	7	July 15	15	0	74	4.9	7	July 15	22
9	June 30	July 7	July 8	8	July 11	3	0	22	7.3	7	July 11	11
10	July 8	July 14	July 15	7	July 23	8	0	53	6.6	7	July 23	15
11	July 15	July 22	July 22	7	July 24	2	0	7	3.5	......	July 24	9
12	July 22	July 29	July 30	8	Aug. 8	9	1	51	5.1	8	Aug. 9	17
13	July 30	Aug. 5	Aug. 5	6	Aug. 9	5	0	24	4.8	6	Aug. 9	15
14	Aug. 5	Aug. 12	Aug. 12	7	Aug. 16	4	0	17	4.2	6	Aug. 16	11
15	Aug. 12	Aug. 18	Aug. 19	7	Aug. 24	6	0	33	5.5	8	Aug. 24	13
16	Aug. 19	....	Aug. 27	8	Sept. 9	14	0	66	4.7	10	Sept. 9	22
17	Aug. 28	....	Sept. 5	8	Sept. 8	3	0	13	4 +	6	Sept. 8	11
18	Sept. 5	....	Sept. 12	7	Sept. 20	9	1	28	3 +	6	Sept. 21	17
19	Sept. 13	Sept. 19	Sept. 20	7	Sept. 27	8	1	41	5 +	9	Sept. 28	16
20	Sept. 21	Sept. 28	Sept. 30	9	Oct. 2	3	0	10	3 +	4	Oct. 2	12
21	Sept. 30	Oct. 13	Oct. 14	14	Nov. 2	19	5	29	1.5	......	Nov. 7	38
22 [a]	Oct. 14	Oct. 27	....	......	....	......	......	......	......	......	Nov. 22–Nov. 23	39

[a] Oviparous generation.

TABLE II.—*Line of generations of Aphis maidi-radicis from egg to oviparous generation, 1906.*

Generation (from egg).	Date of birth.	Date of becoming adult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	Number of young.	Average young per day of productive period.	Largest number of young in one day.	Date of death or disappearance.	Total length of life.
				Days.		*Days.*	*Days.*					*Days.*
1	Apr. 19	May 2	May 4	15	May 14	10	1	36	3.6	6	May 15	26
2	May 4	May 15	May 16	12	June 4	19	5	64	3.4−	8	June 9	36
3	May 16	May 23	May 24	8	June 2	9	0	50	5.5+	8	June 2	17
4	May 24	June 1	June 2	9	June 9	7	1	41	5.8−	7	June 10	17
5	June 2	June 8	June 9	7	June 17	8	1	40	5.	8	June 18	16
6	June 9	June 17	June 18	9	June 29	11	0	58	5.2+	8	June 29	20
7	June 18	June 26	June 27	9	July 8	11	0	65	5.9+	8	July 8	20
8	June 27	July 3	July 4	7	July 13	9	0	38	4.2+	5	July 13	13
9	July 4	July 11	July 11	7	July 14	3	0	12	4.	6	July 14	11
10	July 11	July 18	July 19	8	July 31	12	0	66	3.3	8	July 31	20
11	July 19	July 25	July 26	7	Aug. 10	15	3	70	4.7−	8	Aug. 13	25
12	July 26	Aug. 1	Aug. 2	7	Aug. 10	9	1	46	5.1+	8	Aug. 11	16
13	Aug. 2	Aug. 8	Aug. 9	7	Aug. 21	14	1	63	4.5	6	Aug. 22	22
14	Aug. 9	Aug. 15	Aug. 16	7	Aug. 27	12	0	58	3. +	8	Aug. 27	19
15	Aug. 16	....	Aug. 22	6	Aug. 24	3	0	13	4. +	6	Aug. 24	9
16	Aug. 22	Aug. 29	Aug. 30	8	Sept. 7	9	1	42	4.6+	7	Sept. 8	18
17	Aug. 30	Sept. 6	Sept. 7	8	Sept. 23	17	0	40	2. +	5	Sept. 23	25
18	Sept. 7	Sept. 13	Sept. 14	7	Sept. 21	8	2	13	1. +	5	Sept. 23	17
19	Sept. 14	Sept. 21	Sept. 22	8	Sept. 23	2	0	4	2.	2	Sept. 23	10
20	Sept. 22	Oct. 1	Oct. 2	10	Oct. 22	13	16	29	2. +	4	Nov. 7	39
21	Oct. 2	Oct. 15	Oct. 17	15	Oct. 29	15	......	29	1. −	8	....	(*d*)
22 [a]	Oct. 17	[b] Oct. 24 [c] Nov. 5	....	......	....	......	......	......	......	......	....	......

[a] Oviparous generation. These aphides were removed to other cages when they became adult.
[b] 1 oviparous female. [c] 2 male. [d] Not less than 30 days.

On the other hand, beginning with the last to be borne by the aphis which hatched April 18, and following down the series of the last borne of each generation, there were but 11 generations. From this it

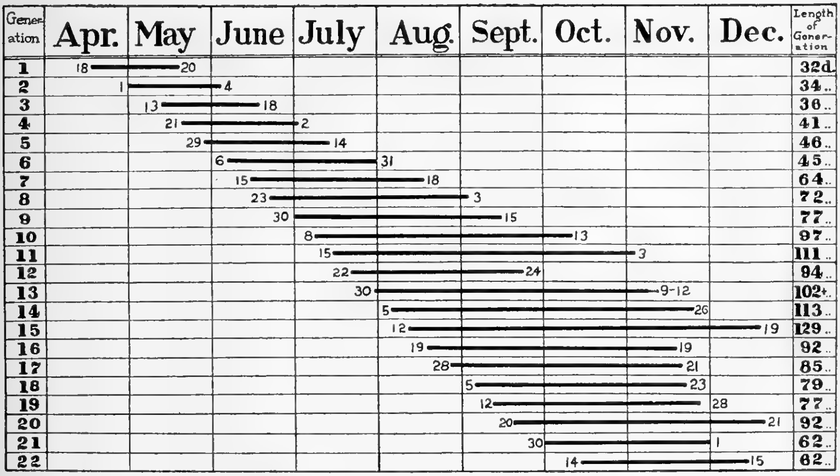

FIG. 31.—Periods and succession of generations in *Aphis maidi-radicis,* 1906.

follows that the mean number of complete generations for the year is 16½. The first generation extended over a period of 31 days, from April 18 to May 20; the second, 34 days; and the third, 36 days (figs.

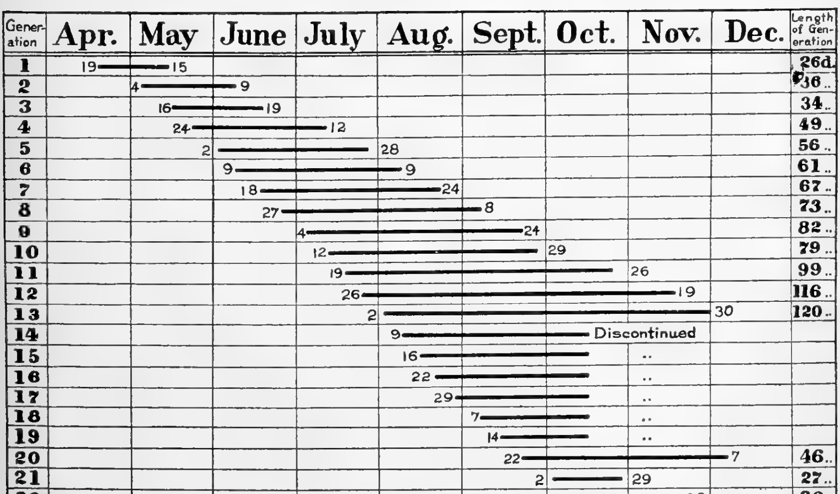

FIG. 32.—Periods and succession of generations in *Aphis maidi-radicis,* 1906.

31, 32). The fifteenth generation proved to be the longest, continuing for 129 days. Then the period of each generation diminished gradually. These data, however, were taken from only one line of generations—that is, the generations obtained from a single stem-mother, isolated in the spring. If we take into consideration the time during which eggs have been found hatching in the field—from April 8 until May 22, a period of 44 days—it will be seen that each of the generations might occur in the field much longer than my insectary experiments would indicate. On May 1 individuals of the first 2 generations coexisted in the insectary; on June 1, 4 generations, from the second to the fifth, inclusive; on July 1, 6 generations, from the fourth to the ninth; on August 1, 7 generations, from the seventh to the thirteenth; on September 1, 10 generations, from the eighth to the seventeenth; on September 12, 11 generations, from the ninth to the nineteenth; and between September 30 and October 24 there were 12 generations in existence, from the tenth to the twenty-first, this being the largest number of generations in existence at any one time. (See figs. 31, 32.) From that date on, the number of generations in existence at any one time rapidly diminished until December 21, at which time all of the aphides were dead. The latest date of birth in a viviparous generation was October 7, and the last survivor of this generation died November 28. The first record of the bisexual oviparous generation in the insectary, in 1906, was October 2, and eggs were found a few days later. Young of this generation were born as late as November 4, and aphides were still alive December 21. However, in 1905 I found individuals of this oviparous generation as early as September 5; also, they were observed in copula, and eggs were found as early as September 30. Bisexual forms may appear in any generation, providing the environmental conditions are such as to favor their development. Thus, in the insectary sexual forms appeared in October and November from 12 different generations, varying from the eleventh to the twenty-second, inclusive, thus indicating that the appearance of the sexes may be conditioned by the temperature. This is illustrated by the occurrence of sexual forms on September 5, 1905, at which time the weather was quite cool for that time of the year, although in 1906 the sexual forms did not appear until October 2, the weather up to that time being milder than in 1905. Between April 2, 1890, and January 17, 1893, Prof. M. V. Slingerland carried *Myzus achyrantes* Monell through 62 generations by keeping the temperature uniform. Although further experiments would be necessary for positive proof, still, from what is now known, it appears that with the necessary conditions for the development of young—food and heat—the aphides would be able to reproduce parthenogenetically for an indefinite period. Numerous records were made by me of instances in which the first young were viviparous and the last oviparous. In these cases it was noticed that after the production of viviparous forms the aphis would rest a few days before beginning to produce the sexual forms.

VIVIPAROUS GENERATION.

In 1906, between April 18 and October 3, 128 individual experiments were carried on with viviparous females, and the following averages are taken from the entire number of experiments (see Table III):

TABLE III.—*Data of individual experiments with Aphis maidi-radicis, viviparous generation, 1906.*

Date of birth.	Date of becoming adult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	Number of young.	Average young per day of productive period.	Largest number of young for one day.	Date of death.	Total length of life.
			Days.		*Days.*	*Days.*					*Days.*
Apr. 18	Apr. 30	May 1	13	May 18	17	2	96	5.6 +	10	May 20	32
Apr. 19	May 2	May 4	15	May 14	10	1	36	3.6	6	May 15	26
May 1	May 12	May 13	12	May 27	14	6	74	5.3 −	10	June 2	32
May 4	May 15	May 16	12	June 4	19	5	64	3.4 −	8	June 9	36
May 13	May 19	May 21	8	May 30	9	1	53	6.6 +	9	May 31	18
May 14	May 23	May 24	10	June 1	8	1	35	4 −	7	June 2	19
May 16	...do.....	...do.....	8	June 2	9	0	50	5.5 +	8	...do.....	17
May 18	....	May 26	8	June 4	9	0	42	4.6 +	10	June 4	17
May 21	May 27	May 29	8	...do.....	6	0	31	5.3 +	7	June 6	14
May 24	....	June 2	9	June 15	13	0	58	4.4 +	7	June 15	22
Do....	June 1	...do.....	9	June 9	7	1	41	5.8 −	7	June 10	17
May 26	June 4	June 4	9	...do.....	5	0	33	6.6	8	June 9	14
May 29	June 5	June 6	8	June 24	18	8	89	4.9 +	9	July 2	34
May 31	....	June 8	8	June 19	11	0	34	3 +	7	June 19	19
June 2	June 8	June 9	7	June 17	8	1	40	5	8	June 18	16
June 3	June 9	June 10	7	June 16	6	2	24	4	5	...do.....	15
June 4	June 12	June 14	10	June 29	15	2	73	4.8 +	10	July 1	27
June 6	June 14	June 15	9	July 2	17	9	76	4.4 +	7	July 11	35
June 8	June 17	June 18	10	...do.....	14	0	62	4.4 +	9	July 2	24
June 9	...do.....	...do.....	9	June 29	11	0	58	5.3 −	8	June 29	20
June 10	....	...do.....	8	...do.....	11	2	51	4.6 +	7	July 1	21
Do....	June 19	June 20	10	July 1	11	8	48	4.3 +	7	July 9	29
Do....	June 18	June 19	9	June 30	11	2	72	2	11	July 2	22
June 14	June 21	June 22	8	...do....	8	0	53	6.6 +	10	June 30	16
June 6	June 16	June 18	12	June 25	7	0	21	3	6	June 25	19
June 18	June 27	June 27	9	July 4	7	3	37	5.2 +	8	July 7	19
Do....	June 26	...do.....	9	July 8	11	0	65	5.9 +	8	July 8	20
Do....	....	June 26	8	July 2	6	1	45	7 +	9	July 3	15
Do....	June 25	...do.....	8	July 1	5	0	29	5.8	10	July 1	13
June 19	June 26	June 28	9	July 13	15	0	44	3 −	8	July 13	24
Do....	...do.....	June 27	8	July 5	8	1	51	6.3 +	10	July 6	17
June 20	....	June 28	8	July 8	10	1	50	5	8	July 9	19
June 22	June 29	June 30	8	July 11	11	0	62	5.6 +	8	July 11	19
June 23	....	...do.....	7	July 15	15	0	74	4.9 +	7	July 15	22
June 27	....	July 4	7	July 10	6	0	29	4.8 +	8	July 10	13
Do....	July 3	...do.....	7	July 13	9	0	38	4.2 +	8	July 13	13
Do....	July 2	July 3	6	July 16	13	0	59	4.5 +	9	...do.....	19
June 28	July 6	July 6	8	July 15	9	1	48	5.3 +	7	July 16	18
June 30	July 7	July 8	8	July 11	3	0	22	7.3 +	7	July 11	11
July 3	July 10	July 11	8	July 20	9	0	44	4.9 +	7	July 20	17
July 4	July 11	July 12	8	...do....	8	1	42	5.2 +	8	July 21	17
July 6	July 12	July 13	7	July 24	11	1	52	4.7 +	7	July 25	19
July 8	July 13	July 14	6	July 27	13	10	64	4.9 +	8	Aug. 6	29
Do....	July 14	July 15	7	July 23	8	0	53	6.6 +	7	July 23	15
Do....	...do.....	July 14	6	July 25	11	0	56	5 +	9	July 25	17
July 11	July 17	July 18	7	July 24	7	1	49	7	10	...do.....	14
Do....	July 18	July 19	8	July 31	12	0	66	3.3	8	July 31	20
July 12	...do.....	...do.....	7	July 28	9	0	54	6	8	July 28	16
July 13	July 21	July 21	7	July 29	8	1	44	5.5	7	July 30	16
Do....	July 18	July 19	6	...do.....	10	2	45	4.5	7	July 31	18
July 14	July 21	July 21	7	July 27	6	0	25	4.1 +	8	July 27	13
Do....	...do.....	July 22	8	Aug. 1	10	0	62	6.2	10	Aug. 1	18
July 18	July 23	July 24	6	July 29	5	0	29	5.8	8	July 29	11
July 19	July 25	July 26	7	Aug. 10	15	3	70	4.7	8	Aug. 13	25
Do....	...do.....	...do.....	7	Aug. 4	9	1	55	6.1 +	7	Aug. 5	17
Do....	...do.....	...do.....	7	Aug. 5	10	0	51	5.1	7	...do.....	17
July 21	July 28	July 28	7	Aug. 6	9	2	47	5.2 +	8	Aug. 8	18
Do....	...do.....	July 29	8	Aug. 3	5	0	30	6	9	Aug. 3	13
July 22	...do.....	...do.....	7	Aug. 6	8	0	46	5.7 +	8	Aug. 6	15
Do....	July 29	July 30	8	Aug. 8	9	1	51	5.1	8	Aug. 9	17

TABLE III.—*Data of individual experiments with Aphis maidi-radicis, viviparous generation, 1906*—Continued.

Date of birth.	Date of becoming adult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	Number of young.	Average young per day of productive period.	Largest number of young for one day.	Date of death.	Total length of life.
			Days.		*Days.*	*Days.*					*Days.*
July 26	Aug. 1	Aug. 2	7	Aug. 10	9	1	46	5.1 +	8	Aug. 11	16
Do....	...do.....	...do.....	7	Aug. 8	7	0	49	7	8	Aug. 8	14
Do....	...do.....	...do.....	7	Aug. 9	8	0	43	5.3 +	9	Aug. 9	15
July 27	Aug. 2	...do.....	6	...do.....	8	0	46	5.7 +	10	...do.....	14
July 28	....	Aug. 5	8	Aug. 14	9	0	46	5.1 +	6	Aug. 14	17
July 29	Aug. 4	...do.....	7	Aug. 11	6	1	35	5.8 +	8	Aug. 12	14
July 30	Aug. 5	...do.....	6	Aug. 9	5	0	24	4.8	6	Aug. 9	15
July 29	Aug. 4	...do.....	7	Aug. 18	13	0	55	4.2 +	9	Aug. 18	20
Aug 1	Aug. 7	Aug. 7	6	Aug. 13	6	1	37	6 +	8	Aug. 14	13
Aug. 2	Aug. 8	Aug. 9	7	Aug. 21	14	1	63	4.5	6	Aug. 22	22
Do....	Aug. 7	Aug. 8	6	Aug. 15	7	0	45	6.4 +	9	Aug. 15	13
Aug. 5	Aug. 13	Aug. 13	8	Aug. 22	9	0	44	4.8 +	8	Aug. 22	17
Do....	Aug. 12	...do.....	8	Aug. 19	7	0	31	4.4 +	5	Aug. 19	14
Do....	Aug. 11	Aug. 12	7	Aug. 22	10	0	54	5.4	8	Aug. 22	17
Do....	...do.....	...do.....	7	Aug. 18	6	1	35	5.8 +	8	Aug. 19	14
Aug. 7	Aug. 15	Aug. 15	8	Aug. 26	11	0	50	4.5 +	9	Aug. 26	19
Aug. 9	...do.....	Aug. 16	7	Aug. 24	8	0	41	5.1 +	8	Aug. 24	15
Do....	...do.....	...do.....	7	Aug. 27	12	0	58	3 +	8	Aug. 27	19
Do....	Aug. 17	Aug. 17	8	Aug. 23	6	0	31	5.1 +	7	Aug. 23	14
Aug. 12	Aug. 19	Aug. 19	7	Aug. 29	10	0	48	4.8	7	Aug. 29	17
Aug. 13	...do.....	Aug. 20	7	...do.....	9	0	60	6.6 +	9	...do.....	16
Aug. 12	Aug. 18	Aug. 19	7	Aug. 24	6	0	33	5.5	8	Aug. 24	13
Aug. 15	Aug. 21	Aug. 22	7	Sept. 2	11	0	51	4.6 +	9	Sept. 2	18
Aug. 16	Aug. 22	Aug. 23	7	...do.....	10	0	56	5.6	7	...do.....	17
Aug. 17	Aug. 23	...do.....	6	...do.....	10	0	47	4.7	7	...do.....	16
Do....	...do.....	...do.....	7	Sept. 3	11	0	49	4.4 +	6	Sept. 3	18
Aug. 19	Aug. 26	Aug. 26	7	Sept. 5	10	0	47	4.7	7	Sept. 5	17
Do....	...do.....	Aug. 27	8	Sept. 15	19	0	48	2.5 +	8	Sept. 15	27
Do....	....	...do.....	8	Sept. 9	14	0	66	4.7 +	10	Sept. 9	22
Aug. 20	Aug. 25	Aug. 26	6	Sept. 3	8	0	42	6	7	Sept. 3	14
Aug. 22	Aug. 29	Aug. 30	8	Sept. 8	9	1	50	5.5 +	6	Sept. 9	18
Do....	...do.....	...do.....	8	Sept. 7	9	1	42	4.6 +	7	Sept. 8	18
Aug. 23	Aug. 31	Aug. 31	8	Sept. 10	10	2	51	5.1	7	Sept. 12	20
Do....	...do.....	...do.....	8	Sept. 6	7	2	34	4.8 +	7	Sept. 8	17
Do....	....	Sept. 2	10	Sept. 15	13	1	56	4.2 +	7	Sept. 16	24
Aug. 24	....	...do.....	9	Sept. 8	6	0	27	4.5	6	Sept. 8	15
Aug. 26	....	...do.....	7	Sept. 10	8	0	40	5	8	Sept. 10	15
Aug. 28	Sept. 4	Sept. 4	7	Sept. 9	5	0	24	4.8	5	Sept. 9	12
Aug. 30	Sept. 7	Sept. 7	8	Sept. 12	5	0	22	4.5	7	Sept. 12	13
Do....	Sept. 6	...do.....	8	Sept. 23	16	0	40	2.4 +	5	Sept. 23	24
Aug. 31	Sept. 7	Sept. 8	8	Sept. 19	11	0	23	2 +	6	Sept. 19	19
Do....	Sept. 8	Sept. 9	9	Sept. 21	12	0	23	2 −	5	Sept. 21	21
Sept. 2	Sept. 10	Sept. 11	9	Sept. 16	5	0	23	4.6	5	Sept. 16	14
Do....	...do.....	...do.....	9	Sept. 17	6	1	33	5.5	7	Sept. 18	16
Sept. 4	Sept. 11	...do.....	7	Sept. 28	17	2	49	2.8 +	6	Sept. 30	26
Do....	...do.....	...do.....	7	Sept. 19	8	1	37	4.6 +	6	Sept. 20	16
Sept. 5	....	Sept. 12	7	Sept. 20	9	1	28	3 +	6	Sept. 21	17
Sept. 7	Sept. 14	Sept. 15	8	Sept. 25	10	0	41	4.1	7	Sept. 25	18
Sept. 11	Sept. 18	Sept. 19	8	Sept. 26	7	0	35	5	9	Sept. 26	15
Do....	Sept. 19	...do.....	8	Sept. 24	6	0	30	5	9	Sept. 24	14
Sept. 13	...do.....	Sept. 20	7	Sept. 27	8	1	41	5 +	9	Sept. 28	16
Sept. 15	Sept. 22	Sept. 23	8	Oct. 6	14	0	32	2.2 +	5	Oct. 6	22
Sept. 16	...do.....	Sept. 22	6	Oct. 7	16	6	23	1.4 +	4	Oct. 13	28
Sept. 17	Sept. 25	Sept. 25	8	Oct. 15	20	6	28	1.5	4	Oct. 22	34
Sept. 18	Sept. 24	...do.....	7	Oct. 8	14	2	25	1.7 +	4	Oct. 10	23
Sept. 19	Sept. 25	Sept. 26	7	...do.....	13	3	20	1.5 +	5	Oct. 11	23
Do....	Sept. 26	Sept. 27	8	Oct. 17	20	7	56	2.8	7	Oct. 27	35
Sept. 20	Sept. 27	...do.....	7	Oct. 15	18	1	52	2.8 +	5	Oct. 16	26
Sept. 22	Oct. 1	Oct. 2	10	Oct. 22	20	18	29	1.4 +	4	Nov. 7	48
Do....	Sept. 30	Oct. 1	9	Oct. 17	16	3	21	1.3 +	7	Oct. 21	28
Do....	Sept. 29	...do.....	9	Nov. 2	32	1	35	1 +	4	Nov. 3	42
Sept. 27	Oct. 7	Oct. 9	12	Oct. 31	22	8	26	1.1 +	4	Nov. 9	42
Sept. 30	Oct. 13	Oct. 14	14	Nov. 2	18	5	29	1.6 +	4	Nov. 7	36
Sept. 26	Oct. 5	Oct. 6	10	Oct. 24	14	3	21	1.5	3	Oct. 27	27
Oct. 2	Oct. 15	Oct. 17	15	Oct. 29	12	......	29	2.4 +	8	....	27
Do....	Oct. 13	Oct. 15	13	Oct. 24	9	2	22	2.4 +	4	Oct. 26	24
Do....	Oct. 14	...do.....	13	...do.....	9	0	23	2.5 +	5	Oct. 24	22
Oct. 3	Oct. 16	Oct. 17	14	Nov. 26	40	2	49	1.2 +	3	Nov. 28	56
Total.....	....	....	1,044	....	1,367	......	5,651	570.82	......	....	2,573
Average..	....	....	8.1+	....	10.6+	......	44.1+	4.4+	......	....	20.1+

The immature stage was found to be quite variable in length, covering from 6 to 15 days, with an average of 8.1+ days. This is approximately the same as that obtained from experiments of 1905, in which, from 97 records, the average length of this nymphal period was 8.3+ days. During the first few generations and also the last generation the time from the birth of an aphis until the birth of its first young was much longer than it was during the warmer summer months. The time between the birth of the first and that of the last young likewise varied considerably, being from 3 to 40 days, the period being noticeably longer in early spring and in the fall. The average for the entire year was 10.6+ days. Usually the female would live several days after the production of her last young. The entire length of life of the aphis varied between 11 and 56 days, with an average for the year of 20.1+ days. During the summer months the aphides, as a rule, had a shorter life and produced more young than in the cooler days of the year. The average number of young per female for the year was 44.1+. The variation in the number of young was from 20 to 96, the latter number being the largest number produced by a single female. For the year the average number of young brought forth by an individual female in a single day was 4.4+, the largest number being 11. However, in 1905 as many as 12 were born in one day from one female. The average number of young from April 18 until September 1 was, in 102 experiments, 4.9+; from September 1 to October 3 the average for 26 experiments was 2.4+ young per day, or one-half as many. It may be noted, in passing, that, as the records made in 97 experiments in 1905 vary only slightly from those obtained in the 128 experiments of 1906, the figures here given are probably sufficiently accurate for any year.

In 1905 a very interesting incident was observed. A wingless aphis taken in the field June 23 was placed in an insectary cage, and within the next few days gave birth to 6 young. It then discontinued the production of young for several days, then molted, became winged, and produced 21 more young.

Buckton, in his "Monograph of British Aphides," Volume I, page 87, says:

> Several early observers have erroneously stated that the female aphis is at different periods of her life both viviparous and oviparous. The acuteness of Newport failed him when he concluded "that aphides"—meaning the same individual—"deposit at one time true ova and at others produce living young." * * * It may be pretty certainly asserted that the viviparous aphis is never oviparous, and that the converse also is true.

In one experiment in 1906 an aphis born October 6 became adult October 24 and gave birth to a single young November 2, but did not produce any more young, and soon died. Upon an examination of her body only eggs were found.

All my aphides which were reared individually, in vials, were wingless. Other aphides, however, of the same mothers, and placed in cages containing many other aphides as well as a less abundant food supply, often became winged. In Science, Volume XXI, January 27, 1903, pages 48–49, Prof. M. V. Slingerland gives an account of rearing individually 62 generations of *Myzus achyrantes* during a period of 2 years and 10 months, only wingless agamic females being produced. From these and other evidences obtained it may be inferred that the development of the winged forms among aphides is largely caused by an insufficient food supply.

The number of molts is invariably four, the time of occurrence of the different molts being shown in Table IV.

TABLE IV.—*Periods of molts of Aphis maidi-radicis, viviparous generation, 1906.*

Date of birth.	Age at first molt.	Age at second molt.	Age at third molt.	Age at fourth molt.	Age at birth of first young.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*
April 18	4	8	10	12	13
April 19	5	8	10	13	15
May 1	2	4	7	11	12
May 4	3	6	8	11	12
May 13	2	3	4	6	8
May 21	2	3	4	6	8
June 27	1	2	4	6	7
June 28	1	3	6	8	8

As a rule, reproduction did not begin until the next day after the fourth molt, though it sometimes occurred within a few hours after the molt. Often in the last generations, in autumn, reproduction did not begin until two days after the last molt.

OVIPAROUS GENERATION.

The oviparous generation was found in the insectary, in 1906, from October 2 to December 21. Records of 47 individuals of this generation were obtained (Table V); the records, however, are not complete in all cases. The length of the immature stage—from birth to adult—varied from 10 to 39 days, this latter being a very exceptional record.

TABLE V.—*Data of individual experiments with Aphis maidi-radicis, oviparous generation, 1906.*

Date of birth.	Date of maturity.	Age at maturity.	Date of death.	Age at death.	Number of eggs laid.	Number of eggs in body at death.	Total number of eggs.	Sex.
		Days.		Days.				
October 6	Oct. 21	15	Nov. 5	30	10	1	11	Female.
Do.	Oct. 22	16	...do.	30				Male.
October 8	Oct. 24	16	Nov. 14	37	4	2	6	Female.
Do.	...do.	16	Nov. 10	33				Male.
October 9	Oct. 22	13	[a]Oct. 26	[b]17				Female.
Do.	...do.	13	[a]Nov. 2	[b]24				Do.
October 15	Oct. 31	16	Nov. 28	44	7	2	9	Do.
October 7	Oct. 20	13	Oct. 22	15				Do.
October 15	Nov. 3	19	[a]Nov. 23	[b]39				Male.
October 17	Nov. 5	19	Nov. 8	22				Do.
October 15	Oct. 31	16	[a]Oct. 31	[b]16				Do.
Do.	...do.	16	[a]Nov. 2	[b]18				Do.
Do.	Nov. 1	17	[a]Nov. 9	[b]25				Do.
October 13	Oct. 27	14	Nov. 12	30				Do.
October 29	Nov. 24	26	Dec. 11	43				Female.
October 15	Oct. 29	14	Nov. 15	31	3	2	5	Do.
October 22	Nov. 11	20	Nov. 26	35				Male.
October 13	Oct. 23	10	[a]Oct. 29	[b]16				Female.
Do.	...do.	10	..do. [a]	[b]16				Do.
October 20	Nov. 7	18	Nov. 12	23				Male.
October 19	Oct. 29	10	[a]Nov. 2	[b]13				Female.
October 20	Nov. 1–2	12–13	..do. [a]	[b]13				Do.
October 21	...do.	12–13	..do. [a]	[b]13				Do.
October 26	Nov. 17	22	Dec. 1	36				Male.
Do.	Dec. 4	39	Dec. 15	50				Female.
October 24	Nov. 7	14	Nov. 30	37				Do.
October 21	Nov. 8–9	18–19	[a]Nov. 14	[b]24				Do.
Do.	...do.	18–19	..do. [a]	[b]24				Do.
October 24	Nov. 10–11	17–18	..do. [a]	[b]21				Do.
Do.	Nov. 16–17	23–24	Dec. 5	43				Do.
November 2	Nov. 21	19	Dec. 5	33				Do.
Do.	...do.	19	Dec. 19	47				Do.
October 6	Oct. 20	14	[a]Oct. 25	[b]19				Do.
Do.	...do.	14	[a]Oct. 26	[b]20				Do.
Do.	...do.	14	[a]Oct. 27	[b]21				Do.
Do.	...do.	14	..do. [a]	[b]21				Do.
October 7	...do.	13	Nov. 21	43				Do.
October 9	Oct. 21	12	[a]Oct. 28	[b]19				Do.
Do.	...do.	12	Nov. 12	34	3	8	11	Do.
Do.	Oct. 24	15	[a]Oct. 29	[b]20				Do.
Do.	...do.	15	..do. [a]	[b]20				Do.
Do.	...do.	15	..do. [a]	[b]20				Do.
Do.	...do.	15	Oct. 31	22				Do.
Do.	...do.	15	[a]Nov. 3	[b]25				Do.
Do.	...do.	15	..do. [a]	[b]25				Do.
October 12	...do.	12	Nov. 23	42	4	6	10	Do.
October 16	Oct. 31	15	...do.	38	3	5	8	Do.
October 18	Nov. 3–4	16–17	Dec. 1	44	2	5	7	Do.

[a] Removed. [b] Age when removed.

The average of 47 records is 16+ days. The average total life of 38 individuals was 30.9+ days, with a maximum (1906) of 50 days. In 1905 one aphis of this oviparous generation lived to the age of 61 days. A few records were made as to the number of eggs laid by individual females, and this was found to vary up to 10, which was probably not far from the actual number that is ordinarily laid, though 4 was the average number in the counts made. Eggs were found in the bodies of nearly all the females after death; the potential reproductive capacity of the female seems to exceed her vitality.

It is easy to distinguish immature males from oviparous females after the second molt by their color. The males have a distinct reddish hue, while the females have a greenish color.

The number of molts in the oviparous generation is four, as in the viviparous generation. From Table VI, showing the periods between the molts, it appears that the males are more deliberate in their growth and require a longer time than the females for their full development.

TABLE VI.—*Periods of molts of Aphis maidi-radicis, oviparous generation, 1906.*

Date of birth.	Age at first molt.	Age at second molt.	Age at third molt.	Age at fourth molt.	Period from birth to adult.	Sex.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	
October 11	3	5	9	13	13	Female.
Do	3	5	9	13	13	Do.
Do	3	5	9	14	14	Do.
October 16	4	6	11	20	20	Do.
October 17	2	5	9	13	13	Do.
Do	3	6	10	21	21	Male.
October 21	4	9	14	21	21	Do.
Do	3	8	14	23	23	Do.
October 22	5	9	13	16	16	Female.

DESCRIPTIONS.[a]

Aphis maidi-radicis Forbes.

VIVIPAROUS GENERATION.

Before first molt and less than 1 hour old.—General color pale pea-green. Legs and antennæ colorless and transparent. Eyes red. Measurements: Length of body, 0.882 mm.; width, 0.400 mm.; antenna, 0.327 mm.

After first molt and not more than 24 hours old.—General color pea-green. Antennæ almost transparent, excepting last segment, which is darker. Only 5 noticeable segments in the antennæ. Eyes red. Tip of beak darkened. Legs almost transparent, excepting tarsi, which are almost black. Cornicles small, slightly darkened at tip. Measurements: Length of body, 0.927 mm.; width, 0.509 mm.; antenna, 0.339 mm.

After second molt and 72 to 96 hours old.—General color pea-green. Ultimate segment of antennæ dark. Eyes reddish brown. Legs darker than body color. Tip of abdomen dark. Cornicles dark, being darkest at apex, short and very slightly incrassate in middle. Measurements: Length of body, 1.418 mm.; width, 0.709 mm.;

[a] In giving the number of segments of the antennæ I have not, as most writers do, counted the filament as a separate and distinct segment. There is certainly no articulation between the thickened basal portion and the filament of this last segment; and, thus, they can not be referred to as distinct segments.

The measurements, and the observations on colors, were taken from live specimens unless otherwise stated. Color terms are according to Ridgway's "Nomenclature of Colors."

antenna (alcoholic specimen), I, 0.040 mm.; II, 0.040 mm.; III, 0.101 mm.; IV, 0.050 mm.; V, basal, 0.061 mm.; filament, 0.098 mm.; total, 0.390 mm.

After third molt.—General color light chromium-green. Head with pale brownish tint. Ultimate and part of the penultimate segments of the antennæ darkened. Antenna with only 5 distinct segments; a slight constriction in the third shows the commencing of the formation of another segment. Eyes reddish brown. Legs dark, the tarsus and distal ends of the femur and tibia being almost black. Tip of abdomen dark, as are also the cornicles, which are darkest at the apex. Cornicles noticeably longer than in preceding stages; basal half more or less swollen and the tip slightly dilated. Measurements: Length of body, 2.063 mm.; width, 0.981 mm.; cornicles, 0.127 mm.; antenna (alcoholic specimens), I, 0.064 mm.; II, 0.064 mm.; III, 0.183 mm.; IV, 0.067 mm.; V, basal, 0.071 mm.; filament, 0.112 mm.; total, 0.561 mm.

Adult wingless viviparous female.—Head black. Thoracic and first abdominal segments with median transverse black markings, the prothorax being almost entirely black. On each side of the abdomen are 2 parallel rows of minute black markings—one on each side of the cornicle. These rows are not constant, the upper one sometimes being indistinct or wanting. Posterior 3 segments of abdomen with black transverse median markings. Eyes reddish brown. All of antenna dusky except the third segment. Cornicles and tips of style black. Coxæ, most of the femora, apex of tibiæ, and the tarsi black. Measurements: Length of body, 2.09 mm.; width, 1.036 mm.; antenna, I, 0.036 mm.; II, 0.054 mm.; III, 0.181 mm.; IV, 0.091 mm.; V, 0.091 mm.; VI, basal, 0.109 mm.; filament, 0.118 mm.; total, 0.680 mm.

Winged viviparous female.—Head black, thorax blackish, abdomen pale green, with a black marking on each side of the second, third, and fourth segments; transverse black markings on the last 2, and sometimes last 3, segments; a black ring around each cornicle, and a few small black markings irregularly scattered over abdomen. Antennæ dark; usually 7 or 8 sensoria on the third segment, sometimes only 6; 1 sensorium near the apex of each of the fourth and fifth segments; several more or less distinct sensoria at the apex of the basal portion of the sixth. Eyes dark reddish-brown. Cornicles and style as in wingless pseudogynes. Measurements (alcoholic specimens): Length of body, 1.468 mm.; width, 0.605 mm.; length of wing, 2.33 mm.; antenna, I, 0.036 mm.; II, 0.055 mm.; III, 0.187 mm.; IV, 0.095 mm.; V, 0.106 mm.; VI, basal, 0.099 mm.; filament, 0.194 mm.; total, 0.772 mm.

OVIPAROUS GENERATION.

Before first molt and less than 24 hours old.—General color pea-green. Beak not reaching beyond the coxæ of the third pair of legs, apical segment dark. Antennæ colorless, except last segment, which is darker than the remainder. Eyes black. Legs pale, except the tarsi, which are black. Measurements: Length of body, 0.954 mm.; width, 0.486 mm.; antenna, I, 0.038 mm.; II, 0.038 mm.; III, 0.114 mm.; IV, 0.153 mm.; total 0.343 mm.

After first molt and 5 to 6 days old.—General color dirty pea-green, with very slight tinge of red. Last segment of antenna dark. Tarsi black. Measurements: Length of body, 1.145 mm.; width, 0.573 mm.

Oviparous female after third molt.—Color of head and first thoracic segment very dark green. Remainder of body slate-gray, with a reddish tint. The bloom which covers the body gives to the aphis the grayish color. Tips of antennæ dark. Tarsi black. Cornicles darker than body color, with a black ring at the base of each. Measurements: Length of body, 1.985 mm.; width, 1.050 mm.

Adult wingless oviparous female.—General color plumbeous, which is due to the bloom covering the body. Head black, and first thoracic segment very dark beneath the bloom. Abdomen tinged with pink. In alcoholic specimens from which the bloom has been removed, the markings as in the pseudogynes, except that the black markings on the last 3 abdominal segments are not present. Antennæ dark, with one large circular sensorium near the apical end of the fifth segment, and several at the apical end of the thickened base of the sixth. Beak reaching beyond the middle coxæ. Eyes black. Legs dark; the hind tibiæ noticeably swollen and thickly covered with small circular sensoria. Cornicles black and of the same shape as in the pseudogynes. Apical half of style dark. Measurements: Length of body, 2.201 mm.; width, 1.218 mm.; antenna, I, 0.038 mm.; II, 0.047 mm.; III, 0.172 mm.; IV, 0.076 mm.; V, 0.095 mm.; VI, basal, 0.100 mm.; filament, 0.154 mm.; total, 0.682 mm.

Male after third molt.—Head and first thoracic segment pale green, between pea-green and sage-green. Abdomen drab. Measurements: Length of body, 1.546 mm.; width, 0.687 mm.

Adult wingless male.—Head black. Thoracic segments each with a transverse black marking, this giving the thorax a blackish appearance. Similar but shorter markings occur on the first 3 and the last 3 abdominal segments. The spots on the sides of the body are arranged in more or less uniform rows. Third antennal segment with 12 or more sensoria irregularly distributed, most numerous near the apex; fourth with 5 to 7 sensoria; fifth with 2 to 4 similar sensoria and a larger one near the apex; and several at apex of the basal part of the sixth. Eyes black. Antennæ, legs, and cornicles black. Measurements (alcoholic specimens): Length of body, 1.636–1.745 mm.; width, 0.909–0.945 mm.; antenna, I, 0.081 mm.; II, 0.054 mm.; III, 0.200 mm.; IV, 0.136 mm.; V. 0.100 mm.; VI, basal, 0.109 mm.; filament, 0.181 mm.; total, 0.861 mm.; cornicle, 0.082 mm.

Eggs.—Elliptical-oval, yellow or greenish when first laid, gradually darkening to a jet-black. In spring just before hatching the eggs change from black to pale green. Length, 0.782 mm.; width, 0.391 mm.

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[a] This bibliography is practically complete, and contains a number of references not found in the Bibliography of Economic Entomology, by Henshaw and Banks. Those titles which have been inaccessible are marked with an asterisk. Those which are considered the most important have the date preceding them in italics.

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Brief notes on the life history of the corn root-aphis.

1891.—FORBES, S. A.—Seventeenth Report of the State Entomologist of Illinois for 1889 and 1890. <Trans. Dept. Agr. Ill., Springfield, Vol. XXVIII, pp. 64–70, colored plate "B," figs. 1, 2, 3, 4. Separate: Springfield, Ill., 1891.

Aphis maidi-radicis, n. sp. Proposes name for the root form of the corn aphis, and gives a full account of the life history, covering, as points of special interest, time and place of oviposition, stage and place of hibernation, relations of root-aphis to leaf-aphis of corn, other food plants, and the relations of the root-aphis to ants. Economic measures are suggested.

1891. FORBES, S. A.—A summary history of the corn root-aphis. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. III, pp. 233–238.

Covers the same points in the life history of the corn root-aphis as in the citation above.

* 1891. OSBORN, H.—The corn root-aphis. <Orange Judd Farmer, Chicago, Ill., April 25, 1891, p. 260.

Gives suggestions made by Doctor Forbes as to the methods to be used in diminishing the injury by this aphis.

1891. PEARSON, J.—Destructiveness of the corn-root plant-louse in Nebraska. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, p. 142.

In Nebraska some farmers lost as much as one-third of their crop. He suggests rotation of corn with small grain.

1891. WEED, C. M.—Sixth contribution to a knowledge of the life history of certain little-known Aphididæ. <Bul. Ill. State Lab. Nat. Hist., Urbana, Vol. III, art. 12. (Written December, 1887.)

Aphis maidis (?), root form. Summary of known life history. Hatching of aphides from eggs in spring. True sexes produced in fall and eggs are laid which are cared for by ants through the winter. Descriptions of the wingless male and the egg.

1891. Weed, C. M.—Insects and Insecticides. <Hanover, N. H., pp. 209–210, fig. 110.

The corn root-aphis (*Aphis maidis* ?). General life history; gives the rotation of crops as the only known successful remedy.

1891. Williams, T. A.—Host-plant list of North American Aphididæ. <Special Bul. 1, Univ. Nebr., Dept. Ent., Lincoln, pp. 10, 14, 16, 21, 23.

Lists of food plants of *Aphis maidis*, feeding on roots, as dock (*Rumex altissimus*), *Setaria glauca*, *S. viridis*, knotweed (*Polygonum persicaria*), plantain (*Plantago major*), ragweed (*Ambrosia trifida*), and smartweed (*Polygonum* sp.).

1892. Bruner, L.—Report of Entomologist. <Ann. Rep. Nebr. State Board Agr. for 1891, Lincoln, pp. 300–304, fig. 77.

Aphis maidi-radicis Forbes. Gives descriptions of all forms. Quotes the life history from that given by Professor Forbes.

1892. Riley, C. V., and Howard, L. O.—Review of Professor Forbes's Sixth Report. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 9 and 10, p. 293.

Mentions that it contains a summary history of the corn root-aphis and a colored plate of same.

1892. Webster, F. M.—Early published references to some of our injurious insects. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 7 and 8, p. 264.

Gives references to the original descriptions of *Aphis maidis*, root and aerial forms. Gives reference to a note in American Farmer, Vol. IV, p. 71, May 24, 1822, from Mr. Tho. Emory, of Poplar Grove (State not given), relating to a disease of wheat known as "sedging," who says, "I believe this insect is the same as that known by the name of the root-louse in corn, so frequently found in that plant," etc.

1892. Riley, C. V., and Howard, L. O.—The corn root-aphis. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 7 and 8, p. 285.

Short review of Doctor Weed's article on the corn root-aphis, published as a bulletin of the Illinois State Laboratory of Natural History.

1893. Riley, C. V., and Howard, L. O.—The corn-root plant-louse. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. VI, p. 32.

Crop of corn in Maryland owned by E. P. Thomas was damaged 50 per cent last year by this aphis; also injury this year (June 27, 1893).

1894. Forbes, S. A.—Eighteenth Report of the State Entomologist of Illinois. <Trans. Dept. Agr. Ill. for 1893, Springfield, Vol. XXXI, pp. 57, 58–85, Pl. VII, figs. 5, 6, Pl. VIII, figs. 1, 2, 3, 4, 5. Separate: Springfield, Ill., 1894.

The corn root-aphis (*Aphis maidi-radicis* Forbes). Injury to corn and to other plants; life history; relation to the corn leaf-aphis; natural enemies; economic procedure; discusses in full (1) rotation, (2) fertilizers and insecticides, (3) breaking up the ants' nests in fall by plowing, etc., (4) early spring plowing, etc. Descriptions of wingless, winged, and pupa of viviparous female, wingless oviparous female, wingless male, and egg.

1894. Osborn, H.—Corn insects: Their injuries and how to treat them. <Iowa Agr. Exp. Sta., Des Moines, Iowa, Bul. 24, pp. 994–995, fig. 1.

Mentions *Aphis maidi-radicis* as an important corn insect, although as yet it hardly seems probable that the species has become very much distributed in Iowa.

1894. SEMPERS, F. W.—Injurious insects and the use of insecticides. <Philadelphia, Pa., p. 157.

Short account of the corn root-aphis, with remedies. "No artificial remedy is known for this pest. In small garden patches kerosene emulsion might be used for drenching about the roots, but treatment with this insecticide has not been regarded as practicable on a large scale."

1895. COMSTOCK, JOHN HENRY, and COMSTOCK, ANNA BOTSFORD.—Manual for the Study of Insects. <Ithaca, N. Y., p. 158.

Mentions dependence of root-aphis upon ants as given by Forbes.

1896. FORBES, S. A.—Insects injurious to the seed and root of Indian corn. <Ill. Agr. Exp. Sta., Urbana, Bul. 44, pp. 237–257, figs. 33–37.

Largely a recapitulation of the account given in the Eighteenth Report of the State Entomologist of Illinois.

1896. SMITH, J. B.—Economic entomology. <Philadelphia, Pa., p. 134.

Mentions the corn root-aphis and methods to be used against it.

1896. HOPKINS, A. D., and RUMSEY, W. E.—Practical entomology. <W. Va. Agr. Exp. Sta., Charleston, Bul. 44, p. 279.

Short and general account of the life history of *Aphis maidi-radicis*. It was found to be exceedingly common and destructive to corn in Jackson, W. Va., in May, 1891. Remedies are given.

*1898. WEBSTER, F. M.—Entomology. <Ohio Farmer, Cleveland, Ohio, September 1, 1898, p. 143.

Notes on *Aphis maidi-radicis*.

1899. KING, GEO. B.—China asters infested by a coccid. <Psyche, Cambridge, Mass., Vol. VIII, p. 312.

Reports that *Aphis maidi-radicis* is found on roots of asters in Massachusetts.

1900. LUGGER, O.—Bugs injurious to cultivated plants. <Minn. Agr. Exp. Sta., St. Paul, Bul. 69, pp. 184–185, fig. 154½.

Quotes Osborn in regard to the corn root-aphis.

1900. SMITH, J. B.—Insects of New Jersey. <Supplement to Twenty-seventh Ann. Rep. State Board Agr. N. J. for 1899, Trenton, p. 104.

Lists *Aphis maidis* Fitch and speaks of it as often causing serious injury to the young plants by its attacks on the roots.

1901. BRUNER, L.—Corn-root insects. <Nebraska Farmer, Lincoln, Nebr., February 14, 1901, figs.

General account of the life history of the corn root-aphis, with suggested remedies.

1901. HUNTER, W. D.—The Aphididæ of North America. <Ia. Agr. Exp. Sta., Ames, Bul. 60, pp. 98–99.

Lists *Aphis maidi-radicis* from Iowa; gives other States in which it is found; food plants and bibliography of literature.

1901. SANDERSON, E. D.—The corn root-louse. <Twelfth Ann. Rep. Del. Agr. Exp. Sta. for 1900, Wilmington, p. 211.

Sweet and sugar corn worse affected than field corn. Aphides common on weeds early in the season and were found on squash roots in June.

1902. SANDERSON, E. D.—Insects injurious to staple crops. <New York, N. Y., pp. 134–141, figs. 74–76.

The corn root-louse (*Aphis maidi-radicis* Forbes). A general description of the aphis; distribution; food habits; life history; care by ants; remedies.

1902. WASHBURN, F. L.—Insects notably injurious in 1902. <Seventh Ann. Rep. State Ent. Minn., St. Anthony Park, p. 64, fig. 155. Also as Bul. 77, Minn. Agr. Exp. Sta., November, 1902.

Brief notes on *Aphis maidis* Fitch (root and aerial forms) as occurring in Minnesota; remedies.

*1904. STEDMAN, J. M.—Common corn insects. <Mo. State Board Agr., Bul. 3, No. 11, pp. 11–17.

Notes on the corn root-aphis in Missouri.

1905. FORBES, S. A.—Field experiments and observations on insects injurious to corn. <Ill. Agr. Exp. Sta., Urbana, Bul. 104, pp. 102–123.

Discuss experiments made in 1904–1905 to control the corn root-aphis by means of treatment of the soil before planting. Also gives additional notes on the life history.

1905. FORBES, S. A.—Injurious insects of corn. A conference on the corn insects of Illinois, at the Tenth Ann. Meeting of the Ill. Farmers' Institute, at Joliet, Ill. <Springfield, Ill. Plate. Also in Rep. Ill. Farmers' Institute, Springfield, Vol. X, pp. 35–45.

Gives account of the corn root-aphis and experiments made in the past year. Questions and answers. One colored plate of the corn root-aphis and the root-aphis ant.

1905. FORBES, S. A.—The principal insects injurious to the corn plant. <Report Ill. Farmers' Institute, Springfield, Vol. X, pp. 240–251, figs. 17–22.

Injury to corn and to other plants; life history; relation to ants; economic procedure.

1905. KOHLER, A. R.—Insects injurious to corn. <Iowa Agriculturist, Ames, Iowa, Vol. VI, No. 3, pp. 84–85.

Short account of the corn root-aphis.

1905. PETTIT, R. H.—Insects of the garden. <Mich. Agr. Exp. Sta., Agricultural College, Bul. 233, p. 53. Also in Nineteenth Ann. Rep. Mich. Agr. Exp. Sta., Agricultural College, 1906, p. 204.

Mentions *Aphis maidi-radicis* as a corn insect, but that thus far it has not been observed in Michigan.

1905. SYMONS, T. B.—Common injurious and beneficial insects in Maryland. <Md. Agr. Exp. Sta., College Park, Bul. 101, pp. 160–161.

The corn root-aphis. Short notes and remedies.

1906. DAVIS, J. J.—The corn root-louse (*Aphis maidi-radicis* Forbes). <Illinois Agriculturist, Urbana, Vol. X, March, pp. 213–218, 6 figs. Abstract: Wallace's Farmer, Des Moines, Iowa, Vol. XXXI, May 11, 1906, p. 637, 6 figs.

General account of habits, life history, etc., and remedies.

1906. FORBES, S. A.—The corn root-aphis and its attendant ant. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Bul. 60, pp. 29–41.

A complete account of the corn root-aphis. Discusses economic importance, life history, the attendant ant, relation of ant and aphis, injury to corn, natural checks on increase, practical economic measures, and a preventive routine.

1906. KIRKALDY, G. W.—Catalogue of the hemipterous family Aphidæ, with their typical species, together with a list of the species described as new from 1885 to 1895. <Can. Ent., London, Ont., Vol. XXXVIII, p. 13.

Lists *Aphis maidi-radicis* Forbes.

1906. SANBORN, C. E.—Kansas Aphididæ, with catalogue of North American Aphididæ, and with host-plant and plant-host list. Part 2. <Kansas Univ. Sci. Bul., Lawrence, Vol. III, No. 8, p. 258.

Lists food plants of *Aphis maidi-radicis* Forbes as *Amarantus hybridus, Erigeron canadensis, Oxalis stricta, Plantago major, Portulaca oleracea, Rumex crispus, Setaria italica germanica ochloa,* and corn.

1907. CHITTENDEN, F. H.—Insects injurious to vegetables. <New York, pp. 189–190, fig. 121.

Short account of the corn root-aphis, including economic treatment.

1907. FORBES, S. A.—The corn root-louse. <Fayette County Democrat, Effingham, Ill., Vol. XLVII, No. 19, March 6, 1907; Bureau County (Ill.) Record, March 6; The Weekly Pantagraph, Bloomington, Ill., Vol. XC, No. 12, March 22. Also in many other Illinois newspapers.

Gives detailed accounts of the new oil-of-lemon treatment, which he has found to be the most effective method of controlling the corn root-aphis.

1907. STOUT, J. P.—Control of the corn root-aphis. <Illinois Agriculturist, Urbana, April, pp. 245–247, 4 figs.

Gives methods which have been successfully used to combat the corn root-aphis, including the oil-of-lemon treatment, which Doctor Forbes has proved to be the most practical method of controlling this root-aphis.

1907. WEBSTER, F. M.—The corn leaf-aphis and corn root-aphis. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Cir 86, May 6, 1907, figs. 3, 4.

Gives general description and discusses: Root-aphis and the little brown ant; life history and habits; natural enemies; preventive and remedial measures.

1907. FORBES, S. A.—Insects in relation to health. <Rept. Ill. Farmers' Inst., Springfield, vol. 12, pp. 263–265.

In a few introductory remarks, preceding a lecture on "Insects in relation to health," Doctor Forbes reports on the success of the oil-of-lemon treatment for corn seed to protect it from the attacks of the corn root-aphis. Methods of treating the seed are given.

1908. FORBES, S. A.—Experiments with repellents against the corn root-aphis. <Journ. Econ. Ent., Concord, N. H., vol. 1, No. 2, pp. 81–83.

Abstract of a paper read by Doctor Forbes at the 20th annual meeting of the Association of Economic Entomologists. Gives in detail results of field experiments, in 1906, against the corn root-aphis by treatment of the seed with oil of lemon, carbolic acid, formalin, and kerosene.

1908. FORBES, S. A.—Experiments with repellents against the corn root-aphis. <Orange Judd Farmer, Chicago, Ill, vol. 44, No. 16, April 15, pp. 501, 504.

Gives results of field experiments, in 1906, against the corn root-aphis by a treatment of the seed with oil of lemon, carbolic acid, formalin, and kerosene. Several farmers who used the oil-of-lemon treatment in 1907 reported injury by the treatment. Mentions that further experiments will be made in Illinois in 1908.

THE CORN LEAF-APHIS.

(*Aphis maidis* Fitch.)

GENERAL ACCOUNT.

The corn leaf-aphis was first found injuring corn by Dr. Asa Fitch, and in his Second Report of the Insects of New York (1856) he describes it, and proposes for it the name of *Aphis maidis*, giving an account of its injuries to corn. Although since that time considerable work has been done on this aphis, we do not yet know how it spends the winter. In 1862 Mr. Benjamin D. Walsh found an aphis living on the roots of corn about Rock Island, Ill., and, although he was doubtful as to its identity, he distinguished it by calling it the root form of *Aphis maidis*. From that time until 1891 these two forms were supposed to be the same species, until Doctor Forbes, who had, since his first knowledge of them, regarded them as probably two distinct species, named the subterranean form *Aphis maidi-radicis* in the Seventeenth Report of the State Entomologist of Illinois.

Aphis maidis has always been considered more or less injurious to corn, sorghum, and broom corn, although it seldom becomes seriously so. In some cases, however, it injures the corn ears by sucking the sap from the silk and killing it, thus preventing fertilization of the kernels. Only rarely, however, does it stunt the growth of the plant, at least in Illinois, the reason probably being that in this State the aphis does not commence its attacks upon the plant until the last part of June or the first of July, at which time the plant is strong enough to withstand the drain made upon its sap supply by the aphis. This aphis sometimes does considerable injury to the quality of the brush of broom corn by discoloring it, the discoloration being "due to a bacterial affection following upon the plant-louse punctures" (Forbes).

This aphis has a very wide distribution, being found in all parts of the United States where corn is grown; that is, from Maine to California and Texas. Prof. F. M. Webster has reported finding it on sorghum in Australia, where, he says, it is sometimes quite obnoxious, and in a recent circular he says that "the insect is also known from Japan."

FOOD PLANTS.

Though the usual food plants are corn, sorghum, and broom corn, this species feeds also on various other plants, as barley, *Setaria glauca*, and *Oxalis*. At Urbana, Ill., September 7, 1906, in an infested cornfield, I found *Aphis maidis* also breeding on *Panicum crus-galli* and *Panicum sanguinale*.

In our insectary, in 1906, plants of *Panicum crus-galli* and *Panicum sanguinale*, which had accidentally grown up in some unused pots, became almost covered with *Aphis maidis*. Numbers of these aphides were placed in a Comstock cage containing the common weeds found around cornfields, namely, *Setaria glauca*, *Panicum crus-galli*, *Polygonum pennsylvanicum*, *Panicum proliferum*, *Panicum sanguinale*, broom corn, sorghum, and corn. When examined two days later (September 10, 1906) the aphides were breeding freely on all plants except corn, which was at that time just sprouting. November 4, aphides were on all plants except *Panicum crus-galli*, *Polygonum* *pennsylvanicum*, and *Panicum proliferum*, which plants were then dead. December 9, there were a few on the sorghum and corn, these being the only plants alive at that time. When examined about a week later all plants in the cage were dead and no aphides could be found. It might be mentioned that this cage was kept at the outdoor temperature. This aphis shows a decided preference for broom corn over Indian corn and sorghum. Both in the field and in the insectary aphides which had been living on sorghum plants for a number of generations always changed to broom-corn plants when these were placed in the cages.

LIFE HISTORY.

As stated above, we do not know where and how this aphis passes the winter. In Illinois it first appears in midsummer, the earliest date being June 26, 1906, at which time Mr. E. O. G. Kelly found it quite numerous on broom corn at Mattoon, in central Illinois. We know that it reproduces parthenogenetically from the time of its first appearance in the fields until its disappearance in the fall. In the fall, so far as has yet been observed, these aphides gradually die off as freezing weather comes, leaving neither eggs nor hibernating adults upon or about the corn plants. I did not make any observations in the field in 1906, but in 1905 (a more severe season than 1906) I found living *Aphis maidis* on sorghum as late as October 28, and all found at that date were either winged or the pupæ of winged viviparous females. Numerous experiments have been made by Doctor Forbes and his assistants to determine the manner in which this species hibernates, and whether or not there is a sexual generation in the fall, as is usually the case with aphides. Since these investigations were thorough, it seems possible that the aphides may not spend the winter in the egg stage, at least in central or northern Illinois. There are at least two permissible suppositions as to the winter history of these insects. They may hibernate as adults in the warmer States, or even in southern Illinois, and, as the summer progresses, gradually diffuse themselves to the North with the advance of the season and infest the plants in these northern States. This supposition is plausible, inasmuch as this species has been found in Mississippi on barley in January; but the fact that aphides are probably unable to travel great distances is against it. No work has been done as yet on this line of investigation, and it is possible that if one began his search for this aphis in the far South—even in the southern part of Illinois—he would find it at a much earlier date than it has heretofore been reported, and that he could follow its gradual diffusion northward. The other and more likely theory is that, like many aphides, it has an alternate food plant on which it passes the winter and spring.

I have worked out in the insectary (1906) the summer history as regards the number of generations, rate of multiplication, number of young, etc. *Aphis maidis* was collected by Mr. Kelly June 26, and specimens sent in by him were reared on sorghum and broom corn. From that date until killed by the cold weather in the fall a maximum of 17 generations was obtained. (See Table VII and fig. 33.)

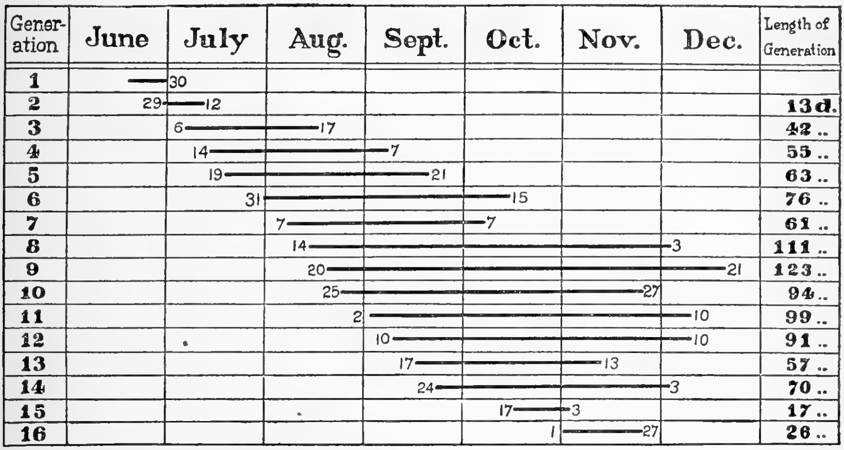

FIG. 33.—Periods and succession of generations in *Aphis maidis*, 1906.

TABLE VII.—*Line of generations of Aphis maidis, June 26–November 22, 1906.*

Generation in insectary.	Date of birth.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Number of young.	Average young per day of productive period.	Largest number of young in 1 day (at least).	Period after last young.	Date of death or disappearance.	Total length of life.	Food plant used.
	1906.		*Days.*		*Days.*				*Days.*		*Days.*	
1	[a]June 26	June 28–June 29	......	....	......	6	......	......	......	....	......	Sorghum.
2	June 29	July 6	7	July 12	7	18	2.6–	3	0	July 12....	14	Do.
3	July 9-11	July 15	5–6	Aug. 4	20	38	1.9	5	13	Aug. 17 ...	39	Broom corn.
4	July 15	July 21	6	Aug. 8	18	44	2.4+	5	11	Aug. 19 ...	35	Do.
5	July 25	July 31	6	Aug. 18	18	35	2 –	3	6	Aug. 24 ...	30	Do.
6	July 31	Aug. 7	7	Sept. 2	26	38	1.5–	4	0	Sept. 2....	33	Do.
7	Aug. 7	Aug. 13	6	Sept. 6	24	47	1.9+	5	1	Sept. 8....	31	Do.
8	Aug. 13	Aug. 19	6	Aug. 30	12	36	3	4	0	Aug. 30 ...	18	Do.
9	Aug. 19	Aug. 25	5	Sept. 6	12	29	2.4+	4	0	Sept. 7....	17	Do.
10	Aug. 25	Sept. 2	8	Sept. 12	10	17	1.7	2	0	Sept. 12...	18	Do.
11	Sept. 2	Sept. 9	7	Oct. 11	32	52	1.6+	4	4	Oct. 15....	43	Do.
12	Sept. 9	Sept. 16	7	Sept. 23	7	20	2.8+	3	0	Sept. 23...	14	Do.
13	Sept. 16	Sept. 24	8	Oct. 15	21	33	1.5+	3	0	Oct. 15....	29	Do.
14	Sept. 24	Oct. 4	10	Oct. 4	2	1	.5	......	0	Oct. 4....	11	Do.
15	Oct. 4	Oct. 16	12	Oct. 17	2	4	2	......	......	Oct. 17–22.	14	Do.
16	Oct. 16	Nov. 1	15	Oct. 2	1	2	2	......	......	Nov. 3....	16	Do.
17	[b]Nov. 1	....	......	....	......	......	......	......	......	....	......	

[a] Collected on broom corn.
[b] Became adult November 22, but disappeared before giving birth to any young.

TABLE VIII.—*Data of individual experiments with Aphis maidis, viviparous generation, 1906.*

Date of birth.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Number of young.	Average young per day of productive period.	Largest number of young in one day (at least).	Period after last young.	Date of death or disappearance.	Total length of life.	Food plant used.
		Days.		*Days.*				*Days.*		*Days.*	
June 28–29	July 6	7–8	July 12	7	18	2.6 −	3	0	July 12	14	Sorghum.
July 9–10	July 15	5–6	Aug. 4	20	38	1.9	5	13	Aug. 17	39	Broom corn.
July 6	July 14	8	Aug. 6	23	33	1.4 +	3	5	Aug. 11	36	Sorghum.
July 9	do	5	July 30	16	22	1.3 +	2	11	do	32	Do.
July 14	July 20	6	Aug. 3	13	38	2.9 +	6	0	Aug. 3	19	Broom corn.
July 15	July 21	6	Aug. 8	18	44	2.4 +	5	11	Aug. 19	35	Do.
July 27	Aug. 1	5	Aug. 22	21	49	2.4 −	5	6	Aug. 28	32	Do.
July 25	July 31	6	Aug. 18	18	35	2 −	3	6	Aug. 24	30	Do.
July 31	Aug. 7	7	Sept. 2	26	38	1.5 −	4	0	Sept. 2	45	Do.
August 1	do	6	Aug. 11	5	13	2.6	4	0	Aug. 11–13	*a* 11	Do.
August 7	Aug. 13	6	Sept. 6	24	47	1.9 +	5	1	Sept. 8	31	Do.
Do	Aug. 14	7	Aug. 20	7	26	3.7 +	6	0	Aug. 20	*a* 14	Do.
August 10	Aug. 16	6	Sept. 13	28	49	1.7 +	4	8	Sept. 21	42	Do.
August 13	Aug. 19	6	Aug. 30	12	36	3	4	0	Aug. 30	18	Do.
August 14	Aug. 20	6	Sept. 16	27	47	1.7	6	10	Sept. 26	43	Do.
August 17	Aug. 22	5	do	25	64	2.5 +	4	19	Oct. 6	49	Do.
August 20	Aug. 25	5	Sept. 6	12	29	2.4 +	4	0	Sept. 7	17	Do.
Do	Aug. 27	7	Sept. 23	27	65	2.4 +	5	7	Sept. 30	41	Do.
August 3–4	Aug. 10	6–7	Sept. 2	23	32	1.3 +	3	5	Sept. 7	34	Do.
August 22	Aug. 29	7	Sept. 9	11	14	1.2 +	3	0	Sept. 9	18	Do.
August 25	Sept. 2	8	Sept. 12	10	17	1.7	2	0	Sept. 12	18	Do.
August 27	Sept. 7	11	Sept. 8	2	5	2.5		0	Sept. 8	13	Do.
September 7	Sept. 14	7	Sept. 26	12	28	2.3 +	4	0	Sept. 26	19	Do.
September 2	Sept. 9	7	Sept. 11	32	52	1.6 +	4	4	Oct. 15	43	Do.
August 31–September 2	Sept. 8	6–8	Sept. 18	10	23	2.3	3	0	Sept. 18	16–18	Do.
September 7	Sept. 14	7	Sept. 23	9	26	2.8 +		0	Sept. 23	16	Do.
September 9	Sept. 16	7	do	7	20	2.8 +	3	0	do	14	Do.
Do	Sept. 15	6	Oct. 5	20	38	1.9 +	5	10	Oct. 15	36	Do.
September 14	Sept. 21	7	Nov. 8	48	59	1.2	4		Nov. 8–13	55	Do.
September 16	Sept. 24	8	Oct. 15	21	33	1.5 +	3	0	Oct. 15	29	Do.
September 24	Oct. 4	10	Oct. 4	*a* 2	(*a*)				Oct. 5	*a* 11	Do.
September 21	Sept. 28	7	Sept. 30	*a* 3	7	2.3 +			Sept. 30	*a* 10	Do.
October 4	Oct. 16	12	Oct. 17	*a* 2	*a* 4	2			Oct. 17–22	14	Do.
September 23	Oct. 2	9	Oct. 28	26	*a* 35	1.3 +	4	37–44	Dec. 3–10	72	Do.
Do	do	9	Nov. 13	42	31	*a* 0.7 +	4	14	Nov. 27	65	Do.
October 1	Oct. 11	10	Oct. 12	*a* 1	*a* 1	*a* 1 +			Oct. 11–13	*a* 11	Do.
October 17	Nov. 1	15	Oct. 2	*a* 1	*a* 2	*a* 2			Nov. 3	16	Do.
October 20	{Oct. 28–Nov. 1}	8–12	Nov. 27	26–30	14+	(*a*)		6	Dec. 3–10	44	Do.
October 25	Nov. 18	24	Nov. 22	*a* 4	*a* 3	*a* 0.7 +			Nov. 22	28	Do.
November 1	Nov. 22–27	22–27	Dec. 3–10	(*a*)	(*a*)	(*a*)			Dec. 10	40	Do.
Average		8.15		19.0+	33.5	2.04+				31.6+	

a Not counted in making averages.

Although no exact figures can be given as to the minimum number of generations (breeding always from the last born of each generation), still, from my experiments, it may be definitely said that there were not more than 9 generations after June 26. The aphides were kept in the unheated insectary greenhouse, and thus the temperature was approximately the same as that out of doors. The last date recorded for living aphides was December 21. The immature stage covered from 5 to 24 days, varying with the season; thus, in the warmer parts of the year, from the last of June until the middle of September, the average for 30 experiments was 6.6 days, while from the middle of September until the 1st of November for 10 experiments the average was 12.8 days. The average for the entire 40 experiments was 8.1+ days. (Table VIII.)

The length of the period for producing young varied up to 48 days, with an average, for the entire series of experiments, of 19 days. The mother usually lived a few days after the birth of her last young. The entire length of life averaged 31.6+ days. The average number of young produced by a single aphis, in the 33 experiments of which record was kept, was 33.5+, while the largest number was 65. Individual aphides in some cases produced as many as 6 or 8 young per day, but the usual number was 2. The number of molts is invariably 4. Table IX gives the records of a few individuals, showing the number of molts and the time between each molt.

TABLE IX.—*Periods of molts of Aphis maidis, viviparous generation, 1906–7.*

Date of birth.	Age at first molt.	Age at second molt.	Age at third molt.	Age at fourth molt.	Age at birth of first young.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*
July 23, 1905	2	3	5	8	9
Do	2	4	5	6	7
July 24, 1905	1	3	5	7	7
July 27, 1905	2	3	4	6	7
August 4, 1905	1	3	4	6	6
August 5, 1906	1	2	4	6	6
August 14, 1906	2	3	4	6	6

DESCRIPTIONS.

Aphis maidis Fitch.

VIVIPAROUS GENERATION.

Before first molt and less than 1 hour old.—General color light pea-green. Eyes red. Antennæ transparent, only 4 distinct segments, or 5 if the filament be counted, the third having a slight constriction, which is the beginning of a division of that segment. Legs transparent. Cornicles vasiform. Measurements: Length of body, 0.545 mm.; width, 0.236 mm.

After first molt and 24–48 hours old.—General color between pea-green and chromium-green. Eyes red. Antennæ as in the earlier stages, but not transparent, while the constriction of the third segment is more distinct, and there is a sensorium at the apical end of the third segment. Fore part of head darker than body color. Legs paler than body color, except parts of the femur and tarsus, which are darker; the tip of the abdomen also is darker. Cornicles longer and more distinct than before first molt. Measurements: Length of body, 0.927 mm.; width, 0.363 mm.; antennæ, 0.325 mm.

After second molt and 48–72 hours old.—General color chromium-green, the sides being slightly darker. Head and first thoracic segment bottle-green. Eyes dark red. Antennæ pale green, with black tips. What was spoken of in the earlier stages as the third segment is now divided into two distinct segments; otherwise, except as to size, the antennæ are the same as in the earlier stages. Tips of legs black. Tip of abdomen dark chromium-green. The black cornicles are surrounded at their bases by dark green patches. Measurements: Length of body, 1.090 mm.; width, 0.454 mm.; antennæ, 0.342 mm.

After third molt and 96–120 hours old.—General color chromium-green. Head and first thoracic segment darker green. Eyes dark red. First and last segments of the antennæ black. As yet only 5 distinct segments, or 6 if the filament be counted. Tarsi black; femora of the posterior pairs of legs partly black. Tip of abdomen dark green; penultimate segment with a stripe of dark green nearly covering the entire segment. Cornicles black, with dark-green basal spots. Measurements: Length of body, 1.254 mm.; width, 0.527 mm.; antennæ, I, 0.044 mm.; II, 0.037 mm.; III, 0.132 mm.; IV, 0.061 mm.; V, basal, 0.057 mm.; filament, 0.117 mm.; total, 0.448 mm.

Adult wingless female.—Head black. Antennæ black, excepting third segment. Eyes very dark reddish brown. Beak dark, its apex black, shading to brown. General color of body blue-green. Fore segments and tip of abdomen very dark green. Legs black, excepting middle portion of femur. Cornicles black, slightly incrassate at the base and with a dark-green basal patch. The adult gradually becomes darker in color as it grows older, and when it has about finished with the production of young it is almost black in color, having a slightly greenish and brownish tint. Measurements (from alcoholic specimens collected on broom corn at Mattoon, Ill., July 6, 1906): Length of body, 2.363 mm.; width, 1.091 mm.; antennæ, I, 0.067 mm.; II, 0.054 mm.; III, 0.193 mm.; IV, 0.115 mm.; V, 0.111 mm.; VI, basal, 0.077 mm.; filament, 0.176 mm.; total, 0.793 mm.; cornicles, 0.203 mm.; style, 0.101 mm. The specimens reared in the insectary were somewhat smaller than the above.

Adult winged female.—Head black. Antennæ black, and with 6 segments, or 7 if the filament be counted. Antennal sensoria circular, 16 to 20 on III, 4 on IV, several at apical end of V, and also at apical end of the basal part of VI. Eyes dark brown or black. Thorax and legs black. Abdomen pale bluish green. Three black spots on each side of the body and anterior to the cornicles, and a black basal spot surrounding each cornicle. Posterior to the cornicles are 2 black spots, one on each side, and also 3 more or less distinct transverse black bands. Cornicles black, slightly incrassate at middle, dilated at apex. Distal half of dorsally curved style black, and the remainder margined with black to the base. Measurements (alcoholic specimens): Length of body, 1.709 mm.; width, 0.618 mm.; wing expanse, 5.786 mm.; antennæ, I, 0.065 mm.; II, 0.057 mm.; III, 0.293 mm.; IV, 0.154 mm.; V, 0.154 mm.; VI, basal, 0.106 mm.; filament, 0.228 mm.; total, 1.057 mm.; cornicles, 0.130 mm.; style, 0.081 mm.

Pupa of winged female.—Body pale green. Head dark brown, with a more or less distinct median white line. Antennæ darker at either end. Antennæ with a sensorium at the end of V, and 2 or more at the distal end of the basal portion of VI. Wing-pads, tip of abdomen, and cornicles black. Legs dark, almost black. Cornicles noticeably incrassate at middle and slightly dilated at the tip. Measurements (alcoholic specimens): Length of body, 1.999 mm.; width, 0.799 mm.; antennæ, I, 0.067 mm.; II, 0.057 mm.; III, 0.183 mm.; IV, 0.125 mm.; V, 0.098 mm.; VI, basal, 0.084 mm.; filament, 0.159 mm.; total, 0.773 mm.; cornicles, 0.155 mm.

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Lists *Aphis maidis* Fitch as being found on the tassel, ear-stalks ,and roots of Indian corn.

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1883. POPENOE, E. A.—Third Biennial Report Kansas State Board Agriculture, Topeka, p. 617.

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Description of winged viviparous female of *Aphis maidis*. Gives food plants as *Setaria glauca, Sorghum halepense,* and *Zea mays*.

1904. SANDERSON, E. D.—Insects of 1903 in Texas. <U. S. Dept. Agr., Div. Ent., Washington, D. C., Bul. 46, p. 93.

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1905. FORBES, S. A.—Twenty-third Report of the State Entomologist of Illinois. <Chicago, pp. 123–133, figs. 115, 117.

The corn leaf-aphis (*Aphis maidis* Fitch). General descriptions of this aphis and its effects on plants. Reported as a corn insect from New York to Texas, Minnesota, and California. Gives in detail field observations and insectary experiments made to determine the winter history, alternate food plants, if any, etc., of the leaf aphis.

1905. PETTIT, R. H.—Insects of the garden. <Mich. Agr. Exp. Sta., Agricultural College, Bul. 233, December, p. 55. Also Nineteenth Ann. Rep. Mich. Exp. Sta., 1906, p. 206.

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1907. WEBSTER, F. M.—The corn leaf-aphis and corn root-aphis. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Cir. 86, pp. 1–3, May 6, figs 1, 2.

Short review of the history; appearance and habits; field experiments. Reports the occurrence of the leaf-aphis in Japan.

THE SORGHUM APHIS.

(*Sipha* [*Chaitophorus*] *flava* Forbes.)

The sorghum aphis was first described by Dr. S. A. Forbes in 1883, in the Thirteenth Report of the State Entomologist of Illinois. Doctor Forbes has further mentioned it in several of his reports as State entomologist, but so far as I know nothing else has been written about it.

LIFE HISTORY.

The life history was, until 1905, unknown, but during that year I made some studies upon this insect and found, among other things, that it passed the winter in the egg stage. In 1906 this aphis was first collected June 28 at Mattoon, Ill., by Mr. E. O. G. Kelly, on sorghum and *Panicum crus-galli*, and the life history from that date until the egg stage in the fall was obtained. Eggs thus obtained were carried through the winter and young hatching from them were reared. The generations were continued during the entire summer until the egg stage in the fall. During my absences in the summer of 1907 the experiments were carried on by Messrs. M. C. Tanquary and E. L. Dillon. June 28 is not the earliest at which this aphis has been collected in the field, as Doctor Forbes has found it on grass as early as May 7. I found 4 young aphides on timothy May 23, 1907, and these were bred on grass. They became winged adults as follows: One on May 30, 2 on June 2, and 1 on June 4. Inasmuch as I found these young aphides separately, and as no mother aphis was found after a careful search, I had supposed them to be stem-mothers, but, so far as I am able to learn, no record of stem-mothers being winged has ever been made. The eggs began to hatch in the insectary March 16 (1907), and it is probable that in the field the hatching period is chiefly the month of April.

Sorghum and broom corn are the usual plants infested by this species, and upon these it is sometimes abundant and destructive. Doctor Forbes has reported it from sorghum, broom corn, Indian corn, *Setaria*, *Panicum*, and wheat. Mr. Kelly first reported its occurrence on *Panicum crus-galli*, and in 1906 I reared it through a number of generations on *Panicum sanguinale*, and collected it in the field from blue grass, oats, and timothy. Mr. Paul Hayhurst, of the Bureau of Entomology, U. S. Department of Agriculture, wrote me of finding it on *Setaria glauca*. Thus, so far as known, *Sipha flava* feeds only on plants of the grass family (Gramineæ). In Europe there are at present 8 or 9 known species of the genus *Sipha*, and, according to Del Guercio,[a] all, with the exception of one species, *Sipha bignonæ* Macch., feed only upon the grasses of the families Gramineæ and Juncaceæ. *Sipha bignonæ* is probably not a typical *Sipha*, and it was originally doubtfully placed under the genus *Lachnus* by Macchiati.[b] In America two species (*S. rubifolii* and *S. flava*) have been placed under the genus *Sipha*. *S. rubifolii* is found only on blackberry (*Rubus*), but this species probably belongs to an undescribed genus, and undoubtedly does not properly belong under the genus *Sipha* of Passerini.

Heretofore this aphis has never been positively reported outside of Illinois, but this year (1907) Mr. Hayhurst sent me specimens from Minnesota, Virginia, and Oklahoma, and wrote me that he found it also in New York, West Virginia, and Texas. It seems likely, therefore, that it is distributed over the United States, more or less generally, east of the Mississippi River. It will probably be found to be more generally distributed in the South, because all of the known facts regarding the distribution of this species, as well as of the European species of *Sipha*, indicate that they are probably of subtropical origin.

Young hatching from eggs March 18 were reared to adults and successive generations obtained. In one case the *first young of the first young* was taken all the way through the series, 16 generations being obtained. (Table X.)

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[a] GUERCIO, G. DEL.—Contribuzione alla Conoscenza della Sipha Pass. ed alla loro posizione nella Famiglia degli Afidi. <Redia, Firenze, Italy, Vol. II (1904), pp. 127–153.

[b] MACCHIATI, LUIGI.—Fauna e flora degli Afidi di Calabria. <Bul. Soc. Ent. Ital., Vol. XV (1883), p. 262.

TABLE X.—*Line of generations of Sipha flava from egg to oviparous generation, 1907.*

Generation (from egg).	Date of birth.	Date of first young.	Age at birth of first young.	Last young.	Productive period.	Number of young.	Average young per day of productive period.	Largest number of young in one day.	Life after last young.	Date of death or disappearance.	Total length of life.	Plant used.
			Days.		*Days.*				*Days.*		*Days.*	
1	Mar. 18	Apr. 15	28	June 6	52	48	0.9+	4	12	June 19	92	Sorghum.
2	Apr. 15	May 16	31	June 24	39	81	2.0+	5	6	June 30	76	Broom corn.
3	May 16	May 29	13	June 22	24	73	3.0+	6	8	June 30	45	Do.
4	May 29	June 11	13	July 9	28	80	2.8+	7	9	July 18	50	Do.
5	June 11	June 21	10	July 11	20	80	4	7	10	July 21	40	Do.
6	June 22	July 1	9	Aug. 12	42	56	1.3+	5	0	Aug. 12	51	Do.
7	July 1	July 8	7	July 19	11	37	3.3+	4	0	July 19	18	Do.
8	July 8	July 16	8	Aug. 16	31	63	2.0+	5	17	Sept. 2	56	Do.
9	July 16	July 24	8	Aug. 20	27	57	2.1+	5	3	Aug. 23	38	Do.
10	July 24	Aug. 5	12	Sept. 8	34	69	2.0+	6	4	Sept. 12	50	Do.
11	Aug. 5	Aug. 13	8	Sept. 16	34	81	2.3+	6	15	Oct. 1	57	Do.
12	Aug. 18	Aug. 28	10	Sept. 20	23	69	3	6	0	Sept. 20	33	Do,
13	Aug. 28	Sept. 6	9	Oct. 7	31	74	2.3+	7	23	Nov. 1	63	Do.
14	Sept. 6	Sept 17	11	Oct. 16	29	55	1.9−	5	47	Dec. 2	87	Do.
15	Sept. 17	Oct. 2	15	Oct. 22	20	17	0.8+	5	2	Oct. 24	37	Do.
[a]16	Oct. 2	......	......	......	......	......	......	......	......	......	......	......

[a] Sexual generation.

On the other hand, beginning with the last to be borne by the aphis which had hatched March 18, and following down the series of the last born of each generation, there were but 7 generations in all. From this it follows that the mean number of complete generations

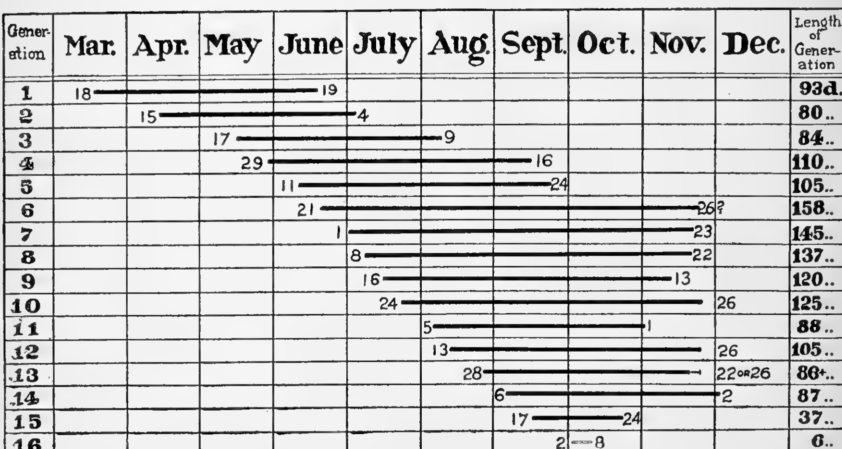

FIG. 34.—Periods and succession of generations in *Sipha flava*, 1907.

for the year is 11½. The first generation lasted for 93 days, from March 18 to June 19, the second extended over a period of 80 days, the third 84 days, and the fourth 110 days. The sixth generation was the longest-lived, continuing for 158 days, the period of the latest generations diminishing gradually. (See fig. 34.) As in the case of *Aphis maidi-radicis*, if the time during which eggs are probably hatching in the field is taken into consideration, it will be seen that each of the generations might occur in the field much longer than these artificial experiments would indicate.

On April 15 individuals of the first 2 generations coexisted in the insectary; on May 15, the first 3 generations; on June 15, the first 4 generations; on July 1, 6 generations, from the second to the seventh, inclusive; on August 1, 8 generations, from the third to the tenth; on September 1, 10 generations, from the fourth to the thirteenth, and between September 6 and October 8 there were 11 generations in existence, this being the largest number of generations in existence at any one time. From that date on, the number of generations in existence at any one time rapidly diminished until December 2, at which time all of the aphides were dead. (See fig. 34.)

The vivaria used in rearing these aphides were simple, each consisting of a pot of earth containing a young sorghum plant, over which was placed a lamp chimney closed at the top with a fine-meshed cloth. Individuals were transferred from one plant to another by means of a soft camel's-hair brush, and these would usually remain in the same place, even though the leaf became wilted or dying, and thus it was an easy matter to keep track of them and to obtain the numbers of young from day to day. Likewise, in the field this species migrates from one part of the plant to another only to a slight extent. The individuals are usually found on the lower surface of the older and lower leaves, in groups, and the young are almost always found feeding on the leaf around the mother aphis. Another peculiarity of this species is that it is not attended by ants, as are most of the aphides found in the field.

VIVIPAROUS GENERATION.

All the following data were obtained in 1906 and 1907, unless otherwise stated. The length of time between the birth of an aphis and that of its first young was between 7 and 31 days, and the average for 79 experiments was 13.3 days.

TABLE XI.—*Data of individual experiments on Sipha flava, viviparous generation, 1906–7.*

Date of birth.	Date of first young.	Age at birth of first young.	Last young.	Productive period.	Number of young.	Average young per day of productive period.	Length of life after last young.	Total length of life.
1906.	1906.	*Days.*	1906.	*Days.*			*Days.*	*Days.*
July 1	July 12	11	July 18	6	14	2.3+	0	17
July 9–10	July 19	9–10	July 25	6	15	2.5	0	15–16
July 12–15	July 21	8–9	...do.....	4	9	2.2+	0	12–13
July 18	July 27	9	Aug. 16	20	49	2.5−	2	29
July 19	...do.....	8	Aug. 4	8	28	3.5	0	16
July 21	July 31	10	Aug. 24	24	68	2.8+	1	34
July 27	Aug. 4	8	Aug. 26	22	65	2.9+	13	43
Do	...do.....	8	Aug. 28	24	65	2.7+	27	59
July 31	Aug. 8	8	Aug. 30	22	59	2.7+	2	32
August 4	Aug. 13	9	...do.....	27	80	3 −	10	46

TABLE XI.—*Data of individual experiments on Sipha flava, viviparous generation, 1906–7*—Continued.

Date of birth.	Date of first young.	Age at birth of first young.	Last young.	Productive period.	Number of young.	Average young per day of productive period.	Length of life after last young.	Total length of life.
1906.	1906.	*Days.*	1906.	*Days.*			*Days.*	*Days.*
August 6	Aug. 15	9	Sept. 9	25	73	2.9+	13	47
August 8	Aug. 16	8	Sept. 16	31	77	2.5+	14	53
August 13	Aug. 21	8	Sept. 13	23	78	3.3+	0	31
August 15	Aug. 23	8	Sept. 20	28	89	3.1+	8	44
August 16	Aug. 24	8	Sept. 13	20	49	2.5–	0	28
August 14–16	Aug. 22	6–8	Sept. 11	20	60	3	14	42
August 21	Aug. 30	9	Sept. 23	24	83	3.4+	21	54
August 22	Sept. 2	11	Oct. 4	32	83	2.6–	15	58
August 23	Sept. 1	9	Sept. 28	27	79	2.9+	27	63
August 24	Sept. 4	10	Oct. 3	29	67	2.3+	11	50
August 30	Sept. 9	10	Oct. 14	35	63	1.8	31	76
September 2	Sept. 10	8	Oct. 6	26	75	2.8	27	61
Do	Sept. 11	9	Sept. 30	19	58	3 +	1	29
September 6	Sept. 14	8	Oct. 7	23	69	3	13	44
September 9	Sept. 18	9	Nov. 8	51	58	1 +	38	98
September 10	Sept. 19	9	Sept. 29	10	35	3.5	2	21
September 10–11	Sept. 23	12–13	Sept. 29	6	16	2.6+	0	18–19
September 11	Sept. 21	10	Oct. 31	40	50	1.2+	51	101
September 14	Sept. 24	10	Nov. 3	40	44	1 +	24–25	74–75
September 18	Oct. 2	14	Nov. 17	46	32	.6+	28	94
September 19	Sept. 30	11	Nov. 20	51	56	1 +	31	93
September 21	Oct. 4	13	Nov. 10	37	56	1.5+	41	91
1907.	1907.		1907.					
March 18	Apr. 15	28	June 6	52	48	.9+	12	92
March 19	Apr. 16	28	May 14	28	33	1.1+	2	58
April 15	May 16	31	June 6	39	81	2 +	5	76
May 13	May 26	13	July 11	46	78	1.6+	0	59
April 16	May 14	28	June 28	45	50	1.1+	5	78
May 17	May 29	12	June 22	24	73	3 +	8	44
May 28	June 11	14	July 18	37	76	2 +	14	65
May 29	June 13	15	July 8	25	80	3.2	11	51
May 30	June 11	12	July 9	28	80	2.8+	9	49
June 11	June 21	10	July 11	20	80	4	10	40
June 13	June 23	10	Aug. 3	41	70	1.7+	2	53
June 24	July 5	12	...do....	29	59	2 +	13	54
June 17	June 27	10	July 17	20	52	2.6	22	52
June 23	July 1	8	Aug. 12	42	56	1.3+	0	50
June 28	July 6	8	July 29	23	70	3 +	14	45
July 2	July 9	7	July 28	19	66	3.4+	9	35
July 4	Aug. 11	7	Aug. 12	32	77	2.4+	10	49
July 5	July 12	7	Aug. 8	27	85	3.1+	17	51
July 7	July 15	8	Aug. 5	21	63	3	2	31
July 8	July 16	8	Aug. 16	31	63	2 +	17	56
July 10	July 19	9	Aug. 8	20	67	3.3+	16	45
July 11	July 19	8	Aug. 16	28	58	2 +	17	53
July 11	July 20	9	Aug. 27	38	50	1.3+	10	57
July 13	July 21	8	Aug. 23	33	67	2 +	7	48
July 15	July 22	7	Aug. 24	33	72	2.1+	14	54
July 16	July 24	8	Aug. 20	27	57	2.1+	4	39
July 19	July 27	8	Aug. 27	31	69	2.2+	16	55
Do	July 28	9	Aug. 20	23	57	2.4+	0	32
July 22	July 29	7	Aug. 27	29	75	2.6–	9	45
Do	July 30	8	Aug. 22	23	68	2.9+	2	33
July 24	Aug. 4	11	Sept. 8	35	69	2 –	4	50
July 28	Aug. 6	9	Aug. 27	21	70	3.3+	19	49
July 27	...do....	10	Sept. 9	34	57	1.6+	3	47
July 29	Aug. 7	9	Sept. 1	25	80	3.2	17	51
July 31	Aug. 9	9	Aug. 29	20	68	3.4	0	29
July 20	Aug. 28	8	Aug. 29	32	68	2.1+	17	57
August 5	Aug. 13	8	Sept. 15	33	81	2.4+	15	56
August 6	Aug. 14	8	Sept. 9	26	86	3.3+	15	49
August 9	Aug. 18	9	Sept. 8	21	63	3	0	30
August 18	Aug. 28	10	Sept. 20	23	69	3	0	33
August 19	Aug. 29	10	...do....	22	51	2.3+	0	32
August 24	Sept. 1	8	Sept. 24	23	52	2.2+	4	35
August 28	Sept. 6	9	Oct. 7	31	74	2.3+	24	64
August 31	Sept. 11	11	Oct. 22	41	69	1.6+	0	52
September 3	Sept. 14	11	Oct. 4	20	61	3 +	3	34
September 6	Sept. 17	11	Oct. 16	29	55	1.9–	39	79
September 14	Sept. 23	9	Oct. 30	37	41	1.1+	2	48
Averages	....	13.29+	....	27.63+	61.97+	2.5+	11.5+	49.6+

As shown in Table XI, a longer time was required to reach maturity in the cooler parts of the season. The average number of days required for development during the first of the season—that is, to July 1—was 15.9+; during the warmer part of the year (July 1 to September 1) it was 8.6+; while during the period between September 1 and 21 it was 10.3 days. Both the length of life and the productive period vary in relation to temperature and season, being longest in the cooler parts of the year. The maximum period for the production of young, in my 79 experiments, was 52 days, while the average was 27.6+ days. The maximum length of life of individuals in these same experiments was 101 days and the average was 49.6+ days. Larger numbers of young are produced per day in the warmer parts of the year than in the cooler and later months. The total number of young produced by 79 females was 4,896—an average of 61.9+. The largest number of young per single female was 89, and the average number produced in one day was 2.5+. The largest number of young produced in one day by a single aphis was 9. Almost without exception, the mother aphis lived several days after the production of the last young. The number of molts was invariably 4, and, as will be seen in the accompanying table, they occurred, almost without exception, every two days.

TABLE XII.—*Periods of molts of Sipha flava, viviparous generation, 1906.*

Date of birth.	Age at first molt.	Age at second molt.	Age at third molt.	Age at fourth molt.	Age at birth of first young.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*
August 9	2	4	6	7	8
August 4	1	3	5	6	7
Do	2	4	6	8	9
August 12	2	4	6	7	8
Do	2	4	6	8	8

OVIPAROUS GENERATION.

The first individuals of the oviparous generation to be noticed were born September 24, 1906, although in 1905 aphides of this generation were found as early as August 25. In all cases it required a longer time for the individuals of this generation to become adults than it did for those of the viviparous generations, excepting the stem-mothers, this presumably being largely due to temperature, growth being slower in the cooler parts of the year. The length of the immature stages varied from 15 to 40 days, the latter time, however, being very exceptional in length.

TABLE XIII.—*Oviparous generation of Sipha flava, 1906.*

When born.	Date it became adult.	Period from birth to adult.	Dates of copulation, if obtained.	Date of death or disappearance.	Total length of life.	Sex.	Remarks.
		Days.		1906.	*Days.*		
Oct. 16	Nov. 3	18	Nov. 7 Nov. 17	Dec. 13	57	Male	
Do	Nov. 7	22	Nov. 27 (55° F) Nov. 28 (54° F)	Dec. 17	61	Female	At least 5 eggs.
Oct. 12	Oct. 28	16	Nov. 4 Nov. 15 Nov. 16	Nov. 23	42	do	At least 9 eggs.
Oct. 14	Oct. 30	16		Nov. 1	18	Male	
Do	Nov. 2	19		Nov. 28	45	Female	
Oct. 15	Oct. 31	16	Nov. 8	Dec. 5	51	Male	
Do	Nov. 1	17	Nov. 18	Dec. 5	51	Female	
Oct. 13	Oct. 28	15	Nov. 4	Dec. 21	69	do	12 eggs.
Oct. 29	Dec. 8	40		Dec. 19	51	do	
Oct. 19	Nov. 16	28		1907. Jan. 10	83	do	
Do	Nov. 17	29		1906. Dec. 21	63		
Oct. 9	Oct. 23–27	14–18		Nov. 3	25	Female	
Sept. 24	Oct. 8–15	14–21	Oct. 18 Nov. 22	Dec. 12	79	do	14 eggs.
Do				Oct. 26	32		10 eggs.
Do			Oct. 23 Oct. 27 Nov. 7	Nov. 2	39	Female	All three aphides laid at least 22 eggs and 8 were found in their bodies.
Do			Oct. 28 Nov. 1	Oct. 18	55	do	
Do			Nov. 5 Dec. 3 (45° F)	Dec. 12	79	do	
Oct. 2	Oct. 18	16	Oct. 25 Oct. 30 Nov. 5 Nov. 18	Dec. 21	81	do	At least 11 eggs.
Oct. 4 (4). Oct. 5 (1). Oct. 6 (1).	Oct. 21 (5). Oct. 22	17 (4) 16 (1) 16 (1)	Nov. 3 Nov. 12	Nov. 3 (4). Dec. 21 (2).	30 (4) 77 (1) 76 (1)	Female (6)	Figures in parentheses refer to number of individuals. Total number of eggs laid, 31. One individual laid at least 10 eggs.
Average		19+			52+		

The average time for the 21 cases in which an exact record was kept was 19.5 days. The sexes were first observed in copula October 18, and this was noted occasionally until December 3. At this latter date the temperature in the room where the aphides were kept was 45° F. In 1905 the earliest record of copulation was October 17, and the first eggs were found soon after. As a rule the eggs were laid on the underside of the sorghum leaf, but as might be expected there were some exceptions to this; for example, eggs were sometimes laid on the side of a cage and on the stem of a plant. November 21, 1907, at Urbana, Ill., I found oviparous females on grass, but eggs were not found. This, with the fact that the earliest spring records of finding them out of doors have been on grass, indicate that grass is the alternate food plant to which the sexuparæ migrate in the fall to produce the sexual forms. The number of eggs laid by this species varied, according to my observations, up to 14, and in 19 cases the average was 8.3 eggs per female. There was no uniform period from the laying of one egg to that of another. Usually, however, the interval was one of several days, temperature being the controlling factor. My aphides always laid eggs until the temperature got down to 42° F. In a number of cases, upon the death of an oviparous female the body was examined, and with only one or possibly two exceptions, eggs were found therein. These facts show that there is no definite number of eggs for a sexual female to lay, but that eggs continue to be laid as long as she lives, provided the temperature is not too low. Some individuals of this sexual generation lived until January 17, 1907, though most of them died in November and December, 1906. During most of the month of December the temperature was down to the freezing point, and consequently the females were in a dormant state; as the food plants were dead they certainly obtained no food during this time. The length of life was found to vary up to 83 days, the average, however, in 17 cases, being 57.4 days. The number of molts is 4, the same in this generation as in the viviparous. Table XIV shows the periods between molts in the 7 cases of which record was made.

TABLE XIV.—*Periods of molts of Sipha flava, oviparous generation, 1906.*

Date of birth.	Age at first molt.	Age at second molt.	Age at third molt.	Age at fourth molt.
	Days.	*Days.*	*Days.*	*Days.*
October 12	3	6	10	16
October 13	3	5	9	15
October 14	3	7	12	19
Do	3	6	10	16
October 19	6	11	17	28
Do	6	12	18	29
October 29	6	11	23	40
Average				23+

DESCRIPTIONS.

Sipha (Chaitophorus) flava Forbes.

This aphis does not belong to the genus *Chaitophorus*, which has 6 antennal segments (or 7, counting the filament), and should doubtless be placed in the genus *Sipha* of Passerini, which is described as having 5 antennal segments, or 6 with the filament, the third segment and filament longest; the cornicles tuberculiform.

VIVIPAROUS GENERATION.

Before first molt and less than 24 hours old.—Citron-yellow throughout. Legs and antennæ somewhat transparent and of a lighter tint than the body color. Antennæ apparently only 4-segmented. One sensorium is present at the extremity of the third segment. Eyes brownish red. Numerous tuberculate spines on the body, which are regularly distributed in longitudinal rows, there being 6 conspicuous rows in all, 4 dorsal and 2 lateral. Measurements when not more than 2 hours old: Length of body, 0.618 mm.; width, 0.290 mm.; antenna, 0.270 mm.; lateral spines, 0.072 mm. Not more than 24 hours old: Length of body, 0.690 mm.; width, 0.309 mm.; antenna, 0.290 mm.; lateral spines, 0.072 mm.

The young from eggs differ from the above (those born alive) in that the general color is a dark green, with black spinal markings and with black rings around the cornicles.

After first molt and 48–72 hours old.—General color citron-yellow. Eyes brownish red. Antennæ as before molt, except that there is now a slight constriction near the distal end of the third segment, where it later divides into 2 distinct segments; also, the circular sensorium of the distal end of the third is on a tubercle or short stalk-like process, and at the apex of the thickened base of the fourth segment is another circular sensorium. Five dark lines occur around the openings of the inconspicuous cornicles. Markings as before. Measurements: Length of body, 1.05 mm.; width, 0.49 mm.

After second molt and 60–84 hours old.—General color canary-yellow. Eyes brownish red. There are still only 4 distinct segments of the antennæ, and the constriction of the third segment is more distinct. Cornicles more distinct than in the earlier stages. Measurements: Length of body, 1.45 mm.; width, 0.56 mm.; antenna, 0.43 mm.

After third molt and 124–148 hours old.—General color canary-yellow. Eyes brownish red. The constriction of the third antennal segment becomes more distinct. Cornicles more distinct and almost as fully developed as in the adult. Measurements: Length of body, 1.96 mm.; width, 0.74 mm.; antenna, 0.63 mm.; abdominal bristles, 0.127 mm.

Adult wingless viviparous female.—General color canary-yellow. Eyes brownish red. Antennæ of the same general tint as the body, excepting the last segment, which is darkened; 5-segmented and sparsely hairy, but the few hairs or bristles present conspicuous. Beak short, not extending farther than the coxæ of the middle pair of legs. Six conspicuous bristles project forward from the front of the head and between the bases of the antennæ. Several less conspicuous hairs are found below those just mentioned. Dorsally are 4 longitudinal curving rows of black transverse markings, 2 rows on each side of the median line. Ten longitudinal rows of erect tubercular bristles are present on the dorsal and dorso-lateral sides of the thorax and abdomen. Cornicles short truncated cones, inconspicuous except for the dark ring around the opening. Measurements: Length of body, 1.818 mm.; width, 0.763 mm.; antenna, I, 0.049 mm.; II, 0.049 mm.; III, 0.236 mm.; IV, 0.147 mm.; V, basal, 0.130 mm.; filament, 0.244 mm.; total, 0.855 mm.

Pupa of winged viviparous female.—Head and thoracic segments olive-yellow; abdomen pale yellow, with greenish tint. Eyes dark red. Antennæ 5-segmented, all except last segment concolorous with head. Antennæ and head with bristles, as in other forms. Thorax with several dark-green patches from which arise tuberculate bristles. Legs, excepting tarsi, which are black, concolorous with body. Wing-pads light brown. Abdomen with 8 longitudinal rows of tuberculate spines, each spine with a basal patch of dark green. A longitudinal row of small transverse dashes occurs on each side between the first and second rows of spines, counting from the median line. Cornicles as in the other forms, and with dark-green basal patches. Measurements: Length of body, 1.953 mm.; width, 0.863 mm.; antenna, I, 0.058 mm.; II, 0.048 mm.; III, 0.194 mm.; IV, 0.135 mm.; V, basal, 0.107 mm.; filament, 0.214 mm; total, 0.750 mm.

Winged viviparous female.—Head and abdomen lemon-yellow, with the thoracic segments brownish. Eyes red. Antennæ with several more or less noticeable hairs, much less conspicuous than in the wingless pseudogyne; all except the two basal segments and the basal half of the third segment are dark; a single circular sensorium at apex of fourth segment and several at the apex of the basal portion of the fifth segment. Beak hardly reaching to the coxæ of the second pair of legs. Head and thorax with spinous tubercles much as in the wingless pseudogyne. Legs concolorous with body, excepting tips of tarsi, which are darkened. Stigma and cubitus pale yellow, other wing-veins dusky. Abdomen with 8 longitudinal rows of dark-green spots from which arise conspicuous tuberculate spines. Between the first and second rows of spots from the median line, on each side, is a row of small dark dashes. Cornicles tuberculiform, and with dark-green basal patches. Style slightly constricted in the middle. Measurements: Expanse of wings, 5.744–6.477 mm.; length of body, 1.641 mm.; width, 0.734 mm.; antenna, I, 0.065 mm.; II, 0.065 mm.; III, 0.277 mm.; IV, 0.196 mm.; V, basal, 0.147 mm.; filament, 0.293 mm.; total, 1.043 mm.; style, 0.088 mm.

OVIPAROUS GENERATION.

Before first molt and 24–48 hours old, male or female.—Color sulphur-yellow. Head with a dark patch covering it almost entirely. Eyes red. Antennæ and legs transparent until a day old, gradually darkening until they become concolorous with the darker markings of the body. Antennæ apparently only 4-segmented, a constriction in the apical half of the third segment showing where this segment later divides into two. At the distal end of the third segment is a distinct sensorium, while at the apex of the thickened base of the fourth are one or more indistinct sensoria. Thorax with dark patches covering about one-half of the dorsal surface. Abdomen with dark markings which appear only after the aphis is at least one day old. Abdomen with 4 distinct dorsal rows of tuberculate spines, 2 on either side of the median line, and at least 1 lateral row on each side. At the base of each of these spines is a small darkened area. The small indistinct cornicles are surrounded with dark circular patches. The opening also is marked by a dark ring. Measurements: Length of body, 0.763 mm.; width, 0.362 mm.

Female after second molt and 7 or 8 days old.—General color light apple-green. Antennæ lighter than body color excepting second segment and tip of last segment. Spine spots bice-green in color. Tarsi black. Measurements: Length of body, 1.331 mm.; width, 0.581 mm.; antenna, 0.537 mm.

Female after third molt.—General color apple-green, becoming paler and with a yellowish tinge at the caudal end. Head lighter than body color. Eyes reddish brown. Antennæ pale, excepting the last segment, which is darkened. That segment which in the earlier stages represents the third is now indistinctly separated into 2 segments. The sensorium at the distal end of the fourth (the third of the earlier stages) is quite distinct. The apex of the thickened base of the last segment has numerous distinct sensoria. Legs pale, excepting tarsi, which are black. Cornicles more distinct. Measurements: Length of body, 1.775 mm.; width, 0.725 mm.

Adult wingless oviparous female.—Head, first 2 thoracic segments, and tip of abdomen oil-green in color. Abdomen parrot-green, shading at extremities to oil-green. Eyes dark reddish-brown. Antennæ 5-segmented; 1 sensorium at distal end of fourth and several at the end of basal part of the fifth; bristles few but conspicuous, there being 2 on each of the 2 basal segments, 3 or 4 on the third, and 1 on the fourth. Projecting forward from the head and between the bases of the antennæ are 6 distinct bristles. Beak short, not extending farther than the coxæ of the second pair of legs. On the dorsal surface of the body are 4 rows of small transverse dashes, 2 on each side of the median line; also 8 rows of tuberculate bristles, 4 on each side of the median line. Hind tibiæ noticeably swollen and bearing numerous circular sensoria. Style upcurved. Cornicles as in all the other forms of this species. Measurements (alcoholic specimens): Length of body, 1.67–1.92 mm.; width, 0.72–0.83 mm.; antenna, I, 0.065 mm.; II, 0.065 mm.; III, 0.244 mm.; IV, 0.130 mm.; V, basal, 0.106 mm.; filament, 0.236 mm.; total, 0.846 mm.; style, 0.078 mm.

Male after second molt and 8 or 9 days old.—General color citron-yellow. Antennæ 5-segmented. Sensoria at end of fourth and at distal end of the thickened base of the fifth segment. Measurements: Length of body, 1.098 mm.; width, 0.469 mm.

Male after third molt.—General color sulphur-yellow, shading to greenish at extremities. Eyes brownish red. Other markings as in earlier stages. Measurements: Length of body, 1.603 mm.; width, 0.744 mm.; antenna, I, 0.067 mm.; II, 0.057 mm.; III, 0.162 mm.; IV, 0.133 mm.; V, basal, 0.095 mm.; filament, 0.191 mm.; total 0.705 mm.

Adult male.—General color bright lemon-yellow. Eyes dark reddish brown. Antennæ usually as long as body, the two basal segments concolorous with the body and the others dark; antennæ with a few conspicuous hairs, there being 2 on each of the two basal segments, 5 on the third, and either 1 or 2 on the fourth; circular sensoria numerous (at least 40) and irregularly placed on the third, 15 to 20 on the fourth, and a number at the distal end of the thickened base of the fifth segment. Beak short, not reaching farther than the coxæ of the second pair of legs; its tip dark, the rest concolorous with the body. Six distinct bristles project forward from the front of the head and between the bases of the antennæ. On the dorsal surface of the body are 8 rows of tuberculate bristles, 4 on each side of the median line. There are also 2 rows of dark oval markings on each side of the median line. Measurements (alcoholic specimens): Length of body, 1.12–1.30 mm.; width, 0.45–0.50 mm.; antenna, I, 0.081 mm.; II, 0.065 mm.; III, 0.407 mm.; IV, 0.220 mm.; V, basal, 0.106 mm.; filament, 0.350 mm.; total, 1.229 mm.

Eggs.—Color, when first laid, pale green, with a small dark spot of obscure form showing through the egg-shell at one end. The egg gradually darkens until it becomes a jet-black. There is no noticeable change in color just before the young hatch. Form elliptical-oval. Measurements: Length, 0.652 mm.; width, 0.3015 mm.

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1884. FORBES, S. A.—Thirteenth Report of the State Entomologist of Illinois, for 1883. <App. Trans. Ill. Dept. Agr. for 1883, Springfield, Vol. XXI, pp. 41, 42–46, Pl. III, figs. 1–4. Separate: Springfield, Ill.

Chaitophorus flavus, n. sp. Describes wingless and winged viviparous females and pupa; also injuries and natural enemies. Observed chickens feeding on these plant-lice.

1885. FORBES, S. A.—Fourteenth Report of the State Entomologist of Illinois, for 1884. <App. Trans. Ill. Dept. Agr. for 1884, Springfield, Vol. XXII, p. 70, pl. 6, figs. 1–4. Separate: Springfield, Ill.

Slight contribution to life history. Could find no root form.

1887. OESTLUND, O. W.—Aphididæ of Minnesota. <Geol. and Nat. Hist. Survey of Minn., St. Paul, Bul. 4, p. 40.

Mentions it as *not* having been found in Minnesota.

1891. Williams, T. A.—Host-Plant List of North American Aphididæ. <Univ. Nebr. Dept. Ent., Lincoln, Spec. Bul. 1, pp. 9, 23.

Lists of food plants of *Chaitophorus flavus* Forbes as corn and cultivated sorghum.

1892. Bruner, L.—Report of the Entomologist. <Ann. Rept. Nebr. State Board Agr. for 1891, Lincoln, p. 304.

Makes following note: "*Chaitophorus flavus* Forbes: This sorghum and broom-corn louse has been taken while working on the roots of Indian corn; at least a louse found here in the State was so determined at the time." In a letter from Professor Bruner he tells me that he has no further information concerning this aphis, and that he does not have the specimens so determined.

1901. Hunter, W. D.—The Aphididæ of North America. <Ia. Agr. Exp. Sta., Ames, Bul. 60, p. 87.

Lists it as being found in Illinois on sorghum and *Zea mays*.

1905. Forbes, S. A.—Twenty-third Report of the State Entomologist of Illinois. <Chicago, pp. 210–211, figs. 220, 221.

Gives food plants as sorghum, corn, broom corn, foxtail grass (*Setaria*), crab-grass (*Panicum*), and wheat. Latest date observed was in September.

1906. Sanborn, C. E.—Kansas Aphididæ with host-plant and plant-host list, Pt. 2. <Kans. Univ. Sci. Bul., Lawrence, Vol. III, No. 8, pp. 236, 250, 263.

Food plants of *Chaitophorus flavus* Forbes given as cultivated corn, cultivated sorghum, and *Sorghum halpense* L.

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Technical Series, No. 12, Part IX.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

A NEW GENUS OF ALEYRODIDÆ,

WITH REMARKS ON ALEYRODES NUBIFERA BERGER, AND ALEYRODES CITRI RILEY AND HOWARD.

By A. L. QUAINTANCE,
In Charge of Deciduous Fruit Insect Investigations.

Issued September 1, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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MISCELLANEOUS PAPERS.

A NEW GENUS OF ALEYRODIDÆ, WITH REMARKS ON ALEYRODES NUBIFERA BERGER, AND ALEYRODES CITRI RILEY AND HOWARD.

By A. L. Quaintance,
In Charge of Deciduous Fruit Insect Investigations.

In 1900 the writer described[a] as *Aleyrodes perseæ* a species of white fly found in the Bureau of Entomology collection, received from Fort George, Fla., and collected April 22, 1880, on *Persea carolinensis*. The adult of this species was at the time unknown. The so-called pupa-case, however, exhibited the essential structural characters of this stage for the genus *Aleurodicus*, and it was ventured in the description that the adult when found would show the insect to belong to this genus. Professor Cockerell,[b] for the reasons given, referred this species to *Aleurodicus*, and this assignment seemed to the writer well warranted.

Dr. A. W. Morrill, in the course of his orange white-fly investigations in Florida during the past two or three years, has frequently met with this insect on orange and other plants and has been able to obtain the adult in quantity. He has kindly furnished the writer with abundant specimens of all stages and copies of his notes. The adult, contrary to what had been expected from the structure of the pupa-case, is not an *Aleurodicus*, and presents certain peculiarities not found in other genera of the family, thus necessitating the establishment of a new genus, as follows:

PARALEYRODES, new genus.

With wing venation of Aleyrodes. Pupa-case of Aleurodicus type. Fore wings with but a single vein, and a rudimentary branch near basal fifth. Hind wings with a single unbranched vein. Antennæ four-jointed, apparently due to coalescence into two segments

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[a] Tech. Ser. 8, Div. Ent., U. S. Dept. Agr., p. 32.

[b] Catalogue of the Aleyrodidæ of the World (Proceedings Academy Natural Sciences, Philadelphia, 1902, p. 279).

of joints 3 to 7. Pupa-case with the compound wax pores and large protruding lingula of *Aleurodicus*.

Type, the following species:

Paraleyrodes (Aleurodicus) perseæ Quaintance.

REVISED DESCRIPTION.[a]

Egg.—Elliptical, size about 0.24 mm. by 0.12 mm., with stalk unusually long; smoky in color, the shell smooth; eggs deposited promiscuously in the white, flocculent secretion of the adults.

Larva, first stage.—Size about 0.338 mm. by 0.18 mm., subelliptical, very slightly narrowed caudad; yellowish white, with more or less rectangular spots of orange in the abdominal regions, eye spots reddish. There is a fringe all around of white wax; on the margin, cephalad of eyes, are six setæ, and on lateral margins of thoracic region are three on each side. On caudal margin are six setæ, the middle pair of which is considerably longer than others. On ventral surface, just within margin, all around, is a series of sparsely set, small, tubercled setæ. Legs and antennæ well developed. Vasiform orifice practically as in pupa-case.

Pupa-case.[b]—Size about 0.86 mm. by 0.53 mm. (figs. 35, *a* and *b*). Subelliptical in shape, with slightly undulate outline. Color, under hand lens, yellowish brown; empty pupa-case colorless, very fragile, soon falling from the leaf. On the margin, all around, is a fringe of more or less curled, short, white wax ribbons, and over the case and adjacent leaf area are many fragments of white wax rods, of variable length, profusely produced from the seven pairs of dorsal compound pores, which are situated, a pair on cephalic end and six pairs on the abdominal segments, the cephalic two pairs of which are smaller and nearer the median line. The margin, or rim, of each compound pore

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[a] Extended and corrected from Tech. Ser. 8, Div. Ent., U. S. Dept. Agr. (1890), p. 32.

[b] In the description of the waxy secretion, as originally given (l. c.), this was described as follows:

"There is a profuse dorsal exudation: First, a rather short, downward-curving fringe of pearly white wax, all around, arising from just within margin and curling outward and downward over margin to near surface of leaf. This fringe is hardly continuous but is more or less split apart into ribbons or bands. Second, more dorsally curving columns. These occur in a triangle, one on each side and one at end. These columns of white wax are about as high as pupa case is wide. The pupa-case is almost obscured by this exudation, when viewed from above."

According to Doctor Morrill's observations the secretion, as above described, is abnormal to this species and is due to the effect of parasitism. Of many specimens examined by him, showing the secretion of this character, all were found to be parasitized; and, on the other hand, this type of secretion was never found on pupa-cases not attacked by parasites. The normal secretion therefore is as described in the text.

(fig. 35, *a*) is thickened, and from within the cup there arises a rather large, fluted, cylindrical tube, extending upward about one-half its length beyond the rim of cup. Within tube, at base, is a short conical

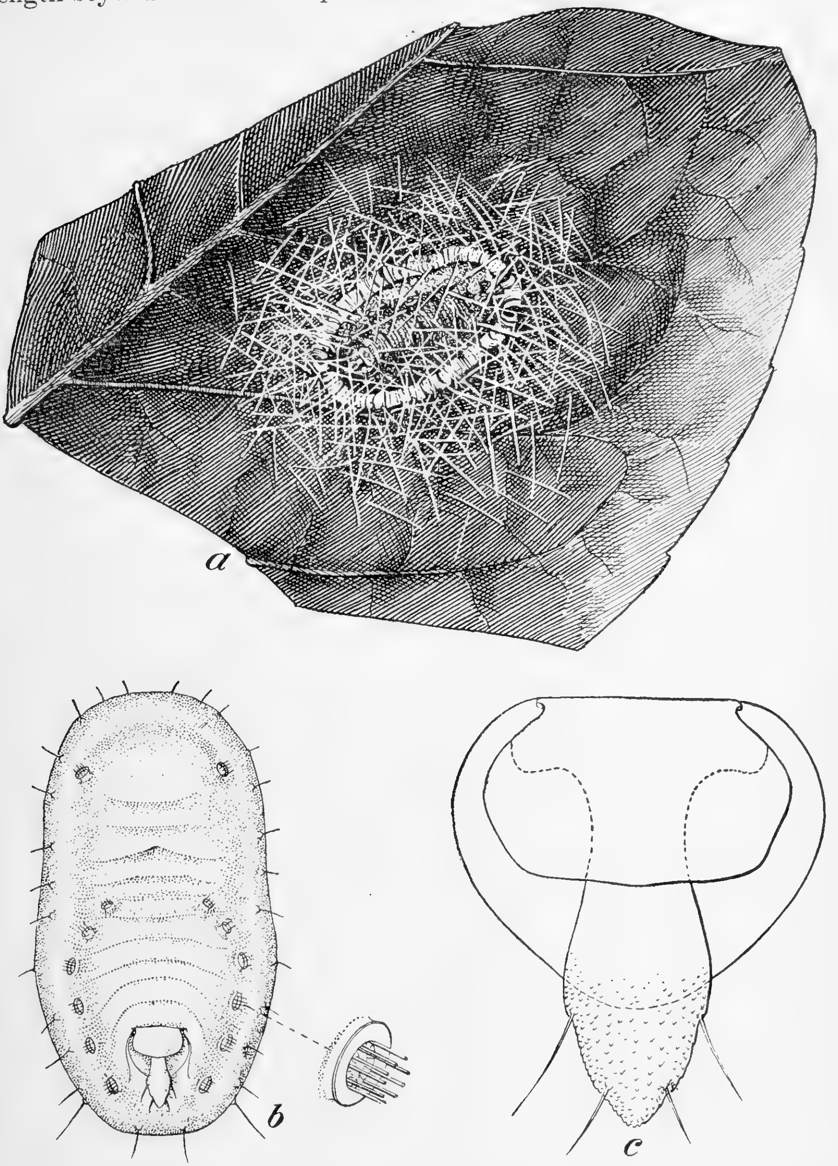

FIG. 35.—*Paraleyrodes perseæ*: *a*, Pupa on leaf, showing fragments of wax rods from dorsal compound pores, enlarged; *b*, pupa-case, much enlarged, with highly magnified compound pore at right; *c*, vasiform orifice, operculum, and lingula of pupa-case, highly magnified. (Original.)

elevation. The entire structure is brownish in color. Dorsum void of well-developed setæ, save a pair just within caudal margin. A pair of minute setæ occurs on margin near caudal end of case. There is, however, just within margin on case, all around, a row of brownish-colored, tubercled setæ. Vasiform orifice subcordate (fig. 35, *c*), about as long as wide. Cephalic margin straight, coinciding with cephalic margin of operculum. Operculum subrectangular, the lateral margins somewhat rounded; considerably wider than long and with caudal margin almost straight. Lingula relatively large, particularly distally, where it becomes broadly spatulate; longer than orifice, and bearing distally two pairs of setæ. Abdominal segments moderately distinct. Rudimentary feet and antennæ very evident.

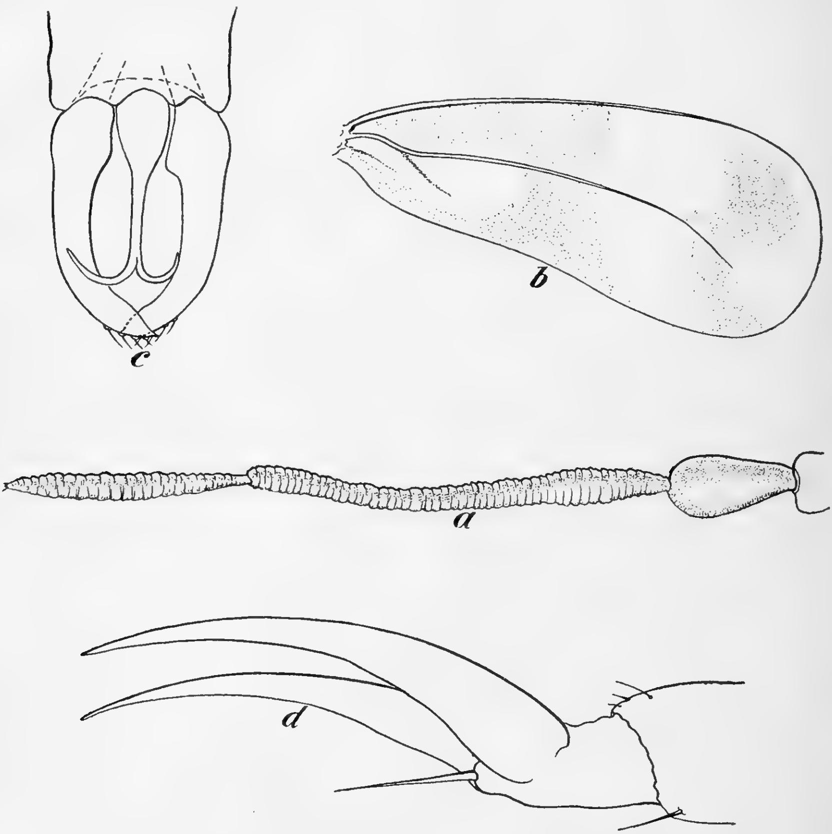

FIG. 36.—*Paraleyrodes perseæ: a,* Antenna of adult; *b,* right fore wing of adult; *c,* male genitalia; *d,* claw of third leg of adult. Highly magnified. (Original.)

Adult.—Body of living specimens buff or pinkish in color, marked with white. Wings whitish, but clouded with dusky. These are held almost flat along the dorsum, and do not meet along the middle line. A copious amount of flocculent white wax is secreted, which becomes scattered over the leaf surface, the sluggish adults resting in little depressions here and there in the waxy covering. Antennæ peculiar and apparently of but four joints (fig. 36, *a*), due to the evident coalescence into two joints of the ringed segments 3 to 7. In the fore wing there is a single vein, as in *Aleyrodes* (fig. 36, *b*), with a rudimentary branch or fold near basal fifth and a very obscure rudimentary vein at very base of wing. Hind wings with but a single vein. Genitalia in male forcipate, penis bifurcate (fig. 36, *c*). Claws long and slender, with central spinous process (fig. 36, *d*). In female, length of body, 0.8 to 0.9 mm.; length of fore wing, 0.8 to 0.9 mm.; width of fore wing, 0.3 to 0.38 mm.; length of antenna, 0.38 to 0.45 mm.; length of hind tibia, 0.25 to 0.3 mm. Male proportionately smaller.

Food plants.—Orange, *Persea carolinensis*, persimmon (?), avocado pear. On orange this insect infests the older leaves, rarely or never occurring on the new growth as is the case with *Aleyrodes citri*.

Doctor Howard has given to the parasite of this species, reared by Doctor Morrill, the manuscript name *Encarsia variegatus*.

Remarks on ALEYRODES NUBIFERA Berger, and ALEYRODES CITRI Riley and Howard.

The recent interesting discovery by Dr. E. W. Berger, entomologist of the Florida Agricultural Experiment Station, that the so-called orange white fly (*Aleyrodes citri*) of Florida represents two distinct though closely related species, led the writer to go carefully over the material in the Bureau of Entomology collection in order to determine to what extent the new species *Aleyrodes nubifera* Berger might possibly be found. The results have been interesting, and, as showing the distribution of the new species, are worth recording. Specimens of *nubifera* are in the collection from the following localities:

Pass Christian, Miss., August 23, 1889, on orange.
Raleigh, N. C., September 25, 1889, on orange.
Raleigh, N. C., October 7, 1889, on orange.
New Orleans, La., March 10, 1890, on orange.
Baton Rouge, La., February 23, 1895, on orange.
Crescent City, Fla., January, 1895, on gardenia.
Crescent City, Fla., January 30, 1895, host not indicated.
Crescent City, Fla., February 24, 1895, on orange.
Crescent City, Fla., March 1, 1895, on orange.
Santiago de las Vegas, Cuba, March 7, 1905, on orange.
Santiago de las Vegas, Cuba, May 6, 1905, on orange and other citrus fruits.
Santiago de las Vegas, Cuba, June 6, 1905, on tangerine orange.
Waco, Fla., October 21, 1908, on orange.
Florida (locality not given), November 23, 1908, on orange.
Florida (locality not given), January 18, 1909, on orange.

As will be noted, specimens of this species have been received at different times since 1889. The material from Crescent City, Fla., was collected by Prof. H. G. Hubbard, and labeled by him as *citri*. In fact, all of the Hubbard specimens in the Bureau collection are *nubifera*, and it thus seems possible that Mr. Hubbard did not see the true *Aleyrodes citri* at all.

The material from Cuba, collected by Mr. C. L. Marlatt, and also sent in by Dr. Mel T. Cook, and provisionally referred by the writer to *citri*, belongs, in fact, to *nubifera*, and our record of *citri* for Cuba is incorrect. So far as we are aware, the insect does not occur on the island at all. As to the origin of *nubifera* and the time of its introduction, if from abroad, we have no information. Its affinities are with Oriental species, and it is not improbable that it was introduced into Florida along with or about the time of the introduction of *citri*.

Recently additional information has been obtained relative to the occurrence of *Aleyrodes citri* in eastern Asia. The writer, at a meeting of the Washington Entomological Society, October 4, 1908, exhibited a specimen of *Aleyrodes citri* from Canton, China, on orange, which had been found in the Bureau collection, without other data. In June, 1908, specimens of lemon leaves from Peking, China, infested with an aleyrodid were received by the Bureau from Mr. F. N. Meyer. Eggs, pupa, and one adult were present, and with this series of stages it was possible to definitely determine the insect as *citri*. In July of the same year leaves of Gardenia from Japan, also infested with *Aleyrodes citri*, were received through Mr. E. M. Ehrhorn, and somewhat later, in 1908, six lots of material, all infested with *Aleyrodes citri*, were received through Mr. E. H. Carnes, four of the sendings being from Nagasaki, Japan, and two from Shanghai, China. Four lots were on orange, one on a citrus plant, and one on an unnamed plant—possibly a Viburnum. The material from Nagasaki had been collected in 1903; the balance in 1908.

In Maskell's collection of Aleyrodidæ, recently secured with his coccid collection by Doctor Howard from the New Zealand Institute, was found what is evidently the type slide of Maskell's *Aleyrodes aurantii*, originally described in the New Zealand Transactions (1896), page 431, as a variety of *eugeniæ*. Careful comparison of this insect with *Aleyrodes citri* proves it to be the same species, and Maskell's name hence becomes a synonym of *citri* Riley and Howard. Maskell's material was from the northwestern Himalayas in India, on *Citrus aurantium*. The great similarity of *eugeniæ* to *citri* was noted by Mr. Maskell, but he attributed undue importance to the presence of the three radiating patches, which, while occurring in *citri*, were not mentioned in the description by Riley and Howard.

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TECHNICAL SERIES, No. 12.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MISCELLANEOUS PAPERS.

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ISSUED DECEMBER 31, 1912.

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TECHNICAL SERIES, No. 12.

U. S. DEPARTMENT OF AGRICULTURE,
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L. O. HOWARD, Entomologist and Chief of Bureau.

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Mabel Colcord, *in charge of library.*

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., October 5, 1912.

SIR: I have the honor to transmit herewith for publication as Technical Series No. 12, of this bureau, nine papers dealing with the classification, description, or habits and life history of various insects belonging to groups of economic importance.

These papers, prepared by different employees of the bureau and published separately during the years 1906–1908, are as follows: Catalogue of Recently Described Coccidæ, by J. G. Sanders; Habits and Life Histories of some Flies of the Family Tabanidæ, by James S. Hine; A Contribution to our Knowledge of the Thysanoptera of California, by Dudley Moulton; New Genera and Species of Aphelininæ, with a Revised Table of Genera, by L. O. Howard; The More Important Aleyrodidæ Infesting Economic Plants, with Description of a New Species Infesting the Orange, by A. L. Quaintance; A Record of Results from Rearings and Dissections of Tachinidæ, by Charles H. T. Townsend; The Orange Thrips, by Dudley Moulton; Biological Studies on Three Species of Aphididæ, by John June Davis; A New Genus of Aleyrodidæ, with Remarks on Aleyrodes nubifera Berger and Aleyrodes citri Riley and Howard, by A. L. Quaintance.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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[1] The nine papers constituting this bulletin were issued in separate form on June 5, 1906; Aug. 29, 1906; Apr. 5, 1907; July 12, 1907; Oct. 21, 1907; Sept. 18, 1908; Feb. 11, 1909; Feb. 20, 1909, and Sept. 1, 1909.

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ERRATA.

Page 18, line 9 from bottom, for *Parlatoria* read *Parlatorea.*
Page 70, line 24, for *bergi* read *bergii.*
Plate VII, facing page 92, for *Aleyrodes anonæ* read *Aleurodicus anonæ.*
Page 93, line 19, for *Spireæ* read *Spiræe.*
Page 105, line 7, after *chitinized* insert comma and omit *anal.*
Page 116, line 3, for *is* read *are.*
Page 122, line 5, for *stop* read *spot.*
Page 153, line 8, for *maidaphides* read *maidaphidis.*

Technical Series, No. 13.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

A REVISION OF THE TYROGLYPHIDÆ

OF THE

UNITED STATES.

BY

NATHAN BANKS,

Assistant Entomologist.

Issued November 14, 1906.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

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1906.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., September 10, 1906.

Sir: I have the honor to submit herewith a manuscript entitled "A Revision of the Tyroglyphidæ of the United States," prepared by Mr. Nathan Banks, assistant entomologist. Mites belonging to the family Tyroglyphidæ are destructive to a variety of stored products and other commodities, certain species injure living plants, while others are useful because they destroy certain injurious insects. The group is therefore one of very considerable economic importance. This paper by Mr. Banks should prove a valuable contribution to the study of these mites and greatly facilitate the determination of the different species; I therefore recommend it for publication as Technical Series, No. 13, of this Bureau.

Respectfully,

F. H. Chittenden,
Acting Chief of Bureau.

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A REVISION OF THE TYROGLYPHIDÆ OF THE UNITED STATES.

HABITS AND ECONOMIC IMPORTANCE.

From an economic standpoint the Tyroglyphidæ are one of the most important groups of mites. But owing to their small size and pale color they have often been overlooked and the damage accredited to some larger insect which happened to be present. By their rapidity in breeding they make up for their minute size, so that articles, such as flour and sugar, are often so badly infested that the whole mass of the substance appears to be in motion. It is chiefly thru their ravages to stored foods that they are inimical to human effort. Dried fruits, dried meats, and grain in mills are perhaps most seriously affected by them. Their frequency in cheese and sugar has won them the names of "cheese mites" and "sugar mites," while the disease known as "grocer's itch" is due to their presence on the hands of persons handling infested products. A list of materials attacked by tyroglyphids would include cheese, flour, sugar, hams, dried meats, hair in furniture, mattresses, and pillows, grains in mills, cereal foods, many drugs, wine, dried fruits, seeds of all kinds, bulbs, roots of plants, mushrooms, feathers, hay, scale-insects, pinned insects of the entomologist's collection, and even the human corpse. Some species are, however, of little economic interest and occur in the nests of mice, moles, and ants, in decaying bark of trees, in sap from wounds in trees, and a few are attached to certain insects. The species of the genus *Monieziella* do some good by feeding on scale-insects. The "bulb mite" or "Eucharis mite," *Rhizoglyphus hyacinthi*, has long been a prominent enemy to hot-house cultivation. It burrows into the healthy tissue of bulbs and roots, thus giving entrance to destructive fungi and bacteria. This is the species infesting Bermuda lily bulbs; and it has lately been shown that an allied species does great damage to the roots of the vine in Europe. Another species has been described that caused injury to the stems of carnations. Still another *Rhizoglyphus* has been found to eat through the grafting wax on grafted plants, bore beneath the bark, and so prevent the union of graft and stock. The mushroom mites, both in this country and in Europe, are prominent obstacles to successful mushroom culture. Cellars apparently clean in the beginning of the season may be so badly infested by Christmas that crops are impossible.

STRUCTURAL CHARACTERISTICS.

The Tyroglyphidæ are pale-colored, soft-bodied mites, devoid of tracheæ; with small, appressed palpi; usually with prominent chelate mandibles; with moderately long legs, ending in one claw, and often a sucker or caroncle; and with a body about twice as long as broad, and broadest behind the middle. There is commonly a distinct suture between cephalothorax and abdomen. There are no eyes, unless certain spots on the front margin of certain Hypopi and on *Carpoglyphus* represent these organs. The dorsum bears a few, usually long, hairs, in size and arrangement constant for each species. The legs have bristles, fine hairs, and sometimes distinct spines, the more prominent of which are constant in position for each species. One long bristle near tip of the penultimate joint is especially prominent; another is a thickened or clavate hair near base of tarsi I and II, and is probably a sense organ. The latter is always upon this joint, altho several authors have figured it on the penultimate joint in some species. On the venter are two apertures; the genital is usually elongate and situate between hind coxæ, and there are often U-shaped marks each side of it known as the genital suckers, which can be protruded. The anal opening is toward the tip of the body, and is often but an elongate slit, with a sucking disk each side of it. In the genus *Glyciphagus* these openings are much larger, and the genital sometimes occupies the entire area between the coxæ.

There are but slight differences in structure between the sexes; but in some cases the male has one pair of legs enlarged, or there may be two forms of the male. In some species the male has two little suckers on the hind tarsi; in others there is a curved plumose bristle on the basal part of front legs. The males are smaller than the females, and have a less tumid abdomen.

TRANSFORMATIONS.

The transformations of the Tyroglyphidæ are among the most marvelous of the animal kingdom. All tyroglyphids lay eggs, often of large size, which are scattered haphazard over the infested material. The young on hatching have six legs and at molting obtain two more. Thenceforward their life history may take the simple and direct path to the adult condition, but often passes through a stage called the *Hypopus*. This *Hypopus* is a very different creature than that from which it developed—the octopod nymph. Its body is hard and chitinous, there is no mouth orifice, and no distinct mouth parts; the legs are short and ill adapted to walking. On its ventral surface near the tip is an area separated from the general surface and provided with several circular marks or sucking disks. By means of these suckers the *Hypopus* attaches itself to an insect or other creature, and is transported to another locality, where it may find a suitable breeding place. The *Hypopus* is therefore a stage in the life of a tyroglyphid fitted for migration. The *Hypopus*, upon reaching a suitable locality, molts into an octopod nymph, which will feed and develop into an adult mite. The causes that will induce a nymph to transform to a *Hypopus* are yet unknown; Mégnin supposed that dryness of the air or a scarcity of food were necessary causes, but Michael has shown that *Hypopi* are developed in the absence of these conditions, and that this stage is a natural and normal means of distributing the species. The structure of the *Hypopus* is characteristic for each species; but it has not yet been found in all species, and in *Glyciphagus* the hypopial stage is only partially developed, so that species should not be described from this stage alone.

In the early days of acarology *Hypopus* stood for a separate genus, allied more to *Gamasus* than to *Tyroglyphus*. Dujardin, in 1850, concluded that *Hypopus* was the pupal stage of Gamasidæ. As investigation proceeded, *Hypopus* was so frequently found in association with *Tyroglyphus* that views were advanced as to their relationship. One was that *Hypopus* was a ferocious parasite, devouring the *Tyroglyphus* from within; another, that *Hypopus* was the male of *Tyroglyphus;* and a third, that *Hypopus* was the real adult of certain species of *Tyroglyphus*. The "Hypopus question" disturbed acarologists for a long time, but was finally settled by the work of Mégnin and Michael.

PREVIOUS WORK ON SPECIES OCCURRING IN THE UNITED STATES.

The Tyroglyphidæ of the United States have never been investigated in a systematic manner. The principal economic species have been called *Tyroglyphus siro* or *T. longior*, but without comparison with European specimens. Fitch, in his Third Report (1856), described a mite, *Acarus ribis*, which may be a tyroglyphid. In 1868 Shimer described a mite as *Acarus malus;* this was interpreted by Riley and some European authors as a tyroglyphid, but from the description it is evidently what Lignières describes as *Hemisarcoptes coccisugus*. Riley, in 1874, described a *Tyroglyphus phylloxeræ* as destroying the grape Phylloxera. I have identified as this a common species of *Rhizoglyphus*. Riley's opinion of the predaceous habit of this species was erroneous, as it undoubtedly feeds on the roots of infested plants. In 1884 Haller described *Tyroglyphus crassipes* and *T. curtus* from "Amerika." I have not recognized them, and do not know whether they were from the United States or not. In 1893 Osborn described a mite infesting mushrooms as *Tyroglyphus lintneri*. I have seen numerous specimens of this species, which is allied to what Canestrini has called *Tyroglyphus siro.* In 1896 Felt described a mite injuring the roots of carnations as *Tyroglyphus heteromorphus.* This species I have seen also, and retain it in the genus *Tyroglyphus.*

OCCURRENCE OF EUROPEAN SPECIES IN THE UNITED STATES.

As regards the occurrence of European species in this country, I have had great difficulties in arriving at definite conclusions, owing to the fact that few European writers have appreciated the importance of minute characters in classification. They have identified as one species forms totally different and treated under different names forms closely allied or identical. The greatest trouble centers around *Tyroglyphus siro*, the type of the genus. Several European acarologists have figured this species. Michael is later than the others, and mentions the other figures in his references. Canestrini has figured more bristles than the others, and they are longer. The pair on dorsum of abdomen behind middle, according to Michael, are very short; with both Canestrini and Berlese they are long. Canestrini and Michael, however, agree and differ from Berlese in showing a pair of short bristles near the larger humeral bristles. Michael figures the male hind tarsus rather short and with the two suckers barely more than their diameter apart, while, according to Berlese, this joint is very much longer and the two suckers are very remote from each other. Canestrini's figure shows the peculiar thickened hair of the anterior tarsi as arising from the preceding joint. Several European writers (especially Robin, Pagenstecher, Karpelles, and Murray) have identified specimens of *Aleurobius farinæ* as *T. siro*, and Doctor Oudemans writes me that he does not know *T. siro;* that the specimens formerly placed by him in that species are *Aleurobius farinæ.* Berlese has suggested that these two species are one, the spurred male of *Aleurobius* being a dimorphic form. The habitat gives no clue to the species. Specimens of a *Tyroglyphus* are referred to elsewhere in this paper which were taken from Limburger cheese, and doubtless of European origin. These are not the *T. siro* of any author, but more related to *T. mycophagus* Mégn. In a collection of mites obtained by the Department of Agriculture from Doctor Berlese is a slide labeled by him as *T. longior.* The specimen seems to be *T. siro* as figured by Canestrini and himself; the hind tarsi are not nearly as long as they figure for *T. longior*, and I can not see any hairs or pectinations on the large bristles of the body. In the same collection is a slide labeled *T. krameri* by Berlese. Michael considers this form to be what he calls *T. mycophagus* Mégn. Their figures show a species with very short abdominal bristles, and the inner cephalic ones much shorter than the outer pair. The slide has three specimens, all females, with four subequal bristles on the cephalothorax, and the bristles at tip of abdomen are as long as body; moreover, these bristles are provided with fine, short hairs. In fact, it agrees very well with Michael's figure of *T. longior*, except that the abdominal bristles are not quite so long. Michael, however, figures the tarsus of this species as much shorter than figured by Canestrini and in my specimens of *T. longior*.

Michael, in detail figure of *Aleurobius farinæ*, male leg I, shows the clavate hair arising from tip of tibia, whereas it should be from basal part of tarsus; at least it is so in my specimens and so figured by Berlese. Michael figures *Aleurobius farinæ* with but two long posterior bristles on the cephalothorax; Canestrini shows four of these, but no long humeral bristle, as in Michael. My specimens have the humeral bristle like Michael's figure and the cephalic as figured by Canestrini. Berlese figures six cephalic bristles, besides the frontal, on this species. Berlese figures the hind tarsi of male *Aleurobius farinæ* with suckers far apart. My specimens agree with Michael in this respect. Michael considers that his *Carpoglyphus anonymus* is the same as *Phycobius anonymus* of Canestrini and *Trichodactylus anonymus* of Berlese; yet Michael's figures show numerous differences from their figures. Michael, for example, shows short spines on the body, while they figure simple hairs.

In view of these and other discrepancies among European authors, I have been sorely tempted to abandon all attempts at identification and describe everything as new. However, I believe that we have *Tyroglyphus longior*, *T.* (*Aleurobius*) *farinæ*, and *Carpoglyphus passularum* in this country, and I should like to think that what I have described below as *T. americanus* was the real *T. siro*, but it certainly is not the *T. siro* of Michael, the latest writer on the European fauna.

GENERA OF THE TYROGLYPHIDÆ.

The genera known to me as occurring in the United States may be separated by the following table. Various other genera are known in Europe, and some of them, and possibly new genera, will be found in our country when it is examined more thoroly for these mites. The forms thus far collected are mostly of economic value, and have been sent to this Department by various persons during the past twenty-five years.

TABLE OF THE GENERA.

1. Dorsal tegument more or less granular; claws very weak, almost invisible; some hairs of body plainly feathered; ventral apertures very large.. *Glyciphagus*.
   Dorsal tegument not granular; claws distinct; no prominent feathered hairs; ventral apertures small.. 2
2. Mandibles not chelate, elongate and toothed below; body without long hairs; palpi enlarged at tip and provided with two divergent bristles..... *Histiostoma*.
   Mandibles chelate; palpi not enlarged at tip, nor with the two bristles...... 3

3. No clavate hair on base of tarsi I and II; no suture between cephalothorax and abdomen; living on bees or in their nests .... *Trichotarsus.*
A clavate or thickened hair on base of tarsi I and II 4
4. The bristle on penultimate joint of legs arises from near the middle; no suture between cephalothorax and abdomen .... *Carpoglyphus.*
The bristle on penultimate joint of legs arises from near tip; a suture between cephalothorax and abdomen 5
5. Cephalothorax with four distinct and long bristles in a transverse row; tarsi I and II about twice as long as preceding joint .... *Tyroglyphus.*
Cephalothorax with but two long, distinct bristles (beside the frontal pair), but sometimes a very minute intermediate pair; tarsi I and II usually short and not twice as long as preceding joint 6
6. Tarsi with some stout spines .... *Rhizoglyphus.*
Tarsi with only fine hairs .... *Monieziella.*

The hypopial stages are known for very few of our forms; it would therefore be of little use to tabulate them. These mites (excepting possibly *Trichotarsus*) should be studied solely from the mature adult and not described from the hypopial stages.

Genus **HISTIOSTOMA** Kramer.

Mandibles not chelate, but elongate, and toothed below; palpi enlarged at tip and bearing two distinct divergent hairs; a distinct suture between cephalothorax and abdomen; male without anal suckers; tarsi with distinct claws; cuticle not granulate; ventral apertures small; rarely with long bristles on body; no long prominent bristle at tip of penultimate joint of legs.

Type.—H. rostroserratus Mégn. (*pectineum* Kramer).

The peculiar mouth parts of this genus separate it rather sharply from all the other Tyroglyphidæ. It, however, has a well-developed hypopial stage, indicating affinity with *Tyroglyphus*. The species are variable in habits, but none, so far, has become of economic importance.

The three species which have been found in this country may be classified by the following table:

Table of the Species.

1. Tarsi I four or five times as long as broad; very slender 2
Tarsi I scarcely three times as long as broad; body broad, especially behind .... *brevipes.*
2. Body about twice as long as broad, with several humps above on the abdomen .... *americanum.*
Body scarcely one and one-half times as long as broad, without humps on abdomen .... *gracilipes.*

Histiostoma gracilipes n. sp. (Pl. I, fig. 9.)

Body hardly one and one-half times as long as broad, sides of abdomen evenly rounded, and without humps above, emarginate behind; at posterior third of body there is a short curved hair, a similar hair at each posterior corner and on each humerus, and two or three submedian pairs on the dorsum; all of these hairs are very short, curved, and often invisible. Legs rather large and long; the tarsi very slender, tarsus I (Pl. I, fig. 12) nearly three times as long as penultimate joint, above with two short spines near base, and before middle one more, below with two rather beyond middle, and with several at tip, and a long curved hair about three-fourths the length of tarsus; hind tarsus fully three times as long as penultimate joint, with a short spine above near base, a pair below beyond middle, and several near and at tip, but no long hair. Hairs on tip of palpi much shorter than in other species.

Length, 0.30 to 0.35 mm.

Numerous specimens on decayed leaves, Washington, D. C., August.

Histiostoma brevipes n. sp.

Body about one and one-fourth times as long as broad, subpyriform in shape, broadly rounded behind, without very distinct humps, but the posterior margin undulate; behind with four simple bristles, each about as long as tarsus, and a pair of similar bristles on the posterior sides; a similar humeral bristle each side. Legs rather short, first pair heavy, provided with short spines; tarsus I (Pl. I, fig. 11) about two and one-half times as long as broad, with two spines below near middle, one above before middle, and near it is the sense hair (instead of at the base); at tip above is a spine, and near by is a fine apical hair, two-thirds the length of the joint; tarsus IV (Pl. I, fig. 10) is fully three times as long as the penultimate joint, with a spine above near base, and one below near middle, and a few at tip. The palpus (Pl. I, fig. 8) has the usual two bristles, the apical one very long, longer than tarsus I, and much longer than in allied species.

Length, 0.28 to 0.33 mm.

Several specimens from dead and diseased larvæ of *Cyllene robiniæ* Forst. in locust at Arlington, Va., July (Hopkins).

Very distinct by short tarsi, position of sense hair, and long hair to palpus. In appearance it is much like Michael's *H. pyriforme*, but without the long apical hairs to posterior tarsi.

Histiostoma americanum n. sp.

Cephalothorax divided into two parts, a broad posterior part and a narrow, elongate anterior portion, in some specimens almost broader in front than behind, and on its anterior margin are two long bristles; below are situated the mouth parts (Pl. I, fig. 7). Abdomen about twice as long as broad, rather broader in front than behind, rather rectangular in shape, almost straight across at base, weakly emarginate behind; above with three large rounded humps each side, two behind lower down on posterior surface, a median one at base above, and less prominent ones on the lower sides; each of the larger humps bears a short, stiff bristle. Legs quite short, with but few, rather thickened, hairs; tarsus I (Pl. I, fig. 4) nearly four times as long as broad, with sense hair at extreme base, a spine slightly beyond and one near middle below, apical hair about one-half as long as joint; tarsus IV (Pl. I, fig. 6) four times as long as penultimate joint, with a spine above near base and one below near middle, apical hair not prominent.

Length, 0.20 mm.

Taken at Washington, D. C., in decaying matter, together with a species of *Rhizoglyphus*.

Genus **GLYCIPHAGUS** Hering.

Cuticle of body more or less granulate; claws very small and inconspicuous; some of the hairs of body plumose, or formed into foliaceous scales; the ventral apertures are very large and occupy all the space between the coxæ; mandibles chelate, usually with a suture between cephalothorax and abdomen; male without anal suckers; female with the bursa copulatrix projecting slightly at tip of the abdomen.

Type.—G. domesticus De Geer.

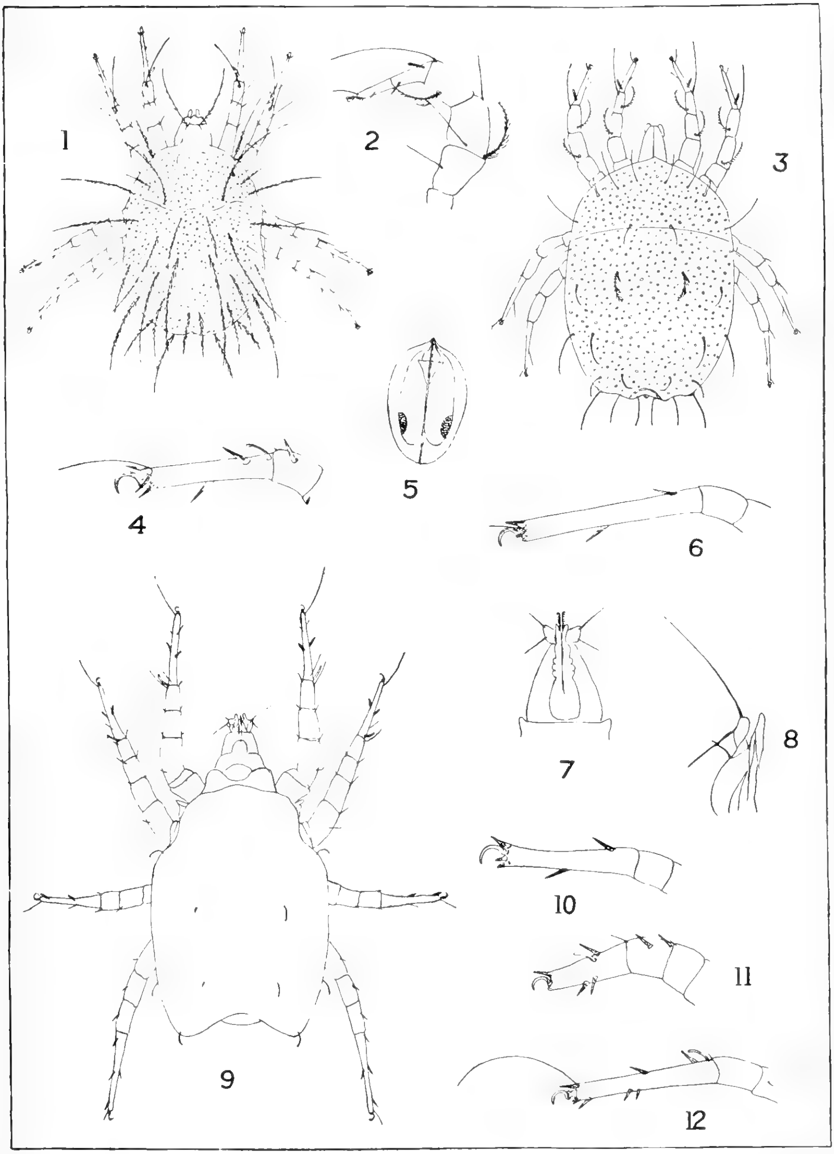
This genus is abundantly represented in Europe, but in this country I have seen but few species or specimens. The genus should form a tribe or subfamily in the Tyroglyphidæ on account of its wide divergence in structure from the typical *Tyroglyphus*. These mites have been found feeding on all sorts of substances, but the name indicates that they are the true "sugar mites," and cause the disease known as "grocer's itch." Two species are known to me.

Glyciphagus obesus n. sp. (Pl. I, fig. 3.)

Body about one and one-half times longer than broad, parallel-sided; pointed in front, broadly rounded behind. Dorsum with scattered, irregular granules. Cephalothorax with four pairs of short, simple bristles; two pairs in front, a submedian pair behind, and one in each posterior corner; and a short, broad hair or scale near margin over coxæ II. Abdomen with a submedian pair of plumose bristles on basal third, a pair of simple bristles nearer to margin on posterior third; three simple bristles each side, and five each side at and near the tip, the outer one the longest. Legs rather short and stout, I (Pl. I, fig. 2) and II with a curved, plumose bristle near base of third joint and near middle of fourth joint, the latter joint with a long, simple bristle at tip; tarsi I and II one and one-half times longer than preceding joint, tarsi III and IV twice as long as preceding joint. Venter minutely granulate, genital aperture (Pl. I, fig. 5) occupying all the space between coxæ and mouth parts.

Length, 0.33 to 0.38 mm.

Taken from a necktie that had been for some time in a drawer, at Berkeley, Cal. (E. J. Wickson.)



TYROGLYPHID MITES.

Fig. 1.—*Glyciphagus robustus*. Fig. 2.—*Glyciphagus obesus*, leg I. Fig. 3.—*Glyciphagus obesus*. Fig. 4.—*Histiostoma americanum*, tarsus I. Fig. 5.—*Glyciphagus obesus*, genital plate. Fig. 6.—*Histiostoma americanum*, tarsus IV. Fig. 7.—*Histiostoma americanum*, mouth parts. Fig. 8.—*Histiostoma brevipes*, palpus. Fig. 9.—*Histiostoma gracilipes*. Fig. 10.—*Histiostoma brevipes*, tarsus IV. Fig. 11.—*Histiostoma brevipes*, tarsus I. Fig. 12.—*Histiostoma gracilipes*, tarsus I.

Glyciphagus robustus n. sp. (Pl. I, fig. 1.)

Body short and broad, rather broader behind middle than elsewhere, broadly rounded behind. Dorsum with many large, rounded granules, irregularly arranged. A submedian pair of long, sparsely plumose bristles on front margin; a still larger pair near the hind margin of the cephalothorax, as near to side as to middle; one bristle in each posterior corner, and two shorter submarginal ones each side in front of the last. Abdomen with about six pairs of long, discal, plumose bristles, the subbasal pair not nearly as long as the others; and six submarginal bristles each side, the two on the posterior margin not nearly as long as the others. Legs rather short, but the tarsi are slender; tarsi I and II twice as long as preceding joint; tarsus IV more than three times as long as preceding joint; all with scattered, simple hairs, a longer hair near tip of third and fourth joints of legs I and II. Venter rather finely granulate; the large, broad genital aperture occupies all the space between coxæ II, III, and IV, but does not extend forward between coxæ I.

Length, 0.24 mm.

Specimens from Leetonia, Ohio, in a lot of seeds, from Mr. H. E. Wolfgang.

Genus TYROGLYPHUS Latreille.

A suture between cephalothorax and abdomen; mandibles chelate; tarsi with distinct claws; cuticle without granulations; ventral apertures small; four distinct posterior bristles on the cephalothorax; tarsi rather slender, in some species with spines; male with anal suckers; in some cases there is a dimorphic male, or the anterior legs of male may be thickened.

Type.—*T. siro* L.

Oudemans uses the name *Acarus* for this genus, but I think the application is strained and that Michael is right in this matter. I include in *Tyroglyphus* the genus *Aleurobius*, which is based on a male character of not more than specific value.

There are doubtless a number of species in the United States. From the materials at hand I separate the following nine species:

Table of the Species.

1. Some bristles on tarsi I and II near middle are distinctly spine-like; the sense-hair about its length from base of joint 2
   No spine-like bristles near middle of tarsi; sense-hair not its length from base of joint 4
2. Hind tarsi with two long hairs, one as long as the joint .... *terminalis.*
   Hind tarsi without such long hairs 3
3. Male with third legs enlarged .... *heteromorphus.*
   Male without enlarged third legs .... *armipes.*

4. Of the terminal abdominal bristles at least six or more are very long, nearly as long as the body 5
Of the terminal abdominal bristles only two are about as long as the abdomen; leg I of male greatly thickened, and with a spine at apex of femur below .... *farinæ*.
5. Bristles of body distinctly plumose or pectinate; tarsi very long .... *longior*.
Bristles of body not pectinate 6
6. Cephalothorax very short; legs I and II of male stouter than usual .... *breviceps*.
Cephalothorax longer, legs normal 7
7. On living trees, usually with scale insects; third and fourth joints of hind legs more than twice as long as broad; abdominal bristles long .... *cocciphilus*.
On mushrooms, or decaying matter; third and fourth joints of hind legs not twice as long as broad; abdominal bristles very long .... *lintneri*.
In mills, stored foods, grains, etc.; third and fourth joints of hind legs scarcely twice as long as broad; abdominal bristles shorter .... *americanus*.

Tyroglyphus farinæ De Geer. (Pl. II, fig. 14.)

Cephalothorax with four long subequal bristles above in a transverse row, a short pair in front over the mandibles; one on each humerus, not as long as width of body, and a very short one near by; two pairs on the middle of dorsum, rather farther back than usual, the posterior pair the longer, but these not more than one-half the length of the abdomen; two hairs on each posterior side, not one-half the length of abdomen, and near the tip are two more pairs of bristles, one of which is nearly as long as the abdomen, the other pair being much shorter; a pair of short bristles near anus below (Pl. II, fig. 16). Legs rather short, and the front pair thickened; in the male very greatly so, and the femur provided with a sharp, apical process below at tip, and two small teeth on next joint. The long bristle on penultimate joint is as long as the tarsus in all legs; tarsus I (Pl. II, fig. 17) is scarcely twice as long as the preceding joint, tarsus IV (Pl. II, fig. 14) more than twice as long as penultimate joint; the third and fourth joints of the hind legs are about twice as long as broad; none of the hairs on the legs is spine-like.

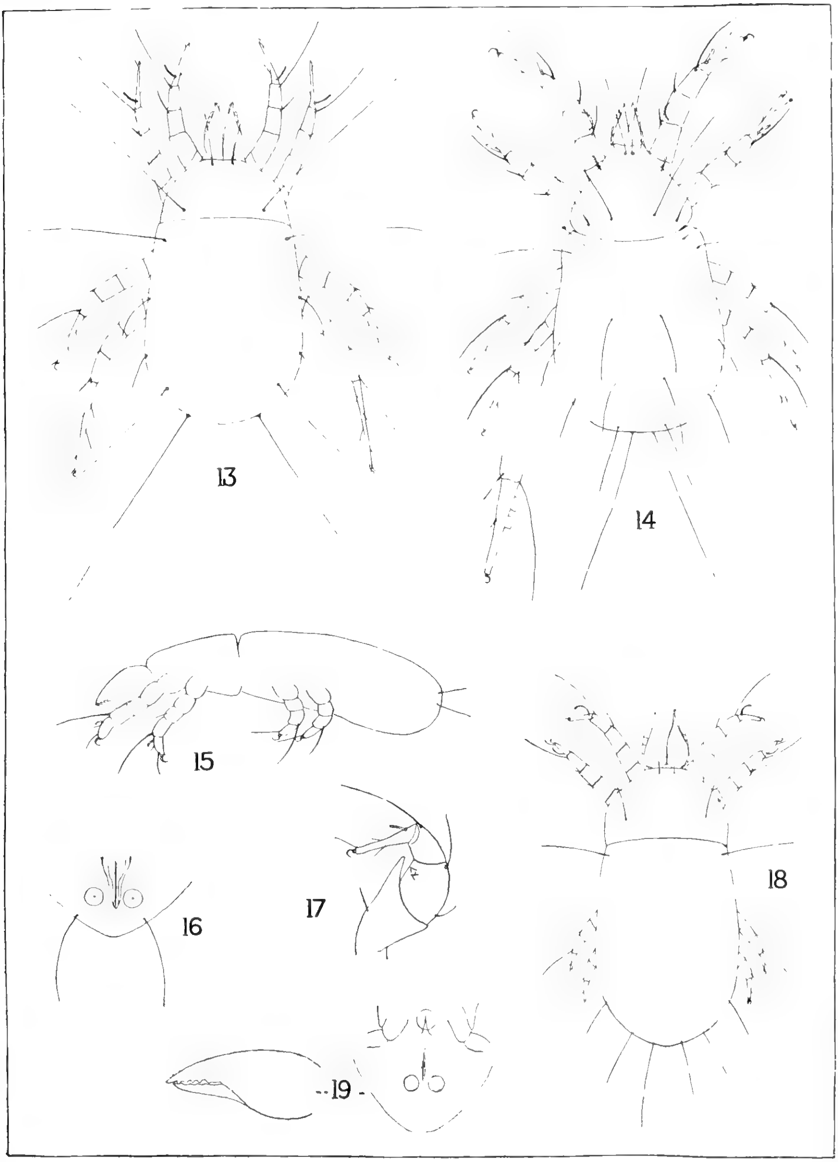
Length, 0.45 to 0.60 mm.

Specimens have been examined from various localities, all, however, in the North, as Marblehead, Mass., Lancaster, Pa., Adrian, Mich., and Minneapolis, Minn., in mills, granaries, and seeds.

I keep this species in the genus *Tyroglyphus*, since the genus *Aleurobius* is based on a secondary sexual character; in other respects it is a true *Tyroglyphus*. If this genus is used, then other genera should be made for *T. heteromorphus* and *T. armipes*, which is, I think, unnecessary.

Tyroglyphus longior Gervais.

Cephalothorax with four long, subequal bristles in a transverse row, and two shorter bristles on front margin; two long humeral bristles; two pairs of submedian bristles on dorsum, the anterior pair more than one half the length of abdomen, the posterior pair as long as the



TYROGLYPHID MITES.

Fig. 13.—*Monieziella longipes*. Fig. 14.—*Tyroglyphus farinæ* and tarsus IV of male. Fig. 15.—*Monieziella angusta*. Fig. 16.—*Tyroglyphus farinæ*, venter of male. Fig. 17.—*Tyroglyphus farinæ*, leg I of male. Fig. 18.—*Monieziella brevitarsis*. Fig. 19.—*Monieziella brevitarsis*, male venter and mandible.

entire body, behind toward tip are six pairs of bristles, most of them fully as long as entire body; all these bristles of body are seen to be hairy (Pl. V, fig. 44); the cephalic bristles show these hairs more distinctly toward tip. The basal joints of the legs are of the usual length, but the tarsi are extremely slender; tarsus I (Pl. V, fig. 44) is about as long as the three preceding joints together, while tarsus IV (Pl. V, fig. 44) is about as long as the rest of the leg; the bristles on legs are about as usual, fine and slender, but that at the tip of the penultimate joint of leg IV is scarcely half as long as the tarsus; the hair near tip of tarsus is rather short on all legs.

Length, 0.40 to 0.60 mm.

This species is readily known by the hairy bristles of body and by its extremely long tarsi. It has been received only a few times, but usually in great abundance and usually attended with some predaceous mites—*Cheyletus* or *Gamasus*. Specimens have been examined from grain in mill at Milwaukee, Wis.; from Winfield, Ontario, Canada, in house and barn in great numbers, and Doctor Oudemans writes me that he has seen it from California.

Tyroglyphus lintneri Osborn. (Pl. III, fig. 29.)

Cephalothorax with four long, subequal bristles in a slightly curved transverse row; a pair on front margin, longer than the mandibles; two long humeral bristles and a short one close by; two pairs of submedian bristles on the dorsum of abdomen, the anterior pair about one-half the length of the abdomen, the posterior pair as long as abdomen; and six each side near tip, all very long except the inner one, which is scarcely as long as abdomen, and a short pair on venter near the anus. The legs have the usual bristles, the long one at end of penultimate joint is plainly longer than the tarsi in all the legs; the hind tarsi (Pl. III, fig. 24) are fully as long as the two preceding joints together; there is a curved plumose bristle above on the third joint of legs I and II. (Male genitalia, see Pl. III, fig. 25.)

Length, 0.30 to 0.38 mm.

This mite is very similar in all respects to the *T. americanus*, but the bristles of abdomen are longer and somewhat differently arranged. In the male the tubercle-like suckers on hind tarsi (Pl. III, fig. 24) are farther apart than in *T. americanus;* in the female the vulva (Pl. III, fig. 23) shows a broader emargination behind than in that species. These differences, associated with the different habitat, demand some recognition in nomenclature; therefore I consider the mushroom mite as a distinct species. It differs at once from *T. longior* in the simple bristles of the body.

This species has been received from Freehold, N. J.; Hazelton and West Chester, Pa.; and from York Corner, Me. It does enormous damage to mushrooms, but appears to be a native species. Lintner records it from Jamesport, Suffolk County, N. Y.

Tyroglyphus americanus n. sp. (Pl. III, fig. 20).

Cephalothorax with four long, fine, equal bristles in a slightly curved transverse row, a pair of shorter bristles on front margin; two long humeral bristles, longer than width of body, a pair of submedian bristles each side on the dorsum, the anterior rather short, the posterior very long, as long as abdomen; on posterior margin and near the tip are six bristles each side, five of them about as long as abdomen, the other much shorter and near the median line. Legs of moderate length, like figures of *T. siro*, but the tarsi (Pl. III, fig. 22) are more elongate and slender then in Michael's figure of that species; the usual bristles are present, none spine-like; that at tip of penultimate joints is very long; there is a curved plumose bristle above on the third joint of legs I and II; the hair at tip of tarsus is not one-half the length of the joint; in the male the sucker-like tubercles on tarsus IV are but little more than their diameter apart. (Genitalia, Pl. III, fig. 21.)

Length 0.27 to 0.30 mm.

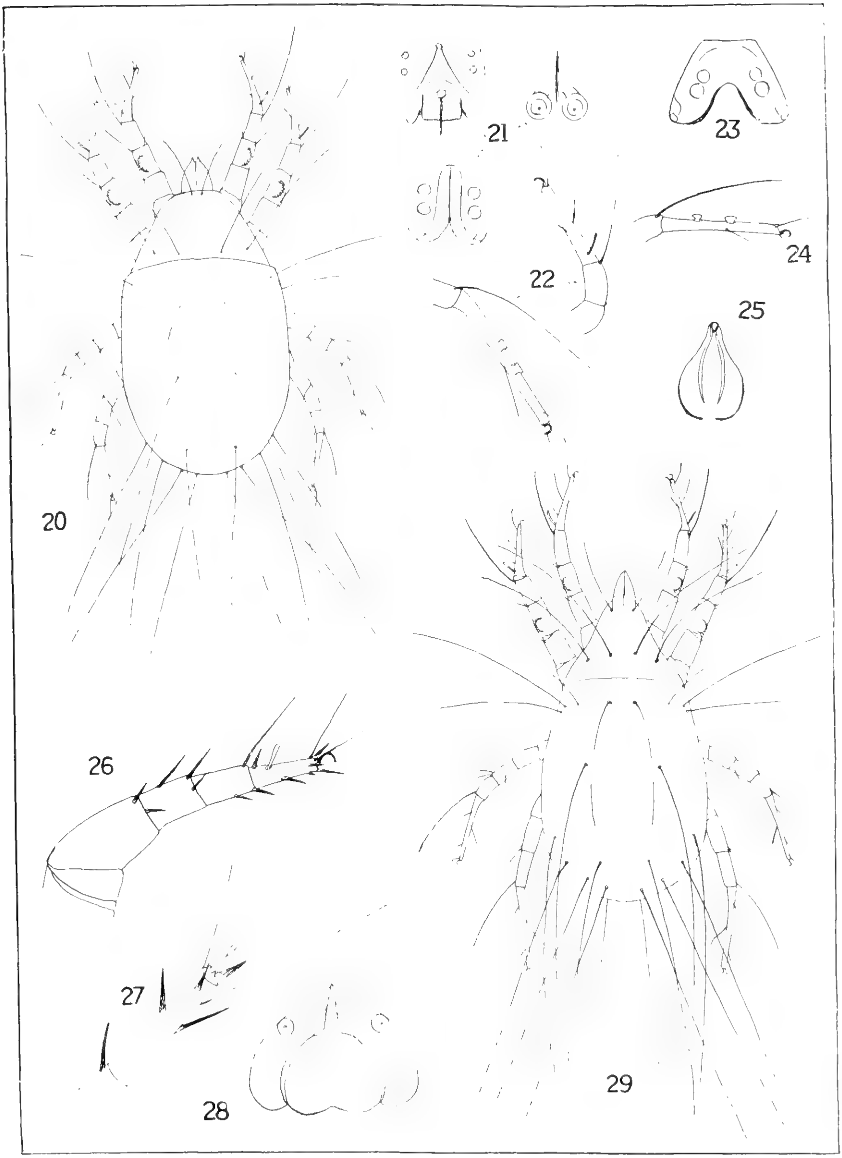
This species is close to Michael's identification of *T. siro*, but has much longer bristles and longer tarsi; indeed the hind tarsi are as long as the two preceding joints together; however, it can not be *T. longior*, since the bristles are not serrate. It may be that some European writers have mixt this species with *T. longior*, but I regard Michael's identification of *T. longior* as correct, that is, a mite with long serrate bristles, and the same as the form I regard as *T. longior* in this paper.

There are many specimens of this species in the collection of the Department of Agriculture, as follows: Washington, D. C., on rotten plums; Paola, Kans., in flaxseed; Minneapolis, Minn., in wheat; Savannah, Ga., in rice; College Station, Tex., in cotton seed; Racine, Wis., in flax mill, and on decaying orange at Washington, D. C.

Many of the references to *T. siro* and *T. longior* in our economic literature doubtless refer to this species.

Tyroglyphus cocciphilus n. sp.

Cephalothorax with four long bristles in a transverse row, the middle pair plainly longer than the outer pair, yet the latter is as long as width of body; a short pair on the front margin, longer than the mandibles; two pairs on dorsum, the basal pair about one-half the length of body, the posterior pair about as long as entire body; two long humeral bristles each side and a short one near by; behind and near tip are 12 bristles, 3 on each posterior side and 3 each side near tip in a vertical or longitudinal line, all about as long as abdomen or a little longer; a short pair below near anus. Legs of moderate length, with the usual bristles, none spine-like; the tarsus (Pl. IV, fig. 35) about as long as two preceding joints together in all the legs, the bristle at tip of



TYROGLYPHID MITES.

Fig. 20.—*Tyroglyphus americanus.* Fig. 21.—*Tyroglyphus americanus*, genitalia. Fig. 22.—*Tyroglyphus americanus*, tarsi I and IV. Fig. 23.—*Tyroglyphus lintneri*, vulva. Fig. 24.—*Tyroglyphus lintneri*, tarsus IV of male. Fig. 25.—*Tyroglyphus lintneri*, genitalia of male. Fig. 26.—*Tyroglyphus terminalis*, leg I. Fig. 27.—*Tyroglyphus terminalis*, tarsus IV. Fig. 28.—*Tyroglyphus terminalis*, vulva. Fig. 29.—*Tyroglyphus lintneri.*

penultimate joint about as long as tarsus; third and fourth joints of hind legs more than twice as long as broad; in the male the suckers on hind tarsi (Pl. IV, fig. 35) are more than twice their diameter apart and nearly as close to each end of joint as to each other. (Vulva and anal suckers, Pl. IV, fig. 33; male aperture, Pl. IV, fig. 34.)

Length, 0.35 to 0.40 mm.

Specimens from Columbia, Pa., with *Lecanium* on plum; also with oyster-shell scale on osage orange (probably from Missouri), with mealy bug on guava at Rock Ledge, Fla., and on orange leaves at Sanford, Fla.

This species is very close to *T. lintneri* Osb., and might have been considered as only a variation of that species but for the totally different habitat. The legs are rather more slender, but the hind tarsi are no longer, and the hair at the tip of the penultimate joint is not as long as in *T. lintneri*, nor as heavy.

Tyroglyphus breviceps n. sp. (Pl. IV, fig. 30).

Cephalothorax very short, in proportion to the length of the body; four rather long, subequal bristles above in a transverse row, and a short pair in front over mandibles; two moderately long humeral bristles; two submedian pairs on the dorsum, the basal pair short, the other scarcely as long as abdomen; six bristles each side and near tip, rather widely separated at base, from two-thirds to fully the length of the body; a short pair below near anus; tarsus about twice as long as preceding joint, the bristle at tip of latter as long as tarsus on the front legs (Pl. IV, fig. 32), and three-fourths as long on the hind legs; each tarsus with a fine bristle beneath near middle; hind tarsus (Pl. IV, fig. 31), with apical hair not one-half the length of tarsus; the third and fourth joints in hind leg not twice as long as broad.

Length, 0.35 to 0.50 mm.

The hairs are a little shorter than in *T. americanus* and the legs rather stouter, and especially so in the front legs of the male.

Specimens from Victoria, Tex., taken from dead larvæ of the cotton boll weevil.

Tyroglyphus terminalis n. sp.

Cephalothorax with four bristles in a transverse row, the outer pair nearly twice as long as the inner pair, a pair of short bristles on anterior margin; two humeral bristles, about two-thirds the width of the body, two pairs of bristles above on abdomen, and five pairs near tip, all about one-half the length of the abdomen except one pair each side near tip, which are about as long as the abdomen; all are simple. Legs rather stout, especially the anterior pair (Pl. III, fig. 26), the bristles stout, and many of those on the tarsi are spine-like; tarsus I is not twice the length of the penultimate joint, while the hind tarsi (Pl. III, fig. 27) are about as long as two preceding joints together;

the hair near tip of tarsus is very long in all legs, but the hind tarsi have two long hairs near tip, one of them longer than the tarsus. (Vulva, Pl. III, fig. 28.)

Length, 0.50 mm.

Specimens from Limburger cheese, Washington, D. C. (Dr. G. Marx).

This species is near Michael's figure of *Tyroglyphus mycophagus*, but the mite is not so slender, the bristles are longer, and those on tarsi are longer. I am not certain that Michael has correctly identified Mégnin's species.

Tyroglyphus heteromorphus Felt.

Male (Pl. IV, fig. 39).—Cephalothorax with four long bristles in a transverse row, but the inner pair is not one-half as long as the outer pair; a pair of short bristles on anterior margin; two bristles on each humerus, one short, the other as long as width of body; two pairs of submedian bristles on dorsum, each about two-thirds the length of the abdomen; a rather long bristle on the middle each side, another long one behind this, then a short one, and three long ones each side near tip, each but little shorter than abdomen. Legs with the usual bristles, that at apex of penultimate joint scarcely as long as tarsus; the sense hair on tarsi I (Pl. IV, fig. 38) and II is about its length from the base; most of the tarsal bristles are distinctly spine-like; the hair at tip of tarsus IV (Pl. IV, fig. 36) is not one-half the length of the joint, the bristle at tip of penultimate joint of leg IV is not one-half as long as tarsus, the latter joint as long as two preceding joints together; leg III (Pl. IV, fig. 37) enlarged, as in figure, ending in a large claw and two very long bristles.

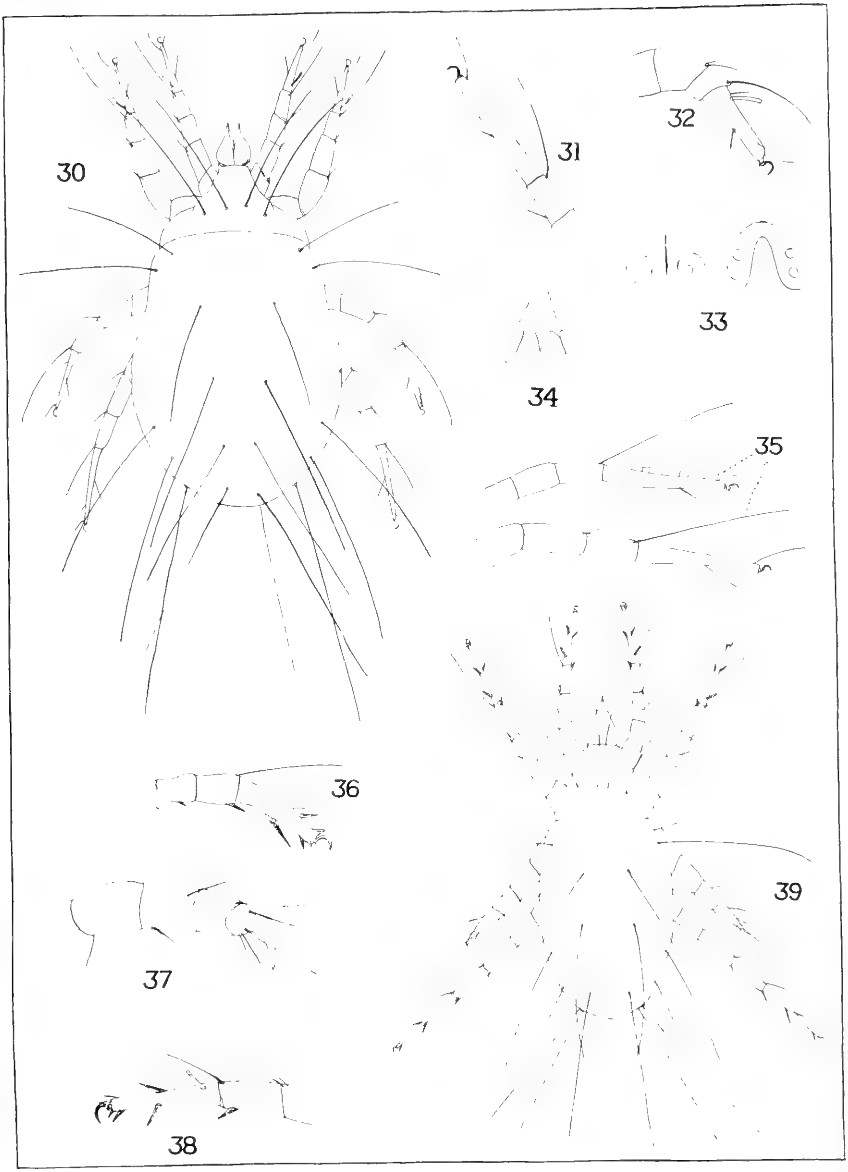
The female differs in having the bristles of body shorter, especially the abdominal ones; there are four at tip which are not one-half as long as width of body; the tarsi, especially the hind tarsi, are shorter than in the male. The abdomen is, of course, broader, and larger in proportion to the cephalothorax.

Length 0.60 to 1 mm.

A peculiar species, which I have seen only from decaying asparagus roots from near Washington, D. C. It was described as injuring the roots of carnations at Berlin, Mass. The *Rhizoglyphus agilis* Michael, 1903, may be a synonym; however, there are several minor differences which may possibly be due to Michael's inaccurate figures.

Tyroglyphus armipes n. sp.

Cephalothorax with four long bristles in a transverse row, but the inner pair is not half as long as the outer pair; a pair of short bristles on front margin. Male with two bristles on each humerus, one short, the other nearly as long as width of body; three pairs of bristles on dorsum, basal pair very short, the others long and reaching beyond tip



TYROGLYPHID MITES.

Fig. 30.—*Tyroglyphus breviceps*. Fig. 31.—*Tyroglyphus breviceps*, tarsus IV. Fig. 32.—*Tyroglyphus breviceps*, leg I. Fig. 33.—*Tyroglyphus cocciphilus*, vulva and anal suckers. Fig. 34.—*Tyroglyphus cocciphilus*, male aperture Fig. 35.—*Tyroglyphus cocciphilus*, tarsus IV—male and female. Fig. 36.—*Tyroglyphus heteromorphus*, tarsus IV. Fig. 37.—*Tyroglyphus heteromorphus*, leg III of male. Fig. 38.—*Tyroglyphus heteromorphus*, tarsus I. Fig. 39.—*Tyroglyphus heteromorphus*, male.

of abdomen; two on each posterior side, quite long, and behind are four each side, three of which are about as long as the abdomen, the inner pair much shorter. Legs rather slender, tarsi as long as two preceding joints together; most of the tarsal hairs are spine-like; the hair at tip of penultimate joint is rather shorter than tarsi, but in leg IV (Pl. V, fig. 41) it is about two-thirds as long as tarsus; the hair at tip of tarsus not one-half length of tarsus. (Tarsus I, Pl. V, fig. 42.) In the female the bristles are much shorter, the humeral bristle not nearly as long as width of body, those on dorsum not reaching to tip, the posterior lateral ones very short, and those behind near tip are scarcely one-half as long as width of body. (Vulva, Pl. V, fig. 43.)

Length, 0.75 to 1 mm.

Specimens from Lincoln Nebr. and from Atlanta, Ga., on dead larvæ of corn pyralid.

Genus **RHIZOGLYPHUS** Claparède.

A suture between cephalothorax and abdomen; mandibles chelate; tarsi with distinct claws; cuticle not granulate; ventral apertures small; only two distinct posterior bristles on the cephalothorax, but in some forms a minute intermediate pair is present; tarsi short and stout, provided with some stout spines; male with anal suckers, and in some cases there is a dimorphic male with the third pair of legs greatly enlarged and ending in a large curved claw. The species are vegetable feeders, and attack healthy living tissues, usually the part in the ground.

Type.—R. hyacinthi Boisd. (*echinopus* Robin).

This genus was based on the absence of a caroncle to tarsus, a character of variable value in allied genera. Michael uses the dimorphic male as a distinguishing character, but I would rather not use a sexual character for a genus, so base the genus on the two posterior cephalic bristles and spiny tarsi.

I distinguish six species in our fauna by the following table:

Table of the Species.

1. Tarsus I with a large spine close to the sense hair 3
   Tarsus I without a spine near the sense hair 2
2. Abdominal bristles as long as width of body; tarsi longer .... *tarsalis*
   Abdominal bristles much shorter than width of body; tarsi shorter ... *phylloxeræ*
3. Tarsus I fully two and one-half to three times as long as broad .... *longitarsis*
   Tarsus I not more than twice as long as broad 4
4. Body three times as long as broad; legs very short .... *elongatus*
   Body less than three times as long as broad 5
5. Hind tarsus two and one-half to three times as long as broad; abdominal bristles longer; no dimorphic male seen .... *rhizophagus*
   Hind tarsus about twice as long as broad; abdominal bristles very short; a dimorphic male is common .... *hyacinthi*

Rhizoglyphus phylloxeræ Riley. (Pl. VI, fig. 61.)

Cephalothorax with a pair of frontal bristles and a pair of much larger posterior bristles, also a pair of minute intermediate bristles; one bristle on each humerus; in the female there are six short bristles near the tip of the abdomen, the longest pair not one-half the width of the body; a submedian pair of short ones behind the middle of the dorsum, and one short bristle on each posterior side. The male has eight bristles at tip of abdomen, some about as long as width of body; while the dimorphic male with the thickened leg III (Pl. VI, fig. 60) has these apical bristles about as long as the abdomen, and two pairs of long bristles on the dorsum. The legs are rather long; tarsus I (Pl. VI, fig. 59) has no spine above near the sense hair, but toward the middle is a stiff bristle; the other spines are present and are long, the apical hairs are shorter than the joint; the bristle from the penultimate joint is longer than the tarsus in all except the hind legs; tarsus IV (Pl. VI, fig. 57) is about as long as two preceding joints together, and in the male is still more elongate; it has two spines below near middle; the apical hairs are shorter than the joint. The enlarged leg III of the dimorphic male ends in a long claw; several bristles are near by, but no tooth. In life these mites are rather yellowish white, with chestnut-brown legs and a dark spot on each posterior side of the abdomen.

Length 0.75 to 1 mm.

I identify this with Riley's species, since his figures of the legs show a rather slender tarsus, and the other characters shown by his figure agree with this form.

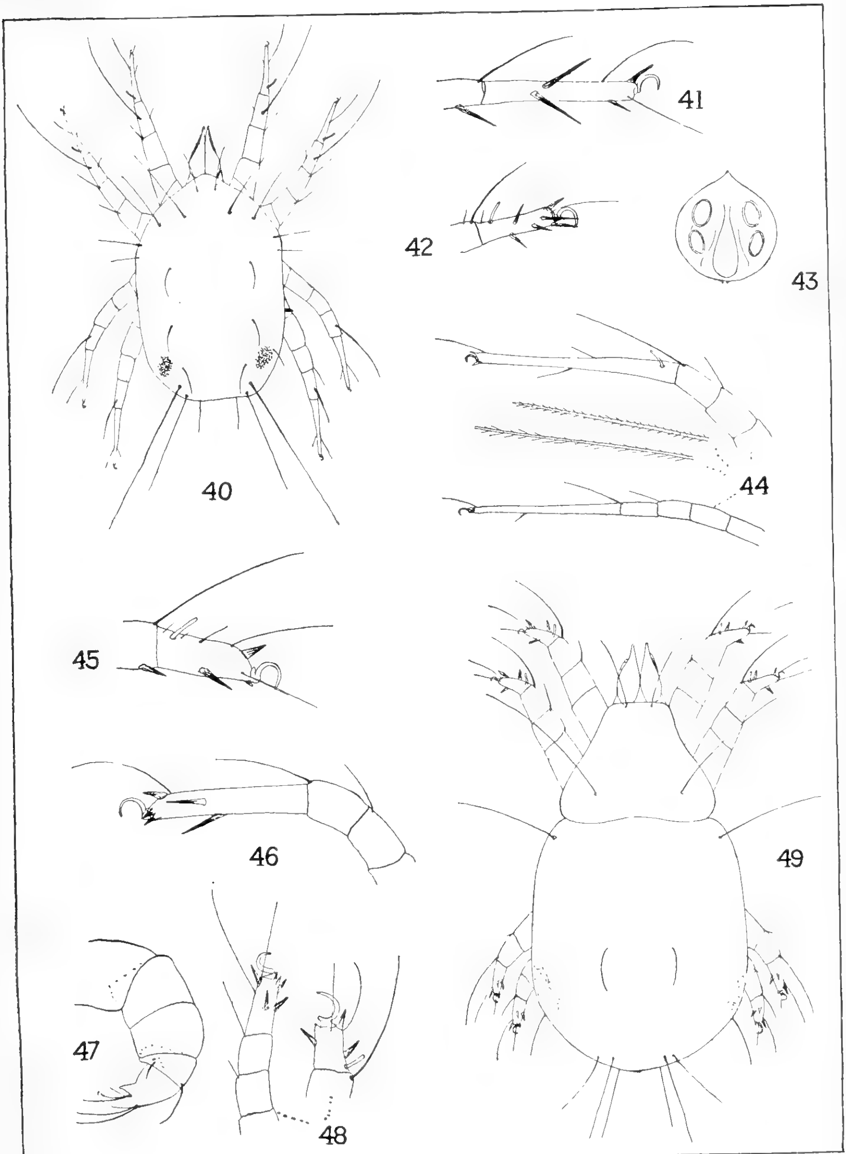
Specimens have been examined from the roots of cowpeas from Macon, Ga.; from Auburn, Ky., on scabby potatoes; from Lawrence, Mass., on young potato plants, and from Akron, Ohio, on rotten potatoes; also from Illinois, infesting pine cones.

Michael has considered that Riley's species was a synonym of *R. echinopus* Mégn. (*hyacinthi* Boisd.). This species is, however, abundantly distinct from the "bulb mite," and perhaps does not now occur in Europe, altho it was introduced into France. At that time it was supposed to feed on the Phylloxera.

Rhizoglyphus tarsalis n. sp.

This species is similar in nearly all respects to *R. phylloxeræ;* that is, there is no spine on tarsus I (Pl. V, fig. 45) near the sense hair, and the tarsi are long. I have not seen any males, but the female differs from *R. phylloxeræ* in having the bristles near tip of abdomen nearly as long as width of body, and in the plainly longer hind tarsi (Pl. V, fig. 46), which are longer than the preceding two joints together.

The specimens come from Spreckels, Cal., taken from sugar beets by Mr. E. S. G. Titus.



TYROGLYPHID MITES.

Fig. 40.—*Carpoglyphus passularum*. Fig. 41.—*Tyroglyphus armipes*, tarsus IV. Fig. 42.—*Tyroglyphus armipes*, tarsus I. Fig. 43.—*Tyroglyphus armipes*, vulva. Fig. 44 —*Tyroglyphus longior*, tarsi I and IV, and body hairs. Fig. 45.—*Rhizoglyphus tarsalis*, tarsus I. Fig. 46.—*Rhizoglyphus t rsalis*, tarsus IV. Fig. 47.—*Rhizoglyphus hyacinthi*, leg III of male. Fig. 48.—*Rhizoglyphus hyacinthi*, tarsi I and IV. Fig. 49.—*Rhizoglyphus hyacinthi*.

Rhizoglyphus hyacinthi Boisd. (Pl. V, fig. 49.)

Cephalothorax with a pair of frontal bristles, and a pair of large and long posterior bristles (intermediate bristles not visible); a rather long humeral bristle; a submedian pair of short bristles on the dorsum, one on each posterior side and six near the tip, all short, the longest scarcely one-half the width of body. Legs short and stout, the tarsus I (Pl. V, fig. 48, at right) but little longer than preceding joint, the spine above is close to the sense hair, and the apical hairs are longer than the joint; the bristle at tip of penultimate joint is longer than the tarsus in all except the hind legs; the hind tarsus (Pl. V, fig. 48, at left) is about twice as long as broad, with two spines below near middle, the usual apical spines, and the apical hairs are longer than the joint. In the male there are six hairs near tip of abdomen above, some nearly as long as width of body, and below are four rather long, subequal bristles in a straight transverse row; in the dimorphic male leg III (Pl. V, fig. 47) is enormously thickened, and ends in a stout claw, with a stout tooth at inner base. In color it is white with brownish head and legs, and a dark spot on each posterior side of the abdomen.

Length, 0.55 to 0.75 mm.

Specimens have been taken from the bulbs of Bermuda lilies shipped to this country.

Under the name of *R. echinopus* Mégn. several European authors have gathered various species; whether this form, which seems partial to bulbs, is the same as Mégnin's species I can not tell from descriptions; however, I think it identical with the *R. echinopus* of Michael. Its ravages in various bulbs and orchids have given it the name of "bulb mite" and "Eucharis mite." The damage caused by it to Bermuda lilies has been treated by Mr. A. F. Woods in 1897, in a paper entitled "Bermuda lily disease." (See bibliography, p. 27.) The *R. mégnini* of Haller appears to be a distinct species, with plainly shorter bristles.

Rhizoglyphus rhizophagus n. sp. (Pl. VI, fig. 50.)

Cephalothorax with a pair of frontal bristles, and a pair of long posterior bristles (no intermediate bristles visible); a humeral bristle fully one-half the width of body, two on each posterior side and six at tip in the female, all short, the longest about one-half the width of the body, and a submedian pair above on dorsum. Legs short, the anterior pairs very heavy, the tarsi I (Pl. VI, fig. 51) and II with a spine above near the sensory hair; and one below, rather before the middle; apical hairs longer than the joint; the bristle from penultimate joint longer than the tarsus in all legs, except the hind pair; hind tarsus (Pl. VI, fig. 52) two and one-half to three times as long as broad, two spines below near middle, and the usual spines at apex; the apical hairs as long as the joint. In the male the abdomen has eight bristles near tip, one pair rather more than one-half the width of the body; and on the venter (Pl. VI, fig. 56) behind anus are four subequal bristles in a transverse row; the leg III of male is like that of IV and not thickened in the many males examined by me.

Length 0.65 to 0.80 mm.

This species differs from *R. hyacinthi* in several minute points, namely: the longer tarsi, especially hind tarsi; the position and size of certain bristles, and the proportionately larger front legs.

Specimens have been studied from Missoula, Mont., on roots of apple trees; from Missouri, under a cottonwood stump, and on onions, from Glenellen, Cal.

Rhizoglyphus elongatus n. sp. (Pl. VI, fig. 53).

Cephalothorax with a pair of long frontal bristles, and a pair of posterior bristles, barely longer than the others, no intermediate bristles visible; a humeral bristle each side no longer than cephalic bristles, and six short bristles near tip of abdomen, the superior pair the longest, but no longer than frontal bristles. Body very elongate, more than three times as long as broad, mandibles large. Legs very short and stout; tarsus I (Pl. VI, fig. 54), but little longer than penultimate joint, a spine above near the sense hair, one below beyond middle, and two near tip, apical bristles short; the bristle from tip of penultimate joint very large and prominent, and longer than tarsus in all legs; hind tarsus but little longer than front ones, and with short apical hairs.

Length 0.30 to 0.35 mm.

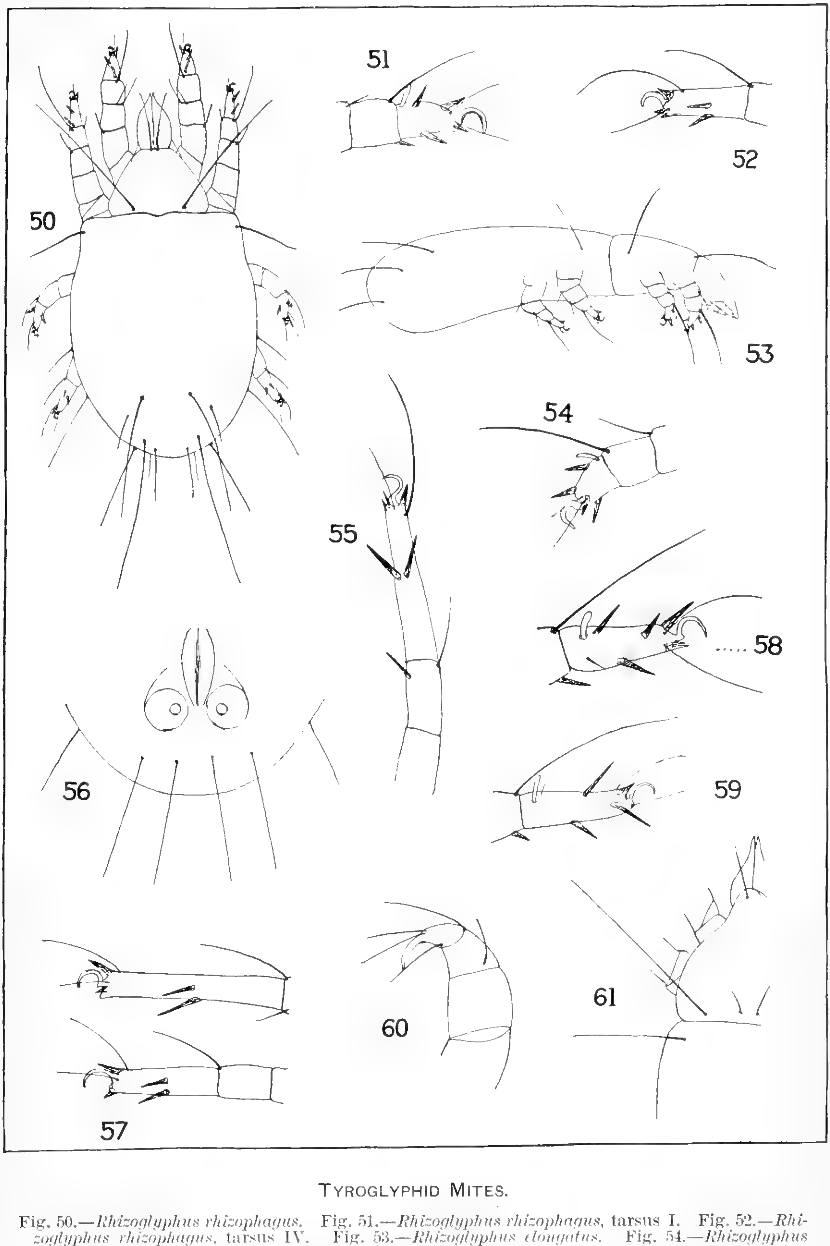
The only specimens seen were taken from the roots of clover in October, 1879, probably in Missouri. Distinct by elongate body, very short legs, and short posterior bristles of cephalothorax.

Rhizoglyphus longitarsis n. sp.

Cephalothorax with a pair of long frontal bristles, a pair of very long and large posterior bristles, and a pair of minute intermediate bristles; a long humeral bristle; the female with six bristles near tip of abdomen, none more than one-third the width of body; in the male the bristles are longer, some nearly as long as width of body, and on the venter, behind anus, are four bristles in a transverse row, but the outer pair is very much longer than the inner pair. The legs are rather long; tarsus I (Pl. VI, fig. 58) about two and one-half times as long as broad, and with a spine close to the sense hair, one below near middle and two others near tip; the apical hairs nearly as long as the joint; the bristle at tip of penultimate joint is longer than the tarsus in all legs, except the hind pair; the hind tarsus (Pl. VI, fig. 55) is very long and slender, with two spines beyond middle, and the apical hairs about two-thirds the length of the joint.

Length 0.75 mm.

I have seen specimens from Emporia, Kans., taken from the rotten bulbs of *Caladium esculentum*.



TYROGLYPHID MITES.

Fig. 50.—*Rhizoglyphus rhizophagus*. Fig. 51.—*Rhizoglyphus rhizophagus*, tarsus I. Fig. 52.—*Rhizoglyphus rhizophagus*, tarsus IV. Fig. 53.—*Rhizoglyphus elongatus*. Fig. 54.—*Rhizoglyphus elongatus*, tarsus I. Fig. 55.—*Rhizoglyphus longitarsis*, tarsus IV. Fig. 56.—*Rhizoglyphus rhizophagus*, male venter. Fig. 57.—*Rhizoglyphus phylloxeræ*, tarsi IV—male and female. Fig. 58.—*Rhizoglyphus longitarsis*, tarsus I. Fig. 59.—*Rhizoglyphus phylloxeræ*, tarsus I. Fig. 60.—*Rhizoglyphus phylloxeræ*, leg III of male. Fig. 61.—*Rhizoglyphus phylloxeræ*, half of front of body.

Genus **MONIEZIELLA** Berlese.

A suture between cephalothorax and abdomen; mandibles large, chelate; tarsi with distinct claws; cuticle without granulations; ventral apertures small; but two distinct posterior bristles on the cephalothorax; tarsi without spines; male with ventral suckers; abdomen usually more elongate than in *Tyroglyphus*. All the species so far known are predaceous or feed on recently killed animal matter.

Type.—M. entomophagus Lab.

The genus *Histiogaster* is based on *H. carpio* Kramer, a species with spiny tarsi, a peculiar male abdomen, and of very different habits; so that I retain *Monieziella* as distinct from it.

There are probably from five to ten species in our fauna. I have recognized the following three species:

TABLE OF THE SPECIES.

1. Body about three or four times as long as broad; apparently no cephalic nor humeral bristles .... *angusta*
   Body scarcely twice as long as broad; cephalic and humeral bristles distinct.. 2
2. Tarsi barely longer than preceding joint........ *brevitarsis*
   Tarsi nearly twice as long as preceding joint........ *longipes*

Monieziella angusta n. sp. (Pl. II, fig. 15.)

Body three to four times as long as broad; apparently without any cephalic or humeral bristles, and only four short ones near the tip of abdomen. Legs very short; tarsi not longer than the penultimate joint; the bristle from this joint longer than tarsi, especially in the anterior legs, where it is very prominent.

Length, 0.30 to 0.35 mm.

Specimens taken from under scale insects (*Aspidiotus*) at Haywood, Cal., and stated to be feeding on the coccids and their eggs.

This is probably what Doctor Riley figures in the Fifth Missouri Report as *Tyroglyphus malus;* however, his figure shows some bristles on the head which I can not see in the specimens before me. Michael has identified Riley's species with the European *M.* (*Histiogaster*) *entomophagus;* but Michael's figures show a form very different; more elongate and with shorter bristles. The *Tyroglyphus malus* of Lignières is probably a *Monieziella*, but a different species, perhaps *M. entomophagus*, as asserted by Michael.

Monieziella longipes n. sp. (Pl. II, fig. 13.)

Cephalothorax with a pair of frontal bristles, and a pair of very long posterior bristles; a long, fine humeral bristle each side; two shorter bristles on the margin, and four rather long bristles near tip of body, the inner pair nearly as long as the abdomen. Legs rather slender, and the tarsi nearly as long as the preceding two joints together, and in the hind pair still longer; the hair at tip of the penultimate joint is longer than the tarsus in all except the hind legs.

Length, 0.33 mm.

Specimens from among *Mytilaspis* scales at Crescent City, Fla. (Hubbard).

Monieziella brevitarsis n. sp. (Pl. II, fig. 18.)

Cephalothorax with a pair of short frontal bristles and a pair of longer posterior bristles; a humeral bristle each side rather more than one-half the width of body, and three bristles each side on posterior margin toward tip, the outer one very short, the next longer, and the inner pair about one-third the length of the abdomen. Body scarcely twice as long as broad; mandibles (Pl. II, fig. 19) large and prominent. Legs short, with only a few short bristles, but that at tip of the penultimate joint is rather longer than the tarsus; the latter joint is only a trifle longer than the preceding joint, but much more slender; the sense hair on tarsi I and II is much curved. (Male venter, Pl. II, fig. 19.)

Length, 0.35 mm.

What is evidently the *Hypopus* of this form has a projection on the anterior part of the cephalothorax, with a black eye-spot each side; the legs I and II are thick and heavy; leg III ends in a claw, as do I and II; but leg IV terminates in two long bristles, the outer one much the longer, but both longer than the leg, and there is also a short bristle near tip of the legs. The ventral sucking plate has six suckers—two in front, smaller than others, and four in a curved row behind.

Specimens have been taken from *Chilocorus* at Southern Pines, N. C., and Marshallville, Ga., and it evidently feeds on the San Jose scale.

Genus CARPOGLYPHUS Robin.

No suture between cephalothorax and abdomen; mandibles chelate; tarsi with distinct claws; cuticle without granulations; ventral apertures small; the epimera of the first two pairs of legs joined to each other and to the sternum, thus forming a sort of skeleton; tarsal claw arising from a clavate onychium; the bristle on penultimate joint of legs arises from near middle, not at tip of joint. The legs are rather slender, not thickened in the male; the male has no anal suckers. On the anterior margin of cephalothorax near base of mandibles there is each side a rounded eye-like spot or projection, very doubtfully an eye. No *Hypopus* is known.

Type.—*C. passularum* Robin.

There are doubtless several species; I have described one from Java; *C. anonymus* of Berlese and Michael has very short bristles on cephalothorax, and Michael shows them spine-like, so that their figures probably represent a species different from that of Canestrini. and which I find in the United States. The species of this genus feed on a great variety of substances, perhaps favoring dried fruits.

Carpoglyphus passularum Hering. (Pl. V, fig. 40.)

Cephalothorax with a pair of short frontal bristles, apparently a little back from the front margin; four posterior bristles in a curved, transverse row, none very long; a humeral bristle each side, with a short one near by; two submedian pairs of short bristles on the dorsum; two short ones on each posterior side margin; a short pair near tip above, and three each side at tip, one pair very short, the others more than one-half length of body. Legs moderately long, tarsi long and tapering; the sense hair on tarsi I and II tapers to tip; the bristle above on penultimate joint is situated near the middle and not at tip, and is very large and prominent, and longer than the tarsus in all except the hind pair of legs. There are a number of hairs on legs, but no spines; the hair near apex of tarsus is long and rather farther from the tip than usual in tyroglyphids.

Length, 0.40 to 0.50 mm.

Specimens have been seen from Fresno, Cal., on figs; from St. Anthony Park, Minn., on dried figs and apples; from Albany, N. Y., on smoked ham, and on pollen of honey bees from Ohio.

Genus TRICHOTARSUS Canestrini.

No suture between cephalothorax and abdomen; mandibles chelate; legs ending in distinct claws; male without suckers on hind tarsus; no clavate or thickened hair on tarsi I and II; palpi not enlarged at tip; cuticle not granulate; male without anal suckers; vulva of female situated close to beak, between coxæ I; hypopial nymphs found upon bees, adults in nests of bees.

Type.—T. osmiæ Dufour.

The adult form is but little known; I have seen none from this country; the hypopial nymphs are more common, and two forms have been found in the United States. These agree well with the European species, but as the adults are not known, their identification is rather uncertain. They are of no economic value, and therefore I shall simply list the two species as the European forms until such time as mature specimens make possible a more exact identification and satisfactory description.

Trichotarsus xylocopæ Donn.

Prof. H. Osborn has recorded this European species as taken from a California *Xylocopa*, and sent to him by Mr. D. W. Coquillett. I have not seen it, and possibly some other species was concerned.

Trichotarsus osmiæ Duf.

I have taken specimens of a species of *Trichotarsus*, which agree with the European form, from a species of *Osmia* at Sea Cliff, N. Y.; however, the adult females may present some differences. This species differs from *T. xylocopæ* in having two claws at the tips of tarsi I, II, and III.

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O

Technical Series, No. 14.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE

BACTERIA OF THE APIARY,

WITH SPECIAL REFERENCE TO BEE DISEASES.

BY

GERSHOM FRANKLIN WHITE, Ph. D.,

Expert in Animal Bacteriology, Biochemic Division, Bureau of Animal Industry.

Issued November 6, 1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., September 24, 1906.

Sir: I have the honor to transmit the manuscript of a paper on the bacteria of the apiary, with special reference to bee diseases, by Dr. G. F. White, expert in animal bacteriology in the Biochemic Division of the Bureau of Animal Industry. This paper was prepared by Doctor White as a thesis in part fulfilment of the requirements for the degree of doctor of philosophy, at Cornell University, in June, 1905. The Bureau of Entomology considers itself fortunate in obtaining it for publication, since in this way a wider distribution can be made than would be possible were it published in a journal devoted exclusively to bacteriological investigations. It is hoped that the publication of these facts may help to clear up the confusion which now exists concerning the causes of the two most common diseases of the brood of bees. I recommend that the manuscript be published as Technical Series, No. 14, of this Bureau.

Doctor White wishes to acknowledge his indebtedness to Dr. Veranus A. Moore, professor of comparative pathology and bacteriology of Cornell University, under whose direction this work was done; to Dr. E. F. Phillips, acting in charge of apiculture, Bureau of Entomology, United States Department of Agriculture, for encouragement and assistance in the preparation of this manuscript; and to Messrs. Mortimer Stevens, Charles Stewart, N. D. West, and W. D. Wright, bee inspectors of the State of New York, for their interest in the work.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The spread of diseases of the brood of bees is to-day a great menace to the bee-keeping industry of the United States. It is therefore of great importance that all phases of these diseases should be investigated as thoroly as possible, and this paper, it is believed, will help in clearing up some disputed points in regard to the cause of the two most serious brood diseases.

Dr. G. F. White has offered this paper for publication as a bulletin in the Bureau of Entomology because in that way the statements herein contained may become more widely known than would be the case were it published in some journal devoted exclusively to bacteriological investigations. Obviously there are many points still unsettled, and it is hoped that some of these may be taken up for investigation in the near future, but the results so far obtained should by all means be made known to the persons practically engaged in bee keeping.

The necessity for the study of nonpathogenic bacteria found in the apiary may not be at first evident to the ordinary reader. When it is seen, however, that some of the investigators of bee diseases have apparently mistaken *Bacillus A* or some closely allied species for *Bacillus alvei* it will be evident that a study of nonpathogenic germs is necessary to a thoro investigation of the cause of these diseases and a full understanding of the confusion which has existed.

The names which should be used for the diseased conditions of brood was a matter which arose after this paper was offered for publication. It was desired that out of the chaos of names in use certain ones be chosen which would be distinctive and still clear to the bee keepers who are interested in work of this nature. Unfortunately, after a short investigation, Dr. W. R. Howard, of Fort Worth, Tex., gave the name "New York bee disease," or "black brood," to a disease which Cheshire and Cheyne described in 1885 as "foul brood." Since this is the disease in which *Bacillus alvei* is present, we can not drop the name "foul brood," and the word "European" is used to distinguish it from the other disease. The bee keepers of the United States have been taught that the type of brood disease characterized by ropiness of the dead brood is true foul brood, but since *Bacillus alvei* is not found in this disease it obviously is not the same disease as that described by Cheyne. It would be well-nigh impossible, however, to change the name of this disease, and any effort in that direction would merely result in complicating laws now in force which control the infectious diseases of bees and would serve no good purpose. This disease is here designated "American foul brood." These names have been chosen only after consultation with some of the leading bee keepers of the United States, and these distinguishing terms were chosen by the majority of those consulted as indicating the place in which the diseases were first investigated in a thoroly scientific manner. Both diseases are found in Europe, as well as in America, so that the names indicate nothing concerning the geographical distribution of the maladies.

Strangely enough, certain writers for our American apicultural papers have seen fit to take exception to some of the statements made in this paper without having first found out the reasons for the decisions herein published. Apiculture will not be advanced to any appreciable extent by such eagerness to rush into print, especially when there is not a semblance of scientific investigation back of the criticism.

E. F. Phillips,
Acting in Charge of Apiculture.

CONTENTS.

THE BACTERIA OF THE APIARY WITH SPECIAL REFERENCE TO BEE DISEASES.

INTRODUCTION.

Since bacteriology is one of the youngest of the sciences, it is only natural that there should be many problems concerning which there is much confusion, and many others concerning which nothing is known. In a study of the saprophytic bacteria this is especially true; the exploration of this jungle of micro-organisms is scarcely begun. Comparatively few species have been studied and named, and a much less number can be identified. From studies that have been made one is led to believe that the species which might be classed under bacteria outnumber by far all the macroscopic plants known. Comparatively little is as yet known concerning the distribution of these minute organisms in nature, their needs for multiplication and growth, their power of endurance, their relations the one to the other, their relations to man and industries, and their relation to pathogenic species. Both from the standpoint of scientific interest and from the standpoint of practical economy these problems call for further investigation.

By far the greatest amount of work which has been done in the science of bacteriology has been prompted by the direct or indirect economic importance of the question. This is largely true of the present investigation, since honey bees suffer from a number of diseases, some of which are considered in Part II.

TECHNIQUE.

Obtaining Material for Study.

If necessary, bees may be conveniently shipped alive by mail in cages constructed for that purpose. Combs also may be sent by mail in small boxes. If combs, honey, pollen, or larvæ are desired, the hive must be entered. In case older adult bees are wanted it is not difficult to supply the needs from the entrance to the hive. To capture them one may stand at the entrance and catch the unwary toiler as she

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comes in loaded with pollen and honey. After the victim alights on the entrance board, by the aid of a pair of forceps, before she disappears within, one can easily lodge her safely in a petri dish. It is, however, an advantage to study the young adult bees as well as the older ones, and if young ones are desired they may be taken from the combs or from the front of the hive, near the entrance.

Obtaining Cultures.

(*a*) *From combs.*—With sterile forceps small pieces of the comb are put directly into gelatin or agar for plates or incubated in bouillon for 24 hours and then plated. Growing in bouillon and plating on gelatin is usually preferable.

(*b*) *From pollen.*—The same technique is used as for combs, but the direct inoculation of gelatin tubes for plates is generally preferable.

(*c*) *From honey.*—With sterile loops honey is taken from uncapped and capped cells. The caps are removed with sterile forceps and the honey is plated directly on gelatin or agar. Bouillon tubes are inoculated also with varying quantities of the honey.

(*d*) *From larvæ.*—The larva is carefully removed to a sterile dish, and with sterile scissors the body is opened and the contents plated directly, or bouillon cultures are first made and later plated, if a growth appears.

(*e*) *From parts of the adult bee.*—In studying the adult bee, a small piece of blotting paper wet with chloroform is slipt under the cover of the petri dish in which the insects have been placed, and in a short time the bees are under the influence of the anesthetic. Then with sterile scissors a leg, a wing, the head, the thorax, or the abdomen, the intestine being removed, is placed in bouillon and, after 24 hours incubation, plated, preferably on gelatin.

When it is desired to make a study of the bacteria of the intestine, the intestinal tract is removed and studied as follows: The bee is flamed and held in sterile forceps. With another sterile pair of forceps the tip of the abdomen is seized and, by pulling gently, the tip and the entire intestine are easily removed. This can then be plated directly. If gelatin, which is preferable, is used, the intestine itself must not be left in the gelatin or the medium will become liquefied by the presence of the tissue. If one desires to obtain cultures of the anaërobe, which is quite common in the intestine, it is most easily obtained in pure culture by the use of the deep glucose agar (Liborius's method). Cover glass preparations made direct from the walls of the intestine or its contents give one some idea of the great number of bacteria frequently present.

Differentiation and Identification of Bacteria.

These very low forms of plant life show a marked susceptibility to environmental conditions and those desirous of speculating on problems in evolution may find here food for thought and experimentation. On account of this susceptibility, various cultures which belong to the same species may possess slight variations in some one or more specific characters. Consequently one can not say that a species must possess certain definite characters and no others. It is convenient, then, to think of a species as more or less of a group of individuals whose characters approximate each other very closely.

In this paper are described a number of species each of which, in fact, represents a group, the individual cultures of which approximate each other so closely in character that the differences may be easily attributed to environmental conditions which are more or less recent.

Concerning the identification of species, the conditions have been well summed up by Chester. He says:

> Probably nine-tenths of the forms of bacteria already described might as well be forgotten or be given a respectful burial. This will then leave comparatively few well-defined species to form the nuclei of groups in one or another of which we shall be able to place all new sufficiently described forms.

The variations which occur and the very incomplete descriptions which can be found make it impossible to identify many species even to a more or less restricted group. For these reasons some of the cultures are not identified or named, but letters are used for convenience in this paper to represent the specific part. Migula's classification has been used.

The Cultures Which are Described.

Plate cultures were observed for some weeks, the different kinds of colonies which appeared being especially noted. Subcultures were then made in bouillon, and after 24 hours the subculture was replated. Subculturing and replating were then repeated. From this last plate the pure culture was made on agar for study. These were not studied culturally, as a rule, for some weeks, thus allowing time for the organism to eliminate any character due to recent environmental conditions (1).[a]

Morphology, Staining Properties, and Oxygen Requirements, with Suggestions on Variations.

(*a*) *Size.*—The length and thickness of a micro-organism often varies so much with its environmental conditions that certain re-

[a] Numbers in parentheses refer to papers in the bibliography at the end of Part I or that at the end of Part II.

corded dimensions should always be accompanied by facts concerning the medium, age, and temperature of incubation. The measurements recorded in this paper were all taken of organisms in preparations made from a 24-hour agar culture stained with carbol-fuchsin. The involution forms are not reckoned in the results.

(*b*) *Spores.*—The presence of spores was determined in each case by staining the various cultures at different ages. A check was made on their presence by means of the thermal death point.

(*c*) *Flagella.*—Loeffler's method, as modified by Johnson and Mack, was used for staining the flagella (2).

(*d*) *Motility.*—Motility may be present in cultures when first isolated, but after artificial cultivation appear to be entirely lost. The reverse of this also may be noted. No cultures should be recorded as nonmotile until cultures on various media at different temperatures and of different ages shall have been studied. Hanging-drop preparations were made from cultures on agar and bouillon, both incubated and not incubated, and on gelatin.

(*e*) *Staining properties.*—Basic carbol-fuchsin was the stain used almost exclusively. In the use of Gram's staining method, carbolic gentian violet (5 per cent carbolic acid 20 parts, saturated alcoholic solution gential violet 2 parts) was applied to a cover-glass preparation from a 24-hour culture on agar for 5 minutes, placed in Lugol's solution 2 minutes, and placed, without rinsing, in 95 per cent alcohol for 15 minutes, removed, washt in water, and allowed to dry.

(*f*) *Oxygen requirements.*—Determinations were made by observing whether a growth took place in the closed or open arm or both, of the fermentation tube containing glucose bouillon.

Media Employed and Suggestions as to the Description of Cultures.

(*a*) *Bouillon.*—All bouillon used was made from beef (meat 1 part, water 2 parts), to which infusion 1 per cent Witte's peptonum siccum and one-half per cent sodium chlorid were added. The reaction of the solution was then determined by titrating, and made +1.5 to phenolphthalein.

In describing a culture growing in bouillon as a medium, there is usually a more extended description given than in the case of sugar and sugar-free bouillons, since cultures in these media do not differ materially in gross appearance from those observed in the plain bouillon.

(*b*) *Sugar-free bouillon.*—This bouillon is made free from sugar by the use of *B. coli communis*, after which peptone and sodium chlorid (NaCl) were added as in bouillon.

(*c*) *Sugar bouillons.*—Five different sugars—glucose, lactose, saccharose, levulose, and maltose, as well as mannite—were used in the study. If a 1-per-cent solution of glucose in plain bouillon was fermented with the production of gas, fermentation tubes were used for all the sugars and mannite. If no gas was formed in the glucose, the straight tubes were inoculated. The sugars and mannite were used in a 1-per-cent solution in sugar-free bouillon.

(*d*) *Reaction of media.*—The reaction of cultures is determined as it appears on the fifth day in the different media, unless otherwise stated. The medium in the open arm is used to determine the reaction in the fermentation tube. Beginning with a reaction of +1.5 to phenolphthalein, or slightly alkaline to litmus, the detection of an increase in acidity is not difficult. But inasmuch as the production of an alkali is very frequently small in degree, cultures are often in this paper recorded alkaline in reaction when probably the reaction has not changed.

(*e*) *Fermentation with the production of gas.*—Gas may be formed in such small quantities as not to be observed as such, but to be entirely absorbed by the medium. Whenever gas formation is mentioned as a character, visible gas is meant. The analysis of the gas was made in the usual manner by absorbing a portion with potassium hydrate (KOH) and testing the remainder with the flame. The amount absorbed by potassium hydrate (KOH) is referred to as carbon dioxid (CO_2) and the remainder, if an explosion is obtained, as hydrogen (H). This is, naturally, only approximately correct. Since the gas formula may vary from day to day, too much value must not be given to the exact proportion. It is well to observe whether the proportion of hydrogen to carbon dioxid is greater or less than 1.

(*f*) *Agar.*—One per cent agar is used. The description of the growth on this medium is made from the appearance as seen on the surface of an agar slant. The description is usually very brief, since it has, as a rule, little differential value.

(*g*) *Acid agar.*—This medium is made acid by titrating to +3 to phenolphthalein. The absence or presence, as well as the degree of growth, is noted.

(*h*) *Serum.*—The serum used is taken from the horse, sterilized at 55° C. and congealed at 80° C. Deep inoculations are made, and the surface of slanted serum is also inoculated. The degree of growth is usually noted. Cultures are observed for 6 weeks to 2 months. The presence or absence of liquefaction is the chief character sought for. Since room temperature varies so greatly, the time at which liquefaction begins varies, and little differential value, therefore, can be given to the exact time of this phenomenon.

(*i*) *Potato.*—The composition of potato varies so markedly that a description of a culture on this medium may differ materially from that which is observed on another tube of the same medium. It is the aim to omit for the most part the observed variations due to the composition of the different potatoes.

(*j*) *Potato water.*—To potatoes sliced very thin is added an equal amount of water by weight and the mixture is then boiled. This is strained and distributed in straight and fermentation tubes. The reaction of the solution was made +1.5 to phenolphthalein. If any of the micro-organisms ferment glucose with the production of gas, fermentation tubes are inoculated to test the fermentation of starch; if not, straight tubes are inoculated.

(*k*) *Milk.*—If a micro-organism breaks up glucose with the formation of gas, a fermentation tube of milk is inoculated with the culture; if not, straight tubes are used. Separator milk is used. The coagulation of the casein with or without liquefaction is the chief character noted. Very little stress is laid upon the time element in the coagulation of the casein and the other phenomena which are to be observed in milk. Different samples of milk and the different environmental conditions are factors which vary the length of time at which the different phenomena appear.

(*l*) *Litmus milk.*—The reaction as shown by the litmus and the discharging of the color are the chief points observed.

(*m*) *Gelatin.*—The color, degree of growth, the presence or absence of liquefaction, and the form of liquefaction are the chief points observed. The cultures are kept under observation 2 months or longer and, as in serum, the time given at which liquefaction takes place is only approximate.

(*n*) *Indol.*—The cultures are allowed to grow in sugar-free peptonized bouillon for 3 to 5 days, and are tested with potassium nitrite (KNO_2) and sulfuric acid (H_2SO_4) after the ring method. Too much stress may be placed upon the ability of an organism to form indol. This character has been shown to be a somewhat transient one (3).

(*o*) *Reduction of nitrates to nitrites.*—Cultures are cultivated 7 days in a solution of 1 gram of Witte's peptonum siccum and one-fifth gram of sodium nitrate in 1,000 c. c. of tap water. To such a culture and to a control tube are added a mixture of naphthylamine and sulfanilic acid (napthylamine, 1 part; distilled water, 1,000 parts: sulfanilic acid, one-half gram, dissolved in dilute acetic acid in the proportion of 1 part of acid to 16 parts of water). If nitrate is reduced to nitrite, a pink color develops. The control tube should remain clear, or slightly pink—owing to the absorption of a trace of nitrite from the atmosphere.

PART I. BACTERIA OF THE NORMAL APIARY.

Before studying the cause of a disease it is necessary that we know what bacteria are normally present, so that later, in studying diseased conditions, a consideration of these nonpathogenic species may be eliminated. In view of this necessity a bacteriological study of the hives, combs, honey, pollen, larvæ, and adult bees was begun, to determine the bacteria normally present. It was not hoped that all the species isolated could be easily identified, or that all would merit a careful description, but it was hoped that those species which seemed to be localized in any part of the apiary, or upon or within the bees, might be studied and described with sufficient care to guarantee their identification upon being isolated again. The chance of variation in morphology, pathogenesis, and cultural characters due to environmental conditions to which these micro-organisms were being subjected at the time, or to which they had been subjected before isolation or study, has been carefully borne in mind.

BACTERIA FROM THE COMBS.

One might naturally suppose that very many species of bacteria would be present on combs, since these are exposed more or less to the contaminating influence of the air. The reverse, however, seems to be true. The number of different species isolated is comparatively small. Those which appear most often are described below. Some other species mentioned in this paper are found on combs, but inasmuch as they appear most frequently from other sources they are described there. One species of Saccharomyces from the comb, also, is described under the heading " Saccharomyces and fungi."

Bacillus A.

(*B. mesentericus?*)

Occurrence.—Found very frequently on combs, on scrapings from hives, and on the bodies of bees, both diseased and healthy.

Gelatin colonies.—Very young colonies show irregular edges, but very soon liquefaction takes place and the colony gives rise to a circular liquefied area, covered with a gray membrane, which later turns brown.

Agar colonies.—Superficial colonies present a very irregular margin consisting of outgrowths taking place in curves. Deep colonies show a filamentous growth having a moss-like appearance.

Morphology.—In the living condition the bacilli appear clear and often granular, arranged singly, in pairs, and in chains. The flagella are distributed over the body. The rods measure from 3μ to 4μ in length, and from 0.9μ to 1.2μ in thickness.

Motility.—The bacilli are only moderately motile.

Spores.—Spores are formed in the middle of the rod.

Gram's stain.—The bacilli take Gram's stain.

Oxygen requirements.—Aërobic and facultatively anaërobic.

Bouillon.—Luxuriant growth in 24 hours, with cloudiness of medium; a gray flocculent membrane is present. Later, the membrane sinks and the medium clears, leaving a heavy, white, flocculent sediment, with a growth of the organisms adhering to the glass at the surface of the medium. Reaction alkaline.

Glucose.—Luxuriant growth takes place in the bulb, with a moderate, flocculent growth in closed arm. The gradual settling of the organisms causes a heavy white sediment to form in the bend of the tube. The reaction is at first slightly acid, but subsequently becomes alkaline. No gas is formed.

Lactose.—Reaction alkaline.

Saccharose.—Reaction alkaline.

Levulose.—Reaction acid.

Maltose.—Reaction acid.

Mannite.—Reaction alkaline.

Potato water.—Reaction alkaline.

Agar slant.—A luxuriant growth takes place on this medium. The growth gradually increases to a moist, glistening one, being then friable and of a grayish brown color.

Serum.—A luxuriant, brownish, glistening, friable growth spreads over the entire surface. No liquefaction is observed.

Potato.—An abundant fleshy growth of a brown color spreads over the entire surface. The water supports a heavy growth. The potato is slightly discolored.

Milk.—Precipitation takes place rapidly, followed by a gradual digestion of the casein, the medium changing from the top downward to a translucent liquid, becoming at last semi-transparent and viscid.

Litmus milk.—Precipitation of the casein takes place usually within 24 hours, followed by a gradual peptonization. Reduction of the litmus occurs rapidly, leaving the medium slightly brown; later the blue color will return on exposing the milk to the air by shaking. Reaction alkaline.

Gelatin.—An abundant growth takes place with rapid, infundibuliform liquefaction. A heavy, white, friable membrane is formed on the surface of the liquefied medium. A flocculent sediment lies at the bottom of the clear liquefied portion.

Acid agar.—Growth takes place.

Indol.—None has been observed.

Nitrate.—Reduction to nitrite is positive.

Bacterium acidiformans. (Sternberg, 1892.)

Occurrence.—Isolated from the scraping of propolis and wax from the hives and frames of healthy colonies.

Gelatin colonies.—The superficial colonies are friable, convex, opaque, and white with even border; when magnified they are finely granular, sometimes radiately marked. They are from 1 to 4 millimeters in diameter. The deep colonies are spherical or oblong and entire.

Morphology.—When taken from an agar slant 24 hours old, the rods are short, with rounded ends, singly and in pairs. Length about 1.6μ, thickness 0.8μ. They stain uniformly with carbol-fuchsin. Flagella are apparently absent.

Motility.—No motility has been observed in any medium.

Spores.—Spores are apparently absent.

Gram's stain.—The bacteria are decolorized by Gram's method.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—The medium becomes slightly clouded with a feeble ring of growth on the glass at the surface of the liquid. A moderate amount of white friable sediment is formed. Reaction alkaline.

Glucose.—Uniformly and slightly clouded. No gas is formed. Reaction acid.

Lactose.—Reaction acid.

Saccharose.—Reaction alkaline.

Levulose.—Reaction acid.

Maltose.—Reaction acid.

Mannite.—Reaction acid.

Potato water.—Reaction acid.

Agar slant.—A moderate, gray, glistening growth, confined to the area inoculated with the loop, is formed on the inclined surface.

Serum.—A feeble gray growth is formed only on the inoculated surface. No liquefaction takes place.

Potato.—A gray growth covers the inoculated surface.

Milk.—Heat causes a ready coagulation of the casein. Reaction acid.

Litmus milk.—Coagulation of casein occurs promptly on boiling a culture 2 weeks old. Reaction acid.

Gelatin.—Growth of spherical colonies appears along the line of inoculation, the surface growth being grayish and spreading slowly. No liquefaction takes place.

Acid agar.—Growth takes place.

Indol.—A trace was observed.

Nitrate.—No reduction to nitrite could be observed.

BACTERIA FROM POLLEN.

As in the case of the examination of the combs, the number of species of bacteria found in pollen is comparatively small. The following are often found to be present. Other species have been isolated, but their distribution in the pollen is not at all constant.

Bacillus B.

Occurrence.—Found frequently in pollen and in the intestine of healthy honey bees.

Gelatin colonies.—The colonies are egg-yellow with even border. Liquefaction takes place slowly. Surface colonies are about 1.5 millimeters in diameter, have coarsely granular center, finely granular margin, and clear and sharply defined border. A peculiar toruloid growth is often observed.

Morphology.—The organisms are short rods with rounded ends, which stain uniformly with carbol-fuchsin, and are 1μ to 2μ in length. Few short involution forms occur.

Motility.—The bacilli are actively motile in young cultures.

Spores.—No spores have been observed.

Gram's stain.—The bacilli are decolorized by Gram's stain.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—This medium becomes uniformly clouded, frequently with a scanty, friable membrane. Sometimes the organisms settle, clearing the medium and forming a viscid sediment. A growth of the culture adheres to the glass at the surface of the liquid. This, together with the membrane, is of a light egg-yellow color, which deepens somewhat with age. Reaction alkaline.

Glucose.—At first both arms of the fermentation tube are clouded slightly, and the cloudiness later increases. Sometimes a stronger growth occurs in the closed arm than in the open one. Reaction is at first acid, but slowly changes to alkaline.

Lactose.—Reaction alkaline.

Saccharose.—Reaction alkaline.

Levulose.—Reaction alkaline.

Maltose.—Reaction slightly acid.

Mannite.—Reaction slightly acid, later alkaline.

Agar slant.—A moderate, slightly yellow, nonviscid glistening growth appears along the inoculated surface. This growth gradually spreads and deepens in color to an egg-yellow.

Potato.—A moderate, egg-yellow, nonviscid, glistening growth spreads over the entire surface. The potato is slightly discolored.

Milk.—The milk is covered by a yellow growth of the culture, resembling cream. Coagulation takes place on boiling.

Litmus milk.—Reaction alkaline.

Gelatin.—Growth takes place along the line of inoculation. Deep in the medium the colonies are white and spherical; the surface growth is yellow. After a few days liquefaction begins, and at the end of 2 weeks one-half the tube is liquefied. The liquefaction is infundibuliform. Liquefied gelatin is surmounted by a friable, egg-yellow pellicle. The growth in the liquefied portion is flocculent, which, on settling, forms a yellow sediment at the apex.

Indol.—None could be observed.

Nitrates.—No reduction to nitrites occurs.

BACTERIA IN HONEY AND NORMAL LARVÆ.

Comb honey from a large number of sources has been examined and found to be quite uniformly sterile. The healthy larvæ likewise are usually sterile.

BACTERIA UPON THE ADULT BEES.

On the external part of the bee we again find only a few different species. *Bacillus A*, described as found upon the combs, is frequently isolated from the bee. Other species which are found frequently are described below.

Bacterium cyaneus (Micrococcus cyaneus).

Occurrence.—Isolated from the body of a healthy honey bee and from pollen.

Gelatin colonies.—The colonies are lemon-yellow, with entire border, growth taking place readily on this medium. The superficial colonies, having well-defined border, are finely granular, and liquefy the medium within 3 to 6 days.

Morphology.—Short oval rods 0.8μ to 1.7μ in length, 0.7μ to 0.8μ in thickness. Short involution forms are present. The rods occur singly, paired, and in clumps. No flagella have been demonstrated.

Motility.—No motion has been demonstrated.

Spores.—No spores have been demonstrated.

Gram's stain.—The bacterium takes Gram's stain.

Oxygen requirements.—Aërobic.

Bouillon.—At first a slight cloudiness appears, the medium becoming turbid in old cultures. A heavy yellowish-white, slightly viscid ring forms on the tube at the surface of the medium. The sediment, and sometimes the medium, show marked viscidity. Reaction alkaline.

Glucose.—The growth of the culture is confined entirely to the open bulb, in which the medium becomes turbid. No gas is formed. Reaction alkaline.

Lactose.—Reaction alkaline.

Saccharose.—Reaction alkaline.

Levulose.—Reaction alkaline.

Maltose.—Reaction alkaline.

Mannite.—Reaction alkaline.

Potato water.—Reaction alkaline.

Agar slant.—On the surface of the agar there takes place an abundant growth, which is confined to the surface inoculated with the loop. The culture is fleshy, nonviscid, and lemon-yellow. It produces a soluble pigment that diffuses thru the agar, giving it a dark-pink color.

Serum.—Luxuriant growth takes place, accompanied by liquefaction.

Potato.—A lemon-yellow, fleshy, glistening growth spreads over the inclined surface of the potato.

Milk.—Precipitation followed by slow liquefaction of the casein occurs; later the medium becomes alkaline and very viscid.

Litmus milk.—The litmus is discharged and the casein is liquefied. Reaction alkaline.

Gelatin.—Infundibuliform liquefaction soon begins, which is followed by stratiform liquefaction. The liquefied gelatin is turbid and viscid.

Acid agar.—On this medium a moderate lemon-yellow growth is observed.

Indol.—None could be observed.

Nitrates.—No reduction of nitrates could be observed.

Micrococcus C.

Occurrence.—Isolated from the body of a healthy honey bee.

Gelatin colonies.—The surface colonies are round and slightly yellow. Liquefaction begins in from 2 to 4 days. The magnified colonies are finely granular, with sharply defined, entire border.

Morphology.—Cocci, about 0.8μ in diameter, occur in pairs and in small clusters.

Motility.—Nonmotile.

Spores.—Spores are apparently absent.

Gram's stain.—The coccus takes the Gram's stain.

Oxygen requirements.—Aërobic.

Bouillon.—This medium becomes uniformly clouded in 24 hours after inoculation, growth increases, and friable sediment forms. The liquid clears somewhat on standing. Reaction at first slightly acid; later returns to neutral.

Glucose.—The medium in the bulb becomes cloudy, while that in the closed arm remains clear. White friable sediment forms in bend of tube. Reaction acid. No gas is formed.

Lactose.—Reaction slowly becomes acid.

Saccharose.—Reaction acid.

Levulose.—Reaction acid.

Maltose.—Reaction acid.

Mannite.—Reaction acid.

Potato water.—Reaction acid.

Agar slant.—A grayish white, fleshy, nonviscid, glistening growth takes place along the inoculated surface. It does not spread, and retains a distinct boundary.

Serum.—A spreading growth takes place, accompanied by liquefaction.

Potato.—A gray, fleshy, glistening, nonviscid growth forms over the entire cut surface of the potato. The potato is slightly discolored.

Milk.—This medium becomes firmly coagulated and later the casein liquifies with the formation of a milky serum.

Litmus milk.—In this medium coagulation takes place, accompanied by reduction of the litmus. Reaction slightly acid.

Gelatin.—After a day or two infundibuliform liquefaction occurs, being followed by stratiform liquefaction; the liquefied gelatin is turbid. Growth below this portion is in the form of small spherical colonies.

Acid agar.—A white, fleshy, nonviscid growth is observed.

Indol.—A trace was observed.

Nitrates.—Reduced to nitrites.

BACTERIA OF THE INTESTINE OF THE HEALTHY HONEY BEE.

A great many investigations have been made in recent years on the bacteria found present in the intestines of vertebrates (4, 5, 6, 7, 8, 9), and striking similarities are noticed in the species found in many of them. In this investigation the intestinal contents of about 150 bees, mostly from one apiary, have been studied more or less thoroly. Several species which are found to be constant in many of the vertebrates are found in the intestine of the honey bee. Since the temperature of the bee approximates much of the time, especially when in the hive, that of the warm-blooded animals, many of the same species of bacteria inhabit the intestine of this insect as are found thriving in the same locality in man and other animals. A stained cover-glass preparation made directly from a healthy adult field bee reveals, almost without exception, a multitude of bacteria.

In a study of the bacterial flora stress has been placed upon the different species which were found to be more or less constant, rather than upon the actual number of bacteria or species in any quantity of material from a single bee. From the observations which have been made, it appears that the number of species in any individual is comparatively small, but the number of bacteria is in many cases very large. Sometimes, however, the plates show very few colonies, while cover-glass preparations show a very large number of bacteria. These organisms are probably the anaërobe, which is quite constant, as shown by cultures made direct from the intestine into glucose agar (Liborius's method).

When a loopful of the material from the intestine was used for the inoculation, the following data give the approximate findings:

Bee No. 1, 300 to 400 yellow colonies, probably alike.
Bee No. 2, a few colonies of fungi only.
Bee No. 3, 500 colonies, mostly yeast.
Bee No. 4, 100 or more colon-like colonies.
Bee No. 5, 2,000 or more, mostly yellow.
Bee No. 6, 20 or more colonies, mostly yeasts.
Bee No. 8, 400 or more yellow colonies.
Bee No. 9, 30 yeasts with a few fungi.
Bee No. 10, 50 yeast colonies with a few fungi.
Bee No. 11, no growth.
Bee No. 12, 300 colonies, slightly yellow.

Bee No. 13, 2,000 or more gray colonies.

Bee No. 14, yeast colonies and a few colonies of bacteria showing ground-glass appearance.

Bee No. 15, 2,000 or more colon-like colonies (*B. cloacæ*).

The following are the species which have been found to be most constant. The reader is referred also to the description of the yeast plant found very frequently in the intestine of the normal honey bee, described under " Saccharomyces and fungi."

Bacterium D.

Occurrence.—Frequent in the intestine of the healthy honey bee.

Agar colony.—Deep colonies when magnified are coarsely granular, showing a dark brown center, with a thin and ill-defined border.

Morphology.—A preparation made from a young culture taken from a glucose fermentation tube shows rods with rounded ends, occurring singly and in pairs, staining easily and uniformly with carbol-fuchsin, and measuring 0.7μ to 1.5μ in length and 0.5μ to 0.7μ in thickness.

Motility.—No motility could be observed.

Spores.—No spores could be demonstrated in young cultures. In old cultures their presence is questionable.

Oxygen requirements.—Strictly anaërobic.

Bouillon.—In straight tubes no growth occurs.

Glucose.—A moderate cloudiness can be seen in the closed arm, while the open bulb remains clear. No gas is produced. Reaction about neutral.

Glucose agar (Liborius's method).—Growth is rather slow. After 3 days a moderate growth may be observed; later, if cultures have recently been isolated from the bee's intestine, the growth imparts to the medium a diffused haziness or cloudiness. After many generations the culture loses this property.

Glucose gelatin (Liborius's method).—Very slow growth occurs in the depth of the medium. No liquefaction takes place.

Bacillus cloacæ.

Occurrence.—Found in the intestine of a large number of healthy honey bees.

Gelatin colonies.—Superficial colonies are thin and blue to gray in color; deep colonies, brown, regular, granular, and spherical to lenticular.

Agar colonies.—Superficial colonies are partially opaque, brown, finely granular, with well-defined margin; deep colonies are regular, spherical, or lenticular, with well-defined margin.

Morphology.—The rods from 24-hour agar cultures have rounded ends, varying in length from 1μ to 2μ and in width from 0.7μ to 0.9μ. They are usually found singly or in pairs. Involution forms are not uncommon. With carbol-fuchsin they stain uniformly. This species possesses a few peritrichic flagella.

Motility.—Active motility is observed in young cultures.

Spores.—No spores are formed.

Gram's stain.—The bacillus does not take Gram's stain.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—A uniform cloudiness appears in 24 hours. Growth continues until the medium becomes heavily clouded, followed by a gradual settling of many of the organisms, forming a viscid grayish-white sediment. A gray friable membrane, which adheres to the sides of the tube at the surface of the medium, is sometimes produced. Upon agitation this membrane breaks up and sinks to the bottom, leaving a gray ring of the growth adhering to the glass. Reaction alkaline.

Glucose.—The medium in the bulb becomes turbid, while that in the closed arm is uniformly cloudy. A heavy grayish-white sediment is formed. The reaction is at first slightly acid, but in a few days becomes alkaline. Abundant and rapid gas formation takes place, filling usually from one-half to nine-tenths of the closed arm. The ratio of hydrogen to carbon dioxid is approximately 1 to 2; that is, the ratio of hydrogen to carbon dioxid is less than 1.

Lactose.—In this medium gas formation takes place more slowly than in glucose. At the end of 8 days one-fourth of the closed arm is filled with gas. The ratio of hydrogen to carbon dioxid is greater than 1. Reaction acid.

Saccharose.—Gas is formed abundantly and rapidly; more than one-half of the tube is usually filled with gas. The ratio of hydrogen to carbon dioxid is less than 1. Reaction alkaline.

Levulose.—A rapid fermentation takes place; more than one-half of the closed arm is filled with gas. The ratio of hydrogen to carbon dioxid is approximately 1 to 5; that is, less than 1. A slight formation of acid takes place at first, but the reaction rapidly becomes alkaline.

Maltose.—Formation of gas takes place with the result that at the end of 5 days approximately one-half of the tube is filled. The ratio of hydrogen to carbon dioxid will approximate that of 1 to 1. Reaction acid.

Mannite.—Gas is formed rapidly and abundantly; at the end of 5 days the closed arm is usually much more than half filled with the gas. The reaction is at first slightly acid, but soon becomes alkaline. The ratio of hydrogen to carbon dioxid is approximately 1 to 2; that is, less than 1.

Potato water.—Gas forms rapidly and fills half the closed arm. The ratio of hydrogen to carbon dioxid is as 1 to 2; that is, less than 1.

Agar slant.—A moderate, grayish-white, glistening, friable growth appears along the line of inoculation, which usually spreads to the sides of the tube.

Serum.—Moderate gray growth appears, which is confined quite closely to the line of inoculation. Liquefaction takes place slowly after 3 weeks.

Potato.—A moderate amount of gray fleshy growth covers the slope. The potato is slightly discolored.

Milk.—Coagulation takes place after 4 days' growth. Gas is formed.

Litmus milk.—A marked production of acid takes place, followed by firm coagulation.

Gelatin.—A heavy white growth takes place along the line of inoculation; the surface growth is flat, bluish-white, and spreads with an uneven margin. Slow infundibuliform liquefaction takes place after 2 weeks.

Acid agar.—A growth takes place.

Indol.—A trace is sometimes produced.

Nitrates.—Reduction to nitrites is positive.

B. coli communis.

Occurrence.—Found in the intestine of healthy honey bees.

Gelatin colonies.—The superficial colonies are blue, lobate-lobulate, and slightly spreading; when magnified they are brownish yellow in the center and more transparent toward the margin; the deep colonies are spherical to lenticular and brownish yellow, with well-defined borders.

Morphology.—The short rods with rounded ends measure 1.5μ to 2μ in length and 0.7μ to 0.8μ in thickness. They occur singly or in pairs, stain uniformly, and are motile by means of a few peritrichic flagella.

Motility.—The bacilli are actively motile from some cultures.

Spores.—No spores are formed.

Gram's stain.—The bacillus is decolorized by Gram's method.

Oxygen requirements.—It is a facultative anaërobe.

Bouillon.—The medium becomes uniformly clouded in 24 hours, with a slight acid reaction; the medium later becomes alkaline, with a gray and friable sediment. A feeble pellicle is formed and a growth of the organism often adheres to the glass at the surface of the liquid.

Glucose.—Both branches of the fermentation tube become clouded. The sugar splits by fermentation into gas and acid, one-half or more of the closed arm being filled. The ratio of hydrogen to carbon dioxid is 2 to 1.

Lactose.—Gas fills one-fourth of the closed tube. Reaction acid.

Saccharose.—Gas fills one-sixth of the closed tube. Reaction acid.

Levulose.—Gas fills one-half of the closed tube. The value of hydrogen to carbon dioxid is 2 to 1. Reaction acid.

Maltose.—One-sixth of the closed arm is filled with gas. Reaction acid.

Mannite.—One-half of the closed tube is filled with gas. Reaction acid.

Potato water.—Reaction acid.

Agar slant.—A moderate, gray, nonviscid, spreading growth takes place on the surface of the inclined agar.

Serum.—A gray, glistening, nonspreading growth is observed on the inclined serum. No liquefaction takes place.

Potato.—A moderate, fleshy, glistening growth spreads over the inoculated surface. Potato slightly discolored.

Milk.—Coagulation of the casein takes place in about 4 days. A small quantity of gas is produced.

Litmus milk.—Coagulation occurs. Reaction strongly acid.

Gelatin.—A moderate growth occurs along the line of inoculation; the growth is spreading with an irregular margin on the surface. No liquefication occurs.

Acid agar.—A moderate grayish growth occurs on surface.

Indol.—A trace was obtained in some cultures.

Nitrates.—Reduced to nitrites.

B. choleræ suis.

Occurrence.—Isolated from the intestine of healthy honey bees.

Gelatin colonies.—Colonies are translucent by transmitted light; bluish to gray by reflected, the border being uneven and well defined. When the colonies are magnified they appear brownish and finely granular.

Morphology.—The rods are short, with rounded ends, occurring singly and in pairs, and staining uniformly with carbol-fuchsin, 1 to 2.8μ in length, and 0.6μ to 0.8μ in thickness. A few peritrichic flagella are present.

Motility.—Usually only a few are motile at a time in the field, and these present a rapid whirling motion.

Spores.—No spores are formed.

Gram's stain.—The bacteria are decolorized by Gram's stain.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—A uniform, moderate cloudiness arises in this medium in 24 hours; later a grayish-white membrane is formed which, upon shaking the tube, sinks to the bottom, forming a gray sediment. The reaction is at first slightly acid, but later becomes alkaline.

Glucose.—The medium becomes clouded in both arms of the fermentation tube, with the production of a small amount of gas. Reaction acid.

Lactose.—Growth takes place in both arms of the tube, but the sugar is not split into either acid or gas.

Saccharose.—Growth occurs in both arms of the tube, neither acid nor gas being formed.

Levulose.—Growth takes place in both arms with the production of gas and acid; one-third of the closed arm is filled. The ratio of hydrogen to carbon dioxid is about 3 to 1—that is, greater than 1.

Maltose.—The medium in both arms of the tube becomes clouded. Fermentation results in the production of gas sufficient to fill about one-fifth of the tube. Only a small portion of the gas is absorbed by sodium hydroxid, leaving behind an explosive gas.

Mannite.—The medium in both branches of the tube becomes clouded; gas is not formed. Reaction alkaline.

Potato water.—About one-fifth of the closed arm is filled with gas. Reactión acid.

Agar slant.—A moderate, grayish-white, glistening, nonspreading growth is formed along the surface inoculated with the loop.

Serum.—A moderate, gray, glistening, nonspreading growth takes place on the inclined surface. No liquefaction occurs.

Potato.—A feeble, grayish growth is observed. The potato becomes slightly discolored.

Milk.—No coagulation occurs, and no gas is produced. Reaction alkaline.

Litmus milk.—The medium slowly becomes more and more alkaline.

Gelatin.—A moderate, white growth takes place along the line of inoculation. On the surface it spreads with irregular margin. No liquefaction occurs.

Acid agar.—A moderate growth appears.

Indol.—Indol is produced.

Nitrates.—Reduction to nitrites (?).

Bacillus E.

Occurrence.—Isolated from the intestine of healthy honey bees.

Gelatin colonies.—The colonies are lemon-yellow. Surface colonies are convex, smooth, with entire margin; when magnified they are finely granular. Deep colonies, when magnified, are lenticular, finely granular, and may appear dark green. Liquefaction takes place slowly.

Morphology.—The rods are short, with rounded ends, and usually occur singly. The bacilli are 1.5μ to 2μ in length and 0.7μ in thickness. This species possesses a few peritrichic flagella.

Motility.—The bacteria are actively motile.

Spores.—No spores are present.

Gram's stain.—They stain with Gram's stain.

Oxygen requirements.—Aërobic.

Bouillon.—The medium becomes uniformly clouded in 24 hours. Later a tough, yellowish-white membrane is formed, which sinks upon shaking. The medium is very viscid in old cultures. Reaction alkaline.

Glucose.—Growth is confined to the open bulb. No gas formation occurs. Reaction slightly acid.

Lactose.—There is a marked mucous-like appearance in the medium. Reaction alkaline.

Saccharose.—Reaction acid.

Levulose.—Reaction alkaline.

Maltose.—Reaction alkaline.

Mannite.—Reaction slightly acid.

Potato water.—Reaction alkaline.

Agar slant.—A moderate, yellowish-gray, nonviscid growth takes place on the surface.

Serum.—A strong growth takes place and the medium is liquefied.

Potato.—A yellowish-gray, nonviscid growth is observed over the entire inclined surface.

Milk.—Precipitation of casein takes place with very slight digestion (?).

Litmus milk.—Precipitation of the casein occurs. Reaction alkaline.

Gelatin.—A white growth forms along the line of inoculation, which becomes slowly liquefied from above.

Acid agar.—A moderate, slightly yellow growth is observed.

Indol.—None demonstrated.

Nitrates.—No reduction to nitrites occurs.

Bacillus subgastricus.

Occurrence.—Isolated from the intestine of a healthy honey bee.

Gelatin colony.—The colon-like, superficial colonies are thin, blue, spreading, and lobate-lobulate. When magnified they are finely granular, with brown center. Deep colonies are spherical and yellow.

Morphology.—Short rods, singly and in pairs, are from 1.5μ to 2.5μ long and from 0.6μ to 0.8μ thick. They stain uniformly with carbol-fuchsin.

Motility.—Marked whirling motion from gelatin cultures.

Spores.—No spores could be demonstrated.

Gram's stain.—The bacilli are decolorized with Gram's stain.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—This medium becomes clouded in 24 hours. A slight band of growth is formed on the glass at the surface of the liquid. Later a feeble pellicle is sometimes formed. Reaction at first slightly acid, later becomes alkaline.

Glucose.—The medium in both branches of the tube becomes clouded. Gas is readily formed until about one-fourth of the closed branch is filled. The ratio of hydrogen to carbon dioxid is 2 to 1—that is, greater than 1. Reaction strongly acid.

Lactose.—Gas formation occurs. About one-sixth of the tube is filled with gas, part of which is absorbed by sodium hydroxid and another part is explosive. Reaction acid.

Saccharose.—This sugar is fermented to the point of formation of acid, but no gas is formed.

Levulose.—This sugar splits in the process of fermentation to form acid and gas, the gas filling about one-sixth of the tube. A portion of the gas is absorbed by sodium hydroxid, the remainder being explosive.

Maltose.—Fermentation takes place with the formation of acid. No gas is produced.

Mannite.—One-fifth of the closed arm is filled with gas. A portion of the gas is absorbed by sodium hydroxid and a portion is explosive. Reaction acid.

Potato water.—Reaction alkaline.

Agar slant.—A moderate, translucent, gray, nonviscid and glistening growth spreads slowly from the surface inoculated with the loop.

Serum.—A moderate, glistening growth appears along the surface inoculated. No liquefaction occurs.

Potato.—A grayish growth takes place on the sloped surface.

Milk.—Firm coagulation of the milk takes place with the formation of a small amount of clear serum. A small amount of gas is produced.

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Litmus milk.—Reaction strongly acid. Coagulation occurs in about six days.

Gelatin.—White, spherical colonies appear along the line of inoculation. The surface growth is grayish blue and spreading, with irregular margin. Slow liquefaction takes place, beginning usually in 2 weeks.

Acid agar.—A growth takes place.

Indol.—None could be demonstrated.

Nitrates.—No reduction to nitrites occurs.

Bacterium mycoides.

Occurrence.—Isolated from the intestine of a healthy honey bee.

Gelatin colonies.—A rapid growth of root-like colonies appears in 24 hours. In macroscopic appearance it somewhat resembles cotton fibers; when magnified these appear thick and somewhat felted in the center, while toward the margin they are beautifully filamentous. After a day or two the gelatin begins to liquefy.

Morphology.—The rods are large, scarcely rounded at the ends, and frequently in chains. They measure from 2.5μ to 5.5μ long and 1.5μ thick. No flagella have been demonstrated.

Motility.—No motility could be demonstrated.

Spores.—Spores are present.

Gram's stain.—The bacteria are not decolorized by Gram's stain.

Oxygen requirements.—Facultatively anaërobic.

Bouillon.—A decided fleecy growth with heavy, cotton-like sediment occurs.

Glucose.—No gas is formed. Reaction acid.

Lactose.—Reaction acid.

Saccharose.—Reaction acid.

Levulose.—Reaction acid.

Maltose.—Reaction acid.

Mannite.—Reaction acid.

Potato water.—Reaction alkaline.

Agar slant.—A luxuriant growth that appears root-like takes place on this medium. This growth tends to extend into the agar, which causes it to adhere to the medium.

Serum.—A luxuriant growth is formed, accompanied by liquefaction.

Potato.—A thick, gray, moist growth is found, the potato not being discolored.

Milk.—Coagulation occurs promptly, with formation of a clear serum.

Litmus milk.—The color is discharged in 48 hours.

Gelatin.—Hair-like outgrowths occur along the line of inoculation. Liquefaction begins at the surface and proceeds along the needle tract. In a few days the entire medium is liquefied.

Indol.—No indol is produced.

Nitrates.—Reduction to nitrites is positive.

Pseudomonas fluorescens liquefaciens.

Occurrence.—Isolated from the intestine of the healthy honey bee.

Gelatin colonies.—Before liquefaction, the superficial colonies, when magnified, are finely granular, with regular margin; deep colonies are spherical, brown, with regular margin. Liquefaction takes place rapidly. The surface of liquefied gelatin is covered by a friable membrane. Later the liquefied gelatin takes on a green fluorescence.

Morphology.—The bacteria are short rods, varying from 1μ to 2μ in length and from 0.5μ to 0.7μ in thickness. They stain uniformly with carbol-fuchsin and are motile by means of one or more polar flagella.

Spores.—No spores could be demonstrated.

Gram's stain.—The bacteria do not take Gram's stain.

Oxygen requirements.—Aërobic

Temperature requirements.—Culture must be grown at room temperature.

Bouillon.—The medium becomes clouded in 48 hours, forming a moderately tough pellicle. A greenish-yellow fluorescence begins at the surface, which gradually increases until the entire medium takes on that appearance. Reaction alkaline.

Glucose.—A cloudiness is formed in the open arm, but the closed arm is clear. Reaction alkaline.

Lactose.—Reaction alkaline.

Saccharose.—Reaction alkaline.

Levulose.—Reaction alkaline.

Maltose.—Reaction alkaline.

Mannite.—Reaction alkaline.

Agar slant.—At first a gray friable growth is formed confined to the surface inoculated, which later takes on a brown hue. Greenish-yellow fluorescence is observable in the medium.

Serum.—A slow liquefaction occurs.

Potato.—Very scanty growth occurs with slight discoloration.

Milk.—Rapid liquefaction of the casein takes place.

Litmus milk.—Rapid liquefaction of the casein takes place. Reaction alkaline.

Gelatin.—Infundibuliform liquefaction takes place rapidly.

Acid agar.—No growth occurs.

Indol.—No indol observed.

Nitrates.—No reduction to nitrites occurs.

SACCHAROMYCES AND FUNGI.

The first yeast plant described below is of very frequent occurrence in the intestine of the normal bee. *Saccharomyces roseus* can be isolated from the comb. A large number of common fungi were found in the flora of the intestines and in cultures from the pollen and combs.

In addition to the above the third Saccharomyces here described was found in two samples of brood apparently diseased, which could not be diagnosed as any disease commonly known.

Saccharomyces F.

Occurrence.—Very common in the intestine of healthy honey bees.

Gelatin colonies.—Colonies form slowly; the superficial colonies are white, glistening, convex, capitate, and about 1 to 2 millimeters in diameter. When magnified they are finely granular, brownish yellow, with entire margin. Deep colonies are finely granular, with uniform margin, spherical to lenticular, and brownish green.

Morphology.—The cells are oval and on agar in 24 hours attain their full size of 4.5μ in length and 3.5μ in thickness. They stain uniformly with carbol fuchsin.

Motility.—The yeast is not motile.

Gram's stain.—The cells take the Gram's stain.

Oxygen requirements.—Aërobic

Bouillon.—This medium remains clear, with the formation of a friable white sediment. Reaction neutral.

Glucose.—The closed arm remains clear. No gas is formed. Reaction acid.

Lactose.—Reaction neutral.

Saccharose.—Reaction neutral.

Levulose.—Reaction neutral.

Maltose.—Reaction neutral.

Mannite.—Reaction neutral.

Agar.—A white, nonspreading growth occurs.

Serum.—White, moderate, nonviscid, nonspreading growth occurs along the surface inoculated. No liquefaction takes place.

Potato water.—Reaction neutral.

Potato.—Gray, luxuriant, fleshy growth occurs.

Milk.—No change occurs.

Litmus milk.—No change occurs.

Gelatin.—A moderate growth is formed, accompanied by no liquefaction.

Acid agar.—Moderate growth takes place.

Indol.—Negative.

Nitrates.—Reduced to nitrites.

Saccharomyces roseus.

Occurrence.—Isolated from comb of healthy hive.

Gelatin colonies.—Superficial colonies are pink, convex, capitate, with lobate-lobulate margin; when magnified, the deep colonies are irregular, brownish-yellow, and finely granular.

Morphology.—This cell is oval, attaining about 6.5μ in length and 3.5μ in thickness. The cells stain uniformly.

Motility.—No motility occurs.

Gram's stain.—The cells are not decolorized by Gram's stain.

Oxygen requirements.—Aërobic.

Bouillon.—This medium remains clear, forming a pink, friable sediment. A pink band forms at the surface of the medium and adheres to the glass.

Glucose.—The closed arm remains clear. No gas is formed. Reaction acid.

Lactose.—Reaction neutral.

Saccharose.—Reaction neutral.

Levulose.—Reaction slightly acid.

Maltose.—Reaction slightly acid.

Mannite.—Reaction neutral.

Potato water.—Reaction acid.

Glucose agar.—Luxuriant, red growth forms on the surface.

Serum.—A pink, fleshy, nonspreading growth is formed, accompanied by no liquefaction.

Potato.—A thick, nonspreading, red growth occurs.

Milk.—No apparent change takes place. The milk coagulates on boiling.

Litmus milk.—Reaction alkaline.

Gelatin.—Moderate pink growth is formed, accompanied by no liquefaction.

Acid agar.—Slow growth occurs.

Indol.—Negative.

Nitrates.—Reduction to nitrites is positive.

Saccharomyces G.

Occurrence.—Found in the dead larvæ of diseased adult bees.

Morphology.—They appear in hanging-drop preparation in large clusters, stain uniformly with carbol-fuchsin and are oval, nearly spherical, attaining the length of 4.5μ and thickness of 3.5μ.

Gram's stain.—The cells are not decolorized by Gram's stain.

Oxygen requirements.—Aërobic.

Bouillon.—A slight, friable, white sediment is formed, with a clear medium above. Reaction slightly acid.

Glucose.—The medium in the closed arm remains practically clear and about one-fifth of the closed arm is filled with gas. Reaction acid.

Lactose.—Reaction neutral.

Saccharose.—Reaction neutral.

Levulose.—Reaction slightly acid.

Maltose.—Reaction slightly acid.

Mannite.—Reaction neutral.

Potato water.—Reaction acid.

Agar.—A moderate, white growth is formed.

Serum.—Very feeble growth occurs, accompanied by no liquefaction.

Potato.—A luxuriant, moist, white growth occurs.

Milk.—No appreciable change takes place.

Litmus milk.—No appreciable change takes place.

Gelatin.—A moderate, white growth occurs along needle tract and on the surface. No liquefaction results.

Acid agar.—A feeble white growth occurs.

Indol.—None could be demonstrated.

Nitrates.—No reduction to nitrites occurs.

Glucose agar.—A thick, white, fleshy growth occurs.

TABULATION OF MICRO-ORGANISMS NORMALLY PRESENT IN THE APIARY.

The following table will serve to summarize the descriptions of the micro-organisms considered in the foregoing pages:

Species.	Biology. Morphology. Dimensions in microns. Length.	Thickness.	Motility.	Spores. Position in rod.	Spores. Germination.	Stain by grams.	Growth at room temperature.	Growth at 37° C.	Oxygen requirements.	Physiology. Cultural features. Gelatin colonies. Colon-like.	Gelatin colonies. Entire.	Gelatin colonies. Curled.	Bouillon. Membrane.	Bouillon. Cloudy.	Agar.	Serum.	Potato. Degree.	Potato. Discolored.	Gelatin.	Biochemic properties. Growth on acid agar.	Milk. Coagulation.	Milk. Lit. discharged.	Chromogenesis. Potato.	Chromogenesis. Agar.	Fluorescence. Agar.	Liquefaction. Gelatin.	Liquefaction. Casein.	Liquefaction. Serum.	Gas production. Glucose.	Gas production. Lactose.	Gas production. Saccharose.	Gas production. Levulose.	Gas production. Maltose.	Gas production. Mannite.	Gas production. Potato.	Gas production. Milk.	Acid production. Glucose.	Acid production. Lactose.	Acid production. Saccharose.	Acid production. Levulose.	Acid production. Maltose.	Acid production. Mannite.	Acid production. Potato.	Acid production. Milk.	Milk alkaline.	Nitrate to nitrite.	Indol.	Remarks.
Bacillus A	3 –4	0.9–1.2	+	1	..	+	+	+	2	..	..	+	+	..	+	+	3	1	+	+	1	+	—	—	—	+	+	—	—	..	..	..	..	..	..	..	—	—	—	+	+	—	—	—	+	+	—	B. mesentericus (?).
Bact. acidiformans	1.6	.8	—	—	—	—	+	+	2	..	+	..	—	+	+	+	2	—	+	+	3	—	—	—	—	—	—	—	—	..	..	..	..	..	..	..	+	+	—	+	+	+	+	+	—	—	+	
Bacillus B	1 –2	....	+	—	—	—	+	+	2	..	+	..	+	+	+	+	2	1	+	..	3	—	+	+	—	+	—	..	—	..	..	..	..	..	..	..	—	—	—	—	+	+	..	—	+	—	—	
Bact. cyaneus	.8–1.7	.7– .8	—	—	—	+	+	+	1	..	+	..	—	+	+	+	2	..	+	..	1	+	+	+	—	+	+	+	—	..	..	..	..	..	..	..	—	—	—	—	—	—	—	—	+	—	—	
Micrococcus C	.8	.8	—	..	..	+	+	+	1	..	+	..	—	+	+	+	2	1	+	+	2	+	—	—	—	+	+	+	—	..	..	..	..	..	..	..	+	+	+	+	+	+	+	+	—	+	+	Indol trace.
Bacterium D	.7–1.5	.5– .7	—	—	—	..	+	+	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—	..	..	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Spores (?).
B. cloacæ	1 –2	.7– .9	+	—	—	—	+	+	2	+	..	..	+	+	+	+	2	1	+	+	+	—	—	—	—	+	—	..	+	+	+	+	+	+	+	+	—	+	—	—	+	—	..	+	—	+	—	Indol (?).
B. coli communis	1.5–2	.7– .8	+	—	—	—	+	+	2	+	..	..	+	+	+	+	2	1	+	+	+	—	—	—	—	—	—	—	+	+	+	+	+	+	..	+	+	+	+	+	+	+	+	+	—	+	+	Indol trace.
B. choleræ suis	1 –2.8	.6– .8	+	—	—	—	+	+	2	+	..	..	+	+	+	+	1	1	+	+	—	—	—	—	—	—	—	—	+	—	—	+	+	—	+	—	+	—	—	+	..	—	+	—	+	?	+	
Bacillus E	1.5–2	.7	+	—	—	+	+	+	1	..	+	..	+	+	+	+	2	..	+	+	1	..	+	+	—	+	?	+	—	..	..	..	..	..	..	..	+	—	+	—	—	+	—	—	+	—	—	
B. subgastricus	1.5–2.5	.6– .8	+	—	—	—	+	+	2	+	..	..	+	+	+	+	2	..	+	+	+	—	—	—	—	+	—	—	+	+	—	+	—	+	..	+	+	+	+	+	+	+	—	+	—	—	—	
Bact. mycoides	2.5–5.5	1.5	?	+	..	+	+	+	2	..	..	+	+	..	+	+	3	—	+	..	2	+	—	—	—	+	..	..	—	..	..	..	..	..	..	..	+	+	+	+	+	+	—	..	..	+	—	
Ps. fluor. lique	1 –2	.5– .7	+	—	—	—	+	—	1	..	+	..	+	+	+	+	1	1	+	—	1	..	—	—	+	+	+	+	—	..	..	..	..	..	..	..	—	—	—	—	—	—	..	—	+	—	—	
Saccharomyces F	4.5	3.5	—	..	..	+	+	+	1	..	+	..	—	—	+	+	3	..	+	+	—	—	—	—	—	—	—	—	—	..	..	..	..	..	..	..	+	—	—	—	—	—	—	—	—	+	—	
Saccharomyces roseus	6.5	3.5	—	..	..	+	+	+	1	..	+	..	—	—	+	+	3	—	+	+	3	..	+	+	—	—	—	—	—	..	..	..	..	..	..	..	+	—	—	+	+	—	+	—	+	+	—	
Saccharomyces G	4.5	3.5	—	..	..	+	+	+	1	..	..	..	—	—	+	+	3	—	+	+	—	—	—	—	—	—	—	—	+	..	..	..	..	..	..	..	+	—	—	+	+	—	+	—	—	—	—	

SUMMARY TO PART I.

The results of the study of the bacteria found normally in the apiary may be briefly summarized as follows:

(1) The temperature of the hive approximates that of warm-blooded animals.

(2) Upon adult bees and upon the comb there occurs quite constantly a species of bacteria which we refer to in this paper as *Bacillus A*, and which, it is believed, is the organism that some workers have confused with *Bacillus alvei*, the cause of European foul brood (p. 33).

(3) There occurs very constantly in the pollen and intestine of adult bees a species here referred to as *Bacillus B*.

(4) From the combs *Bacterium cyaneus*, *Saccharomyces roseus*, and a Micrococcus referred to here as *Micrococcus C*, have been isolated and studied.

(5) Honey from a healthy hive is, as a rule, sterile.

(6) The normal larvæ are, as a rule, sterile.

(7) There is an anaërobe found quite constantly in the intestine of the healthy honey bee. It is referred to in this paper as *Bacterium D*.

(8) From the intestine there have been isolated and studied the following micro-organisms: *Bacillus cloacæ*, *Bacillus coli communis*, *Bacillus choleræ suis*, *Bacillus subgastricus*, *Bacterium mycoides*, *Pseudomonas fluorescens liquefaciens*, and two referred to as *Bacillus E*, and *Saccharomyces F*. Others less frequently present have been isolated, but not studied.

(9) In two samples of brood with unknown disease there was found a species of yeast plant here referred to as *Saccharomyces G*.

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PART II.—THE DISEASES OF BEES.

The bee industry in this country, and other countries as well, is suffering large losses from various diseases among bees. Those which are most destructive attack the brood and weaken the colony by killing off large numbers of the young larvæ which would otherwise mature. There are other diseases which attack the adults and so decrease the strength of the colony in that way.

In order to combat a disease to the best advantage it is clear that its cause must be known, as well as the means by which the infection is transmitted and the environmental conditions which are favorable for the breaking out of an epidemic. The brood diseases among bees are on the increase. The custom of selling and shipping the honey, which is now carried on more extensively than formerly, the manner in which the products of the apiary are handled, and the absence of a general knowledge by the mass of bee keepers of the nature of the diseases are conditions which must be met before the spread of these diseases can be checked. When a colony is diseased, very little or no profit is realized from it; consequently the wealth and comfort of a very large number of people are greatly endangered by the existence of bee diseases. This suggests the importance, from an economic standpoint, of a thoro knowledge of these disorders.

BRIEF HISTORY.

The attention of investigators has been attracted by these diseased conditions, not only from the economic interests attached thereto, but from the scientific point of view as well. The writings of Aristotle (12) contain an account of certain disorders which were then prevalent among bees; at that time it was thought that the blight of flowers bore a relation to bee diseases. In 1769 Schirach (13) gave the name foul brood to a diseased condition of the brood of bees; he attributed the cause to (*a*) unwholesome food, and (*b*) the placing of the larvæ with head inward in the cell. Leuckhart (14) thought the cause to be a fungus, related to the cause (*Panhistophyton ovatum*) of the disease of the silkworm. Muhlfeld (15), in 1868, thought the trouble to be of two kinds—infectious and noninfectious—and that the cause of the infectious one is the larva of a parasitic fly (*Ichneumon apium mellificarium*) feeding upon the larvæ of the bee. In 1868 Preuss (16) exprest the view that the cause of foul brood is a fermenting fungus belonging to the genus Cryptococcus. Geilen (17), in 1868, thought that when bees alight on the remains of animal bodies the putrefying matter thus carried with them may cause foul brood. The fermentation of bee bread was thought by Lambrecht (18) to be a sufficient cause of the disease; while Hallier (19) thought that various fungi could produce the disorder. On the contrary, Cornallia (20), in 1870, exprest the opinion that a fungus (*Cryptococcus alvearis*) is the specific cause of the trouble. Fischer (21), in 1871, supposed that a predisposing factor of foul brood is to be found in insufficient nourishment. In 1874 Cohn and Eidem received from Schonfeld samples of foul brood and, upon examination, they found spores and rods. In 1885 Cheshire and Cheyne (22) determined the cause and named the germ *Bacillus alvei*. Dickel (23) claimed that a number of different species might be the cause of foul brood. In 1900 Harrison (24) writes on foul brood and *Bacillus alvei*, its cause. Doctor Lambotte (25), in 1902, made some interesting studies concerning the relation of *Bacillus alvei* and *Bacillus mesentericus vulgatus*.

Since so many conflicting views have been held as to the cause of foul brood, one might conclude that the term " foul brood " has been applied incorrectly to a number of different disorders. In the light of more recent work this supposition is strengthened.

In June, 1902, the author, under the direction of Dr. Veranus A. Moore, began an investigation of bee diseases, especially as they existed in New York State. There were recognized at that time by bee inspectors of that State a number of distinct diseases which attacked the brood. Those which caused the greatest loss to the apiarists were known to the bee experts as "black brood," "foul brood," and "pickle brood." The results of the investigations of 1902 (26), 1903 (27), and 1904 (28) on these disorders, and on palsy or paralysis, are embodied in the following pages.

THE TERM "FOUL BROOD" AS HITHERTO APPLIED.

In the discussion of foul brood of bees it must be remembered that until recent years the name has been applied to what is now known to be two distinct diseases.

Schirach, in 1769, gave the name foul brood to a diseased condition in the brood of bees, but it is impossible to know to which of the two he referred. It may be that both diseases existed then as now and that he did not observe the fact that the two were different. We have reason to think that there are, at the present time in Europe, two distinct diseases to which the name foul brood is being applied. It is definitely known that such is the case in America.

It becomes necessary, then, to have two names to designate these two diseased conditions in the brood of bees. For reasons given by Dr. E. F. Phillips, in the preface to this paper, it has been considered advisable to retain the name foul brood and to use a qualifying word to distinguish the two diseases. "European foul brood" and "American foul brood" are the names by which these two diseased conditions are to be designated.

In 1885 Cheyne (22) in England (Europe) found present in the decayed larvæ suffering from a diseased condition known as "foul brood" a new bacillus, which he named *Bacillus alvei* and to which he ascribed the cause of the disease. The diseased condition which contains *Bacillus alvei* is to be called "European foul brood," because this fact was first observed by an investigator working in Europe (England). In 1903 (27) the author observed that there was constantly present in the other diseased condition known as "foul brood" another bacillus which was new, and to which the name *Bacillus larvæ* is given. In view of the fact that *Bacillus larvæ* was constantly found to be present in the larvæ suffering from this disorder in the brood of bees, by investigations carried on in New York State (America) (27) (28), this diseased condition is to be called "American foul brood." From a scientific standpoint this choice of names for two distinct diseases might be easily criticized, but from the standpoint of the apiarist the selection of these names as the common ones for these two distinct disorders seemed almost necessary, or at least advisable.

EUROPEAN FOUL BROOD (FOUL BROOD OF CHEYNE).

The first scientific investigation of this disease bacteriologically was performed by Cheyne in 1885 (22). At this time he isolated a new bacillus from the dead larvæ. It was described by him and given the name *Bacillus alvei* (literally, hive bacillus). This afforded, then, a means for a positive diagnosis of this diseased condition.

Symptoms.

The symptoms of European foul brood, as given by Dr. E. F. Phillips in Circular No. 79, Bureau of Entomology, are as follows:

Adult bees in infected colonies are not very active, but do succeed in cleaning out some of the dried scales. This disease attacks larvæ earlier than does American foul brood, and a comparatively small percentage of the diseased brood is ever capped; the diseased larvæ which are capped over have sunken and perforated cappings. The larvæ when first attacked show a small yellow spot on the body near the head and move uneasily in the cell; when death occurs they turn yellow, then brown, and finally almost black. Decaying larvæ which have died of this disease do not usually stretch out in a long thread when a small stick is inserted and slowly removed; occasionally there is a very slight "ropiness," but this is never very marked. The thoroly dried larvæ form irregular scales which are not strongly adherent to the lower side wall of the cell. There is very little odor from decaying larvæ which have died from this disease, and when an odor is noticeable it is not the "glue pot" odor of American foul brood, but more nearly resembles that of soured dead brood. This disease attacks drone and queen larvæ very soon after the colony is infected. It is, as a rule, much more infectious than American foul brood and spreads more rapidly. On the other hand, it sometimes happens that the disease will disappear of its own accord, a thing which the author never knew to occur in a genuine case of American foul brood. European foul brood is most destructive during the spring and early summer, often almost disappearing in late summer and autumn.

Confusion Regarding Foul Brood in America.

Prof. J. J. Mackenzie in 1882 made what seems to have been a short study of a bee disease as it appeared in Ontario, Canada, which was known to the apiarists of that Province as foul brood. He says very little of the character of the species of bacteria with which he was working, but he supposed that they were *Bacillus alvei* of Cheyne. The author has examined samples of brood from Ontario which have what, in the opinion of bee experts, is the most prevalent disease, and has not found *Bacillus alvei* present in any one. The bacteriological findings and the experience of bee-disease experts show that American foul brood is the prevalent disease in that Province. As the bee experts see the disease in the light of recent studies, there is no authentic report of which we are aware that European foul brood exists in Ontario. We can safely say, then, that *Bacillus alvei* can not be isolated from larvæ taken from the prevalent disease in the above-named Province. No difficulty is exprest on the part of Professor Mackenzie in the isolation of *Bacillus alvei* from any sample. The author is inclined to think, therefore, that this investigator was in error as to the identity of his culture, and therefore his conclusion can have little weight.

The foul brood of bees received some attention also from Prof. F. C. Harrison, of Ontario. In a paper of some length he gives a description of a species of bacteria which he identified as *Bacillus alvei*. The description which he gives and the accompanying photomicrographs (another plate which was given being after Cheyne and correct for *Bacillus alvei*) might easily be that of a member of a group represented by and described as *Bacillus* "*A*" in Part I of this paper. He also says that he has isolated *Bacillus alvei* from diseased larvæ from 13 States of the Union, ranging from New York to California and from Michigan to Florida. European foul brood has had a very limited geographical distribution, spreading only recently from New York to adjoining States. In Professor Harrison's work, too, there seems to have been no difficulty in isolating *Bacillus alvei* from diseased brood diagnosed by bee inspectors as foul brood thruout the United States and Canada. In the experience of the author it has not been possible to obtain *Bacillus alvei* from diseased brood which the inspectors in most of the States and in Canada have been calling foul brood. For the above reasons the author believes that Harrison, too, has made a serious error in the identity of his culture and therefore was not working with *Bacillus alvei* at all. The author considers himself unfortunate in that he was unable to obtain a culture of *Bacillus alvei* for study and identification from Professor Harrison.

Dr. William R. Howard, of Fort Worth, Tex., also studied foul brood somewhat, and gave a description of *Bacillus alvei* as he found it. From his description and from the fact that he, too, worked with a diseased condition which does not contain *Bacillus alvei*, and exprest no difficulty in obtaining his cultures from any samples, the author believes that this investigator made an error in the identification of the culture with which he was working.

Some writers—Cowan, Bertrand, and others—have attempted the positive diagnosis of foul brood with the microscope alone from a preparation made direct from the dead larvæ. If the reader will remember that with the microscope alone it would be impossible to distinguish between *Bacillus larvæ* and *Bacillus alvei*, the verdict of these men can have no weight. As shown later in this paper under black brood (pp. 43–44), the Doctor Howard, of Fort Worth, Tex., referred to above, made an error in supposing that the European foul brood was a new disease and naming it "New York bee disease" or "black brood."

It is very unfortunate for the apiarist that these men should have fallen into error as to the identity of their culture with *Bacillus alvei*, as it has caused great confusion in the names of bee diseases. This confusion in the identity of cultures may be excused to a certain extent by the fact that European foul brood did not appear in this country, or at least did not attract much attention, until after Mackenzie, Harrison, and William R. Howard had done their work on foul brood.

The Present Investigation.

When the author's investigations were begun in 1902 there were two especially troublesome diseases in this country, which were then known to the bee experts as "black brood" and "foul brood."

The following summary and table shows the results of the examination of a number of samples of diseased brood from different apiaries, sent by the New York State bee inspectors during the summer of the year 1902:

Table showing the results of examinations of European foul brood. (The samples were called "black brood" by the apiarists at that time.)

Brood sent by—	Date.	Bacteriological findings.
W. D. Wright	June 4	*Bacillus alvei.*
W. D. Wright	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	June 12	*Bacillus alvei.*
N. D. West	Aug. 5	*Bacillus alvei.*
W. D. Wright	Oct. 8	*Bacillus alvei.*

It can be seen clearly from the above table that the diseased condition which the apiarists were calling "black brood" is really the disease "foul brood" of Cheshire and Cheyne, because of the constant presence of *Bacillus alvei.*

The work upon European foul brood was continued during the year 1903. The following table gives the results of the examination of specimens received during that year. The samples were taken from different apiaries.

Table giving a summary of the examination of specimens of European foul brood ("black brood").

Brood sent by—	Date.	Sources of brood in New York.	Bacteriological findings.
W. D. Wright	May 1	Columbia County	*Bacillus alvei.*
W. D. Wright	May 1	Albany County	*Bacillus alvei.*
N. D. West	June 25	Schoharie County	*Bacillus alvei.*
N. D. West	June 29	Schoharie County	*Bacillus alvei.*
N. D. West	June 29	Schoharie County	*Bacillus alvei.*
N. D. West	June 29	Schoharie County	*Bacillus alvei.*
N. D. West	June 29	Schoharie County	*Bacillus alvei.*
N. D. West	July 6	Schoharie County	*Bacillus alvei.*
N. D. West	July 6	Schoharie County	*Bacillus alvei.*
N. D. West	July 6	Schoharie County	*Bacillus alvei.*
N. D. West	July 10	Montgomery County	*Bacillus alvei.*
N. D. West	July 10	Schoharie County	*Bacillus alvei.*
N. D. West	July 10	Schoharie County	*Bacillus alvei.*
N. D. West	July 10	Schoharie County	*Bacillus alvei.*
N. D. West	July 15	Schoharie County	*Bacillus alvei.*
N. D. West	July 15	Montgomery County	*Bacillus alvei.*
N. D. West	July 22	Schoharie County	*Bacillus alvei.*
N. D. West	July 22	Schoharie County	*Bacillus alvei.*
N. D. West	July 22	Schoharie County	*Bacillus alvei.*
N. D. West	July 30	Schoharie County	*Bacillus alvei.*
N. D. West	July 30	Schoharie County	*Bacillus alvei.*
N. D. West	July 30	Greene County	*Bacillus alvei.*
N. D. West	July 30	Albany County	*Bacillus alvei.*
N. D. West	July 30	Greene County	*Bacillus alvei.*
N. D. West	Aug. 20	Greene County	*Bacillus alvei.*
N. D. West	Aug. 20	Greene County	*Bacillus alvei.*

The above table shows that *Bacillus alvei* was present in each specimen of European foul brood received. Frequently pure cultures of this species were obtained from dead larvæ, but with it sometimes were associated other rod-shaped bacteria of different species.

In 1904 the work upon bee diseases was confined principally to the diagnosis of the diseased brood sent in and a further study of the organisms found. *Bacillus alvei* was found in a large number of samples received from New York State and in some received from Pennsylvania.

Bacillus alvei.

Occurrence.—This bacillus was found in all samples of European foul brood examined.

Morphology.—The bacillus is a motile, rod-shaped organism, occurring singly and in pairs, and varying when taken from the surface of agar from 1.2μ to 3.9μ in length, and from 0.5μ to 0.7μ in width. Involution forms are sometimes present. Spores are produced and occupy an intermediate position in the organism. They are oval and vary from 1.5μ to 2μ in length and from 0.7μ to 1μ in breadth; they exhibit polar germination. The few flagella are arranged peritrichic.

Oxygen requirements.—This bacillus is a facultative anaërobe which grows at room temperature, but better at 37° C.

Bouillon.—The medium becomes uniformly clouded in 24 hours; later it shows a tendency to clear by a settling of the organisms. A somewhat viscid sediment is thus formed in the bottom of the tube. In older cultures a slightly gray band of growth adheres to the glass at the surface of the medium. The acidity is at first slightly increased, and a pellicle is sometimes formed.

Glucose.—The medium in both branches of the fermentation tube becomes uniformly clouded. Gas is not formed. Reaction acid.

Lactose.—The medium becomes uniformly clouded in both branches of the fermentation tube, but the cloudiness is not so marked as when glucose is used. The acidity is slightly increased, as shown by phenolphthalein. No gas is formed.

Saccharose.—The bouillon in this case also becomes clouded in both arms. A heavier growth is observed than when lactose is used, but less than when glucose is used. Acidity is slightly increased. Gas is not formed.

Agar plates.—Small, grayish, circular colonies form in 24 hours. When many are on the plate, they do not exceed 2 millimeters in diameter. Under low magnification they appear granular, with no definite margin. When fewer colonies are on the plate, the granular center of the colony is surrounded by numerous smaller but similar growths. The organism has a tendency to grow into the medium rather than upon the surface. Sometimes, however, when there are but a few colonies on the plate a thin, transparent growth spreads rapidly over the surface. Later it takes on a brown tint.

Agar slant.—A gray layer spreads over the surface in 24 hours, which later takes on a slightly brown color. A strong, slightly viscid growth occurs in the condensation water.

Acid agar.—Growth takes place with the reactions varying from neutral to +3.5 to phenolphthalein.

Serum.—A slightly raised growth which is confined quite closely to the line of inoculation appears on the surface of solidified serum.

Potato.—On this medium the bacillus grows rather slowly at first, but after 3 or 4 days a milky growth is observed, which increases until a luxuriant growth is formed, which varies from a lemon-yellow to a gray color, and which later becomes tinted with brown.

Milk.—Acidity is increased after inoculation. Coagulation usually takes place after the third day.

Litmus milk.—Much of the blue color is discharged, leaving the coagulated milk of a light brown.

Gelatin colonies.—Gelatin is a medium in which it develops slowly. The colony becomes very irregular in outline, owing to thread-like outgrowths which take place in curves from its border. Growth is better when 5 per cent glycerin is added. From the small, white, spherical colonies which form along the line of puncture gray, thread-like growths shoot out thru the medium. In about 2 months the gelatin is changed to a thick liquid, holding gray flocculent masses of organisms which gradually settle, forming a strong, slightly viscid sediment.

Indol.—In old cultures a decided indol reaction is obtained.

Power to resist disinfectants.—Preliminary observations give the following results: The spore form resists drying for a considerable time. Spores which have been drying for 1 year germinate promptly when introduced into bouillon. The vegetative form: One per cent carbolic acid kills in 10 minutes; 3 per cent carbolic acid kills in 2 minutes; mercuric chlorid solution, 1 to 1,000, kills in 1 minute; mercuric chlorid solution, 1 to 2,000, kills in 2 minutes.

Spore form.—Mercuric chlorid, 1 to 1,000, kills in 30 minutes.

Pathogenesis in vertebrates.—Inoculations into guinea pigs and frogs have not proven this organism to be pathogenic to these animals.

Inoculation Experiments.

That part of the investigation which involves the producing of the disease experimentally by inoculating with pure cultures of the organism is usually the most difficult one. Very rarely indeed is one able to produce the disease with symptoms closely simulating those found in nature. The experimental production of a disease involves many variable factors, such as attenuation of the organism, methods of inoculation, resistance of the host, and the immediate environment.

On August 4, 1902, we inoculated a hive containing nothing but healthy brood, free from bacteria, by feeding with sirup (sugar and water in equal parts) to which was added the growth from the surface of the plate cultures containing spores and bouillon cultures of *Bacillus alvei*. Similar feedings were given to these bees from one to three times a week until September 28, but symptoms of foul brood did not develop. On August 6 cultures were made from a few of the hive larvæ. They were found to contain the bacilli.

Inoculation experiments were again made in 1903. Because of a failure to produce a diseased condition with cultures of *Bacillus alvei* in the experiment of 1902, the variable factors above mentioned were carefully considered in the experiment of this year. The inoculations were made when climatic conditions were such as seemed to favor the ravages of the disease in the apiaries; namely, low temperature, dampness, and cloudiness. A colony of black bees was used, as they were almost universally considered more susceptible. Cultures of *Bacillus alvei* were freshly isolated from foul-brood specimens and kept in stock on bee-larvæ agar (described under American foul brood, pp. 41–42). All cultures were incubated at 34° C., which temperature is observed to be slightly below that of the hive. The spore form of *Bacillus alvei* was used.

Inoculations were made in different ways. A diseased condition appeared in the hive when the following method was used: The agar from plates on which the culture was grown was finely crusht and mixt with sterile sirup. A jelly glass, in the lid of which holes had been punctured, was filled and inverted on strips of wood inside the hive. In this way the bees take up the culture with the sirup as rapidly as it flows out of the glasses. A colony having brood free from *Bacillus alvei* was fed in the above manner on August 8, with repeated feedings on the 9th, 10th, 12th, 13th, 15th, and 17th. On the 12th *Bacillus alvei* was found in the living larvæ and on the 17th many larvæ were dead under cappings and some were dead which were not capped; all were soft and of a dull color. Many of the capped cells containing dead larvæ had their capping freshly punctured. *Bacillus alvei* was usually obtained from these larvæ in pure cultures. In no cell examined where the cell capping was punctured did we find gas-producing organisms; this fact would suggest the conclusion that these punctures which are found in the capping in foul brood are made by the bees and not by gas-producing organisms. During this series of inoculations the days were quite cool and sometimes cloudy and damp. On the 20th of August the temperature was much higher, the bees were more active, and much of the dead brood had been cleaned out by the bees. On the 22d no dead brood was noticed by casually looking over the brood nest. On the 24th of the same month a careful search was made by uncapping all the cells of one brood frame, and 12 decaying larvæ of a brown color were found. At this time the larvæ were not viscid. All the remaining dead brood had evidently been cleaned out by the bees. A condition similar to this, where only a few scattered about in the brood nests contain dead larvæ, occurs sometimes in affected apiaries. Two other colonies which were near by but not inoculated gave no signs of disease.

Mr. N. D. West reports that the climatic conditions seem to have something to do with the extent of the ravages of European foul brood, since the disease is much more destructive in cool, damp weather. This seems to be a very plausible idea. The larvæ at such times may receive more infected food than when fresh is being rapidly gathered; the resistance of the body of the larvæ to the growth of *Bacillus alvei* is at such times much lessened; and the adult bees being less active, the dead larvæ are not cleaned out of the combs so rapidly. The results of the experimental work seem to confirm this theory.

Distribution of Bacillus alvei in Infected Hives.

In order to combat this disease it is well to know where these pathogenic bacteria may be found. The following is a summary of the results of the investigation along this line:

1. The greatest number of infecting germs are found in the bodies of dead larvæ.

2. The pollen stored in the cells of the foul-brood combs contains many of these infecting organisms.

3. The honey stored in brood combs infected with this disease has been found to contain *Bacillus alvei* in small numbers.

4. The surface of the combs, frames, and hives may be contaminated.

5. The wings, legs, head, thorax, abdomen, and intestinal contents of adult bees are found to be contaminated with *Bacillus alvei*.

6. Cheshire (29), Mackenzie (30), and others have found *Bacillus alvei* in the ovary of the queen. This has suggested a means of infection. From a bacteriological examination of queens from three badly infected hives we were able to isolate *Bacillus alvei* in small numbers in two cases. Since a very large number of this species of bacteria may be found in the intestinal tract and upon all parts of the body, it is very probable that such findings are the results of contamination in making cultures and have no special significance.

Experiments with Formaldehyde Gas.

Within the last few years several articles have appeared in the bee journals entertaining great hopes that a cure for foul brood has been found in the use of formaldehyde gas. The methods described for its use have been tested by the apiarists and bee experts in New York State, with the result that the disease sometimes breaks out anew in colonies so treated.

In order to test the value of formaldehyde gas as a disinfectant when used in foul-brood combs a number of experiments were made in the laboratory. A common frame hive was first used, in which were placed specimens of foul brood. The hive was charged with gas by heating formalin in a closed vessel which was in communication with the hive; 15 c. c. was used each time and evaporated to dryness. The charging of the hive with gas was repeated in this way at the end of 2, 4, 6, and 20 hours. Before each charging and at the end of 24 hours after the first application of gas, cultures were made. Of all the tubes inoculated 90 per cent showed *Bacillus alvei* to be present. There was no decrease in the number of tubes in which *Bacillus alvei* appeared following the several applications of formaldehyde gas.

The examination of specimens of foul brood which had been treated with the gas by an apiarist gave the following results:

Thirty tubes which were inoculated from larvæ, capped and uncapped, showed the presence of *Bacillus alvei* in 21.

Thirty tubes which were inoculated with pollen in cells gave *Bacillus alvei* in 28.

Four series of agar plates showed apparently no diminution in the number of bacteria present.

Further experiments were made by using Novy's anaërobic jar (a very tight chamber) as a chamber in which to put the diseased brood combs and cultures. This vessel will retain the gas much more perfectly than the devices made for practical use in the apiary. Treatment of brood in this jar by recharging with the gas resulted usually in complete disinfection after 2 days. Agar plates containing spores and cheese cloth on which cultures were spread and dried were disinfected after a short length of time by the application of formaldehyde gas.

From the experiments made the conclusion can be drawn that formaldehyde gas is a good disinfectant, but that it penetrates very slowly and that 24 hours' application of the gas to the combs, as usually applied, is not sufficient to kill all the spores in the decayed larvæ (27).

AMERICAN FOUL BROOD.

The diseased condition which we shall call American foul brood and the micro-organism found constantly present in the diseased and dead larvæ, which we shall call *Bacillus larvæ*, were, for convenience, referred to, respectively, as "X Brood" and *Bacillus* "*X*" in a former report (27). This disease has been called "foul brood" by many bee keepers in this country and in other countries as well. It is the diseased condition with which Mackenzie, Harrison, and William R. Howard were working largely, if not altogether, in their investigations of foul brood. The disorder is, as a rule, dreaded less than European foul brood by the apiarist, yet in the aggregate the bee industry suffers enormous losses from the trouble. The general character of the diseased brood is so much like that of foul brood that the two may be easily confused by those unfamiliar with the variety of appearances which one finds in each disease and a few characters which are differential. Therefore it is not strange that the mistaken diagnosis should be made from the symptoms manifested by these two diseases. When, however, European foul brood and American foul brood are subjected to a bacteriological examination, the diagnosis is easy. Experts when comparing specimens of the two diseased conditions are able to see a difference in the gross appearance.

Symptoms.

The symptoms are given by Dr. E. F. Phillips in Circular No. 79, Bureau of Entomology, as follows:

The adult bees of an infected colony are usually rather inactive and do little toward cleaning out infected material. When the larvæ are first affected they turn to a light chocolate color, and in the advanced stages of decay they become darker, resembling roasted coffee in color. Usually the larvæ are attacked at about the time of capping, and most of the cells containing infected larvæ are capped. As decay proceeds these cappings become sunken and perforated, and, as the healthy brood emerges, the comb shows the scattered cells containing larvæ which have died of disease still capped. The most noticeable characteristic of this infection is the fact that when a small stick is inserted in a larva which has died of the disease, and slowly removed, the broken-down tissues adhere to it and will often stretch out for several inches before breaking. When the larva dries it forms a tightly adhering scale of very dark brown color, which can best be observed when the comb is held so that a bright light strikes the lower side wall. Decaying larvæ which have died of this disease have a very characteristic odor, which resembles a poor quality of glue. This disease seldom attacks drone or queen larvæ. It appears to be much more virulent in the western part of the United States than in the East.

A microscopic preparation from the diseased, but not dead larvæ, or from larvæ recently dead, at first shows a few comparatively long slender rods; later these increase rapidly in number, and spores also are seen. In the later stages of decay in the ropy mass and the dried scales spores only are found; these occur in very large numbers. When this investigation was begun, in 1902, it was observed (26) that in the dried dead larvæ there are very large numbers of spores, but these, when inoculated into the media commonly used in the laboratory, fail to grow. The cultures were sterile, except for an occasional contamination.

The Present Investigation.

The following samples from different sources were examined in 1902:

Results of examination of specimens of American foul brood diagnosed by the experts at that time simply as "foul brood."

Brood sent by—	Date.	Source.	Bacteriological findings.
Charles Stewart	June 12	New York	No growth.
W. D. Wright	Sept. 19	Wisconsin	2 unidentified bacilli.
W. D. Wright	Oct. 19	Canada	No growth.
W. D. Wright	Nov. 11	Wisconsin	No growth; 4 samples.

Inasmuch as *Bacillus alvei* was absent, it is evident that this condition is not European foul brood (26).

In 1903 the investigations were continued. Several media were devised in which it was hoped that it would be possible to obtain a germination of the spores which were observed the year before and which failed to grow on our ordinary media. The one which proved successful was prepared as follows: Larvæ are picked from the brood combs of a number of frames of healthy brood and a bouillon (bee-larvæ bouillon) is made from them following the same directions as when bouillon is made from meat. Our first growth from these spores was secured in an agar (bee-larvæ agar) made from this special bouillon when Liborius's method for cultivating anaërobes was used.

The technique for making cultures successfully from the diseased material is not difficult if the following method is used: Place a loopful of the decayed tissue of the larvæ into a tube of bouillon; heat to 65° C. for 10 minutes to kill any vegetative forms which might be present; incubate for 12 hours, and heat again to 65° C. for 10 minutes. This is usually sufficient, but it may be necessary to repeat the same process. Liquefied bee-larvæ agar in a test tube is then inoculated and incubated. The successive heating will destroy the vegetative stage of any spore-producing species which is common about the apiary, *e. g.*, members of the group represented by *Bacillus A*, as described on pp. 13–14 of this paper. Agar slant and bouillon, when inoculated from this source, remain sterile; but when bee-larvæ agar is used a slow but abundant growth takes place. Under certain conditions the growth appears very near or at the surface when cultures are made in the above manner. A surface growth can be obtained after a few generations by reinoculating slant agar of this same medium.

The above method was used successfully in diagnosing the following samples from different apiaries:

Results of examination of specimens of American foul brood, formerly called simply "foul brood."

Brood sent by—	Date.	Source.	Bacteriological findings.
W. D. Wright	Oct. 19, 1902	Canada	*Bacillus larvæ.*
W. D. Wright	Nov. 11, 1902	Wisconsin	*Bacillus larvæ.*
W. D. Wright	Nov. 11, 1902	Wisconsin	*Bacillus larvæ.*
C. H. W. Weber	July 24, 1903	Ohio	*Bacillus larvæ.*
N. D. West	Aug. 3, 1903	Broome County, N. Y	*Bacillus larvæ.*
N. D. West	Aug. 3, 1903	Broome County, N. Y	*Bacillus larvæ.*
N. D. West	Aug. 3, 1903	Chenango County, N. Y	*Bacillus larvæ.*

The results of these examinations show that *Bacillus larvæ* was present in all the specimens examined, which suggests that it very probably figures as an etiological factor in this disease. Other bacteria of different species are occasionally found associated with this bacillus.

Bacillus larvæ.

Occurrence.—Constantly present in diseased brood from colonies affected with American foul brood.

Gelatin.—There is no growth.

Morphology.—It is a slender rod, having a tendency to form in chains. This is especially true when grown in bee-larvæ bouillon.

Motility.—The bacillus is rather sluggishly motile.

Spores.—Spore formation takes place. This can be observed best in the different stages of the disease and decay of the larvæ.

Oxygen requirements.—When Liborius's method is used, the best growth usually appears near to but not on the surface. After a few generations a surface growth may be obtained.

Bouillon.—There is no growth.

Glucose bouillon.—There is no growth.

Lactose.—There is no growth.

Saccharose.—There is no growth.

Agar plate.—There is no growth.

Bee-larvæ agar.—The inoculations must be made with the medium liquefied. The growth takes place near to but rarely on the surface. Cultures must pass thru a few generations before a satisfactory surface growth can be secured.

Bee-larvæ agar slant.—On the surface of this medium a thin, gray, nonviscid growth takes place.

Glucose agar.—Slight growth has been observed in the medium. No gas is produced.

Potato.—There is no growth.

Milk.—There is no growth.

Litmus milk.—There is no growth.

Fermentation.—In bee-larvæ bouillon no gas is produced.

Indol.—There is no growth in sugar-free bouillon.

THE SO-CALLED " PICKLE BROOD."

The name " pickle brood " was given by Dr. William R. Howard, of Fort Worth, Tex., to a disorder found in the brood of bees. He stated that the cause of the disease was a specific fungus which he called *Aspergillus pollinis*. His results have not been confirmed by other investigators.

The bee keepers are sustaining a loss from a diseased condition in their apiaries which they are diagnosing as " pickle brood." The larvæ usually die late in the larval stage. Most of them are found on end in the cell, the head frequently blackened and the body of a watery, granular consistency.

The following table gives a summary of the results of an examination of specimens received labeled " pickle brood: "

Results of examination of specimens of so-called "pickle brood."

Brood sent by—	Date.	Bacteriological findings.
W. D. Wright	June 17, 1902	Two unidentified micrococci.
W. D. Wright	July 31, 1902	No growth.
W. D. Wright	Aug. 4, 1902	No growth.
M. Stevens	Aug. 20, 1902	Unidentified bacilli.
W. D. Wright	Sept. 2, 1902	Unidentified bacilli.
W. D. Wright	June 24, 1903	Unidentified bacilli and yeast.
N. D. West	Aug. 5, 1903	No growth.
M. Stevens	Aug. 20, 1903	No growth.

The results of the examinations show that *Aspergillus pollinis* was not found. Further investigations must be made before any conclusion can be drawn as to the real cause of this trouble.

THE SO-CALLED " BLACK BROOD."

In 1890 some specimens of diseased brood were sent from New York State to Dr. William R. Howard, of Fort Worth, Tex., and unfortunately, after a short and inadequate study of the disease, he reported it to be a new disease and called it "New York bee disease" or "black brood." He described as its cause a species of bacteria which he called *Bacillus millii* (31).

In our investigations of this diseased condition, which have covered five years, we have not found an organism corresponding to *Bacillus millii* in any of the specimens that we have received; but we have found *Bacillus alvei*, the supposed cause of foul brood, to be present constantly in samples of brood which the bee experts of New York State say are samples of the same diseased condition as that received by Howard.

From this we conclude that the diseased brood that has received the name of "New York bee disease" or "black brood" is really genuine European foul brood.

PALSY OR PARALYSIS.

The disease known to the apiarists as palsy or paralysis attacks the adult bees. The name is suggestive of the symptoms manifested by the diseased bees. A number of bees affected were received from Messrs. W. D. Wright and Charles Stewart, taken from apiaries in New York State. In 1903 bacteriological examinations were made of a number of bees so affected. Several species of bacteria were isolated and some experimental inoculations made, but no conclusions could be drawn from the results obtained as to the cause of the disorder.

From a study of the normal flora of the bee it was soon found that we had here quite a number of species of bacteria present. This fact stimulated a study of the normal flora, the results of which are recorded in Part I. From this point the work can be carried on with the hope that, if the disease has a bacterium as an etiological factor, it may be found. It is believed by some bee keepers that *Bacillus gaytoni* of Cheshire is the cause of paralysis, but this is not claimed by Cheshire, and the belief is not grounded on bacteriological findings.

SUMMARY TO PART II.

Following is a brief summary of the results of the present investigation of bee diseases:

(1) There are a number of diseased conditions which affect the apiary.

(2) The disease which seems to cause the most rapid loss to the apiarist is European foul brood, in which is found *Bacillus alvei*—first isolated, studied, and named by Cheshire and Cheyne in 1885.

(3) The distribution of *Bacillus alvei* in the infected hive is as follows:

(*a*) The greatest number of infecting germs are found in the bodies of dead larvæ.

(*b*) The pollen stored in the cells of the foul-brood combs contains many of these infecting organisms.

(*c*) The honey stored in brood combs infected with this disease has been found to contain a few bacilli of this species.

(*d*) The surface of combs, frames, and hives may be contaminated.

(*e*) The wings, head, legs, thorax, abdomen, and intestinal contents of adult bees were found to be contaminated with *Bacillus alvei.*

(*f*) *Bacillus alvei* may appear in cultures made from the ovary of queens from European foul-brood colonies, but the presence of this species suggests contamination from the body of the queen while the cultures are being made and has no special significance.

(4) The disease which seems to be most widespread in the United States we have called American foul brood, and the organism which has been found constantly present in the disease we have called *Bacillus larvæ.* This disorder was thought by many in this country and other countries as well to be the foul brood described by Cheshire and Cheyne, but such is not the case.

(5) From the nature of American foul brood it is thought that the organism has a similar distribution to that of *Bacillus alvei.*

(6) It appears that European foul brood was erroneously called "New York bee disease" or "black brood" by Dr. Wm. R. Howard in 1900.

(7) There is a diseased condition affecting the brood of bees which is being called by the bee keepers "pickle brood." No conclusion can be drawn from the investigation so far as to the cause of the disease.

(8) *Aspergillus pollinis*, ascribed by Dr. William R. Howard as the cause of pickle brood, has not been found in this investigation and is not believed by the author to have any etiological relation to the so-called "pickle brood."

(9) Palsy or paralysis is a diseased condition of the adult bees. No conclusion can yet be drawn as to its cause.

(10) Formaldehyde gas as ordinarily used in the apiaries is insufficient to insure complete disinfection.

CONCLUSIONS.

In a paragraph the author wishes, if possible, to present the status of the bee diseases in this country. It should be remembered, firstly, that "black brood" can now be dropt from our vocabulary, and probably does not exist; secondly, that the term "foul brood" was being applied to two distinct diseases. One of these diseases we now refer to as European foul brood, because it first received a scientific study from a European investigator. We refer to the other disease as American foul brood, because it was first studied scientifically in America. There is one more disorder in the brood of bees which has attracted considerable attention—the so-called "pickle brood." There are, then, these three principal diseases: European foul brood, American foul brood, and the so-called "pickle brood."

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist and Chief of Bureau.

A REVISION OF THE IXODOIDEA, OR TICKS, OF THE UNITED STATES.

BY

NATHAN BANKS,
Assistant Entomologist.

Issued June 6, 1908.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 11, 1908.

Sir: I have the honor to transmit herewith the manuscript of a revision of the Ixodoidea, or ticks, of the United States, by Mr. Nathan Banks, assistant entomologist in this Bureau. In view of the importance which some of the ticks have assumed as the known transmitters of certain diseases it becomes very necessary that the different species be distinguished with certainty. This has hitherto been a matter of great difficulty, since there has been no work of a systematic character dealing with all the known species of ticks occurring in the United States. To supply this need and as a basis for the life history work undertaken by this Bureau on the cattle tick and other ticks, this bulletin has been prepared. I recommend its publication as Technical Series No. 15 of the Bureau of Entomology.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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A REVISION OF THE IXODOIDEA, OR TICKS, OF THE UNITED STATES.

STRUCTURE.

The Ixodidæ, or ticks, are all mites of considerable size; even the young or "seed-ticks" are visible to the naked eye, while a full-grown engorged female may be half an inch long. Their abundance on many of the domestic animals and occasional occurrence on man have rendered them well-known objects of disgust in every clime.

The body is covered by a tough leathery skin, which in the female becomes greatly distended as she engorges herself with the blood of the host. Before distention the tick is of a somewhat triangular outline, flat, with prominent, slender legs and a beak-like rostrum in front. When the female becomes swollen these characters may be hardly noticeable and the whole creature may look like some large seed or bean. In most of the forms there is on the front part of the dorsum a corneous *shield* known as the *scutum*. In the male this scutum covers the greater part of the body, but in the female only a small part in front. Articulated to the anterior margin of this scutum, and usually within a slight emargination, is a small sub-triangular piece, called the *capitulum*, or head. This capitulum bears the palpi, the mandibles, the mandibular sheaths, and the hypostome. The last three organs together form the *proboscis*, or *haustellum*. The *hypostome* is a median piece beneath (really of two pieces) bearing many recurved teeth or denticles. The more basal of these denticles are in rows, and the number of these rows has been used in the differentiation of species, but is subject to some variation. At the tips of the mandibles are two or three processes, known as the *apophyses;* these have also been used in specific classification, but are now also known to be inconstant. The hypostome and mandibles are inserted into the host when the tick feeds, and so firmly do the recurved teeth of the hypostome hold that if one tries to remove a tick by force the body may be torn from the attached capitulum.

The *palpi* are inserted at the sides of the mouth parts and are of four segments, but commonly one sees only two, for the basal is short and broad, and the apical is very small and often situated in a depression near the tip of the third. The palpi are usually somewhat concave on the side toward the mouth parts, so that they may sheath these parts. The comparative lengths of the second and third joints of the palpi give useful characters in separating the genera of ticks.

On the dorsum of the capitulum of adult female ticks there are two depressed pitted areas known as the *porose areas.* No one has as yet determined their function. All female ticks of the subfamily Ixodinæ which do not have these organs fully exposed are immature and should not be described as new species. Various species, and even genera, have been based on immature forms, owing to a failure to recognize this point. The genera *Phaulixodes*, *Herpetobia*, *Sarconyssus*, and *Gonixodes* fall in this class.

The shield is usually irregularly hexagonal in shape. On each lateral margin is a pale eye-like spot or ocellus; in some genera these eyes are wanting. The posterior margin of the body in most forms is marked by a number (8 to 10) of short impressed furrows, which outline a series of lobes or *festoons;* these are more distinct in the male than in the female, and when the latter is distended with blood they are barely visible. On the underside or *venter* of the body there are two median apertures; the anterior one not far from the beak is the *genital pore;* the posterior one is the *anus.* In many forms there is a curved groove behind the anus and from it a median furrow, while in other species there is a curved groove in front of the anus and reaching back each side toward the margin of the body. In all forms there is a more lateral groove each side reaching forward to the genital pore. In the males of several genera there are one or two corneous triangular plates each side of the anus, the *anal plates.* Occasionally the abdomen terminates in a median process, or tail.

The legs arise from each side of the anterior part of the venter; the coxæ are sometimes close together, sometimes more widely separate. The legs are usually slender, subequal in length, but the fourth pair is rather the longest, and sometimes larger than the others. Each is composed of at least six joints, as follows, from base outward: *Coxa*, *trochanter*, *femur*, *tibia*, *metatarsus*, and *tarsus.* The latter is commonly more or less definitely divided into two parts. At the tip of the tarsus is a pair of large claws situated on a rather long pedicel, and between them is usually a *pulvillum.* On the upper surface of tarsus I is a pit covered by a membrane; this is known as *Haller's organ*, from its discoverer, and is supposed to be an organ of audition. One or more of the coxæ are armed behind by spine-like processes or teeth. In the males of some species the hind coxæ are greatly enlarged. Above, and usually slightly behind the hind coxæ, are the *stigmal plates* containing near their centers the *stigmal orifice* or *spiracle.* Each plate is a corneous piece, the surface of which is marked by granules of smaller or larger size. The shape and sculpture of the stigmal plate is quite constant in each species, but differs in the sexes.

In some genera there are on the dorsum, near the middle, a pair of small circular or oval plates, called by Doctor Stiles the *dorso-submedian porose plates;* no one has yet discovered their use.

Ticks are usually dull-colored, but some forms are brightly mottled with brown, white, yellow, or red. However, each species has a characteristic shade of color, which, when once known, helps in field identification; the colors accredited to the species in this paper are those shown by alcoholic materials. In life most of the colors are lighter or more vivid than after immersion in spirits.

LIFE HISTORY.

Ticks are parasitic during the greater period of their life; most of them, however, leave the host to moult, and all, to deposit eggs. Mammals are their ordinary hosts, but birds and reptiles are also infested, and two species of ticks have been taken from insects. Many of them show a decided preference for a certain animal, but a number of our common species have been found on a great variety of animals. Some ticks have apparently changed their host; for example, the Texas fever tick, now chiefly found on cattle, originally infested deer, and possibly bison.

In sucking the blood of their hosts the ticks, unless extremely numerous, do but slight harm, but several of them have been shown to transmit the germs of some disease, so that they become, in several cases, economic pests of prime importance.

The life history of ticks has been investigated by several authors, notably Curtice, Morgan, Lounsbury, and Hunter and Hooker. The female tick, as the result of her bloodthirsty nature, becomes enormously distended, and is then mature. The male mates with the female for some days, after which the latter drops to the ground to deposit eggs. These issue as elongate masses in front of the tick, and may be as many as 1,000 to 10,000 in number. During the operation the head is withdrawn into the body so that the surface of the capitulum is close to the genital pore. As the eggs issue they are coated with a viscous substance secreted from glands opening in the membrane between the shield and the head. These glands are partly eversible and enwrap each egg as it issues from the ovipositor. The eggs are usually placed upon the surface of the soil or just beneath it, and the larvæ hatch in a few days. The young ticks, known as "seed-ticks," ascend the nearest support of grass or herb and patiently await the coming of some animal. Delay and disappointment must often end in starvation and death. The seed ticks are, however, able to endure long fasts, and many finally secure an attachment to some animal. In a few days the young tick is rapidly distended by blood, and drops to the ground. Here it seeks a hiding place and rests, during which time there are many changes in the internal anatomy. In three or four days the skin splits and from the six-legged larva there issues the octopod nymph. Climbing a plant it awaits the passing of some suitable animal, and, when attached, feeds and falls off again to moult, this time to the adult condition. It again waits for a host, and, finding one, feeds and starts the life cycle anew. The Texas fever tick and its allies do not drop off for moulting, but cast the skin while on the host. This enables a more rapid increase in the species. They drop to the ground, however, for the purpose of depositing eggs. Several other ticks pass the first moult while on the host, and some Argasidæ deposit eggs on posts above ground.

In the true ticks there is a considerable difference between the abdomen of the male and that of the female in the development of the dorsal shield. In several genera the male has plates near the anus, and in some cases the hind pair of legs is enlarged in the male; the porose areas are found only in the female; the sexes are, therefore, very easily distinguished.

The males and females feed side by side; but the younger stages are often restricted to a different part of the host; thus the larvæ of several species occur in the ears, while the adults are on the body of the host.

Ticks are able to live for long periods without food or moisture. Four to six months are common periods, and cases are recorded of female ticks fasting for eleven or twelve months. The argasids can live for a much longer time; specimens of *Argas* have remained alive in pill boxes for two years and three months without food, and Riley records one specimen living for five years in a corked vial without food. Even the young may live several months without food. This amazing vitality largely offsets the difficulty the tick may have in finding a host.

Ticks are also well fitted to withstand immersion in water; even the eggs and young stages live through long periods of submergence, so that rains have little effect upon tick life.

GEOGRAPHICAL DISTRIBUTION.

Africa is the home of ticks, all the known genera occurring there, and more species than on any other continent. Of the genera found in the United States, *Rhipicephalus*, *Margaropus*, and *Amblyomma* are tropical, and several of our species in these genera occur in Central and South America. *Dermacentor* is our most characteristic genus, and we have more species than any other country. *Ixodes* and *Hæmaphysalis* are northern genera, both as well represented in Europe as in this country. Two common tropical genera, *Hyalomma* and *Aponomma*, have not yet been taken in this country. The two genera of Argasidæ favor warm countries. Two of the European species occur in our country, doubtless from importations. Several other European species have been accredited to the United States, but in all cases through erroneous determinations. In the United States the species of *Rhipicephalus* and *Margaropus* are restricted to the Southern States. Several species of *Amblyomma* spread northward along the coasts and up the great valleys. The species of *Dermacentor* are more restricted in distribution, and more abundant in the Northwest. In *Ixodes* the western species are quite unlike those of the East. One species of *Hæmaphysalis* is widely distributed in this country. Although a few species are as yet known from only one host, it is improbable that any are confined to one species of animal. *Dermacentor* is usually found on large mammals and *Ixodes* on small mammals.

ABUNDANCE.

Dermacentor is our most common tick, and the males are about as numerous as the females. *Rhipicephalus* and *Margaropus* are abundant locally, but the males of *Margaropus* are not so often seen. In *Amblyomma* the males are slightly less common than females. In *Ixodes* the males are comparatively rare, and in several species unknown to me. One species in the South is quite abundant, but of the other *Ixodes* only a few are taken at one time.

HISTORICAL.

Since the group is of such great economic importance, the need of a technical revision of the species is apparent. There has never been such a revision of our species. Say described a few species in 1821, Packard several more in 1869, and Fitch in 1871. Koch, in 1844, described a host of ticks from all over the world, naturally including a few from the United States. Each of the authors worked independently of the others. The late Dr. George Marx was much interested in this family of mites, and intended to monograph it, or at least our native species. To this end he had prepared many fine drawings and a considerable body of manuscript. I have had access to this material, and can testify to its high scientific character. In the genus *Dermacentor*, for example, he had the forms known to him separated out as I shall use them in this paper. Later writers confused several of these species, which he rightly held to be distinct. Doctor Marx's manuscript is not suitable for publication, being fragmentary and out of date, but many of his figures are so valuable that I have added two plates made up of them. These of course should be credited to him.

In 1896 Dr. George Neumann, of Toulouse, France, began the publication of a Revision of the Ixodidæ. Doctor Neumann attempted to monograph the ticks of the entire world, a task which in 1896 doubtless seemed quite possible, and the "Revision" was completed in four parts. Since then he has examined thousands of specimens, and his studies have appeared in five notes on the Ixodidæ supplementary to the "Revision." It is quite natural that in examining such a host of specimens from all parts of the world at varying intervals he should be inclined to unite forms which to the student of local faunæ seem abundantly distinct. It is in this way that I differ from Doctor Neumann as to the species occurring in this country. I have seen practically all the material that he studied from the United States, including most of his types, and also collections from many colleges and other institutions in this country, together with larger collections made in the past few years. The types of Say and Fitch are lost, but through the kindness of Mr. Samuel Henshaw I have examined the types of Packard, now in the Museum of Comparative Zoology. This enables me to place correctly several species hitherto misplaced by authors. In 1899 Doctors Salmon and Stiles published a finely illustrated work on the cattle ticks of the United States. At that time their material was largely in Doctor Neumann's hands, and since then several species have been collected in this country, and Neumann himself has changed his opinions regarding several species.

During the past year Messrs. W. D. Hunter and W. A. Hooker, of this Bureau, have issued a bulletin (No. 72) on the cattle tick and other species, with much ethologic matter and valuable breeding notes. In this paper 38 species are recorded from this country, and 3 unplaced forms, doubtless identical with some of the known species. More species are to be expected in *Ixodes*, so that our tick fauna may yet have 50 species.

CLASSIFICATION.

Latreille, in 1795, made two genera for the ticks, *Argas* and *Ixodes*. The striking differences between the two were recognized by following acarologists, some of whom even placed *Argas* with the Gamasidæ. Koch, in 1844, divided these two genera into ten—just about as they stand to-day. He arranged these ten genera within three families—Argasidæ, Ixodidæ (long palpi), and Rhipistomidæ (short palpi). These three groups have been generally adopted by later authors. Neumann has modified it somewhat by using rostrum long or short to separate the last two families. But this will hardly distinguish some species of *Amblyomma* and *Dermacentor*. Doctor Marx, in 1892, made a somewhat different arrangement, dividing the group into two—Catastomata and Antistomata. The former is the Argasidæ of Koch, the later he separates into three families—Hæmalastoridæ, Ixodidæ, and Rhipistomidæ. The Hæmalastoridæ of Marx is based on a misconception; the type of *Hæmalastor* is a *Hyalomma*, while *Sarconyssus* belongs to *Eschatocephalus*.

These classifications have placed a great deal of prominence on the length of the palpi. Lahille, in 1905, in his tabular arrangement of the genera, has subordinated this character to others, and I fully agree with him. He places, and I believe correctly, *Amblyomma* near *Dermacentor* instead of near *Ixodes*. Lahille, however, bases his main divisions of the Ixodidæ on certain characters of the male; whether the male has five anal plates (Perissopli), or four anal plates (Artiopli), or no anal plates (Anopli). By this arrangement he separates *Hyalomma* from *Amblyomma*, while other authors—and here I agree with these latter—place these genera close together. Indeed, the character used to distinguish the females of these two genera is not always easy of verification, so that several writers have made mistakes in this matter.

Moreover, I fail to see the importance in secondary sexual characters that Lahille places upon them. They certainly are not of sufficient value to characterize groups higher than genera, and are better employed for groups of lesser rank.

Therefore I have made use of another character to divide the Ixodidæ into two groups, namely, the presence or absence of a curved groove in front of the anus and continued back each side. In *Ixodes* this groove is present, in other ticks it is absent, and in most forms there is a small groove behind the anus, not seen in *Ixodes*. *Ixodes* differs in various other ways from the other ticks, notably in lacking festoons to the posterior margin of the body. I have therefore placed *Ixodes* (and *Ceratixodes*) in a subfamily, Ixodinæ, as opposed to the other ticks, Amblyomminæ. *Rhipicephalus* (and *Margaropus*), by the peculiar shape of the capitulum, have long been considered distinct from other ticks, and for them a tribe is established, the Rhipicephalini; likewise *Hæmaphysalis*, by its peculiar palpi, will warrant another tribe, the Hæmaphysalini. *Amblyomma*, *Hyalomma*, and *Aponomma* are more closely related to each other than to *Dermacentor*. Two more tribes will thus be requisite, the Dermacentorini and the Amblyommini, distinguished not only by the length of the palpi, but also by the lengths of the divisions of the tarsi. These characters will apply to both sexes and even to the nymphal forms. Other less important points aid in distinguishing the groups, as evidenced by the synoptic tables.

Long after the above was written, I received a paper by Mr. Cecil Warburton (Notes on Ticks, December, 1907), in which he proposes practically the same classification as I have proposed above. He uses the position of the anal groove to separate *Ixodes* from all other Ixodidæ, but for this group and all his groups uses new names, instead of subfamily and tribal names based on the genus. He, however, keeps *Dermacentor* in the same group as *Rhipicephalus*, which I consider ill-advised and have placed them apart, *Dermacentor* closer to *Amblyomma*. Mr. Warburton has also put more value on the length of the palpi than I think justified, and also used, more than I, the secondary sexual characters of the male. A summary of my classification appeared in the Proceedings of the Entomological Society of Washington, Volume VIII, page 62, August, 1907.

Doctor Neumann has also lately (Sjöstedts Kili-mandjaro-Meru Expedition, page 20) given an arrangement of the genera in three sections. He, however, places, and I believe wrongly, *Hyalomma* near *Rhipicephalus*.

Our two families of ticks are very different, as seen from the following statement of characters:

TABLE OF THE FAMILIES.

No corneous shield on dorsum; head hidden beneath front of body; anus near middle of venter; skin roughened ________ *Argasidæ*.

A corneous shield present on dorsum; head distinct in front of body; anus behind the middle of venter; skin only finely striated ________ *Ixodidæ*.

Family ARGASIDÆ.

No dorsal shield; head hidden under front of body; anus near middle of venter; skin roughened; coxæ usually contiguous or nearly so; tarsi without apical pulvillum.

In the larvæ the head and mouth parts are distinct, in front of the body, as in the true ticks; there are also indications of a pulvillum at base of claws. However, there is not as much difference between the sexes as in the Ixodidæ; so it seems probable that each family has specialized along different lines. The argasids remain on their hosts for only a short time, and many of them are most active at night.

Our two genera are closely related, but may be distinguished as follows:

TABLE OF THE GENERA.

Margin of body thin and acute ________ *Argas*.

Margin of body rounded ________ *Ornithodoros*.

Genus ARGAS Latreille.

Body strongly depressed, elongate oval in shape, usually narrower in front, margins thin and acute; palpi hidden under front of body. Skin strongly wrinkled and with scattered smooth patches, most numerous near the margin. No eyes.

Type.—*A. reflexus* Fabricius.

The famous "Miana bug" of Persia (*Argas persicus* Fischer) belongs to this genus. The bite of this species was reputed to produce death, and the early travelers in that country give long and exaggerated accounts of the creature.

I have seen two species from our country, which may be tabulated as below:

TABLE OF THE SPECIES.

Anterior tibiæ and metatarsi each about three times as long as broad, *miniatus*.

Anterior tibiæ and metatarsi each plainly less than three times as long as broad .... *brevipes*.

Argas miniatus Koch.

Dark red-brown, legs pale yellowish, body nearly twice as long as broad, broader behind than in front, broadest behind the middle, tapering, and almost pointed in front, the margin often slightly upturned, except behind; surface densely and irregularly scarred and pitted, the smooth scars of varying sizes and more numerous on sides and behind, in latter part arranged somewhat in rows, a median row and two or more lateral less distinct; ventral surface scarred as above, most densely around the sides; palpi very short and lacking more than their length from reaching the anterior border; on rostrum at base of palpi is a transverse row of four bristles; the stigmal plate, which is scarcely distinct from the surrounding tissue, is a raised spot above the coxa IV and with a curved anterior rim. Legs (Pl. I, figs. 1, 2) rather slender; tarsi barely longer than preceding joints, and suddenly narrowed at tip; the legs have very few hairs; coxæ II, III, and IV are contiguous and radiate, coxa I is distinctly separate from the others, and at the sides of the beak.

The male differs but little from the female; it is usually smaller; the male genital pore is not nearly as broad as the vulva, and is situated farther back, and behind it is a short curved groove each side.

Length of swollen female, 8 to 10 mm.

This species is a common enemy of poultry in the Southwest, from southern Texas to California. It occurs, also, on other animals, rather rarely on cattle. Doctors Stiles and Salmon have described the hexapod larva of this species. I have followed Neumann in uniting *Argas sanchezi* Dugès to this species, as the slight difference in the structure of the mandibles is not constant.

I have seen specimens from Austin, Georgetown, El Paso, Patton, San Antonio, Brackettsville, and Colorado City, Tex.; from Merced and Riverside, Cal.; from Deming, N. Mex., and from Catalina Springs, Ariz.

Argas brevipes n. sp.

This species is similar in shape and general appearance to the common *A. miniatus*. It differs in the much shorter legs, as may be seen by the figures (Pl. I, figs. 3, 4). The joints appear somewhat more roughened than in *A. miniatus*, and the tibia and metatarsus of leg I are distinctly swollen below before the tip. There are fewer smooth spots on the dorsum of the body, and they are wider apart; on the anterior part are three pairs of smooth spots, and a row each side of them of four; outside of these rows the spots are irregular.

The skin is as densely wrinkled as in *A. miniatus*.

Length of swollen female, 5 to 7 mm.

Three specimens from Tucson, Ariz.; two were from a cavity in *Cereus giganteus*, which was used, perhaps, by a bird.

Argas reflexus Fabricius.

This is the pigeon tick of Europe. I have not seen it from this country, but Prof. H. Osborn, in Bulletin No. 5, of this office, page 256, says: " It is common, I believe, as far north as St. Louis." Several pigeon raisers have informed me that they do not know it, but Thomas Wright, of Massachusetts, claims he has seen it in that State. The species is more ovate in form than our *A. miniatus*, and the color is grayer.

Genus ORNITHODOROS Koch.

Body depressed, oval or elongate, sides subparallel, margin of body rounded, not acute; palpi hidden under a median anterior process. Skin usually with many irregular tubercles or granules. Eyes sometimes present.

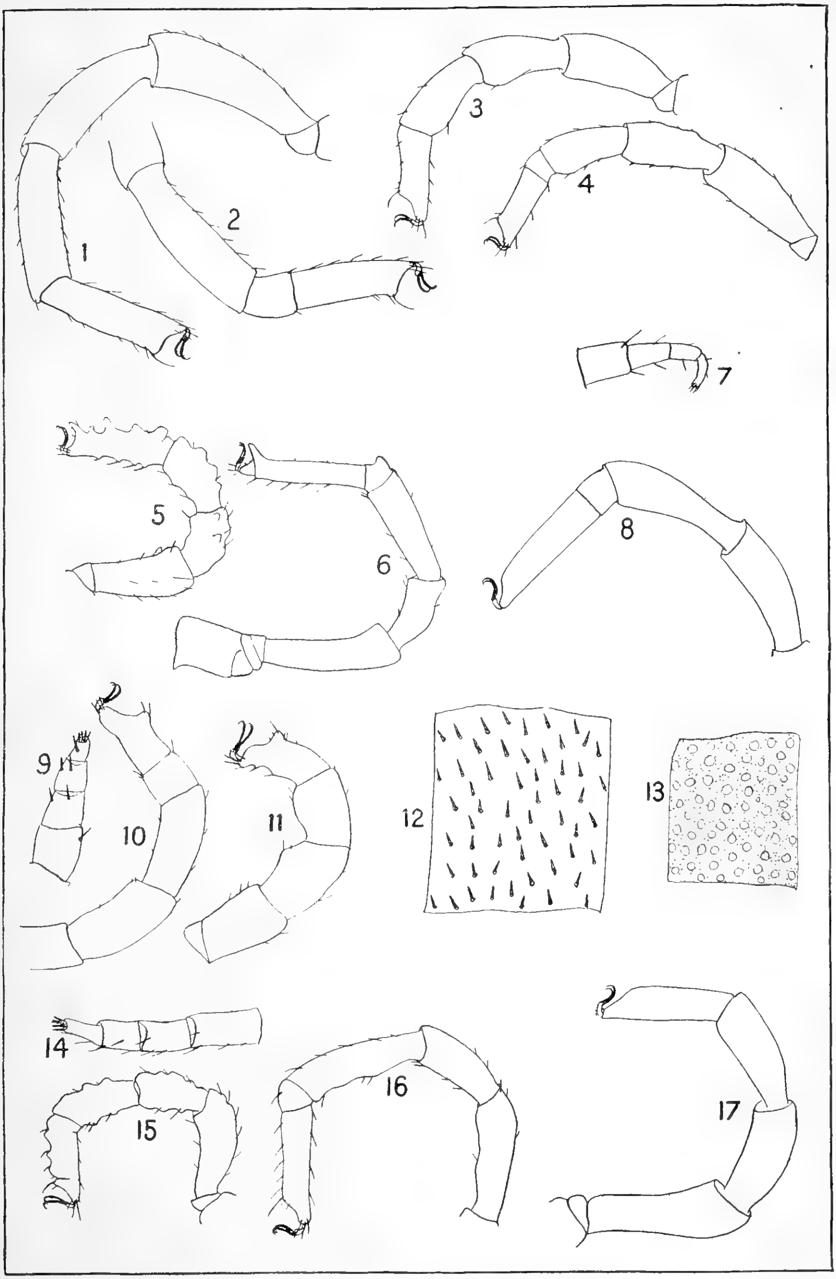
Type.—*O. savignyi* Audouin.

A few species of this genus occur in all tropical countries, four of them in the southern United States. Their bite is so very painful that wherever they occur the inhabitants have given them common names. Three of our species have received common names in Mexico. *O. megnini* is known as " garrapata," a term also applied to various other ticks; *O. turicata* as " turicata," and *O. talaje* as " talaxi." Dr. Jesus Aleman (quoted by Dugès and Mégnin) gives a long account of the inflammation and disorders consequent to the bite of *O. turicata*, and Sallé has written of the pain due to the bite of *O. talaje*.

Our four species may be separated as follows:

TABLE OF THE SPECIES.

1. Body provided with many short stiff bristles, hind tarsi scarcely three times as long as broad at base, with one subterminal hump above, anterior tarsi also with one subterminal hump; body rounded in front; no eyes ---------- *megnini*.
   Body without bristles, but covered with rounded tubercles or granules; hind tarsi more slender ---------- 2



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Argas miniatus*, leg I. Fig. 2.—*Argas miniatus*, leg IV. Fig. 3.—*Argas brevipes*, leg I. Fig. 4.—*Argas brevipes*, leg IV. Fig. 5.—*Ornithodoros coriaceus*, leg I. Fig. 6.—*Ornithodoros coriaceus*, leg IV. Fig. 7.—*Ornithodoros talaje*, palpus. Fig. 8.—*Ornithodoros talaje*, leg IV. Fig. 9.—*Ornithodoros megnini*, palpus. Fig. 10.—*Ornithodoros megnini*, leg IV. Fig. 11.—*Ornithodoros megnini*, leg I. Fig. 12.—*Ornithodoros megnini*, tegument. Fig. 13.—*Ornithodoros turicata*, tegument. Fig. 14.—*Ornithodoros turicata*, palpus. Fig. 15.—*Ornithodoros turicata*, leg I. Fig. 16.—*Ornithodoros turicata*, leg IV. Fig. 17.—*Ornithodoros talaje*, leg I. (Original.)

2. Two pairs of eyes present; tarsi IV with a prominent subterminal spur above; front of body conical in the middle; leg I strongly roughened ---------- *coriaceus.*
   No eyes; no such spur on hind tarsi ---------- 3
3. Front of body conical in middle; tarsi I without humps above ---------- *talaje.*
   Body rounded in front; tarsi and metatarsi each with three humps ---------- *turicata.*

Ornithodoros megnini Dugès.

Color red-brown to black, legs paler. Body broadly rounded in front and behind, a constriction much behind the middle. Body covered with many short, stiff, spine-like bristles (Pl. I, fig. 12), stouter in front than behind, and on venter mostly hair-like, skin only minutely roughened. Several broad depressions above, and on venter three elongate grooves behind and two in front. Rostrum and palpi (Pl. I, fig. 9) short. Legs (Pl. I, figs. 10, 11) short and stout; tibia and metatarsus of leg I not twice as long as broad, all tarsi with a subterminal hump, no other tubercles, hind tarsi not three times as long as broad at base, all legs with a few scattered hairs. No eyes.

Length of swollen female, 7 to 8 mm.

Male similar, but rather smaller and more slender. The nymphal stage (which is frequently observed) has a body about one and a half times as long as broad, broadest in front of leg III, much narrowed behind, broadly rounded in front and behind, the body covered with spine-like bristles, larger than on the adult, the legs more slender and more hairy. This nymph was first described and figured by Mégnin. Marx proposed for it the name *Rhynchoprion spinosum.*

This species is easily known from all other species of *Ornithodoros* by its bristly body, as well as by shape of tarsi. These, with the greater difference between the adult and nymphal instars, indicate that this species might well be the type of a subgenus. First found by Dugès in the ears of Mexican horses, it has been taken abundantly in the southwestern part of the United States, usually from the ears of cattle, but sometimes from other animals, including man.

Specimens have been examined from the following localities: Aycock, La.; Georgetown, San Antonio, and Victoria, Tex.; Albert, Santa Fé, and Mineral Hill, N. Mex.; Yuma, Ariz.; Los Angeles, Santa Rosa, Santa Clara County, and Humboldt County, Cal.; Ash Meadow, Nev.; Fremont County, Idaho; Davenport and Ames, Iowa, and Lexington, Ky.

Its frequent occurrence in ears has won it the common name of "ear tick" or "spinose ear-tick."

Ornithodoros turicata Dugès.

Color light brown, legs paler. Body broadly rounded in front and behind, only slightly constricted behind leg III, the sides being nearly parallel. Surface of body (Pl. I, fig. 13) covered with many small subequal, subconical granules. Impressions on dorsum small and indistinct, usually a curved one in front, subparallel to anterior margin, and some in pairs behind; on venter is a distinct median groove behind from anus, a curved transverse one half-way from anus to tip, and subcoxal ones extending obliquely outward behind hind coxæ. No eyes. Palpi (Pl. I, fig. 14) rather slender; legs (Pl. I, figs. 15, 16) moderately long, the hind legs about as long as width of body. Tibiæ, metatarsi, and tarsi I, II, and III with three tubercles above on each, those on the tarsi most distinct; hind legs without any definite tubercles, the tarsi being very slender; all legs with a few scattered hairs; all tibiæ and metatarsi more than twice as long as broad.

Length of swollen female, 6 to 7 mm.

I have seen specimens of this species from Keene, Kissimmee, and Crescent City, Fla. (in gopher holes): Burnet and Brownwood, Tex.; Las Cruces, N. Mex.; Phoenix, Ariz. (on cattle), and San Diego, Cal. (on cattle).

The first description of this species was by Dugès, in 1876, in the newspaper El Repertorio del Guanajuato, and later (1883) in La Naturaleza. Mégnin, in 1885, gave a fuller description with figures, based on specimens sent him by Dugès. One of his figures shows the hind tarsi with a subterminal hump, not found in my specimens. In the National collection is a vial from Doctor Dugès labeled "*O. turicata*, cotype." In this vial are 10 specimens, 7 of *O. megnini* and 3 of *O. turicata* as I have identified it, without a hump on the hind tarsus. I therefore suspect that Mégnin incorrectly delineated this appendage.

This species was taken from hogs in Mexico, and also in Texas, and, like the other species, will attack man.

Ornithodoros coriaceus Koch.

Color dark brown to black, legs paler. Anterior margin of the body rather cone-shaped in middle, broadly rounded behind, sides subparallel, only slightly constricted behind legs III. The body is covered by small, rather elongate granules, usually of a yellowish color, in striking contrast to the dark skin; venter with granules on the posterior part, less distinct in front. There are some fine hairs, at least near the margin of body. On the dorsum are several depressed areas where the granules are few or absent. Venter with a median groove from anus behind, and from in front of anus one extends obliquely down on the sides. Behind leg I is a smooth rounded spot or eye, and behind leg II is another, rather smaller, eye. The rostrum is usually depressed into a cavity, so as to be barely visible. The palpi are short, the last joint cylindrical and deflected backward. The legs (Pl. I, figs. 5, 6) are long and slender, the fourth pair nearly as long as width of body; tibiæ, metatarsi, and tarsi I, II, III have several prominent tubercles above, and tarsi IV have a basal hump and a prominent subterminal spur above. All legs with a few hairs; the tibia and metatarsus are more than twice as long as broad.

Length of swollen female, 7 to 8 mm.

Described by Koch from Mexico. I have seen specimens from San Francisco and from Santa Clara County, California. It has been taken from cattle and from cattlemen. The spur on the hind tarsus is very characteristic and, with the eyes, will readily separate it from our other species.

Ornithodoros talaje Guérin.

Color light to dark brown, legs paler. Body cone-like in front, broadly rounded behind, a broad depressed groove each side, united in front. About four depressed smooth patches each side on dorsum, the hind pair more elongate. Venter with a groove each side running obliquely down on sides, a median groove from anus behind; a depressed area in front of anus, and toward tip a prominent transverse groove with recurved tips. Body thickly covered with large roughened and sculptured granules, smaller on the middle of the venter. No eyes. Rostrum usually sunk in a cavity, the thin edges of which may partially overlap it; these edges are roughened like the surrounding surface. The palpi (Pl. I, fig. 7) are short, and have the last joint slender and deflected backward. The entire rostrum is retractible, so that one may see only the tips of the palpi. The legs (Pl. I, figs. 8, 17) are short, but slender, and provided with many fine hairs; there are no humps nor tubercles on any of the tarsi, tibiæ, or metatarsi. All tarsi are very slender; the tibiæ and metatarsi more than twice as long as broad.

Length of swollen female, 5 to 6 mm.

This species was described by Guérin Méneville from Guatemala, and I have examined specimens from Gum Cave, Citrus County, Fla.; Brownsville, Tex., and San Clemente Island, California.

The figures by Nicolet in Guérin's article are quite detailed, and leave no doubt as to the identification of the species. It is readily known by the simple tarsi and by the sculptured tubercles of the body. It was not described until 1849 in spite of the fact that in the Magasin de Zoologie, Année 1845, it appears in the same form as in the Revue et Magasin de Zoologie, Année 1849. That volume of the Magasin de Zoologie was begun in 1845, but not finished until 1849; moreover, as shown by the article itself, the tick was not collected until May, 1847.

Family IXODIDÆ.

Dorsum of the body more or less covered by a corneous shield; head distinct in front of body; anus behind middle of venter; skin finely striated. Coxæ more or less separated; tarsi with a pulvillum. Stigmal plate behind coxæ IV. Male with dorsum almost entirely covered by the corneous shield; in the female the shield is restricted to the anterior part of dorsum, and there are on the capitulum a pair of porose areas, not seen in males or in immature stages.

The genera and higher groups known from our country may be separated by the following table:

Table of the Genera.

1. Venter showing a curved groove a short distance in front of the anus and extending back each side to the hind margin; no posterior marginal festoons; stigmal plate nearly circular; no ocelli; hind coxæ of male not enlarged ---------- (Ixodinæ.) 2

 Venter showing more or less distinctly a curved groove behind the anus, but none in front of it; the male with distinct marginal festoons, more or less distinct in the female ---------- (Amblyomminæ.) 3

2. Capitulum slightly angulate on the sides; palpi with the third joint shorter than broad, and broadly rounded ---------- *Ceratixodes.*

 Capitulum not angulate on sides; palpi with the third joint longer than broad, and slightly tapering toward the tip ---------- *Ixodes.*

3. Sides of capitulum angulate; ocelli present; male with anal plates; palpi very short ---------- (Rhipicephalini.) 4

 Sides of capitulum not angulate ---------- 5

4. Palpi with acute transverse ridges; stigmal plate nearly circular; porose areas elliptical, distant; no distinct groove behind anus ---------- *Margaropus.*

 Palpi without transverse ridges; stigmal plate comma shaped; porose areas triangular, approximate; a distinct groove behind anus, *Rhipicephalus.*

5. Outer angle of the second joint of the short palpi acutely produced; no ocelli; male without anal plates ---------- (Hæmaphysalini) *Hæmaphysalis.*

 Outer angle of second joint of palpi not acutely produced ---------- 6

6. Palpi longer, second joint about twice as long as broad; coxæ IV of male not enlarged; tarsi II, III, and IV plainly divided, the basal part much shorter than the apical part ---------- (Amblyommini) *Amblyomma.*

 Palpi shorter, second joint barely longer than broad; coxæ IV of male enlarged; tarsi II, III, and IV indistinctly divided, the parts subequal in length ---------- (Dermacentorini) *Dermacentor.*

Genus CERATIXODES Neumann.

Venter showing furrows as in *Ixodes.* Capitulum not produced anteriorly in the middle, but the sides somewhat angulate; porose areas oval, transverse. Palpi short, third joint no longer than broad, and broadly rounded. Shield unmarked, no ocelli. Coxa I close to rostrum, barely toothed behind; coxa IV of male not enlarged. Posterior margin of body without festoons. Stigmal plate circular.

Tarsi II, III, and IV divided, the parts of variable length, no tooth-like claw at apex.

Type.—*C.* (*Ixodes*) *putus* Cambridge.

Our two species are separable as follows:

TABLE OF THE SPECIES.

1. Shield of female broadest on first third; divisions of tarsi II, III, and IV subequal in length; capitulum less angulate on side________________*putus*.
   Shield of female broadest on middle third; basal division of tarsi II, III, and IV much shorter than apical; capitulum more angulate on sides__ *signatus*.

Ceratixodes signatus Birula.

Female.—Shield reddish brown, legs paler, abdomen yellowish brown. Capitulum (Pl. II, fig. 3) very broad, lateral angles acute, hind angles not distinct, porose areas occupying nearly the whole of upper surface, palpi short and thick, with some scattered bristles, third joint but little swollen on inner side at base. Shield (Pl. II, fig. 1) much longer than broad, broadest on middle third, the lateral lobes only well separated in front, surface with many rather small punctures, abdomen with a few very short hairs; the abdomen, in swollen female, is very elongate; legs large and very slender; tarsi (Pl. II, fig. 2) tapering to tip; coxæ I, II, and III (Pl. II, fig. 1) with a small apical process behind. Stigmal plate circular, peritreme circular, surface with many minute granulations.

Length of female shield, 1.5 mm.

Several specimens from Pacific Grove, Cal., on a cormorant. It was described by Birula from Unalaska Island, and through the kindness of that gentleman I have examined one of his cotypes. Apparently the same species has been described by Neumann from Japan as *Ixodes parvirostris*.

Ceratixodes putus Cambridge.

Female.—Shield and legs dull yellowish; abdomen pale brownish. Capitulum (Pl. II, fig. 4; Pl. IX, fig. 6) more than twice as broad as long, rather wider at outer base of palpi than elsewhere, hind angles not prominent, porose areas large, approximate, pointing outward. Palpi (Pl. II, fig. 4) rather large, second joint with four long bristles on the inner side below, third joint with a swelling on the inner side near base, the apical joint large, with a bristle each side. Shield (Pl. II, fig. 6) plainly longer than broad, broadest on anterior third, somewhat concave and tapering behind, tip rounded, the lateral lobes distinctly separated, surface with many irregularly placed deep punctures, not all of an even size; abdomen above and below with many long hairs. Legs large and slender, the tarsi (Pl. II, fig. 5) strongly humped above before tip; coxæ wholly unarmed.

Stigmal plate (Pl. II, fig. 8; Pl. IX, fig. 6) large, nearly circular, with a circular peritreme, surface minutely granulate.

Length of female shield, 1.7 mm.

Male.—Body subrectangular, narrowed in front of third pair of legs, broadly rounded behind. Shield not reaching to tip, with many subequal punctures, some hairs near hind margin of body; venter finely punctate; stigmal plate as in the female. Capitulum three times as broad as long, with a median depression; mandibles about one-half as long as palpi, hypostome still shorter, palpi (Pl. II, fig. 7) cylindrical, third joint prolonged in an acute point, the fourth joint projecting below from near the base. Legs rather slender; coxæ unarmed; the tarsi tapering, fourth with apical tooth and subterminal tubercle beneath.

Length of male, 3.8 mm.

Specimens come from St. Paul Island, Alaska, and Bering Island. Birula records it from Unalaska, and Kramer and Neuman from Bering Island. Cambridge described it from Kerguelen Island, Antarctic Ocean, and Evans and others have taken it from the western isles of Scotland. It is probable that the *Ixodes uriæ* of White (a manuscript name) from Arctic America is the same species. It occurs on several large migratory sea birds.

Genus IXODES Latreille.

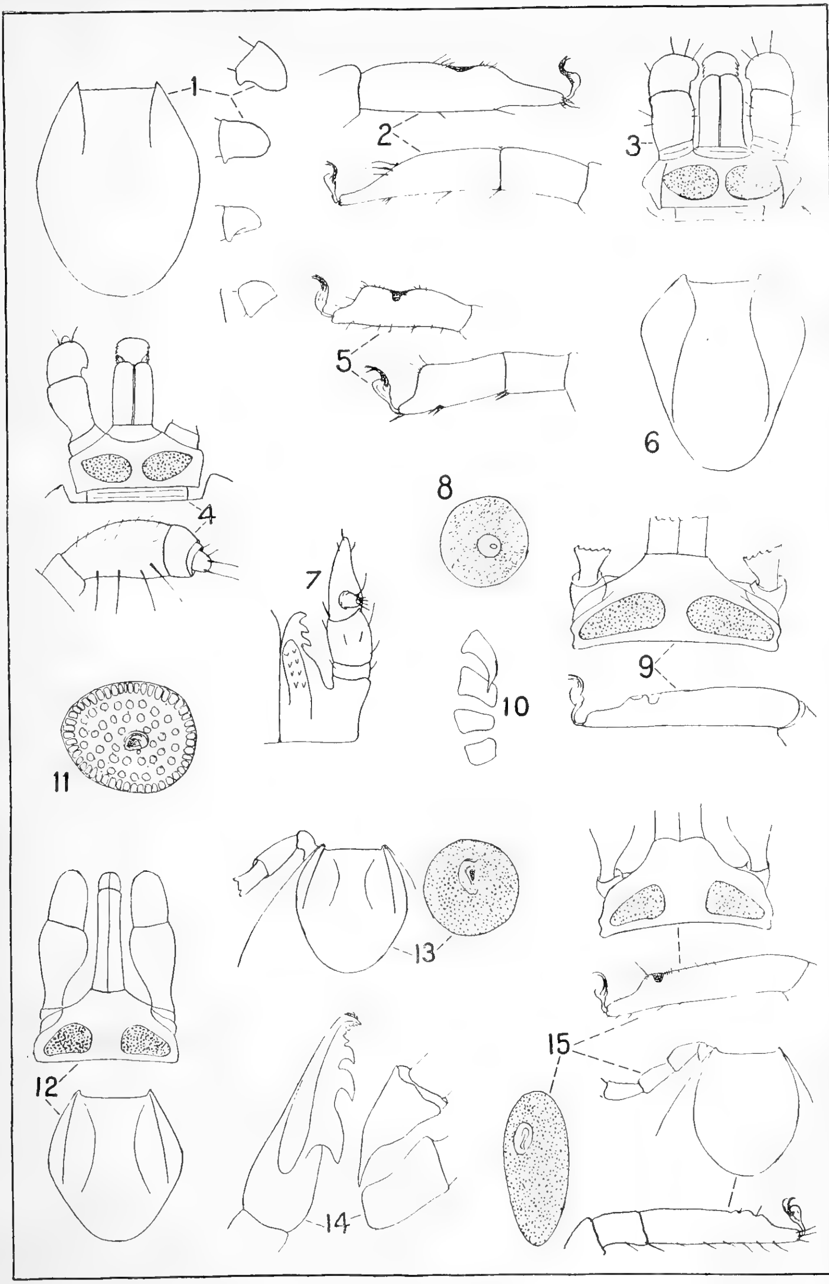
Venter showing a pair of submedian grooves reaching forward from hind margin of body and connected in front of anus; no groove behind anus. Capitulum produced anteriorly in the middle; porose areas subtriangular. Palpi rather slender, at least in female, the second joint usually twice as long as broad, the third not very much shorter, longer than broad and tapering toward tip. Shield without markings; no ocelli. Coxa I close to rostrum, with one or two teeth behind; coxa IV of male not enlarged. Posterior margin of body without festoons. Stigmal plate circular or elliptic. Tarsi II, III, and IV divided, the basal part shorter than the apical part, and no tooth-like claw at apex.

Type.—*Ixodes ricinus* Linnæus.

Our species are numerous, and probably there are several yet to be found by more thorough exploration.

TABLE OF THE SPECIES.

1. Tarsus I fully one and one-half times as long as the metatarsus ------- 2
   Tarsus I barely more than one and one-fourth times as long as the metatarsus ------- 6
2. A stout backward-directed tooth on under side of rostrum from near base of each palpus; shield fully twice as long as broad, with definite lateral carinæ; porose areas about as long as broad ---- *diversifossus.*
   No such teeth on rostrum below, at most only a tubercle; shield broader, and rarely with definite carinæ; porose areas plainly broader than long ------- 3



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Ceratixodes signatus*, female shield and coxæ. Fig. 2.—*Ceratixodes signatus*, tarsi I and IV. Fig. 3.—*Ceratixodes signatus*, capitulum of female. Fig. 4.—*Ceratixodes putus*, capitulum and palpus of female. Fig. 5.—*Ceratixodes putus*, tarsi I and IV. Fig. 6.—*Ceratixodes putus*, shield of female. Fig. 7.—*Ceratixodes putus*, palpus of male below. Fig. 8.—*Ceratixodes putus*, stigmal plate of female. Fig. 9.—*Ixodes ricinus*, capitulum and tarsus I of female. Fig. 10.—*Ixodes ricinus*, coxæ of female. Fig. 11.—*Ixodes scapularis ?*, stigmal plate of nymph. Fig. 12.—*Ixodes californicus*, female shield and capitulum. Fig. 13.—*Ixodes ricinus*, female shield and stigmal plate. Fig. 14.—*Ixodes scapularis*, mandible, and coxæ I and II. Fig. 15.—*Ixodes scapularis*, capitulum, tarsi I and IV, and shield, of female; stigmal plate of male. (Original.)

3. Shield about one and one-half times longer than broad; all coxæ with spines; second joint of palpus about four times as long as broad; porose areas occupying greater part of capitulum; a small tooth at base of each palpus ---------- *brunneus.*
   Shield but little longer than broad; only coxa I spined (in female); second joint of palpus scarcely three times as long as broad; porose areas smaller ---------- 4
4. Shield not angulate on sides, no lateral carinæ; porose areas separated by fully their length; tarsus I rather shorter ---------- *scapularis.*
   Shield slightly angulate on sides, with traces of lateral carinæ ---------- 5
5. Porose areas large, separated by less than their length; coxa I with very long spine ---------- *ricinus.*
   Porose areas smaller, more widely separate; coxa I with shorter spine; shield more rhomboidal ---------- *californicus.*
6. Shield with definite lateral carinæ ---------- 7
   Shield without definite lateral carinæ; coxa I with a short spine ---------- 11
7. A large tooth each side under rostrum; coxa I with one long spine ---------- 10
   No such teeth under rostrum ---------- 8
8. Shield fully one and one-half times as long as broad; coxa I with rather short spine; porose areas triangular ---------- *angustus.*
   Shield not one and one-half times as long as broad; coxa I with long spine; porose areas not triangular ---------- 9
9. Porose areas as long as broad, the area separating them with a scar ---------- *sculptus.*
   Porose areas broader than long, no scar between them ---------- *cookei.*
10. Shield narrowed behind; hind angles of capitulum very prominent; porose areas broader than long, very small ---------- *pratti.*
   Shield very broad behind; hind angles of the capitulum barely distinct; porose areas nearly as long as broad ---------- *dentatus.*
11. Shield finely punctate, about one and one-half times as long as broad; third joint of palpus longer than broad; porose areas small, separated by their width ---------- *marxi.*
   Shield coarsely punctate, barely longer than broad; last joint of palpus about as broad as long; porose areas larger, not separated by width ---------- *hexagonus.*

Ixodes arcticus Osborn.

This was described from one specimen taken from a seal from the Pribilof Islands. It is recorded (No. 3500) in the type catalogue of the Division of Insects, U. S. National Museum, but diligent search on several occasions has failed to discover the specimen, therefore I am compelled to copy the description of Professor Osborn, which is not as specific as I could wish, yet indicates that the species is a good one:

"Elongate oboval, slightly contracted behind the middle, finely transversely striated; dorsal shield deep chestnut brown, oval except where truncated to join head; two divergent impressed lines or furrows from near the anterior margin to behind the middle, where they terminate abruptly, and external to which, near their ends, are short, impressed lighter marks, one on either side. Palpi rather short, blunt, truncate at apex, sharp edged, flat, and somewhat impressed above; legs blackish except the joints, long, strong. The dorsum of the expanded abdomen has two deep parallel furrows anteriorly and three posteriorly, and the ventral surface has the ordinary furrows of the genus, much as in *ricinus*. The color of the alcoholic specimens is a testaceous yellow. Length of expanded female, 6 mm. Length of dorsal shield, 1.25 mm.; width, 0.92 mm."

Ixodes californicus Banks.

Female.—Shield yellow-brown, legs darker brown, abdomen yellowish gray, unspotted. Capitulum (Pl. II, fig. 12) not nearly as broad as in *I. ricinus*, the posterior angles acute, the porose areas subtriangular, but plainly broader than long, and separated by about their length, inner edge oblique; palpi moderate, second joint plainly a little longer than the third, the latter not twice as long as broad. Shield (Pl. II, fig. 12) but little longer than broad, somewhat trapezoidal, the outer sides rather angulate before the middle, lateral carinæ not distinct, but traceable, punctuations numerous and fine. Abdomen striate, punctate, and hairy; ventral furrows divergent behind, legs rather slender, very hairy below, tarsus I fully one and one-half times longer than metatarsus, tapering to the tip, tarsus IV but little longer than metatarsus, tapering; coxa I with a long, sharp, basal spine, and a minute tooth at apex behind to all coxæ; stigmal plate rather small, nearly circular, and its surface finely granulate.

Length of female shield, 1.2 mm.

Male.—Similar to that of *I. scapularis*, but the shield has more nearly parallel sides, and the stigmal plate is nearly circular, the palpi are very short, and coxa I has a long, sharp spine behind.

Length of male, 2 mm.

Specimens from Claremont, Santa Clara County, Santa Cruz Mountains, and Redwood Creek, Humboldt County, all California. The hosts were gray fox and black-tail deer.

Separated from *I. ricinus* by shape of the porose areas, and from *I. scapularis* by more distinct lateral carinæ, and many minor points.

Ixodes ricinus Linnæus. (Pl. IX, fig. 5.)

Female.—Shield reddish brown, body, legs, and palpi a paler brown, unspotted. Capitulum (Pl. II, fig. 9) very broad and short, porose areas twice as broad as long, not separated by their length, inner edge rounded, outer ends nearly reaching to basal angle of capitulum; palpi moderate, second joint barely longer than the last, the latter fully twice as long as broad. Shield (Pl. II, fig. 13) rather elliptical, plainly longer than broad, and the outer sides somewhat angulate much before the middle, lateral carinæ short and indistinct; many small, equal punctures, most numerous behind. Legs long, tarsus I (Pl. II, fig. 9) fully one and one-half times as long as metatarsus, tapering to tip, tarsus IV also slender and tapering; coxa I with a long sharp spine at base and a minute one at tip, II with a small tooth at tip behind, others practically unarmed. (See Pl. II, fig. 10.) Abdomen above and below punctate and with many hairs; in female before engorgement there is a submarginal groove, incomplete behind; both ventral furrows divergent behind. Stigmal plate (Pl. II, fig. 13) rather large, circular, its surface minutely granulate.

Length of female shield, 1.1 mm.

Specimens in Marx collection from Kansas on sheep and from Texas on cattle. I have compared these with European specimens and they seem to be identical. Possibly they were introduced into this country with the hosts. I have not seen a male. Practically all of the previous records of this species in this country apply to *Ixodes scapularis* or to *I. cookei.*

Ixodes scapularis Say. (Pl. IX, figs. 1, 2.)

Female.—Shield dark red-brown, almost black; legs and palpi paler; abdomen brown. Capitulum (Pl. II, fig. 15; Pl. IX, fig. 2) quite broad, hind angles acute, porose areas rather large, but plainly smaller than in *I. ricinus*, much broader than long and separated by fully their length, their inner edge somewhat truncate, and their outer angle not far from hind angle of capitulum; palpi elongate, second joint a little longer than the last, which is hardly twice as long as broad. Shield (Pl. II, fig. 15) broad in front, plainly longer than broad, broadly rounded behind, outer sides not angulate, and no lateral carinæ; punctuations fine and numerous all over surface. Legs long and slender; tarsus I fully one and one-half times as long as the metatarsus, and tapering to tip; tarsus IV plainly shorter than I, tapering to tip (see Pl. II, fig. 15); trochanters I and II swollen behind; all legs very hairy below; coxa I (Pl. IX, fig. 2) with a long sharp spine behind at base, and a small apical tooth, coxæ II and III with apical tooth, IV unarmed (see Pl. II, fig. 14). Abdomen finely striate, hairy, not prominently punctate; before engorgement there is a submarginal groove each side; stigmal plate (Pl. IX, fig. 2) circular, its surface finely and evenly granulate; ventral furrows divergent behind.

Length of female shield, 1.3 mm.

Male.—Dark colored as in female; the palpi are very short, second and third joints no longer than broad; shield with subparallel sides, densely punctate and very hairy; legs and coxæ as in the female; the stigmal plate (Pl. II, fig. 15) large, and elongate.

Length of male, 2 mm.

From many places in the South, especially abundant in Florida and southern Texas, where it occurs on dogs and man as well as on various wild animals; from Norfolk, Va., on cattle; McGregor, Iowa; Texas (Belfrage Coll.); North Carolina, and Texas (Marx Coll.); Maryland, on sheep; Indiana.

This species is readily separated from *I. ricinus* by smaller porose areas and by the dark shield. It has been confused with *I. ricinus* by Neumann in the Marx collection; however, Neumann described the same species as new, *I. affinis*, from Costa Rica, and I have examined some of his type material.

Ixodes brunneus Koch.

Female.—Shield brown, paler through the middle; palpi brown, pale on base; legs pale brownish yellow, tarsi paler, other joints marked with brown; abdomen brown, usually paler than the shield. Capitulum (Pl. III, fig. 9) small, hind angles not prominent; porose areas very large, angulate in front, separated by about one-half their length; palpi very slender, second joint plainly longer than last, latter fully twice as long as broad. Shield (Pl. III, fig. 9) about one and one-half times longer than broad, widest rather before the middle and tapering each way, no lateral carinæ, but submedian grooves distinct, surface with many fine punctures, lateral lobes wrinkled. Legs slender, tarsus I very long, about twice as long as the preceding joint, tapering to tip, hind tarsus also tapering, but not so much longer than the metatarsus; coxæ I with a large, short spine at base and all coxæ with a distinct tooth at apex behind; trochanters II and III swollen behind. Body striate and punctate, with numerous hairs; anal furrows parallel behind; stigmal plate large, circular, and its surface with quite large granules.

Length of female shield, 1.5 mm.

Two females from a tufted tit, Raleigh, N. C. (Brimley Coll.); also one female from hermit thrush, Baltimore, Md. (Hassall Coll.). This is the specimen named by Neumann *Ixodes frontalis*. At that time, however, he had not seen the type of *I. brunneus*. Later, in a key, he separates them on the ground that *brunneus* has the tarsi attenuated gradually, while in *frontalis* they are narrowed suddenly before the tip. In this specimen the tarsi are certainly not attenuated suddenly, but are like the North Carolina specimens. There is another specimen, in the collection of the Massachusetts Agricultural College, which was taken from the neck of a "chipping bird," May 1, 1895, probably from Amherst, or near by; and the *Ixodes kelloggi*, recently described by Nuttall and Warburton, is evidently the same species, although the description is very brief. Their specimens came from Californian birds. Koch described the species from one female from *Fringilla albicollis*, from North America. I have not seen the male. Evidently the species is confined to birds.

Ixodes diversifossus Neumann.

Female.—Shield, capitulum, and legs very dark red-brown; abdomen grayish yellow. Capitulum (Pl. III, fig. 12) rather triangular, long, hind angles very prominent; porose areas rather small, subtriangular, much more than width apart; palpi long and slender. Shield (Pl. III, fig. 14) plainly a little longer than broad, broadly rounded behind, broadest in front of middle, lateral carinæ distinct, reaching margin; surface with mostly small punctures, but those near the margin behind are very large. Abdomen striate and punctate; anal grooves subparallel; stigmal plate (Pl. III, fig. 14) large, nearly circular, coarsely granulate; coxæ I (Pl. III, fig. 14) with a large, sharp, basal spine, a small apical cone beyond it, and similar cone on coxæ II (Pl. III, fig. 14) and III, that on coxæ IV very indistinct; legs long and slender, tarsi slender, tarsus I (Pl. III, fig. 14) about twice as long as preceding joint; all tarsi taper to tip. Under the beak at base of palpi is a large backward-directed tooth each side (see Pl. III, fig. 14).

Length of female shield, 1.6 mm.

Two specimens (the types) from a raccoon, New Mexico, in the Hassall collection, and kindly loaned by Doctor Hassall.

Ixodes bicornis Neumann, described after the types of *I. diversifossus* were returned to the United States, comes extremely close to this species, and I think is identical. It is from Mexico, and I have specimens from Doctor Dugès agreeing closely with the description and also with the types of *I. diversifossus.* The male is still unknown.

Ixodes pratti n. sp.

Female.—Dark reddish brown, legs and palpi paler. Capitulum (Pl. IV, fig. 1) broad, outer angles rather prominent, posterior angles distinctly prolonged; porose areas broader than long, and separated by one-half their width; palpi short, second joint about one and one-half times as long as broad, last joint scarcely as broad as long; below there is near the base of each palpus a distinct, stout, downward-projecting tooth (see Pl. IV, fig. 1). (Hypostome, Pl. IV, fig. 5.) Shield (Pl. IV, fig. 1) a trifle longer than broad, narrowed behind, lateral carinæ distinct and reaching to the margin, surface rather densely punctate, and many of the punctures quite large. Abdomen striate and punctate, with very fine hairs; anal grooves plainly divergent; stigmal plate (Pl. IV, fig. 1) small, almost circular, its surface with rather large granules. Coxæ with a minute tooth at apex behind; coxa I (Pl. IV, fig. 1) with a moderately long basal spine (not as long as in *I. cookei*). Legs short and slender, quite hairy, and the tarsi (Pl. IV, fig. 4) tapering to the tip.

Length of female shield, 0.9 mm.

Male.—Body very slender, more than twice as long as broad, dark brown, and very hairy; a deeply impressed lateral and posterior groove; surface densely punctate. Capitulum not broader behind than long in middle, sides parallel, posterior angles not prolonged; palpi short, but longer than width of capitulum, the third joint a little longer than broad, legs rather short, coxæ I with a very long, slender spine behind, II with two humps behind, and III with one hump; venter punctate; stigmal plate (Pl. IV, fig. 4) twice as long as broad, finely granulate.

Length, 2 mm.

A pair from Kerrville, Tex., May; one female from Sherwood, Tex., on a prairie dog (F. C. Pratt), and two females from Walker Pass, Death Valley, California, from *Thomomys* (Fisher).

This species differs from *Ixodes diversifossus* by the shorter tarsi I, by the absence of large pits on posterior part of the shield, by shorter spine on coxa I, by shorter palpi, and has several minor differences. Nymphs, probably of this species, are from Kerrville on skunk, and from Del Rio on rock squirrel; the stigmal plate is elliptical, and of peculiar sculpture, as figured (Pl. IV, fig. 3).

Ixodes dentatus Neumann. (Pl. IX, fig. 3.)

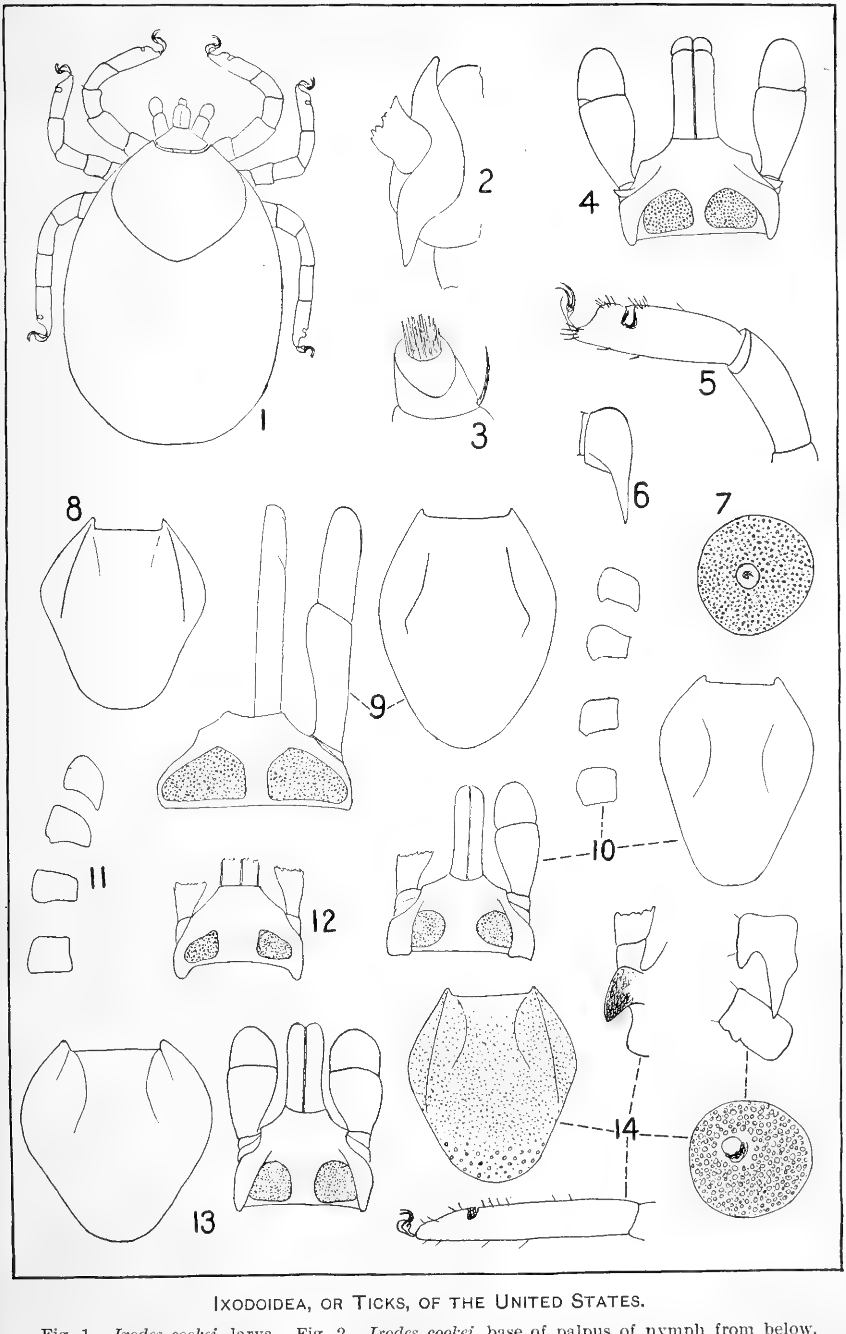
Female.—Shield, capitulum, and legs dark red-brown; abdomen nearly black. Capitulum (Pl. IV, fig. 6; Pl. IX, fig. 3) small, hind angles rather prominent; porose areas broader than long, nearly their width apart; shield (Pl. IV, fig. 6; Pl. IX, fig. 3) only a little longer than broad, broad behind, lateral carinæ distinct, reaching the hind margin, the middle area behind densely, finely punctate, elsewhere with few punctures. Abdomen (engorged female) elongate, striate and punctate, with many very short hairs; stigmal plate circular, its surface minutely granulate, the stigma nearly central. The under side of the rostrum shows a stout recurved tooth each side, just behind the bases of palpi (Pl. IV, fig. 6; Pl. IX, fig. 7). Coxæ I with a long basal spine behind, and a small apical tubercle, and similar one on coxæ II, others unarmed (Pl. IV, fig. 6); legs short, finely haired.

Length of female shield, 1 mm.

Described from the type specimen in the Marx collection, taken from a rabbit in Maryland; the palpi are broken off. This is the only specimen I have seen; it is very distinct, not only by the teeth on the rostrum, but also by the shape of the shield.

Ixodes cookei Packard. (Pl. IX, fig. 4.)

Female.—Shield yellow-brown, legs and palpi somewhat paler, abdomen gray-brown. Capitulum (Pl. III, fig. 4; Pl. IX, fig. 4) rather broad, triangular, the hind angles moderately prominent, the



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Ixodes cookei*, larva. Fig. 2.—*Ixodes cookei*, base of palpus of nymph from below. Fig. 3.—*Ixodes cookei*, tip of palpus of nymph. Fig. 4.—*Ixodes cookei*, capitulum of female. Fig. 5.—*Ixodes cookei*, tarsus I. Fig. 6.—*Ixodes cookei*, coxa I. Fig. 7.—*Ixodes cookei*, stigmal plate of female. Fig. 8.—*Ixodes cookei*, shield of female. Fig. 9.—*Ixodes brunneus*, capitulum and shield of female. Fig. 10.—*Ixodes marxi*, capitulum, coxæ, and shield, of female. Fig. 11.—*Ixodes hexagonus*, coxæ of female. Fig. 12.—*Ixodes diversifossus*, capitulum of female. Fig. 13.—*Ixodes hexagonus*, capitulum and shield of female. Fig. 14.—*Ixodes diversifossus*, shield, tarsus I, stigmal plate, coxæ I and II, and tooth beneath rostrum—all of female. (Original.)

porose areas about one-fourth broader than long, one-half their diameter apart; palpi short and broad, the last joint barely, if any, longer than broad, and plainly shorter than second joint. Shield (Pl. III, fig. 8) only a trifle longer than broad, somewhat narrowed behind, widest part plainly in front of the middle, its surface densely and rather coarsely punctate, the lateral carinæ moderately distinct, running out slightly behind the widest part. Abdomen punctate and with extremely short hairs; in engorged specimens elongate; the anal furrows subparallel behind; the stigmal plate (Pl. III, fig. 7; Pl. IX, fig. 4) large, elliptical, the surface granulate and the stigma situated before the middle; coxæ with a small apical tooth behind, and coxa I (Pl. III, fig. 6) with a long stout spine at base; legs rather long and large, tarsi suddenly narrowed before tip, tarsus I (Pl. III, fig. 5) but little longer than the metatarsus.

Length of female shield, 1.5 mm.

Male.—Yellow-brown, the palpi very short, the apical joint fully as long as second; shield nearly one and two-thirds times longer than broad, broadly rounded behind, rather densely and evenly punctate, showing three shallow furrows, the median one not reaching as far forward as the sublateral pair; stigmal plate large and like that of the female; the coxæ armed the same, but the basal spine on coxa I has a more slender point.

Length of male, 3.3 mm.

This species is common on small mammals in the Eastern States, as far west as the Rockies. I have seen it from Norway, Me.; Salem, Amherst, and Sherborne, Mass.; Washington Hollow, Manlius, Albany, Catskills, Crane Point, and Rensselaer and Greene counties, New York; Pine County, New Jersey; Plummers Island, Maryland; Washington, D. C.; Agricultural College, Michigan; Iowa; St. Anthony Park, Minn.; Brookings, S. Dak.; Denver, Colo.; Kansas; Kerrville, Tex., and Guelph, Ontario, Canada. The known hosts include fox, mink, weasel, skunk, pocket gopher, striped gopher, porcupine, woodchuck, raccoon, dog, cat, and robin. I have examined Packard's type of this species, now in the Museum of Comparative Zoology, and typical specimens of *Ixodes hexagonus* var. *longispinosus* of Neumann which are identical with Packard's form. I consider Fitch's *I. cruciarius* to be the same; Fitch gave three descriptions of this species—two from specimens from human beings, the other from a specimen from mink; they evidently apply to this species; all were from New York. In both cases on human beings the bite was very severe, and medical attention was necessary in one case.

Ixodes angustus Neumann.

Female.—Shield pale brownish yellow; legs very pale yellowish; abdomen yellowish gray. Capitulum (Pl. IV, fig. 2) small, triangular, posterior angles acute, the porose areas long, triangular, nearly as long as broad; palpi with the second joint plainly a little longer than the last, the latter about one and one-half times as long as broad. Shield (Pl. IV, fig. 2) elongate, fully one and one-half times as long as broad, broadest near middle, broadly rounded behind, lateral carinæ distinct, but running out before the posterior third, surface minutely punctate. Abdomen (engorged) very elongate, with very short hairs, the anal grooves slightly approximating behind; stigmal plate (Pl. IV, fig. 2) transversely elliptical, its surface minutely granulate. Legs short, tarsus I suddenly narrowing before tip, other tarsi tapering to tip, tarsus I but little longer than metatarsus; coxæ I with a rather short, stout spine at base behind, and a tooth near apex, a similar tooth on coxæ II and III, coxæ IV unarmed (see Pl. IV, fig. 2).

Length of female shield, 1 mm.

Male.—The only one seen is very small; elliptical; the capitulum subtriangular, the palpi extremely short, barely longer than width of capitulum; the shield elliptical, about one and three-fourths times as long as broad, and but little broader in middle.

Length of male, 1.5 mm.

The type is a female taken from *Neotoma occidentalis* at Shoshone Falls, Idaho, collected by Dr. Cooper Curtice, and now in the collection of the Bureau of Animal Industry, this Department. Other specimens come from various rodents of the Northwest; Glacier Bay, Alaska; Portland, Oregon; Massett, British Columbia; Walker Pass and Siskiyou County, California. In the Fourth Memoire of his Revision Neumann gives a second description based on two specimens from Argentina, of what he thinks is this species; it differs in several points of structure, and evidently is not the same species, since the many specimens of *I. angustus* examined by me agree closely with the type.

Ixodes sculptus Neumann.

Female.—Shield yellow-brown; legs and palpi paler; abdomen yellow-brown. Capitulum (Pl. IV, fig. 7) elongate-triangular, posterior angles scarcely prominent; porose areas large, much longer than broad, and only about one-half their breadth apart, this space containing an elongate depression or scar. Last joint of palpus one and one-half times as long as broad, second joint plainly a little longer. Shield (Pl. IV, fig. 7) one and one-fourth times as long as broad, broadly rounded behind, lateral carinæ strong, somewhat incurved, almost reaching the margin, the surface densely and very minutely punctate. Abdomen punctate and with many longitudinal rows of short yellowish hairs; anal furrows subparallel; stigmal plate rather large, elliptical, its surface minutely granulate; all coxæ (Pl. IV, fig. 9) with a small apical tooth behind, and coxa I with a long basal spine; legs rather long, not very hairy, and the tarsi abruptly narrowed near tip, tarsus I but little longer than the metatarsus.

Length of female shield, 1.4 mm.

The type, in the Marx collection, is from the Santa Cruz Mountains, California. I have also seen two females from Del Rio, Tex., on rock squirrel (Bishopp), which agree closely with the type, except that the color is darker, the shield being dark red-brown, and the abdomen nearly black. They are engorged, and the abdomen is elongate.

Ixodes hexagonus Leach.

Female.—Capitulum and shield yellowish brown; legs and palpi paler; abdomen grayish yellow. Capitulum (Pl. III, fig. 13) rather elongate, hind angles slightly produced, porose areas large, subtriangular, as long as broad, and scarcely half their diameter apart; palpi short, second joint only a little longer than broad, last not as long as broad. Shield (Pl. III, fig. 13) about as broad as long, tapering behind, the anterior sides quite long, no trace of lateral carinæ, surface rather evenly and densely strewn with quite large punctures. Abdomen striate, when engorged elongate; punctures and hairs very weak; anal grooves subparallel; stigmal plate moderately large. nearly oval, the stigma in front of middle, its surface strongly granulate. Coxæ (Pl. III, fig. 11) with a minute black tooth at apex behind, and coxa I with a very short spine at base. Legs moderately large, hairy; tarsi tapering to tip, tarsus I but little longer than the preceding joint.

Length of female shield, 1.2 mm.

Two specimens in the Marx collection from sheep, Kansas, and labeled by Neumann as typical *I. hexagonus.* Possibly they were introduced with the sheep. Also two specimens in the Hassall collection from rabbit, Baltimore, Md., labeled by Neumann as typical *I. hexagonus.* The specimens in the same collection from spermophile, District of Columbia, and pocket gopher, Iowa, also labeled by Neumann as *I. hexagonus*, are not that species, but the *I. cookei* Packard (*longispinosus* Neum.) The four females from the United States agree quite closely with a German specimen in the Marx collection, labeled by Neumann *I. hexagonus;* but the porose areas in the European specimen are more pointed in front, and the shield is rather more coarsely punctate and wrinkled.

I have not seen a male from the United States, and both cases of the species' occurrence may be importations. Nearly all the previous records of this species in this country refer to *I. cookei.*

Ixodes marxi n. sp. (Pl. IX, fig. 8.)

Female.—Shield, capitulum, and legs pale yellowish gray. Capitulum (Pl. III, fig. 10) rather broad, the posterior angles hardly projecting; porose areas somewhat circular, far from sides, and nearly their diameter apart; palpi with last joint fully as long as broad, plainly shorter than the second. Shield (Pl. III, fig. 10) about one and one-half times as long as broad, broadest much before middle, narrowed behind, with concave sides, tip broadly rounded, lateral carinæ practically invisible, surface very finely and rather sparsely punctate. Abdomen with fine punctures and very short hairs; stigmal plate very small, nearly circular, surface granulate; coxæ (Pl. III, fig. 10) almost unarmed, but a small tooth behind on coxæ I and II and a short spine at base of coxa I; legs rather short, tarsi suddenly narrowed before tip.

Length of female shield, 1 mm.

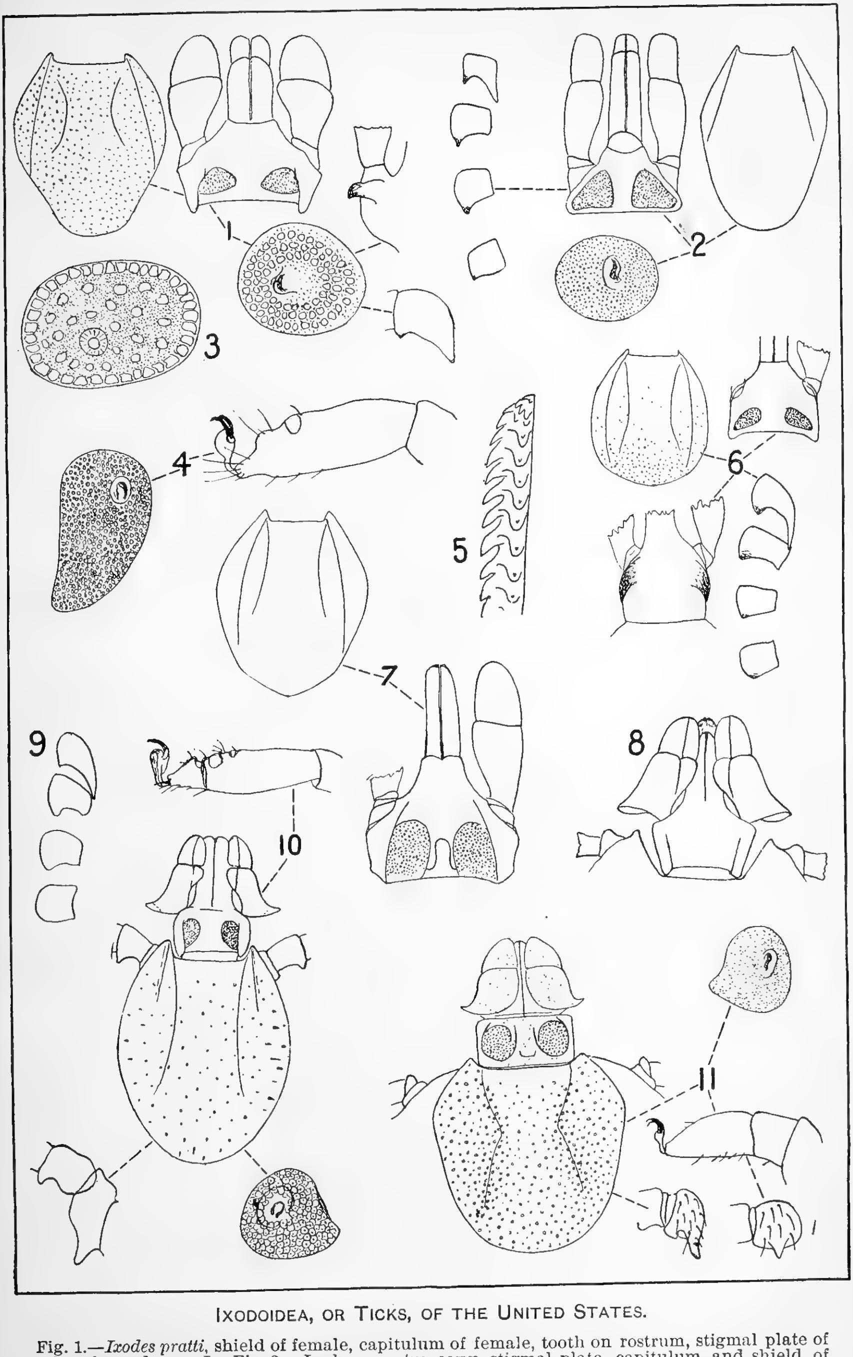
I have seen this species from Washington, D. C.; Salineville and Wauseon, Ohio; Ithaca, N. Y.; Portland, Mich.; Guelph, Ontario, Canada; and Denver, Colo. It has usually been taken on red squirrels, but the specimen from the last locality was from fox. Two of these specimens were referred doubtfully by Neumann to his variety *inchoatus* of *Ixodes hexagonus*, which, however, has an earlier name in *I. canisuga* Johnston, 1849, a common dog tick in Scotland. Through the kindness of Dr. William Evans I have obtained specimens of *I. canisuga* and find that it has a more coarsely punctate shield than our species, and the porose areas are larger, while the legs are larger and there is no trace of a spine at base of coxa I. I have not seen the male of *I. marxi*. I name it in honor of Dr. George Marx, who had recognized its distinctness and given it a manuscript name.

Genus HÆMAPHYSALIS Koch.

Venter showing a curved groove behind the anus, and from this a median furrow back to margin of body. Capitulum not angulate on sides; porose areas large, longitudinal, distant. Palpi short, second joint with an acute basal prolongation outward. Shield without markings; no ocelli. Abdomen showing festoons behind; coxa I with one tooth behind; coxa IV of male not enlarged. No anal plates in male. Stigmal plate broad, with a small outer point. Tarsi II, III, and IV indistinctly divided, the basal part shorter than the apical part, and no tooth-like claw at apex.

Type.—*H. concinna* Koch.

I have seen but two species from our territory; the record of *H. concinna* is due to wrong synonymy.



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Ixodes pratti*, shield of female, capitulum of female, tooth on rostrum, stigmal plate of female, and coxa I. Fig. 2.—*Ixodes angustus*, coxæ, stigmal plate, capitulum, and shield, of female. Fig. 3.—*Ixodes pratti*, stigmal plate of nymph. Fig. 4.—*Ixodes pratti*, stigmal plate of male and tarsus I. Fig. 5.—*Ixodes pratti*, hypostome. Fig. 6.—*Ixodes dentatus*, teeth below on rostrum, coxæ, capitulum, and shield, of female. Fig. 7.—*Ixodes sculptus*, shield and capitulum of female. Fig. 8.—*Hæmaphysalis leporis-palustris*, capitulum of male. Fig. 9.—*Ixodes sculptus*, coxæ of female. Fig. 10.—*Hæmaphysalis leporis-palustris*, tarsus I, capitulum and shield, stigmal plate, and coxa I, of female. Fig. 11.—*Hæmaphysalis chordeilis*, shield and capitulum, coxæ I and IV, tarsus IV, and stigmal plate, of female. (Original.)

TABLE OF THE SPECIES.

Shield of female as broad as long; palpi very heavy and short....... *chordeilis.*
Shield of female longer than broad; palpi more slender....... *leporis-palustris.*

Hæmaphysalis leporis-palustris Packard. (Pl. X, figs. 2, 6.)

Female.—Red-brown to black; shield, mouth parts, and legs red-brown, without markings. Capitulum (Pl. IV, fig. 10) not twice as broad as long, hind angles slightly prominent, porose areas elongate, separated by much more than their width, a ridge on the outer side of each; palpi rather elongate, second joint with a sharp projection on the outer side at base; the inner tip is inflated above, or rather its upper edge; the third joint also has a lamellar edge above projecting over the hypostome, and below there is a row of hairs on the second joint (Pl. X, fig. 2); the rostrum below has a distinct spine at each hind angle. Shield (Pl. IV, fig. 10) plainly longer than broad, with many large punctures above, and the submedian grooves very large and deep. Legs rather slender, the tibiæ and metatarsi I (Pl. IV, fig. 10) and II are convex below; trochanter I has a large projection above, and II and III have projections behind, when seen from below; coxa I (Pl. IV, fig. 10) is bifid behind, the basal projection the longer; other coxæ each with a very small projection; all coxæ have a number of long hairs. Abdomen striate, and with many deep punctures. The stigmal plate (Pl. IV, fig. 10) is as broad as long, with many rather large granules.

Length of female shield, 0.9 mm.

Male.—Paler red-brown; capitulum (Pl. IV, fig. 8) rather narrow, its posterior angles very distinctly prolonged; palpi shorter than in the female, but the inner sides inflated above as in the female; body nearly twice as long as broad, lateral grooves distinct, but no basal furrow to the eleven festoons; dorsal surface rather densely and evenly punctate. The legs are as in the female, and the coxæ armed the same, coxa I being rather more strongly bifid behind; the rostrum shows below the two small teeth behind as in the female. The stigmal plate is subtriangular, as broad behind as long, its surface rather coarsely granulate.

Length of male, 1.6 mm.

The nymph has the shield fully as long as broad, and broadly rounded behind.

Specimens come from Virginia; Shreveport, La.; Columbus and Victoria, Tex., Grand Canyon, Ariz.; Kern County, Cal.; Maverick, Tex.; Keene Valley and Dannemora, N. Y. Packard's types were from North Carolina. It is usually found on rabbits, but the young are often taken from birds, as quail, lark, etc.

Hæmaphysalis chordeilis Packard.

Female.—Shield, legs, and palpi rather uniform reddish brown, abdomen more yellowish brown. Capitulum (Pl. IV, fig. 11) nearly twice as broad as long, hind angles barely prominent; porose areas large, and limited by a ridge each side; palpi broad, second joint with a prominent sharp tooth on outer side at base, the two palpi together broader than long. Shield (Pl. IV, fig. 11) about as broad as long, strongly and densely punctate, the punctures most numerous at the submedian grooves. Legs rather short, tarsi (Pl. IV, fig. 11) shorter than in *H. leporis-palustris*, coxæ (Pl. IV, fig. 11) with distinct projections behind; that on coxa I is fully one-half the width of that joint. Body striate, and with scattered, broad, deep punctures. Stigmal plate (Pl. IV, fig. 11) longer than broad, with a short but distinct dorsal prolongation, its surface finely granulated.

Length of shield, 1 mm.; whole specimen, 5.5 mm.

The types, two engorged females from a nighthawk at Milton, Mass., are in the Museum of Comparative Zoology, where I have studied them. I have also seen a female from Taftsville, Vt., from a turkey.

Neumann, in his "Revision," had placed this species as a synonym of *H. leporis-palustris*, but it is plainly distinct. I have not seen the male, but a nymph from the killdeer, taken at Fort Collins, Colo., may belong to this species.

Genus RHIPICEPHALUS Koch.

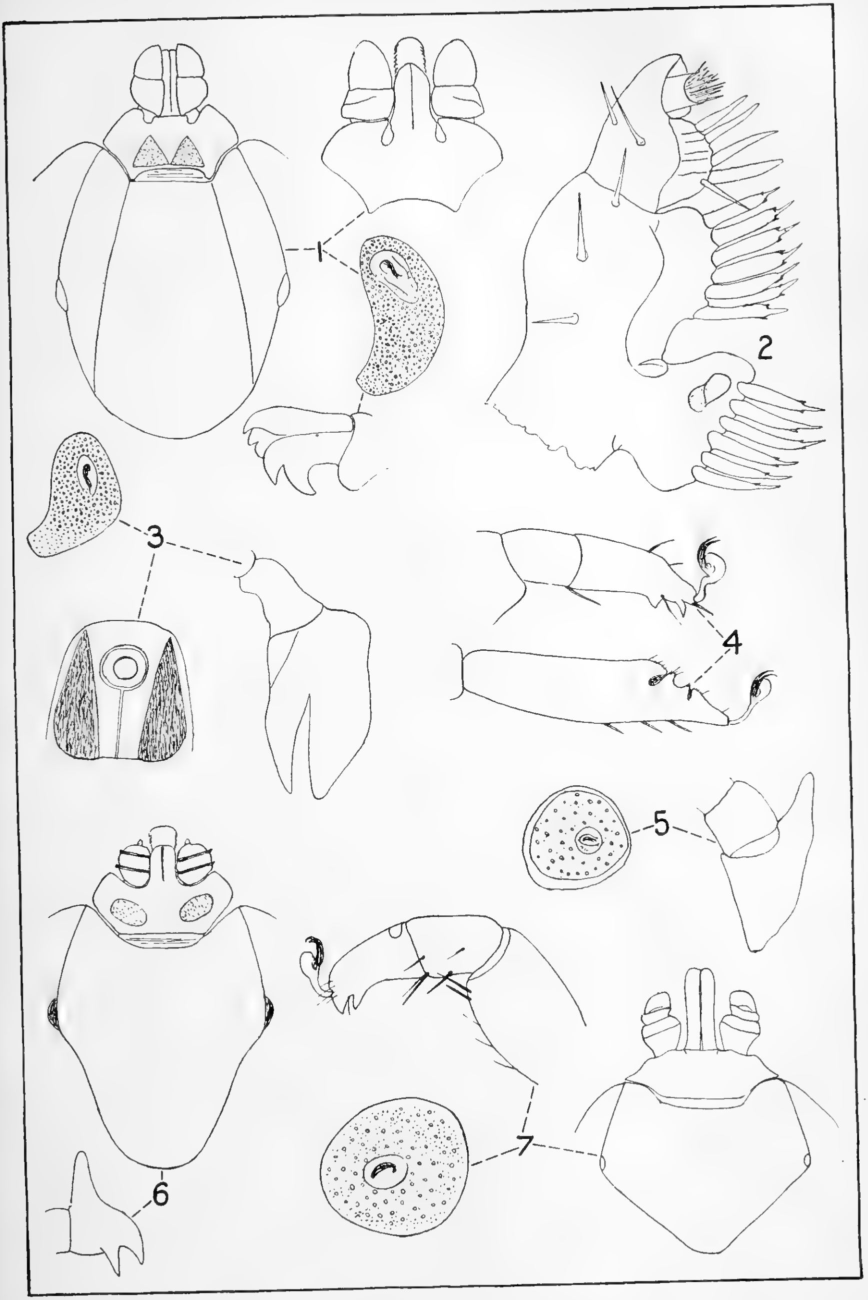
Venter showing a curved groove behind anus and a median line to the posterior margin of body. Capitulum angulate on sides; porose areas triangular, approximate. Palpi short and broad, no transverse ridges. Shield without markings; ocelli present. Abdomen showing festoons behind. Coxa I strongly bidentate behind; hind coxa not enlarged in male. Stigmal plate subcrescentic or reniform. Male with distinct anal plates. Tarsi II, III, and IV indistinctly divided, the basal part shorter than the apical part; no distinct tooth-like claw at apex. The palpi have on the lower edge a series of long flattened teeth, as represented in the figure.

Type.—*R. sanguineus* Latreille.

We have but one species of this genus, a form very similar to the type species.

Rhipicephalus texanus n. sp.

Male.—Red-brown, without markings; legs paler. Capitulum (Pl. V, fig. 1) broad, lateral angles acute, hind angles barely prolonged; palpi (Pl. V, fig. 2) very short, not as long as half the width of the capitulum, but as long as the hypostome, their tips acute. Dor-



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Rhipicephalus texanus*, shield, capitulum, and mandible, of female; capitulum and stigmal plate of male. Fig. 2.—*Rhipicephalus texanus*, palpus from beneath. Fig. 3.—*Rhipicephalus texanus*, stigmal plate of female, anal plates of male, and coxa I. Fig. 4.—*Rhipicephalus texanus*, tarsi I and IV. Fig. 5.—*Margaropus annulatus*, stigmal plate of nymph and coxa I of male. Fig. 6.—*Margaropus annulatus*, shield, capitulum, and coxa I, of female. Fig. 7.—*Margaropus annulatus*, tarsus IV of male, stigmal plate of female, and shield and capitulum of nymph. (Original.)

sum one and one-half times as long as broad, the shield still more narrow, and with subparallel sides, leaving broad lateral and apical margins, the latter with twelve impressed lines; the shield with a definite lateral groove reaching back from the eyes, and behind are seven festoons, without basal groove; also two submedian impressions, and three in the apical part, the median one the longest; surface with many subequal punctures. Legs rather long, the fourth pair thickened, anterior tarsi (Pl. V, fig. 4) rather slender; coxæ I (Pl. V, fig. 3) with two processes behind on the style of *Dermacentor*, the inner one much the thicker, other coxæ unarmed. Each side of the anus is an elongate triangular plate (Pl. V, fig. 3); the apex of the abdomen is somewhat pointed; the stigmal plate (Pl. V, fig. 1) is elongate, barely tapering behind and the tip upcurved, its surface with many small granules.

Length of male, 2.7 mm.

Female.—Red-brown; legs pale; no markings. Capitulum (Pl. V, fig. 1) broad, lateral angles acute, hind angles distinct, but little produced; porose areas triangular, situated on posterior part of capitulum, and touching on basal inner angle; palpi short, apex subacute. Shield (Pl. V, fig. 1) plainly longer than broad, broadly rounded behind, eyes farther back than in most ticks, surface with many large punctures, furrows separating the lateral lobes very distinct and reaching to the hind margin. Legs slender, all tarsi long, coxæ I (Pl. V, fig. 3) armed with two spines as in the male, other coxæ unarmed, but with transverse ridges. Stigmal plate (Pl. V, fig. 3) not very much longer than broad, with a prominent dorsal prolongation, its surface with many distinct granules.

Length of female shield, 1.3 mm.

Specimens have been taken at several places in Texas—San Antonio, Victoria, Brownwood, Brownsville, Green Lake—and from Albuquerque, N. Mex. It also occurs in Mexico. It has been taken from dogs and horses.

Genus MARGAROPUS Karsch.

Venter without distinct curved groove behind anus, but no submedian furrows. Capitulum angulate on sides; porose areas elliptic, distant. Palpi short and broad, second and third joints with transverse ridges. Shield without markings; ocelli present. Abdomen showing more or less distinct festoons behind. Coxa I bidentate behind, coxa IV of male slightly larger than the others. Four anal plates in male. Stigmal plate subcircular. Coxæ I more distant from the rostrum than in most ticks. Tarsi II, III, and IV indistinctly divided, the parts subequal in length; and a distinct tooth-like claw at tip.

Type.—*M. winthemi* Karsch.

The replacement of the familiar *Boophilus* by this almost unknown name is a case where the inflexible application of the law of priority is greatly to be deplored, especially since there is no resulting benefit whatever to science.

But one species has as yet been found in the United States, but an allied form is known from the West Indies, and will, perhaps, some day occur in our country.

Margaropus annulatus Say.

Male.—Small, brownish yellow, legs paler, no markings. Capitulum (Pl. X, fig. 8) rather crescentic, acute on lateral angles, hind angles prolonged into short spines; palpi extremely short, shorter than the hypostome, the joints with transverse acute ridges. Dorsum one and one-half times longer than broad, broadest near hind end, surface usually indicating two furrows in front, sublateral, and three furrows behind, with many rather small subequal punctures; festoons indistinct, but usually nine of them indicated. Legs slender, the first pair short, fourth pair much larger than the others; tarsi (Pl. V, fig. 7) short; all with scattered hairs. Coxæ I (Pl. V, fig. 5) with two spines behind, the inner one very short, the outer one more slender and sometimes very long, and in front a long spine-like process; other coxæ mutic. Two prominent long adanal plates, and each side a smaller, shorter, curved plate; the tips of these four plates are seen, in a dorsal view of the tick, projecting behind the posterior margin. Stigmal plate small, subelliptical, with about twenty-five or thirty large granules and many smaller ones.

Length of female, 2.2 mm.

Female.—Shield red-brown, often very dark, abdomen brighter red-brown; legs pale; no markings. Capitulum (Pl. V, fig. 6; Pl. X, fig. 7) broad, hind angles barely distinct, lateral angles acute; palpi extremely short, much shorter than the hypostome, and with ridges, as in male; porose areas elliptical, widely separated, and pointing outward. Shield (Pl. V, fig. 6) plainly longer than broad, broadest at eyes, quite suddenly narrowed behind the eyes; surface wrinkled, but the middle of front is smooth; a few punctures, mostly lost in the wrinkles. Abdomen with fine hairs; legs small and slender, hairy; coxæ unarmed; stigmal plate (Pl. V, fig. 7) small, only a little longer than broad, with a number of scattered visible granules, and many very minute ones.

Length of female shield, 1.1 mm.

Specimens may be taken from cattle in many parts of the country, but are native only to the Southern States, where they occur on deer and other animals. This is "the cattle tick" and the proven disseminator of southern cattle or splenetic fever. Much has been written upon it, and its life history is fairly well known.

It was described by Say from deer from Florida; described by Koch, and later by Packard, and by Riley as *Ixodes bovis*. Under this name it was long known, until Curtice proposed for it the genus *Boophilus*. Neumann has recently shown that the type of *Margaropus* is a true *Boophilus*, therefore it is necessary to drop the familiar cognomen, under which it had become of prime economic importance. Neumann at first considered *M. annulatus* to be of world-wide distribution; but in 1899 Fuller separated the South African and the Australian forms, and now it is believed that *M. annulatus* occurs only in North America.

Biological and economic accounts of this species can be found in Bulletin No. 72 of this Bureau. This tick is rarely recorded from any animal other than cattle; however, Mr. J. D. Mitchell has found it on sheep, and I have seen specimens taken from ponies in Michigan.

Genus AMBLYOMMA Koch.

Venter with a distinct curved groove behind the anus and a more or less distinct median furrow behind. Capitulum rather small; porose areas longitudinal. Palpi long and slender, second joint about twice as long as broad, third very much shorter than the second. Shield usually with some markings; ocelli present, and on margin of the shield. Abdomen showing festoons behind (except in distended female). Coxa I with one or two teeth behind; coxa IV of male not enlarged, usually with a spine behind. No anal plates in male. Stigmal plate subtriangular or elongate. Tarsi II, III, and IV plainly divided, the basal part much shorter than the apical part, and a distinct tooth-like claw at apex.

Type.—*A. cajennense* Fabricius.

TABLE OF THE SPECIES.

1. Coxa I with but one spine, metatarsi (except I) with two thickened spurs at tips; second joint of palpus not twice as long as third; porose areas elongate; shield brown, with silvery marks ____________ *maculatum.*
   Coxa I with two spines; metatarsi without stout spurs at tips, only slender hairs ____________ 2
2. Projections of coxa I blunt and short; porose areas elongate; second joint of palpus not twice as long as third; coxa IV of male with only a tubercle behind; large species ____________ *tuberculatum.*
   Projections of coxa I longer, and at least one of them sharp-pointed; second joint of palpus twice as long as third; coxa IV of male with a long spine; smaller species ____________ 3
3. Porose areas nearly circular; shield of both sexes pale yellowish, with some silvery streaks and marks, and some reddish spots; shield of female as broad as long ____________ *cajennense.*
   Porose areas elongate; shield brown, in female with an apical silvery mark, in male with two small apical and two or four other silvery spots; shield of female longer than broad ____________ *americanum.*

Amblyomma tuberculatum Marx.

Male.—Shield red-brown, with a narrow silvery stripe each side, slightly above the margin, and connected behind to the silvery spots on the festoons; from behind extend forward a pair of rather broad silvery stripes which unite somewhat behind the middle and are here connected to the lateral silvery stripes. In some specimens these markings are much less extensive, but the spots on the festoons are always distinct. Capitulum pale in middle of front, and also a pale spot on the shield just behind the capitulum; palpi pale; legs reddish brown, with tips of joints white; venter pale yellowish brown. The capitulum is large and long, the hind angles rounded; palpi short, the second joint not twice as long as the last. Dorsum very broad in front, hardly one and one-fourth times longer than broad, with many very small punctures, some larger ones near the anterior angles; surface generally smooth; no lateral grooves, nor any before the festoons, which are not very strongly marked. Legs large and long, hairs and tubercles below, but no spurs at tips of metatarsi; the tarsi are very short; coxæ with two flattened tubercles, except IV, which has only one. Stigmal plate (Pl. VI, fig. 8) elongate, end tapering and upturned, with extremely minute granules.

Length of male, 5.5 to 6 mm.

Female.—Reddish brown, shield with a large silvery mark each side, containing one or two dark spots, and two divaricate silvery stripes extending forward from the hind margin, and sometimes connected to the lateral spots; capitulum paler in front and middle than on the sides and behind; palpi pale; legs red-brown, tips of joints whitish; abdomen brownish, sometimes showing black lines. Capitulum (Pl. VI, fig. 8) large and long, hind angles rounded; porose areas rather small, elongate, well separated, and directed forward; palpi short, second joint not twice as long as last; shield pentagonal, sides rounded, plainly broader than long, and broadest in front of middle, with many minute punctures, but some larger ones on the anterior lateral lobes; body without hairs, usually shining. Legs large and long, no spurs at tips of metatarsi, but most joints with hair-bearing tubercles below; coxæ armed like the male, and just as strongly. Stigmal plates (Pl. VI, fig. 8) elongate, of peculiar shape, being longer on inner than on outer side, an elevated smooth boss occupying the outer concave side, the surface with very minute granulations.

Length of female shield, 3.6 mm.

Specimens come from various parts of Florida, and are associated with the gopher tortoise. The nymphs have, on the shield, a large silvery spot each side, united behind at tips, and in front much broken by the large punctures.

This is our largest tick, and a very distinct species, allies of which occur in tropical countries.

Amblyomma maculatum Koch.

Male.—Shield brown, lineate with silvery white, lines more or less connected; a submedian pair in front, and a similar pair behind, uniting in the middle; two lateral streaks connected near front, and the inner one connected to submedian at middle; usually a few isolated white spots on the festoons, but there is variation in the amount of the white; legs more or less brownish, usually showing white at tips of joints. Capitulum long, its posterior angles acute; palpi short, the second joint about one and one-fourth times longer than the last joint. Dorsum nearly twice as long as broad, with many prominent punctures, most numerous in the middle region and in furrows; several elevated smooth streaks; lateral furrows very prominent, arising in front of eyes; festoons strongly marked. Legs rather heavy, IV (Pl. VI, fig. 5) pair much the largest; all, except I (Pl. VI, fig. 7), with a pair of stout spurs at tip of metatarsus. Coxa I (Pl. VI, fig. 5) with one very long, sharp spine, only a trace of the basal spine; coxæ II and III with a flattened tubercle, IV (Pl. VI, fig. 5) with a slender sharp spine, fully as long as width of joint. Stigmal plate (Pl. VI, fig. 7) long, slender, its tip tapering and upturned, surface with minute granules.

Length of male, 4 mm.

Female.—Shield silvery white behind, on front brown, the white of sides usually showing an elongate brown spot behind, and the white of middle extending forward in two streaks, sometimes wholly divided by a brown median stripe; legs pale brown; abdomen dark. Capitulum (Pl. VI, fig. 10) long, hind angles scarcely acute; porose areas elliptical, widely separated, and directed forward; palpi short second joint but little longer than the last. Shield pentagonal, fully as long as broad, broadest before middle, its lateral lobes strongly punctured, very few punctures behind; abdomen without hairs. Legs large, tarsi slender, metatarsi (except I) with a pair of spurs at tip; coxæ armed as in male, except that the hind coxa bears only a tubercle. Stigmal plate (Pl. VI, fig. 9) longer than usual, with a much smaller dorsal prolongation, its surface furnished with minute granules.

Length of female shield, 2 mm.

Specimens have been examined from various places in Texas—Brazos County, Esperanza Ranch, Brownsville, Victoria, Harlingen, and Columbus. Other localities are Cameron Parish, La.; Virginia (Niles); Orlando, Fla.; Memphis, Tenn.; and Tulare County, California. It was described from "Carolina." The recorded hosts are cattle, horses, dogs, fox, and man. It apparently is not common except in certain localities near the Gulf coast. It is very readily known by the spurs at apex of metatarsi, a character not previously noted by writers.

Amblyomma americanum Linnæus. (Pl. VI, fig. 1.)

Male.—Body usually a pale brown, or yellowish brown, with several small yellow spots—two on the posterior border of shield rather close together, one on each side margin in front of the former, and a pair in front of middle of shield, behind and rather inward from the eyes. Sometimes the anterior of these spots are indistinct, but the posterior pair are nearly always distinct. Legs slightly paler than the body. Capitulum broad, its posterior angles acute; palpi not very long, second joint about one and one-half times as long as last joint. Dorsum elongate, broadest in middle, surface rather evenly, densely, and minutely punctate; lateral furrows not reaching to eyes; festoons distinctly limited. Legs short, IV (Pl. VI, fig. 2) pair but little if any larger than I, all hairy beneath; coxa I (Pl. VI, fig. 3) with two spines, the outer the longer, a flattened tubercle on coxæ II and III, IV with a slender spine behind about as long as width of the joint; stigmal plate (Pl. VI, fig. 3) long, semielliptical, its tip slightly turned up, surface with many minute granulations.

Length of male, 2.4 mm.

Female.—The shield is brown, reddish brown, or almost black, often paler in front, on the posterior lobe a large prominent yellowish spot; legs more or less brownish yellow. Capitulum (Pl. VI, fig. 4) rather narrow, hind angles rounded, porose areas elliptic, divergent, and well separated; palpi slender, second joint twice as long as last. Shield pentagonal, about as broad as long, broadest much in front of the middle, apex nearly truncate, its surface densely punctate; body without hairs; legs very slender, no spurs at tips of any metatarsi; coxæ armed as in the male, except that the spine on coxa IV is barely longer than the tubercles on coxæ II and III. Stigmal plate (Pl. VI, fig. 1) subtriangular, its surface minutely granulate.

Length of female shield, 1.7 mm.

Specimens come from various places in the Eastern States—Washington, D. C.; Falls Church, Va.; Cape Charles, Va.; Chapel Hill, N. C.; Bee Spring and Smiths Grove, Ky.; Springfield, Willow Springs, and St. Louis (Packard's type), Mo.; Florida; Agricultural College, Mich.; Shreveport, La.; Austin, Kerrville, Llano, Dallas, Mountain Home, and Hockley, Tex. Marx recorded it from Labrador and Sanborn from Massachusetts. Fitch recorded it from New York, and it was described by Linnæus from Pennsylvania and New Jersey.

It is now rather uncommon in the Eastern States, never as common as *Dermacentor variabilis.* Fitch wrote in 1870 that although formerly abundant it had then become nearly extinct, he having seen only one specimen from New York, and that taken forty years before he wrote. He says that it occurs in the Southwest in woodlands, and not in cleared sections. It is often taken from cattle, occasionally from horses, hogs, dogs, and goats, once from panther and wolf, sometimes from man, and rarely from any of the small mammals. It is commonly known as the "lone star tick," because of the single yellow spot on shield of female.

The *Acarus americanus* of Linnæus was taken by the traveler Peter Kalm, in 1754, in Pennsylvania and New Jersey. Its description will fit only to that species later described by Packard as *Ixodes unipunctata.* Koch correctly identified and figured the species, but Neumann in his "Revision" considered *americanus* to apply to the *Dermacentor electus* Koch. Later he changed, and used *americanus* for this species. Fitch correctly identified the species.

Amblyomma cajennense Fabricius.

Male.—Pale yellowish or brownish yellow, with several irregular silvery white marks and streaks each side, and a number of brown, often reddish brown, spots, all arranged to form a definite, but complex, pattern; some of the pale spots behind are bordered with brown. Legs and palpi wholly pale yellowish, or greenish yellow, tarsi sometimes darker. Capitulum subtriangular, hind angles rounded; palpi longer than width of the capitulum, the middle joint more than twice as long as the last; body broad, oval, broadest behind middle, with many rather small, subequal punctures, but with four convex smooth spots each side, and a smooth median streak behind; lateral furrows very distinct, reaching fully up to the eyes; behind are twelve deeply impressed lines, the festoons fully twice as long as broad. Legs rather slender, tarsi long, hind tarsus (Pl. VI, fig. 6) with three consecutive teeth below, one at apex; no spurs at tip of any metatarsi, but long hairs below on all joints: coxæ I (Pl. VII, fig. 2) with two spines, the outer one much the longer, coxæ II and III each with a mere tubercle, coxa IV (Pl. VII, fig. 2) with a spine about as long as width of the joint. Stigmal plate (Pl. VII, fig. 1) very long and slender, its surface with many minute granulations. Length of male, 2.7 mm.

Female.—Yellowish; capitulum with some dark on the margin, shield mostly silvery, with a brown line on each margin reaching back from the eyes; legs pale greenish yellow, tarsi often dark, especially of legs I and II. Capitulum (Pl. VII, fig. 1) much broader than long, hind angles acute; porose areas nearly circular, and widely separated; palpi slender, longer than width of the capitulum, middle joint about twice as long as last. Shield pentagonal, a little broader than long, anterior sides slightly convex, posterior sides straight, tip rounded; surface densely punctate; body with scattered white hairs. Legs slender, tarsi (Pl. VII, fig. 2) long, coxæ armed as in the male, except that the spine on coxa IV is barely larger than that on coxæ II and III. Stigmal plate (Pl. VII, fig. 2) subtriangular, as broad behind as long, concave on upper outer edge, its surface covered with minute granules.

Length of female shield, 1.8 mm.

Specimens come from various places in the South and Southwest. It is abundant in southern Texas—San Antonio, Victoria, Brownsville, Uvalde, Rocks Resaca, Weets Ranch, Live Oak County, San Tomas, etc. I have it also from Biscayne Bay, Florida; Fort Bowie, Ariz., and San Diego County, California. The species occurs also in Mexico, Central America, the West Indies, and South America. It infests a great variety of animals, but is not common on cattle or horses. This species was described from Surinam, and later, by Koch, from Brazil under several names. To this species also belongs, I believe, the *Ixodes crenatum* of Say, for none of our other species so aptly fits his description.

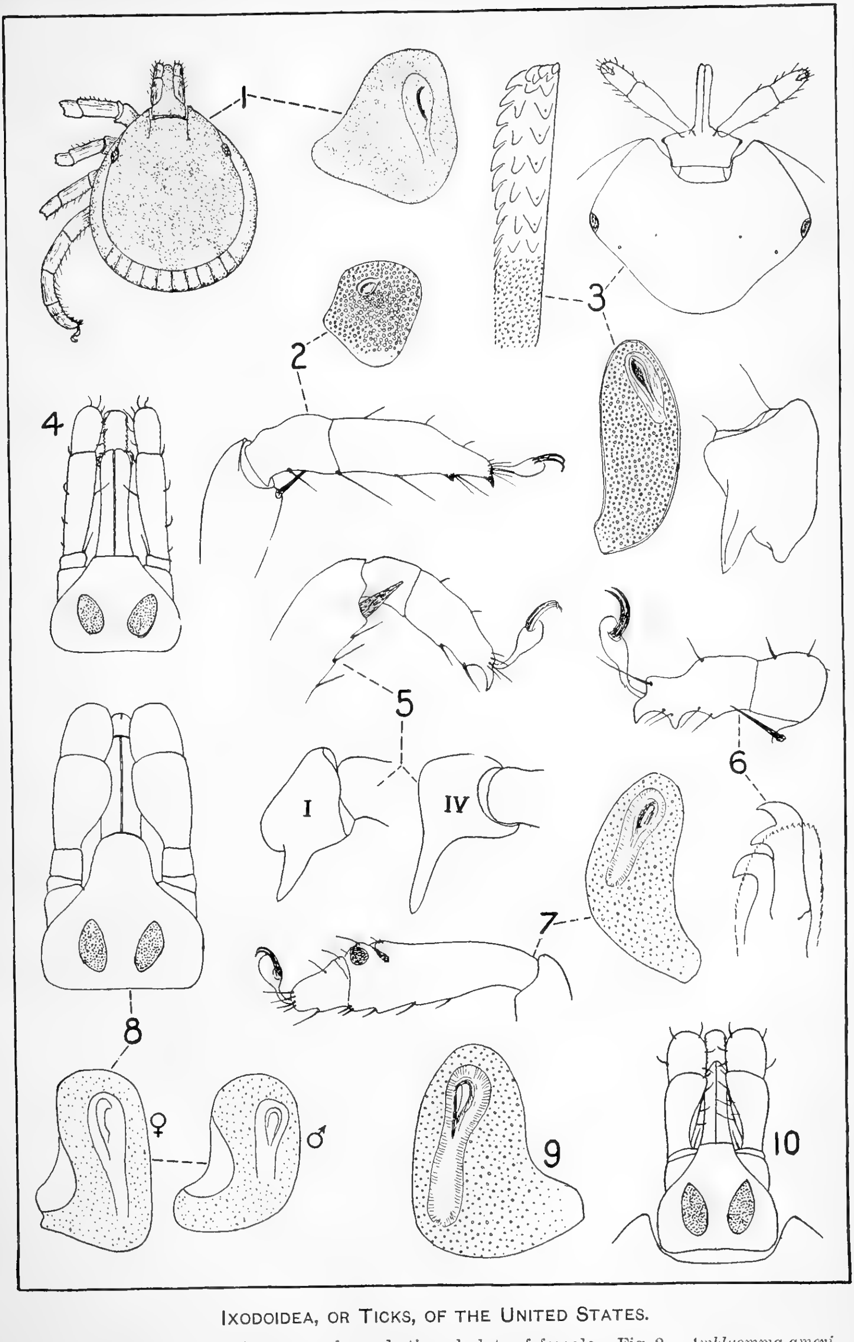
Genus **DERMACENTOR** Koch.

Venter showing indistinctly a curved groove behind the anus, from which a median line extends to margin of body. Capitulum not angulate on sides; porose areas elliptic and transverse. Palpi short and broad, the second joint barely longer than broad and with a basal projection above, but not outward. Shield usually marked with white; ocelli present. Coxa I strongly bidentate behind; coxa IV of male much larger than other coxæ, and leg IV larger than other legs. Abdomen shows festoons behind (except in distended female). No anal plates to male. Stigmal plate large, usually reniform in female, more elongate in male. Tarsi II, III, and IV indistinctly divided, the parts subequal in length, and a minute tooth-like claw at apex.

Type.—*D. reticulatus* Fabricius.

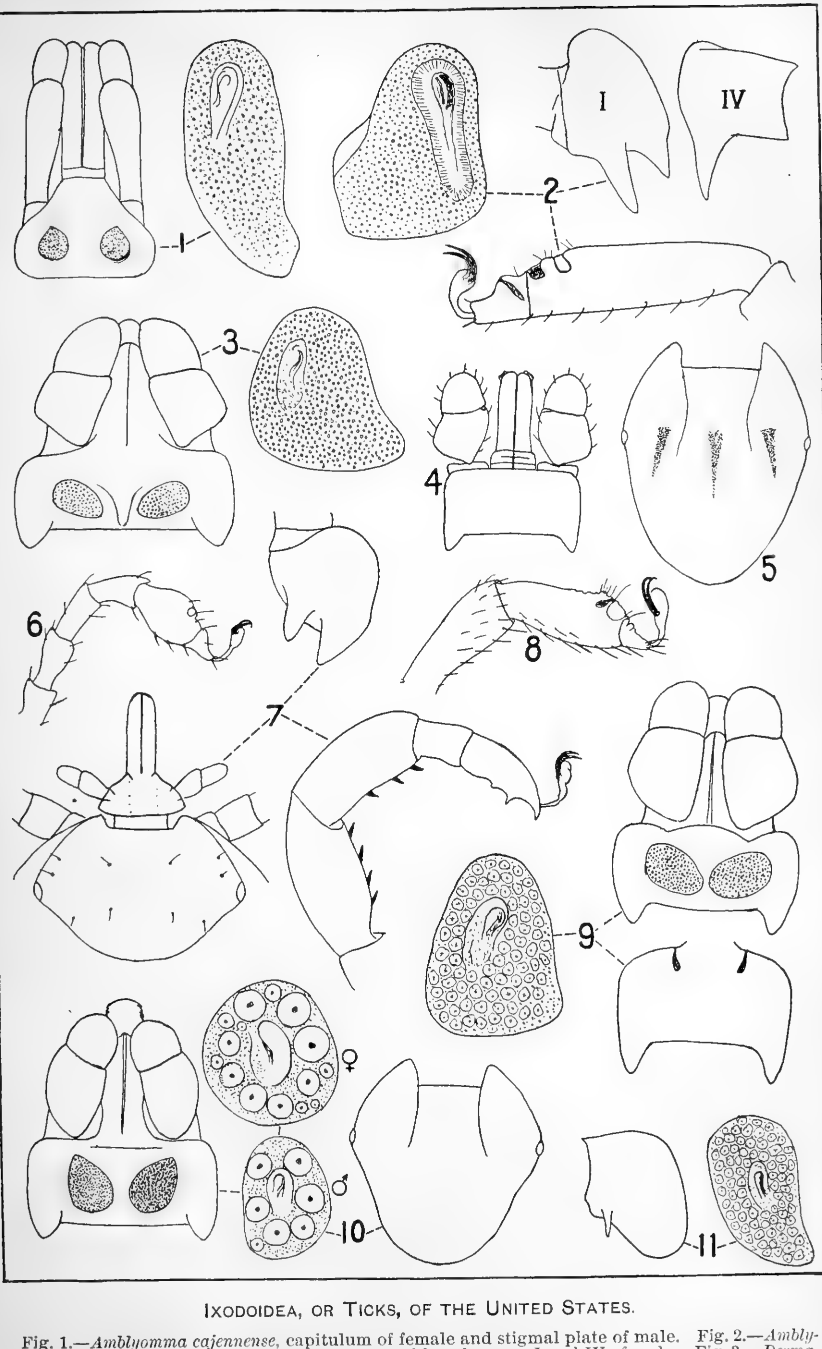
TABLE OF THE SPECIES.

1. Females 2
   Males 8
2. Stigmal plate nearly circular, with from ten to twenty very large more or less isolated granulations; shield without distinct punctures; color dark red-brown, without markings .... *nitens.*
   Stigmal plate with many much smaller, more crowded granulations; shield distinctly punctured, and usually with some pale markings 3



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Amblyomma americanum*, male, and stigmal plate of female. Fig. 2.—*Amblyomma americanum*, stigmal plate of nymph and tarsus IV. Fig. 3.—*Amblyomma americanum*, hypostome, shield, and capitulum of nymph, stigmal plate of male, and coxa I. Fig. 4.—*Amblyomma americanum*, capitulum of female. Fig. 5.—*Amblyomma maculatum*, tarsus IV, and coxæ I and IV. Fig. 6.—*Amblyomma cajennense*, tarsus IV and mandible of male. Fig. 7.—*Amblyomma maculatum*, tarsus I, and stigmal plate of male. Fig. 8.—*Amblyomma tuberculatum*, capitulum of female, stigmal plate of male and of female. Fig. 9.—*Amblyomma maculatum*, stigmal plate of female. Fig. 10.—*Amblyomma maculatum*, capitulum of female. (Original.)



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Amblyomma cajennense*, capitulum of female and stigmal plate of male. Fig. 2.—*Amblyomma cajennense*, stigmal plate and tarsus I of female, coxæ I and IV of male. Fig. 3.—*Dermacentor variabilis*, capitulum and stigmal plate of female. Fig. 4.—*Dermacentor variabilis*, capitulum of male. Fig. 5.—*Dermacentor albipictus*, shield of female. Fig. 6.—*Dermacentor variabilis*, leg I of larva. Fig. 7.—*Dermacentor nitens*, coxa I, leg IV of male, and shield and capitulum of nymph. Fig. 8.—*Dermacentor variabilis*, tarsus I. Fig. 9.—*Dermacentor albipictus*, stigmal plate of female and capitulum of female and of male. Fig. 10.—*Dermacentor nitens*, stigmal plates of male and female, capitulum and shield of female. Fig. 11.—*Dermacentor albipictus*, coxa IV and stigmal plate of male. (Original.)

3. Stigmal plate about as broad as long, with short and broad dorsal prolongation, and covered with many very minute granules, scarcely visible as such; shield plainly longer than broad, and much streaked with white ---- *variabilis.*
   Stigmal plate with much larger granules, at least near the peritreme ---- 4
4. Stigmal plate without distinct dorsal prolongation; shield plainly longer than broad ---- 5
   Stigmal plate with a more or less distinct dorsal prolongation ---- 6
5. Shield mostly white, with brown streaks and spots; porose areas close together ---- *albipictus.*
   Shield dark red-brown, with very little white; porose areas rather widely separate ---- *nigrolineatus.*
6. Shield mostly white, about as broad as long ---- 7
   Shield without white, or but little, plainly a little longer than broad; porose areas but little longer than broad, and well separated. *parumapertus.*
7. Porose areas very small; stigmal plate with rather wide dorsal prolongation ---- *occidentalis.*
   Porose areas larger; stigmal plate with a more narrow dorsal prolongation ---- *venustus.*
8. Stigmal plate with from four to ten very large isolated granules; dorsum without white marks; only eight impressed lines behind ---- *nitens.*
   Stigmal plate with many smaller, more crowded granules; twelve impressed lines behind ---- 9
9. Stigmal plate about as broad behind as long, with dorsal prolongation, the granulations extremely minute; dorsum marked with white streaks and spots ---- *variabilis.*
   Stigmal plate usually plainly longer than broad; the granulations much larger ---- 10
10. Stigmal plate without distinct apical prolongation; the sides of body more nearly parallel ---- 11
   Stigmal plate with distinct apical prolongation; sides of body more divergent ---- 12
11. Dorsum mostly white, with brown streaks and spots in a pattern; hind angles of the capitulum but little produced; coxa IV about one-half as long as broad on base; large species ---- *albipictus.*
   Dorsum red-brown, with black lines, no white; hind angles of capitulum much prolonged; coxa IV not twice as broad on base as long; species of moderate size ---- *nigrolineatus.*
12. Dorsum with few, if any, white spots; coxa IV about as long as broad at base; hind angles of capitulum moderately produced ---- *parumapertus.*
   Dorsum largely white, or much spotted with white ---- 13
13. Stigmal plate more attenuate behind; coxa IV about one-half as long as broad at base; hind angles of capitulum moderately produced ---- *venustus.*
   Stigmal plate less attenuate behind; coxa IV not twice as broad on base as long; hind angles of capitulum much produced ---- *occidentalis.*

Dermacentor bifurcatus Neumann.

This species was described as an Ixodes, and based on a young female from a wild cat, from Texas. Later Neumann placed it as a synonym of *Ixodes brunneus* Koch, then still later stated that it was a *Dermacentor.* It is, therefore, evidently a nymph of some of the previously described Dermacentors; the shape of the stigmal plate would indicate *D. variabilis*, but the lack of markings would indicate *D. parumapertus*. Among Doctor Marx's drawings are several figures of this specimen, and they are presented on the plates (See Pl. X, fig. 1) so that when the life histories of all of our Dermacentors are known it will be possible to place this name under the species to which it belongs.

I have not been able to locate the specimen which, according to Doctor Neumann (*in litt.*), should be in the National Museum collection, but it was not in the material returned, nor indicated on the list of material returned to the Museum.

Dermacentor albipictus Packard. (Pl. X, fig. 11.)

Male.—White above, with brown spots and streaks in a definite pattern; capitulum, palpi, and legs white above, rest reddish brown. Capitulum (Pl. VII, fig. 9) quite broad, hind angles produced, but not as long as in *D. occidentalis;* palpi short, not nearly as long as width of capitulum. Dorsum more slender than in most species, fully one and three-fourths times as long as broad, with a great many rather small punctures, lateral grooves not very distinct, posterior margin with twelve impressed lines. Legs rather large and long, fourth pair much larger than others, teeth below large and distinct. Coxæ armed as usual; coxæ IV (Pl. VII, fig. 11) plainly wider on base than long. Stigmal plate (Pl. VII, fig. 11) elliptical, without distinct dorsal prolongation, its surface provided with many large granules.

Length of male, 4 mm.

Female.—Capitulum, palpi, and legs white above, reddish or yellowish brown beneath; shield mostly white, a long median streak, not reaching apex, a narrower stripe each side, and some spots near eyes, red-brown; elsewhere the white is rarely broken by small brown spots; abdomen dark red-brown. Capitulum (Pl. VII, fig. 9) quite broad, its hind angles only slightly produced, the porose areas very large, and not far apart, the palpi very short and broad, the shield (Pl. VII, fig. 5) plainly longer than broad, usually much longer, and broadest much before the middle, the punctures few and not prominent. Abdomen rather more elongate, the sides more nearly parallel than in allied forms. Legs long, the coxæ armed as usual; stigmal plate (Pl. VII, fig. 9) large, semielliptical, without distinct dorsal prolongation, and covered with many large granules.

Length of female shield, 2–2.2 mm.

This tick occurs throughout the northern parts of the United States and in Canada. I have seen specimens from Adirondack Mountains, New York; Michigan; Nebraska; Montana; Bear, Idaho; Nevada, and Pullman, Wash. It has usually been taken from moose and wapiti, but also recorded from the beaver. Packard first used the name *albipictus* for this moose tick, as shown in the appended catalogue, but later placed under this name a specimen of *D. variabilis.* The types from the moose are still in the Museum of Comparative Zoology, where I have examined them. Neumann, using Marx's manuscript name, described it as *D. variegatus.*

The species is distinguished by its elongate form, especially the long shield, the shape and sculpture of the stigmal plate, and by its large size. This latter character, however, is variable, and specimens are found that are not much larger than the ordinary *D. variabilis.*

Dermacentor parumapertus Neumann.

Male.—Dark red-brown, legs a trifle paler, no white markings, except sometimes a few small spots, and a minute white spot at tips of some joints of the legs. Capitulum (Pl. VIII, fig. 10) moderately broad, hind angles only very slightly produced; palpi very short, not as long as width of capitulum; dorsum one and two-thirds times as long as broad, with many scattered, deep, but not very large punctures, submarginal furrow very distinct on the sides, less so behind; twelve impressed lines near posterior margin. Coxæ spined as usual, hind coxæ barely wider on base than long, legs rather short, hind pair not so much larger than the others, and the teeth below small and indistinct. Stigmal plate (Pl. VIII, fig. 10) elongate, attenuate behind, the fore part around peritreme with large granules, a few down on the narrow portion, which is covered with smaller granules.

Length of male, 2.8 mm.

Female.—Shield and capitulum dark red-brown or almost black, without marks; abdomen blackish; legs red-brown, a faint white mark at tips of some of the joints. Capitulum (Pl. VIII, fig. 10) moderately broad, hind angles distinctly prolonged behind, porose areas rather small, nearly circular, and well separated; palpi as long as width of capitulum. Shield (Pl. VIII, fig. 10) plainly a little longer than broad, with many deep punctures, those in the depressed area each side especially large and numerous, almost confluent. Legs rather small and short; coxæ armed as usual. Stigmal plate (Pl. VIII, fig. 8) small, with a distinct, although short and broad, dorsal prolongation, most of the surface with rather large granules, but those on the prolongation very small.

Length of female shield, 1.1 mm.

Specimens are from Lakeside, Cal. (also Neumann's type in the Marx Coll.), taken on man, and in a chicken house.

Distinguished from other forms most readily by lack of white on shield, by porose areas, and stigmal plate. After describing this species, Neumann later made it a variety of *D. electus* (*variabilis*), but it differs in many important characters from that species, and the granulations of the stigmal plate are much larger.

Dermacentor parumapertus var. **marginatus** n. var.

This form agrees in general with the true *D. parumapertus*, but differs in several minor points. The posterior border of the female shield (Pl. VIII, fig. 6) is margined with white; the porose areas are larger and rather closer together; the lateral lobes of the shield have fewer punctures, and the shield is more contracted behind the eyes; the stigmal plate of the female (Pl. VIII, fig. 6) has a narrower dorsal prolongation, and the inner margin is more convex; the posterior angles of the capitulum (Pl. VIII, fig. 6) are less prominent. Otherwise it is very similar to the type.

Several specimens from Mesa City, Ariz., from a jack rabbit (Cordley).

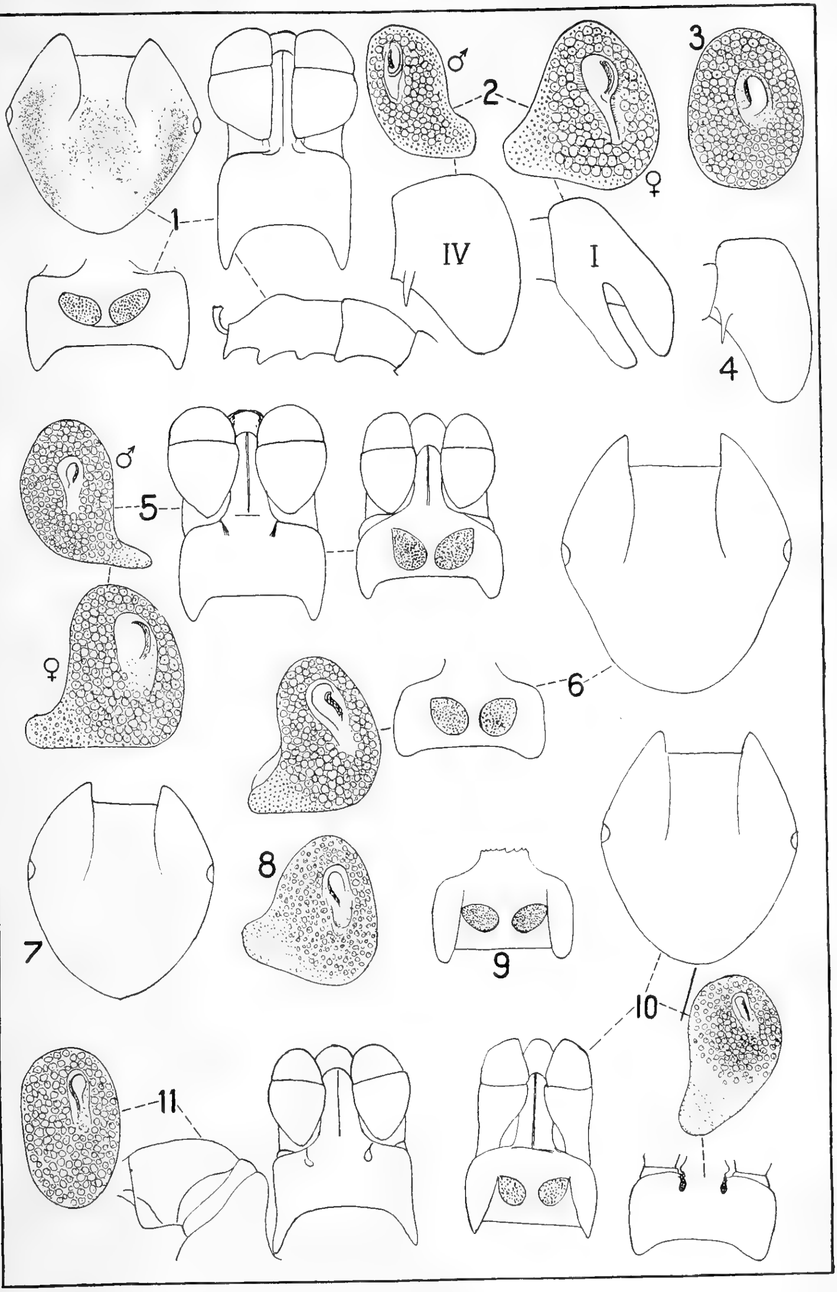
Dermacentor venustus n. sp.

Male.—Red-brown, marked with white, but not so extensively as in *D. occidentalis*, usually but little white on the middle posterior region; legs paler red-brown, tips of joints whitish. Capitulum (Pl. VIII, fig. 5) quite broad, its posterior angles only slightly produced; palpi very short and broad, not as long as width of capitulum. Dorsum about one and two-thirds or one and three-fourths times as long as broad, with many, not very large, punctures; lateral furrows distinct. Legs of moderate size, hind pair plainly larger and heavier, and with the teeth below distinct. Coxæ armed as usual, the coxa IV (Pl. VIII, fig. 4) nearly twice as wide at base as long. Stigmal plate (Pl. VIII, fig. 5) with a rather narrow dorsal prolongation, with large granules on the main part and minute ones on the prolongation.

Length of male, 3.5 to 5 mm.

Female.—Capitulum and legs reddish brown, the latter with tips of joints whitish; shield mostly covered with white—this white not so much broken up by the brown dots as in *D. occidentalis;* abdomen red-brown. Capitulum (Pl. VIII, fig. 5) rather broad, posterior angles but little produced, the porose areas rather large, egg-shaped, and quite close together; palpi shorter than width of capitulum. Shield (Pl. VIII, fig. 7) as broad as long, broadest slightly before the middle, and rather pointed behind, with numerous, not very large punctures. Legs of moderate size, the coxæ armed as usual. The stigmal plate (Pl. VIII, fig. 5) has a rather narrow dorsal prolongation, with large granules on the main part, and small ones on the prolongation.

Length of female shield, 2 mm.



IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Dermacentor occidentalis*, capitulum of male and female, shield of female, and tarsus IV of male. Fig. 2.—*Dermacentor occidentalis*, coxæ I and IV of male, stigmal plates of male and female. Fig. 3.—*Dermacentor nigrolineatus*, stigmal plate of female. Fig. 4.—*Dermacentor venustus*, coxa IV of male. Fig. 5.—*Dermacentor venustus*, capitulum and stigmal plates of male and female. Fig. 6.—*Dermacentor parumapertus* var. *marginatus*, stigmal plate, capitulum, and shield of female. Fig. 7.—*Dermacentor venustus*, shield of female. Fig. 8.—*Dermacentor parumapertus*, stigmal plate of female. Fig. 9.—*Dermacentor nigrolineatus*, capitulum of female. Fig. 10.—*Dermacentor parumapertus*, shield and capitulum of female, stigmal plate and capitulum of male. Fig. 11.—*Dermacentor nigrolineatus*, stigmal plate and capitulum of male. (Original.)

Specimens come from various places in the West; Olympia, Yakima, Klikitat Valley, and Grand Coulee, Wash.; Fort Collins and Boulder, Colo.; Pecos and Las Cruces, N. Mex.; Bozeman, Mont.; Bridger Basin, Utah; Soldier, Idaho, and Texas (on sheep).

This species is quite common in the Northwest. It has been included in *D. occidentalis* by Neumann, but was separated out by Doctor Marx in manuscript under the name I have adopted. It is larger than *D. occidentalis*, with more red and less white in the coloring, and differs in many minor points of structure, as size of porose areas, size of hind coxæ in male, etc. This is the species supposed to be concerned in the transmission of spotted fever in Montana.

Dermacentor occidentalis Neumann. (Pl. X, fig. 9.)

Male.—Red-brown, with many waxy-white markings, often with a waxy bloom, sometimes almost wholly white, but there is red-brown near the eyes, on the festoons, and several submedian spots; moreover, the white is broken by the many red-brown punctures; legs pale reddish brown, marked with white above. Capitulum (Pl. VIII, fig. 1) rather narrow, and the hind angles prolonged into very prominent spines; palpi very short, not as long as the width of the capitulum; dorsum not much more than one and one-half times as long as broad, with many punctures, but mostly small; lateral furrows distinct and long, twelve indented lines behind. Legs of moderate size, tarsus IV (Pl. VIII, fig. 1) with two very distinct teeth below and one less prominent, teeth on other joints distinct; coxæ (Pl. VIII, fig. 2) armed as usual; coxæ IV about one and one-half times as wide at base as long. Stigmal plate (Pl. VIII, fig. 2) elongate, with a broad turned-up tip, almost truncate; large granulations on the main part, small ones on the tip.

Length of male, 3 to 3.5 mm.

Female.—Shield red-brown, mostly covered with white, red-brown near eyes and in the middle region, and the white broken up by the many brown dots at punctures; capitulum and legs red-brown, latter white at tips of joints, and generally paler above than below; abdomen dark red-brown. Capitulum (Pl. VIII, fig. 1) rather small, the hind angles prominent, and the porose areas very small and rather close together. Shield (Pl. VIII, fig. 1) about as broad as long, broadest before middle, and rather pointed behind, with many small punctures and some larger, but not nearly as many large ones as in *D. parumapertus*. Legs rather small, coxæ armed as usual. Stigmal plate (Pl. VIII, fig. 2) with a broad dorsal prolongation, with large granulations in the main part, and minute ones on the prolongation.

Length of female shield, 1.5 mm.

Nearly all specimens come from California—Occidental, San Diego, Goose Lake, Siskiyou County, Santa Clara County, Humboldt County; some taken from deer.

Closely related to *D. venustus*, but with a more narrow capitulum, and with a broader prolongation to stigmal plate, in the male by shorter hind coxæ, and in the female by smaller porose areas. Taken together, I think these characters indicate its distinctness from *D. venustus*.

Neumann first considered *D. occidentalis* and *D. venustus* of Marx as identical with the European *D. reticulatus*. There are, however, many differences, as he later recognized, and *D. reticulatus* (Pl. X, fig. 10) does not, as far as now known, occur in our country. When he described *D. occidentalis*, Neumann included with it *D. venustus* of Marx manuscript. However, I have restricted the name to the form to which Marx applied it. *D. occidentalis* may perhaps be credited to Curtice, for in a paper [a] on ticks in general he refers to this species under this name and with a few words of description; hardly, however, sufficient to identify it, and evidently not intended to be a description of a new species.

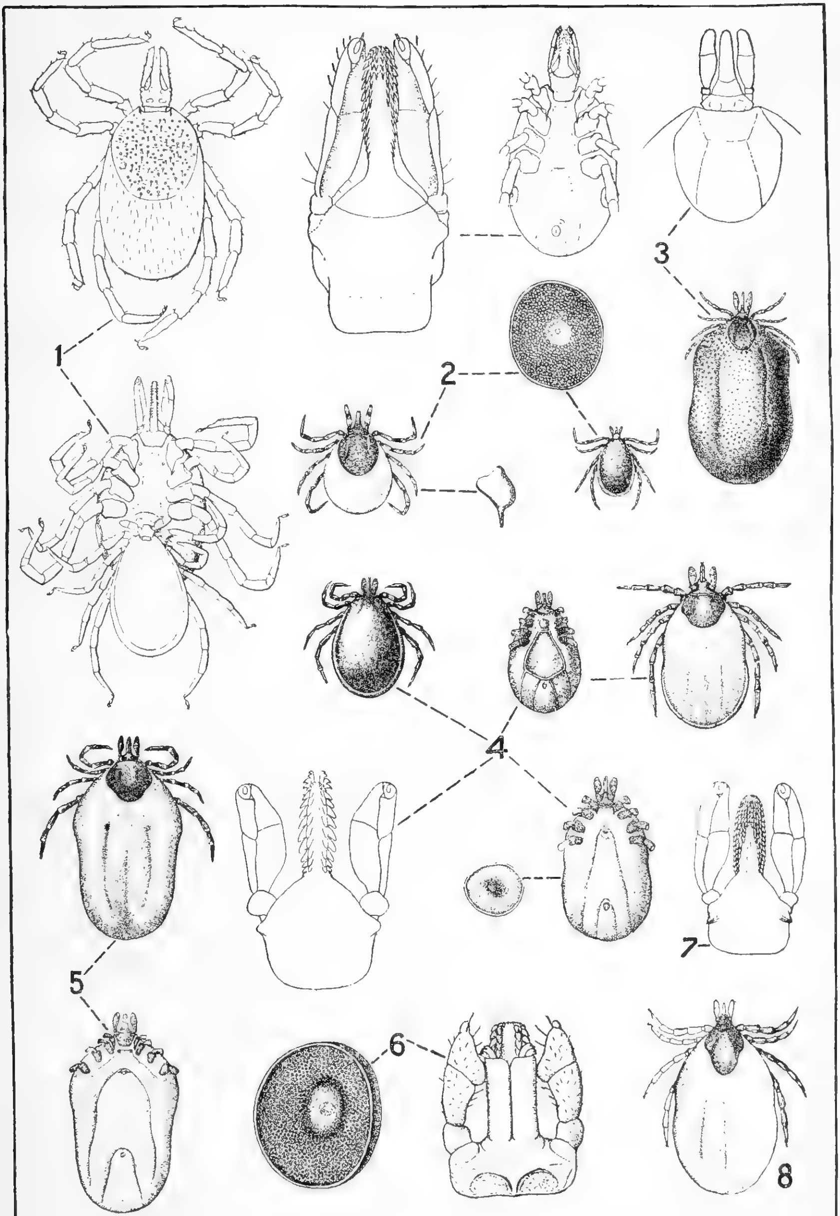
Dermacentor nigrolineatus Packard.

Male.—Rather pale red-brown, no white markings, but the black cæcal marks show through in most specimens as several irregular lines behind; legs more yellow-brown. Capitulum (Pl. VIII, fig. 11) small and narrow, its posterior angles produced into long spines; palpi very small and stout. Dorsum slender, about one and two-thirds times as long as broad; middle anterior region smooth and shining, sides and behind densely punctured, and with many short hairs; lateral furrows not very distinct, twelve impressed lines behind, but the festoons are not as obvious as usual. Legs rather short, coxæ with usual spines, coxa IV but little wider at base than long; stigmal plate (Pl. VIII, fig. 11) large, elliptical, without dorsal prolongation, and covered with many large granules.

Length of male, 3.5 mm.

Female.—Shield red-brown, without marks; legs similar; abdomen dark red-brown. Capitulum (Pl. VIII, fig. 9) scarcely twice as broad as long; hind angles distinctly prolonged behind; porose areas large, oval, and distinctly separated; palpi small and short, not as long as width of capitulum. Shield plainly longer than broad, broadest much before the middle, tapering and almost pointed behind, with very few punctures. Legs small and short, the tarsi very short; coxæ with the usual spines, that on IV no longer than on III. Stig-

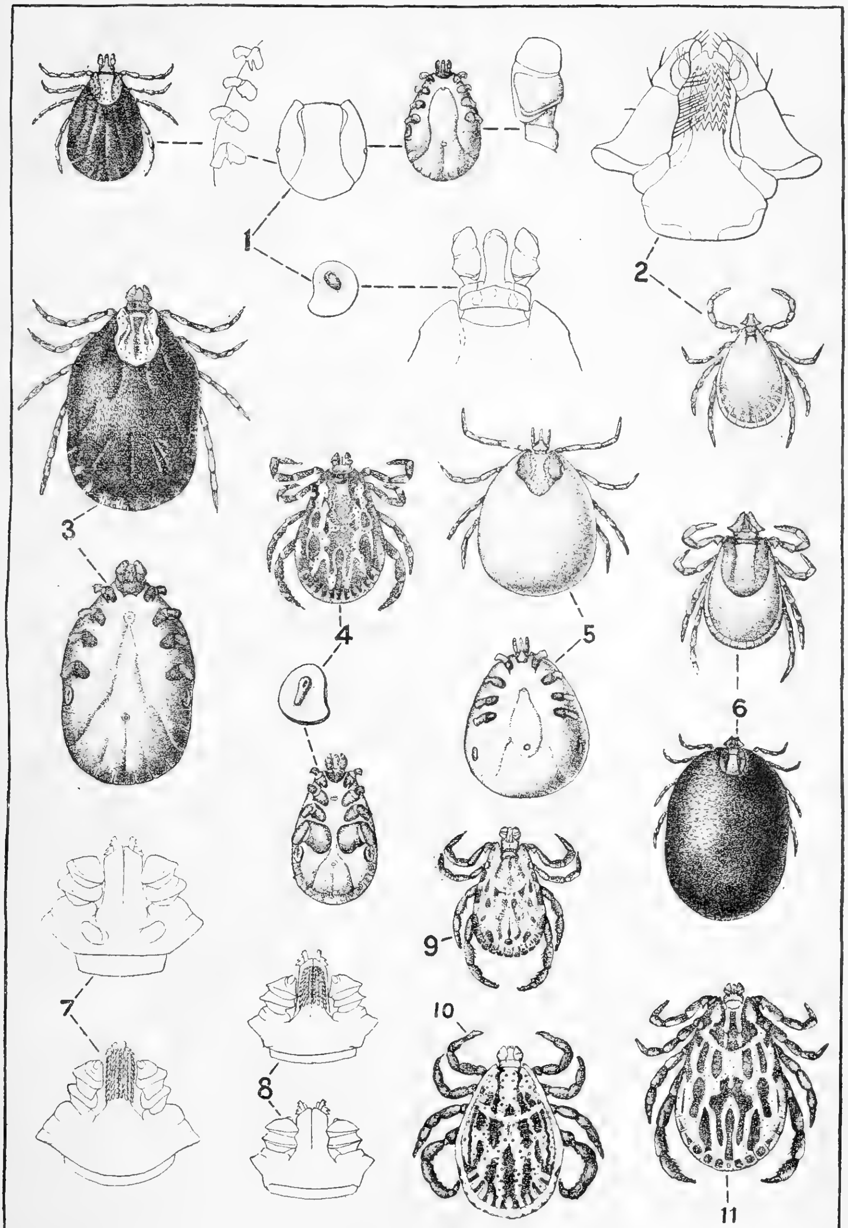
[a] About cattle ticks. Journ. Comp. Med. Vet. Archives, January, 1892.



G. Marx, del.

IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Ixodes scapularis*, fresh female, and male attached to female. Fig. 2.—*Ixodes scapularis*, female, coxa I, male, female stigmal plate, venter of female, and rostrum from beneath. Fig. 3.—*Ixodes dentatus*, engorged female, shield, and capitulum. Fig. 4.—*Ixodes cookei*, male and female above and below, stigmal plate, and rostrum from beneath. Fig. 5.—*Ixodes ricinus*, engorged female, above and below. Fig. 6.—*Ceratixodes putus*, stigmal plate and capitulum. Fig. 7.—*Ixodes dentatus*, rostrum from below. Fig. 8.—*Ixodes marxi*, engorged female. (Drawings by the late Dr. George Marx.) (Original.)



G. Marx, del.

IXODOIDEA, OR TICKS, OF THE UNITED STATES.

Fig. 1.—*Dermacentor bifurcatus*, nymph, coxæ, shield, venter, palpus, stigmal plate, and capitulum. Fig 2.—*Hæmaphysalis leporis-palustris*, male, and rostrum of female beneath. Fig. 3.—*Dermacentor variabilis*, engorged female, above and below. Fig. 4.—*Dermacentor variabilis*, male, above and beneath, and stigmal plate of female. Fig. 5.—*Amblyomma americanum*, nymph, above and below. Fig. 6.—*Hæmaphysalis leporis-palustris*, fresh and engorged females. Fig. 7.—*Margaropus annulatus*, capitulum of female, above and beneath. Fig. 8.—*Margaropus annulatus*, capitulum of male, above and beneath. Fig. 9.—*Dermacentor occidentalis*, male. Fig. 10.—*Dermacentor reticulatus*, male. Fig. 11.—*Dermacentor albipictus*, male. (Drawings by the late Dr. George Marx.) (Original.)

mal plate (Pl. VIII, fig. 3) elliptical, of same shape as in male, no dorsal prolongation, and covered with many large granules.

Length of female shield, 1.2 mm.

Specimens in the New York State collection at Albany, probably from Adirondack Mountains; Packard's type, which I have seen, was from deer from this region; I have some from Catskill Mountains, New York, in June. Recently Mr. W. D. Hunter has received several specimens taken by Mr. Rumsey from deer at Laredo, Tex., and Mr. H. S. Barber took one from deer at Crab Lake, Vilas County, Wis. Neumann placed this species in *Hæmaphysalis* as a synonym of the European *H. concinna*, a species which now seems not to occur in our country. It is allied to *D. albipictus*, but differs in shape of stigmal plate, more distinctly separated porose areas, sharper hind angles to the capitulum, shield more pointed behind, and in shorter tarsi. Quite possibly it is the *Ixodes erraticus* of Say.

Dermacentor variabilis Say. (Pl. X, figs. 3, 4.)

Male.—Red-brown, dorsum with irregular white marks, the usual pattern being a submarginal stripe each side, starting from the anterior angles and reaching straight back to beyond the middle, where they unite, or nearly so, and thence giving off branches straight backward and obliquely outward to the side margin; along the sides and on the festoons are scattered white spots. Specimens from Texas and Florida often have these markings more extensive and more connected together, and some white on the median anterior part of dorsum. Legs red-brown, the tips of the joints white. Capitulum (Pl. VII, fig. 4) about twice as broad as long, its posterior angles slightly produced; palpi nearly as long as width of the capitulum. Dorsum fully one and one-half times as long as broad, with many deep and prominent punctures, but the anterior median region nearly free of them; lateral grooves distinct; twelve impressed lines behind; legs rather long and stout, hind pair much heavier than the others, and the teeth below distinct. Coxæ armed as usual for the genus, the hind coxæ but little broader than long. Stigmal plate large and broad, with a short dorsal prolongation, surface densely covered with minute granules.

Length of male, 4 mm.

Female.—Red-brown, shield with white on the sides, and broadly around the tip; a brown marginal stripe near eye, and sometimes two white streaks in the middle area. Legs red-brown, tips of the joints white. Capitulum (Pl. VII, fig. 3) fully twice as broad as long, its posterior angles only slightly produced, the porose areas oval, of moderate size, and well separated; palpi short and very broad. Shield plainly a little longer than broad, broadest at middle, and posteriorly almost angulate; punctures large, but not very numerous, and few in middle area, usually four forming a trapezium behind the middle. Legs (Pl. VII, fig. 8) rather large and long, the hind pairs with distinct teeth beneath; coxæ armed as usual. Stigmal plate (Pl. VII, fig. 3; Pl. X, fig. 4) large and very broad, in fact as broad behind as long, and covered with many minute granules.

Length of female shield, 2 mm.

Specimens come from many places in the eastern United States, from Labrador to Florida and Texas. West of the Mississippi it is not common, and perhaps only introduced with stock.

This species, described by Say, is probably identical with the *Ixodes cinctus* of Fabricius from North America. Koch's *D. electus* is the same species. It was considered by Neumann at first to be the *Ixodes americanus* of Linnæus, but later he accepted Koch's identification of *I. americanus* as an *Amblyomma*, and used *D. electus* for this *Dermacentor*. Fitch's descriptions of *I. robertsoni* and *I. 5-striatus* offer nothing contrary to this form. Although the western specimens might have been another species, the specimens from Virginia must have been *D. variabilis*.

The pattern of the white markings is practically constant, but the amount of white present is variable. The species is readily known by the broad stigmal plate and the minute granulation thereon. It has been taken from a great variety of animals, including man, but seems to prefer dogs and cattle to smaller animals, doubtless due to the fact that the freshly moulted individuals climb up several feet from the ground in wait for a host. In the larva tarsus I is much enlarged.

Dermacentor nitens Neumann.

Male.—Red-brown, without markings; legs rather yellowish brown. Capitulum rather narrow, hind angles acute, but scarcely prolonged; palpi very short and small, shorter than the hypostome and no longer than the length of the capitulum. Dorsum one and two-thirds as long as broad, broadest slightly behind the middle, shiny, with some punctures in front and on the sides, and behind are seven or eight impressed lines; the lateral furrows are not very distinct, usually three impressed grooves or furrows on the posterior half of dorsum; some scattered hairs, mostly on the sides behind. Legs rather long, fourth pair (Pl. VII, fig. 7) plainly larger than others, and the teeth below very evident; coxa I (Pl. VII, fig. 7) with the usual two teeth, neither very long; coxa II with two equal projections; coxa III with two tubercles, and coxa IV, which is no broader than long, with the usual tooth. Stigmal plate (Pl. VII, fig. 10) but little longer than broad, with from four to ten large, isolated granules.

Length of male, 2.5 to 2.7 mm.

Female.—Wholly red-brown, legs paler, and abdomen darker, no white markings. Capitulum (Pl. VII, fig. 10) of moderate width, with the hind angles only slightly prolonged; porose areas rather large, well separated, and directed more forward than in other species; palpi very short, not reaching to tip of hypostome. Shield (Pl. VII, fig. 10) a trifle longer than broad, broadest in front of middle, very finely punctured; in middle region in front, and on the sides, are irregular wrinkles. Legs rather long, teeth on coxæ shorter than usual; stigmal plate (Pl. VII, fig. 10) nearly circular, provided with ten to twenty more or less isolated granules, all of large size.

Length of female shield, 1.4 mm.

This species was described from Jamaica and Santo Domingo. Recently it has been taken at Brownsville and Harlingen, Tex., and I have some from Fort Bowie, Ariz. In the Museum of Comparative Zoology there are specimens from Grand Anse, Hayti, taken about forty years ago. It appears to prefer horses, and usually occurs in the ears.

D. nitens is strongly separated from all our other species of the genus. Especially noticeable is the sculpture of the stigmal plate; the few impressed lines behind with the male are also peculiar. Likewise the very short palpi, shorter than the hypostome, constitute a peculiar character again seen in the cattle tick, and, as in that species, may indicate some habit connected with the dissemination of disease.

UNPLACED SPECIES.

Ixodes erraticus Say.

"Body oblong-ovate, gradually narrowed before, sides hardly arquated, with distant punctures, those behind more deeply impressed, posterior margin with ten or twelve impressed lines which are abbreviated by a submarginal impressed line, two abbreviated lines before; head, posterior edge transversely rectilinear, angles extended backward abruptly, and subacute; rostrum rather short; palpi oval-orbicular. Found in the Southern States; the color is reddish or ferruginous, with acute black lines." [It may be *Dermacentor nigrolineatus* Pack.]

Ixodes fuscus Say.

"Body fuscous, ovate, punctured; tergum with a few black, obsolete lines, and a profoundly indented submarginal line, posterior marginal impressed line none; no distinct thorax; edge rounded; head, posterior edge rectilinear, angles not prominent beyond the rectilinear edge; eyes not visible; palpi suboval, terminal joint rather longer than the preceding one. A common species." [A true *Ixodes*, and probably the male of *I. scapularis* Say.]

Ixodes cinctus Fabricius.

"Reliquis magis oblongus. Caput ferrugineum. Scutellum triangulum, ferrugineum, margine albo. Thorax et abdomen ferruginea, antice cerea, scutellum late alba. Pedes ferruginei. Habitat in America boreali Dom. v. Rohr. Mus. Dom. de Schestedt." [Either *Dermacentor variabilis* Say or *Amblyomma maculatum* Koch, and probably the former.]

SPECIES ERRONEOUSLY ACCREDITED TO THE UNITED STATES.

Dermacentor reticulatus Fabricius. (Pl. X, fig. 10.)

Neumann at first identified the forms now called *D. occidentalis* and *D. venustus* as this European species. As shown above, these species are quite distinct, and there is no evidence that the true *D. reticulatus* occurs in this country.

Ixodes frontalis Panzer.

As I have stated under *Ixodes brunneus*, Neumann's identification of *I. frontalis* was based on specimens of *I. brunneus*.

Ixodes inchoatus Neumann.

Neumann questionably recorded this from the United States, but the specimens, as I have stated under *I. marxi*, differ greatly from the European *I. inchoatus*, and with more material I have described them as a new species—*I. marxi*.

Hæmaphysalis concinna Koch.

As explained under *Dermacentor nigrolineatus*, the record of *H. concinna* is based on a misidentification of Packard's species.

CATALOGUE.

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