U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 96.

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

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

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PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

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By F. H. CHITTENDEN, *In Charge of Truck Crop and Stored Product Insect Investigations.*

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BUREAU OF ENTOMOLOGY.

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ERRATA.

Page 30, line 19 from bottom, for *pusillus* read *pusillum*.

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U. S. D. A., B. E. Bul. 96, Part I. T. C. & S. P. I. I., March 25, 1911.

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

A LIST OF INSECTS AFFECTING STORED CEREALS.

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

Lists of the insects that attack various cultivated crops are being published from time to time and republished with additional names until we have, of the various species that affect certain crops, some very complete lists. A notable example is the late Dr. J. A. Lintner's list of injurious apple-tree insects, which numbers 356 species.[a] A preliminary list published by the same writer in 1882 contained only 176 species, less than half the number known to affect the apple 14 years later. Similar lists, more or less incomplete, but furnishing a basis for future additions, have been published of insects that affect the strawberry, the grapevine, the blackberry, the corn plant, the sugar beet, etc. Of many crops, however, there are no better published lists than those given in the catalogue of the exhibits in economic entomology at the World's Columbian Exposition issued in 1893 as Bulletin No. 31 (old series) of this bureau and in other similar exhibition catalogues (Bulletins 47, 48, and 53, new series) which have followed.

At the time the writer undertook the investigation of insects affecting stored products, which began with the inspection of cereal and other seeds exhibited at the World's Columbian Exposition at Chicago in 1893, his knowledge—in truth it might be said our knowledge—of these insects was confined to the species exhibited by this bureau at the exposition and catalogued in Bulletin No. 31 (old series). The list of the insects injuring stored corn numbered 20. Of these, two species, *Silvanus cassiæ* Reiche and *Dinoderus punctatus* Say, were incorrectly determined, and a third, *Calandra remotepunctata* Gyll., is a synonym, leaving only 17 species properly named.

In his first gropings for knowledge the writer was gravely informed by certain fellow entomologists of riper experience than himself that everything was well known, that nothing new would be found, and

[a] Lintner, J. A.—List of Injurious Apple-tree Insects. <11th Rep. Ins. N. Y. for 1895, pp. 263–272, 1896.

that the subject possessed no interest. In refutation of these statements it may be said that at the time they were made, in 1893, very little was positively known of the life histories of even our commonest granary insects and that the species themselves were not well known. Since that time many new forms have been added to our list, and many new facts concerning their habits, injuries, distribution, etc., have developed—all of sufficient interest to consume a considerable portion of the writer's time and energy now and perhaps for some years to come.

Inspection of the exhibits of cereal and other seeds at the World's Fair in Chicago, just mentioned, was the means by which many species, hitherto unknown or of little understood habits and distribution, became known, and notes made on their occurrence there and in other localities have added much to our knowledge concerning them. Visits during subsequent years, made by the writer and by agents and assistants, to flour mills, bakeries, and warehouses, and to feed and other stores have added much more to our already acquired information, and the correspondence of the bureau has contributed other facts.

The list which follows was prepared originally for the writer's personal use in the work of investigating insects of this class, but as the comprehensive work contemplated, on insects that affect stored cereals, will not be completed for some time, it has been thought advisable for the benefit of others working along similar lines to publish it now, in connection with and as an introduction to other papers which will follow:

INSECTS AFFECTING STORED CEREALS AND CEREAL PRODUCTS.

CUCUJIDÆ.

1. **Silvanus surinamensis** L. *Silvanus frumentarius* Fab. Saw-toothed grain beetle.	Chittenden: Farmers' Bul. 45, U. S. Dept. Agr., p. 16, 1897. Infests all cereals, dried fruits, etc. A general feeder.
2. **Silvanus bicornis** Er.	Chittenden: Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., pp. 10–11, 1897. Found in wheat granaries and dried figs.
3. **Silvanus mercator** Fauv. Merchant grain beetle.	Bul. 8, n. s., Div. Ent. U. S. Dept. Agr., p. 12, 1897. Habits similar to *S. surinamensis.*
4. **Cathartus gemellatus** Duv. *Silvanus cassiæ* auct. Square-necked grain beetle.	Farmers' Bul. 45, U. S. Dept. Agr., p. 17, 1897. Infests corn and wheat.
5. **Cathartus advena** Waltl. *Silvanus advena* Waltl. Foreign grain beetle.	Farmers' Bul. 45, U. S. Dept. Agr., p. 17, 1897. Attacks grain, meal, and flour; does not develop to any extent in material kept dry and clean.

6. **Læmophlœus minutus** Oliv. — Occurs commonly in cereals, but probably in the main predaceous and scavenging.
   Læmophlœus pusillus Sch.
   Flat grain beetle.
7. **Læmophlœus ferrugineus** Steph. — Curtis: Farm Insects, p. 330, 1860.
   Rust-red grain beetle. — Recorded to occur in granaries in Europe.
8. **Læmophlœus alternans** Er. — Bul. 2, o. s., Div. Ent., U. S. Dept. Agr., p. 32, 1883.
   Infesting a mill. (This is probably an erroneous determination=*minutus*?)
9. **Læmotmetus rhizophagoides** Walk. — Reitter: Harold's Coleop. Hefte, vol. 15, p. 38, 1876.
   Læmotmetus ferrugineus Gerst.
   Oryzœcus cathartoides Reitt. — Arrow: Ent. Mo. Mag., vol. 40, pp. 35–36, 1904.
   Found in stored rice at Berlin, Germany.

DERMESTIDÆ.

10. **Attagenus piceus** Oliv. — Chittenden: Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., pp. 15–19, 1897.
    Attagenus megatoma Fab.
    Black carpet beetle. — Lives on cereal and other seeds, and on woolen goods and other animal material.
11. **Anthrenus verbasci** L. — Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., p. 22, 1897.
    Anthrenus varius L.
    Small cabinet beetle. — Attacks wheat, flour, etc. A cabinet pest.
12. **Trogoderma tarsale** Melsh. — Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., pp. 19–21, 1897.
    Larger cabinet beetle. — Attacks wheat, seeds, nuts, and animal substances in store. It is also a cabinet pest.
13. **Trogoderma ornatum** Say. — Kellicott: Proc. Columbus Hort. Soc., vol. 9, p. 12, 1894.
    Ornate cabinet beetle. — Living on pop corn.
14. **Æthriostoma undulata** Motsch. — Cotes: Indian Museum Notes, vol. 3, p. 119, 1894.
    Destructive to wheat.

OTHER CLAVICORNS.

15. **Tenebroides mauritanicus** L. — Farmers' Bul. 45, U. S. Dept. Agr., p. 18, 1897.
    Trogosita mauritanica L.
    Cadelle. — In various cereal and other seeds.
16. **Lophocateres pusillus** Klug. — Chittenden: Insect Life, Div. Ent., U. S. Dept. Agr., vol. 6, p. 219, 1894.
    Ostoma pusillum Klug.
17. **Typhœa fumata** L. — Well known as occurring in stored products, but prefers decomposing material.
18. **Pharaxonotha kirschi** Reitt. — Chittenden: Insect Life, Div. Ent., U. S. Dept. Agr., vol. 7, p. 327, 1895.
    Thallisella conradti Gorh.
    Mexican grain beetle. — In corn meal and edible tubers.
19. **Carpophilus dimidiatus** Fab. — Chittenden: Insect Life, Div. Ent., U. S. Dept. Agr., vol. 6, p. 219, 1894.
    Breeds in corn meal.

19a. **Carpophilus pallipennis** Say. — Weed, H. E.: Bul. 17, Miss. Agr. Exp. Sta., p. 9, 1891.
    Corn sap-beetle. — Found in corn throughout the winter when stored.

BOSTRYCHIDÆ.

20. **Dinoderus truncatus** Horn Larger grain borer.	Chittenden: Insect Life, Div. Ent., U. S. Dept. Agr., vol. 7, p. 327, 1895. Breeds in corn and edible tubers.
21. **Rhizopertha dominica** Fab *Dinoderus dominica* Fab. *Dinoderus pusillus* Fab. *Rhizopertha pusilla* Fab. Lesser grain borer.	Injurious to cereals in kernel; breeds in corn, rice, wheat, and in other hard substances containing starch.

PTINIDÆ.

22. **Ptinus fur** L White-marked spider beetle.	Bul. 4, n. s., Div. Ent., U. S. Dept. Agr., p. 127, 1899. Injurious to flour, crackers, seeds, etc.
23. **Ptinus brunneus** Dufts Brown spider beetle.	Occurs in same situations as the above, and as its habits are practically identical it probably feeds also on cereals.
24. **Niptus hololeucus** Fald	Fitch (Powers): The Entomologist, vol. 12, p. 46, 1879. In "corn meal;" common in granaries in Europe.
25. **Gibbium psylloides** Czem *Gibbium scotias* Fab.	Schwarz (unpublished). In stale bread in a bakery at Washington, D. C.; in storehouses, etc.
26. **Sitodrepa panicea** L *Anobium paniceum* L. Drug-store beetle.	Bul. 4, n. s., Div. Ent., U. S. Dept. Agr., pp. 124–126, 1899. A general feeder.
27. **Lasioderma serricorne** Fab *Lasioderma testaceum* Dufts. Cigarette beetle.	Bul. 4, n. s., Div. Ent., U. S. Dept. Agr., p. 126, 1899. Habits similar to above; observed to breed in rice, yeast cakes, fish food, etc.
28. **Catorama punctulata** Lec	Quaintance: Bul. 36, Fla. Agr. Exp. Sta., pp. 381–382, 1896. In corn, corn meal, flour, etc.
29. **Catorama zeæ** Waterh *Tricorynus zeæ* Waterh.	Trans. Ent. Soc. London, vol. 5, Proceedings, p. lxviii, 1847–1849. "Attacking the grain of the common maize."

TENEBRIONIDÆ.

30. **Tenebrio molitor** L Yellow mealworm.	Farmers' Bul. 45, U. S. Dept. Agr., pp. 14–15, 1897. Injurious to ground cereals, especially when stale.
31. **Tenebrio obscurus** Fab Dark mealworm.	Farmers' Bul. 45, U. S. Dept. Agr., p. 15, 1897. Infests ground cereals.
32. **Tenebrio tenebrioides** Beauv	Unpublished.
33. **Tribolium confusum** Duv *Tribolium ferrugineum* auct. Confused flour beetle.	Farmers' Bul. 45, U. S. Dept. Agr., pp. 11–12, 1897. A general feeder, injurious to cereals in every form.

34. **Tribolium navale** Fab................Farmers' Bul. 45, U. S. Dept. Agr., pp. 12–13, 1897.
Tribolium ferrugineum Fab.
Rust-red flour beetle. Habits like preceding.

35. **Tribolium madens** Charp............Johnson: Amer. Miller, Jan. 1, 1896, p. 32.
Black flour beetle. Habits similar to two preceding.

36. **Gnathocerus cornutus** Fab.........Farmers' Bul. 45, U. S. Dept. Agr., p. 13, 1897.
Echocerus cornutus Fab.
Broad-horned flour beetle. Infests ground cereals.

37. **Gnathocerus (Echocerus) maxillosus** Fab.......................Farmers' Bul. 45, U. S. Dept. Agr., p. 13, 1897.
Slender-horned flour beetle.
Infests corn and corn meal.

38. **Cænocorse ratzeburgi** Wissm.......Farmers' Bul. 45, U. S. Dept. Agr., p. 13, 1897.
Palorus ratzeburgi Wissm.
Small-eyed flour beetle. Infests cereals, whole and ground.

39. **Cænocorse subdepressa** Woll........Chittenden: Ent. News, vol. 7, p. 138, 1896.
Palorus subdepressus Woll.
Depressed flour beetle. Lives in granaries in Europe and South America and in cereals in the United States.

40. **Latheticus oryzæ** Waterh...........Waterhouse: Ann. & Mag. Nat. Hist., vol. 5, pp. 147–148, Feb., 1880.
Lyphia striolatus Fairm.
Short-horned flour beetle. Breeds in rice, wheat, and barley.

41. **Sitophagus solieri** Muls.
Sitophagus hololeptoides Lap.

42. **Alphitobius diaperinus** Panz........Food habits similar to those of Tenebrio; prefers spoiled material.
Lesser mealworm.

43. **Alphitobius piceus** Oliv.............There are brief notes on occurrence in grain.

44. **Alphitophagus bifasciatus** Say.....Commonly occurs in spoiled cereals, but does not injure sound material.
Phylethus bifasciatus Say.
Alphitophagus 4-pustulatus Steph.

RHYNCHOPHORA.

45. **Calandra granaria** L................Farmers' Bul. 45, U. S. Dept. Agr., pp. 4–5, 1897.
Sitophilus granarius L.
Calandra remotepunctata Gyll. Breeds in all cereals in the kernel, except, perhaps, oats and unhulled rice, and in some prepared cereals, etc.
Granary weevil.

46. **Calandra oryza** L...................Farmers' Bul. 45, U. S. Dept. Agr., pp. 5–6, 1897.
Sitophilus oryzæ L.
Rice weevil. Infests all cereals in kernel.

47. **Caulophilus latinasus** Say..........Chittenden: Tech. Ser. 4, Div. Ent., U. S. Dept. Agr., pp. 29–30, 1896.
Broad-nosed grain weevil.
In corn, chick-peas, ginger, etc.

48. **Brachytarsus alternatus** Say.......Quaintance: Bul. 36, Fla. Agr. Exp. Sta., pp. 380–381, 1896.
Larva and adult injurious to stored corn, cowpeas, and "English peas."

49. **Brachytarsus variegatus** Say.......Lintner: 2d Rep. Ins. N. Y., pp. 139–141, 1885.
Adult exceptionally eats kernels of wheat in bin.

50. **Rhyncolus oryzæ** Gyll	Schönherr: Genera et Species Curculionidum, p. 1075, 1837. Described from specimens found between grains of rice in store at Stockholm.

TINEINA.

51. **Sitotroga cerealella** Oliv. *Gelechia cerealella* Oliv. Angoumois grain moth.	Farmers' Bul. 45, U. S. Dept. Agr., pp. 6–7, 1897. Infests all cereals in kernel.
52. **Tinea granella** L. European grain moth.	Farmers' Bul. 45, U. S. Dept. Agr., p. 7, 1897; also Bull. 8, n. s., Div. Ent., U. S. Dept. Agr., pp. 31–35, 1897.
53. **Tinea biselliella** Hum	Chittenden: Tech. Ser. 4, Div. Ent., U. S. Dept. Agr., p. 30, 1896. Reared from stored wheat and corn, but doubtful if it breeds in cereals.
54. **Tinea pallescentella** Haw	Stainton: Entomologist's Annual, 1857, p. 122. "The larva is granivorous."
55. **Tinea misella** Zell	Gregson: Entomologist's Annual, 1857, p. 121. Reared "from unthrashed wheat."
56. **Batrachedra rileyi** Wals	Chittenden: Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., pp. 32–33, 1897. Attacks corn in field and said to live in it in store.
57. **Acompsia pseudospretella** Stain. *Œcophora pseudospretella* Stain.	Gregson: See Butler's "Our Household Insects," p. 106, 1896. Injurious to rice, brooms, seeds, etc.

PHYCITIDÆ.

58. **Plodia interpunctella** Hübn. *Ephestia zeæ* Fitch. Indian-meal moth.	Farmers' Bul. 45, U. S. Dept. Agr., pp. 9–10, 1897. Attacks all cereals; a general feeder.
59. **Ephestia kuehniella** Zell. Mediterranean flour moth.	Chittenden: Cir. 112, Bur. Ent., U. S. Dept. Agr., 1910. Infests all cereals, but most injurious to flour.
60. **Ephestia cautella** Walk. *Ephestia cahiritella* Zell. *Ephestia passulella* Barr. Fig moth.	Chittenden: Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., p. 7, 1897. Reared from corn meal, dried fruits, seeds, nuts, etc.
61. **Ephestia ficulella** Barr. *Ephestia desuetella* Walk.	Insect Life, Div. Ent., U. S. Dept. Agr., vol. 5, pp. 141, 350, 1893; Chittenden: Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., 1897. In oatmeal at Kingston, Jamaica; recorded also from Galveston, Tex.
62. **Ephestia elutella** Hübn	Bul. 8, n. s., Div. Ent., U. S. Dept. Agr., p. 9, 1897.

OTHER MOTHS.

63. **Pyralis farinalis** L. .... Farmers' Bul. 45, U. S. Dept. Agr., pp. 10–11, 1897.
Asopia farinalis L.
Meal snout-moth.
Attacks cereals, hay, etc., but not known to injure material that is kept quite clean and dry.

64. **Melissoblaptes gularis** Zell. .... Jenner, J. H. A.: The Entomologist, vol. 25, p. 286, 1892.
In "polished Japan rice" in London.

ORTHOPTERA.

(Cockroaches.)

65. **Blatta orientalis** L. .... Marlatt: Cir. 51, Bur. Ent., U. S. Dept. Agr., pp. 8, 9, 1908.
Periplaneta orientalis L.
Stylopyga orientalis L.
Oriental cockroach.

66. **Blattella germanica** L. .... Marlatt: Cir. 51, Bur. Ent., U. S. Dept. Agr., pp. 9, 10, 1908.
Ectobia germanica L.
Phyllodromia germanica L.
German cockroach; croton bug.

67. **Panchlora surinamensis** L. .... Insect Life, Div. Ent., U. S. Dept. Agr., vol. 5, pp. 201, 268, 1893.
Surinam roach.

NEUROPTEROID INSECTS.

(Thysanura, Isoptera, Corrodentia.)

68. **Lepisma saccharina** L. .... Marlatt: Cir. 49, Bur. Ent., U. S. Dept. Agr., 1902.
Silverfish.

69. **Lepisma domestica** Pack. .... Marlatt: Cir. 49, Bur. Ent., U. S. Dept. Agr., 1902.
Fire brat.

70. **Termes flavipes** Koll. .... Marlatt: Cir. 50, Bur. Ent., U. S. Dept. Agr., 1908.
Philotermes flavipes Koll.
White ant.

71. **Troctes divinatoria** Fab. .... Marlatt: Bul. 4, n. s., Div. Ent., U. S. Dept. Agr., pp. 79–81, 1899.
Atropos divinatoria Fab.
Book louse.

72. **Troctes corrodens** Heymons .... Heymons: Deutsch. ent. Zeitschr., 1909, pp. 452–455.

ACARINA.

(Mites.)

73. **Tyroglyphus farinæ** DeG. .... Banks: Tech. Ser. 13, Bur. Ent., U. S. Dept. Agr., p. 14, 1906.
Aleurobius farinæ DeG.
Flour mite.

74. **Tyroglyphus siro** Gerv. .... Lintner: 3d Rep. Inj. Ins. N. Y., pp. 130, 131, 1888.
Cheese mite.

75. **Tyroglyphus longior** Gerv. .... Banks: Tech. Ser. 13, Bur. Ent., U. S. Dept. Agr., p. 14, 1906.
Elevator mite.
Insect Life, Div. Ent., U. S. Dept. Agr., vol. 1, p. 51.

76. **Tyroglyphus americanus** Bks. .... Banks: Tech. Ser. 13, Bur. Ent., U. S. Dept. Agr., p. 16, 1906.
Mill mite.

THE MEXICAN GRAIN BEETLE.

(*Pharaxonotha kirschi* Reitt.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

Among grain-feeding insects which have not yet been permanently introduced into this country as pests, but which have come repeatedly under observation, is a clavicorn beetle, *Pharaxonotha kirschi* Reitt. (fig. 1). This was one of the living species observed by the writer infesting stored grain in the foreign exhibits at the World's Columbian Exposition and was more abundantly distributed throughout these exhibits toward the end of the fall of 1893. At the time of its discovery it was practically unknown to American scientists, with the exception of Dr. George H. Horn.

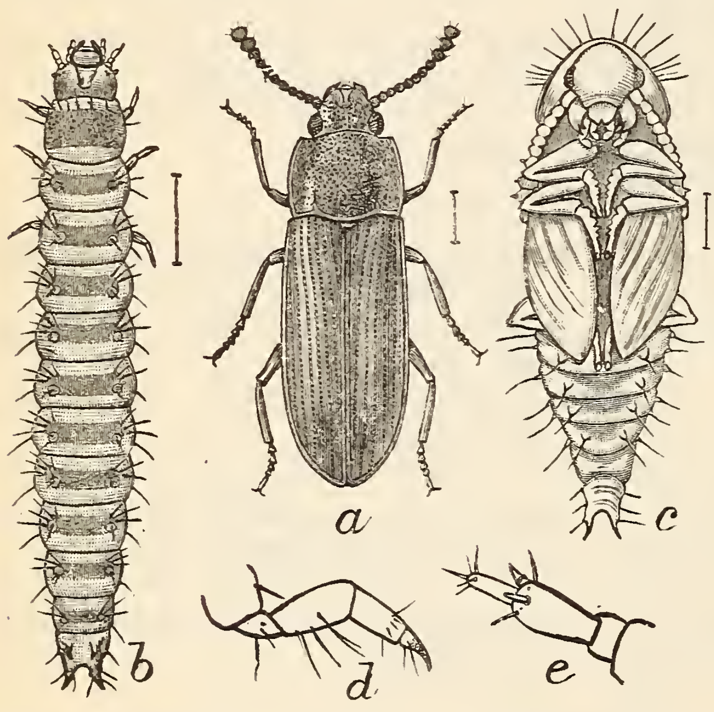

Fig. 1.—The Mexican grain beetle (*Pharaxonotha kirschi*); *a* Beetle; *b*, larva; *c*, pupa; *d*, leg of larva; *e*, antenna of larva. *a, b, c*, Much enlarged; *d, e*, more enlarged. (Original.)

The Bureau of Entomology has also to record two reports of the occurrence of this species in stored corn in Mexico, one dated 1902 and the other 1910, as follows:

December 3, 1902, Mr. A. L. Herrera, of the City of Mexico, sent a sample of stored corn from Tlaxiaco, State of Oaxaca, infested with this and other species of insects which have been previously identified with injury of this nature in Central America.

During the winter of 1910 complaints were made through Mr. Ed. Los McCue, of the Cafetal Carlota Co., Oaxaca, of injury by weevils to corn, and on February 26 the specimens in question reached this office. Upon examination the principal injury proved to be due to the rice weevil (*Calandra oryza* L.), while the square-necked grain beetle (*Cathartus gemellatus* Duv.) and the Mexican grain beetle were also present. No statement was made in regard to the habits of any species, but it was surmised by the correspondent that they all bored into the timbers of the crib. In this event it is probable that one of the grain borers (*Dinoderus truncatus* Horn) was present.

DESCRIPTION.

THE ADULT.

Before proceeding with a technical description of the insect it should be stated that the adult, or beetle, is about three-sixteenths of an inch in length, deep brown in color, and highly polished. It has been mistaken for a tenebrionid and has been compared with Tribolium, but it resembles the Ulomini only superficially and can be distinguished readily by its highly polished surface, by its longer antennæ, and by the five-jointed posterior tarsi.

This species was given the name which it now bears by Reitter in 1875,[1 a] a new genus being erected for its reception and placed by its describer near the genus Antherophagus in the family Cryptophagidæ. Afterwards it was removed to the Erotylidæ, and more recently it has been classified by the same writer[10] as belonging to the Cryptophagidæ and the group Cryptophagini.

The genus Pharaxonotha is characterized by Reitter as follows:

Genus PHARAXONOTHA Reitt.

Antennæ stout, almost as in Antherophagus. Gular margin with a prominent tooth. Prosternum behind the coxæ subdilated, apex obtusely rounded, sides margined. Front biimpressed, prothorax hardly narrower than the elytra, subtransverse, sides entire, angles not thickened, basal and lateral margins slightly thickened, base on each side with an abbreviated and strongly impressed line. Elytra striate-punctate, striæ entire and deeper toward apex, humeral angles acute and slightly prominent, anal abdominal segment subtuberculate at tip. Tarsi 5-jointed, fourth joint shorter and narrower than the preceding. Body elongate, robust, upper side hardly visibly pubescent.

The species is thus described by Reitter:

Pharaxonotha kirschi Reitt.

Oblong, slightly convex, subglabrous, fusco-castaneous, shining; head rather densely and rather deeply, and prothorax less densely punctate, subtransverse, almost truncate at apex, sides nearly straight, bisinuate at base, elytra finely striate-punctate, striæ toward apex less deep, sutural stria posteriorly more impressed; beneath sparsely punctate, very finely and sparsely hairy.

Length, 4–4.5 mm.; width, 1.2–1.5 mm.

The beetle is illustrated in figure 1, *a*.

THE EGG.

The egg is somewhat variable in shape and size. It is more or less elongate-ellipsoidal in form and milk-white in color, and the surface is rather finely shagreened. The length varies from 0.94 to 0.99 mm. and the width from 0.35 mm. to 0.39 mm.

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[a] Numbers in superior type refer to corresponding numbers in the bibliographic list, page 13.

The other stages of this species were not described for lack of time when specimens were fresh and later these were not in condition for specific description.

THE LARVA.

The larva illustrated at *b* of figure 1 is elongate subcylindrical, about six times as long as wide. It is gray, each segment being darker at the middle, while at the sides of each of these darker spaces there are rather well developed piliferous tubercles. An enlarged leg is shown at *d* and an antenna, also enlarged, at *e*. When full grown the larva measures about five-sixteenths of an inch (8.5 mm.) in length.

THE PUPA.

The pupa (fig. 1, *c*) is about the same size as the adult, paler than the larva, nearly white. It will be noticed that the thorax bears conspicuous long hairs and that similar hairs project from tubercles on the abdomen. In the pupa as well as the larva the anal apex terminates in two divergent points.

It should be added that both larva and pupa are delicate and perceptibly softer than the common grain-feeding tenebrionids found in similar locations.

LITERATURE.

The literature on this species is decidedly scanty. The original description appeared in 1875.[1] This was followed by two records of the finding of the insect in cotton bolls from Bahia, Brazil, one in 1880,[2] when it is mentioned as "(4) one specimen of a Diplocœlus not occurring in the United States," and again in 1885 as follows[3]: "(4) one specimen of a cryptophagid beetle, apparently undescribed and not occurring in the United States." Mr. E. A. Schwarz, who saw the specimen referred to, assures the writer that it is this species.

In the collection of the United States National Museum there are also specimens bearing this label: "In corn, Guatemala, March 24, 1884."

Brief mention was made in 1894[5] of the occurrence of this species in exhibits of stored products, the insect being referred to as a "Cryptophagid (?)" with the statement that it was found living in corn meal and edible tubers from the Mexican and Guatemalan exhibits at the World's Fair held in Chicago in 1893. The following year[6] this species was included in a list of foreign insects introduced into the United States in recent years. In 1896[7] similar notes were published in a list of insects known to occur in stored products in Mexico and record was made of the capture of the species near San Antonio, Tex., in December, 1895.

In all, this species has received ten notices, none of them extensive, the remainder, which will not receive mention, being descriptive and synonymical articles and notes.

OBSERVED HABITS.

In order to obtain information in regard to the habits of the insect, a number of living adults was placed in a small rearing jar containing fresh meal and slices of raw potato, the latter to furnish additional moisture, and placed in a cool room. Here the adults showed conclusively that they were perfectly able to withstand the average temperature of an ordinary mill, warehouse, or granary of a latitude such as that of the District of Columbia. The beetles are much more active than the meal-feeding tenebrionids. When they were examined some were usually to be seen moving about on the meal and frequently they tried to climb the sides of the jar, although making little progress. Although they crawled into the meal for concealment, for warmth, or for oviposition, they do not, like Tribolium, burrow or excavate galleries. On the contrary, they form shallow pits or depressions, several beetles occupying the same pit in partial concealment. The eggs are deposited on the surface of the meal.

In one lot of insects of this species kept under observation, an equal number of Tribolium also lived and in perfect harmony. Neither species showed the least signs of being even in the slightest degree predaceous upon the other.

Even with limited material for observation, it soon became manifest that this grain beetle is quite capable of breeding freely in a moderately cool temperature. Beetles began pairing during the first week of April and daily during the warm weather following, but it was noticed that they had already deposited eggs at infrequent intervals during the winter, as a number of larvæ of varying sizes, observed in April, bore witness. The living imagos, seven of which remained alive in the first jar, were now removed to a different jar and placed by themselves. By this time, April 6, some of their progeny were about half-grown larvæ. Of these, the most mature transformed to pupæ May 1 and to imagos May 10, the remainder continuing as larvæ until considerably later.

From another lot of specimens segregated in a second rearing jar and kept in a warm room, it was found that from December 5 to April 10 one adult had issued and many pupæ were present. This gives a full life cycle of eighteen weeks, or four and one-half months, the dry artificial atmosphere probably accounting for the slowness of development.

It has always been noticed that when the larvæ are disturbed they have a habit of rolling up into a ball and remaining thus for a minute or more before resuming their usual activity.

When fully mature, larvæ were observed to come to the surface of the meal in the rearing jars to transform. Save for close observation, the true method of pupation might have escaped notice. When the contents of one jar became too dry, a bit of moistened blotting paper was inserted. The excess of humidity caused by this addition induced uneasiness on the part of the larvæ, which were now full-grown. When, however, the normal degree of temperature was produced, the larvæ attacked the blotting paper, which happened to be placed against the glass, and soon constructed a pupal cell such as they probably produce under more normal conditions. One of these cells of about typical form is rounded irregularly and measures one-fourth of an inch in length by three-eighths of an inch in its widest diameter. The pupa, as in the case of the pupæ of so many other beetles, rests at the bottom of the cocoon on its back.

Larvæ selected during May for the purpose of observing the period of the pupal stage transformed to pupæ July 16 and to imagos July 22, or in between five and one-half and six days for different individuals. Others in a cooler temperature required 8, 9, and 10 days for the pupal period.

Under above conditions (e. g., from June 23 to July 25) the development of this species, from the laying of the egg to the issuance of the beetle, covered 32 days. This was during an exceedingly heated period and is doubtless not far from the minimum period for the life cycle. In another case, where the weather was cooler, comprising portions of the months of April, May, and June, the life cycle required 59 days, or eight and one-half weeks. Three distinct generations were obtained, from the first generation of beetles to their children and finally to the grandchildren.

The species does not appear to be long-lived under confined conditions. Adults, active and breeding, seldom lived longer than three months. Doubtless in the open this period can be greatly extended.

It should be mentioned in connection with the life history of this species that upward of a week is required for the beetle to acquire the full deep shining brown of maturity. The thorax and the apices of the elytra color last, and the latter often remain much lighter colored than the other parts. The beetles, however, are active long before they have acquired this complete coloration. Hence it happens that in most lots of the beetles seen there are many which are not fully colored, although otherwise perfect.

Some other experiments were made to ascertain if the insect is a primary feeder upon perfectly healthy dry seed. In hard wheat, corn, and beans a few larvæ hatched and for a time lived on the meal that the imagos cut from the corn, but failed to develop. In softer, fresher seed in the field they could no doubt breed freely.

ENEMIES.

A single natural enemy was observed in the rearing jars, viz, the predaceous mite *Pediculoides ventricosus* Newp. It occurred in April and May.

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   Mention as a "Cryptophagid (?)" in its occurrence at Chicago, Ill., in Mexican and Guatemalan exhibits of stored products.

6. CHITTENDEN, F. H.—Insect Life, Div. Ent., U. S. Dept. Agr., vol. 7, p. 327, March 29, 1895.

   Identification of species from material breeding in meal and tubers from Mexico and Guatemala at the World's Fair; belief expressed that it will in time be introduced into Southern States.

7. CHITTENDEN, F. H.—U. S. Department of Agriculture, Bureau of Entomology, Technical Series 4, p. 28, 1896.

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9. CHAMPION, G. C.—Entomologists' Monthly Magazine, vol. 40 (2d ser., vol. 15), p. 36, 1904.

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10. REITTER, EDM.—Catalogus Coleopterorum Europæ, p. 331, 1906.

    Removal to the Crytophagidæ; brief bibliography.

THE SIAMESE GRAIN BEETLE.

(*Lophocateres pusillus* Klug.)

By F. H. Chittenden, Sc. D.,
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INTRODUCTORY.

Among other species of injurious insects found for the first time in rice and other cereal exhibits, at the World's Columbian Exposition, held in Chicago in 1893, there was a small trogositid beetle, *Lophocateres pusillus* Klug, which occurred in exhibits from Siam, Liberia, and Ceylon, and which was new to the writer at that time. This species was not then included in our faunal lists, nor does the writer know of any record of its having become established in North America until about 1905[8], although the French coleopterist M. A. Fauvel had expressed the belief that the species might occur in North America. At the time of its discovery at Chicago it could not be ascertained whether this insect was predaceous or granivorous in habit. Nothing more was heard of the insect until ten years later (1903) when living specimens were observed during September in corn from Blanco, Peru, South America.

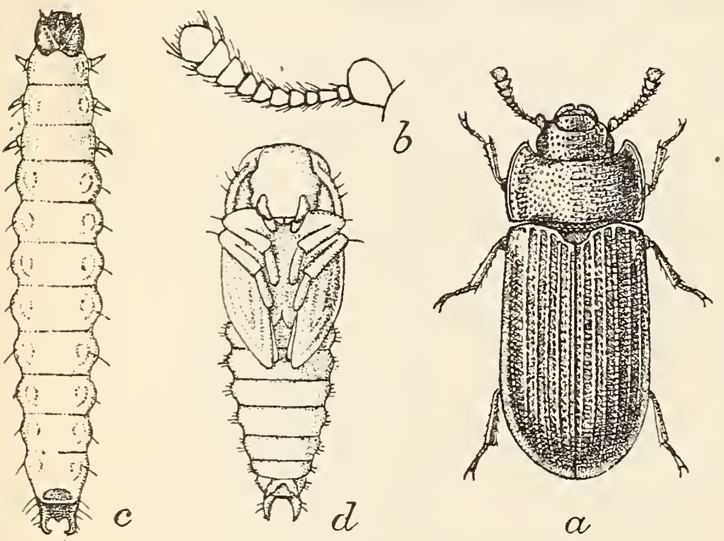

Fig. 2.—The Siamese grain beetle (*Lophocateres pusillus*): *a*, Adult or beetle; *b*, antenna of same; *c*, larva; *d*, pupa. *a*, *c*, *d*, About ten times natural size; *b*, greatly enlarged. (Original.)

November 30, 1904, this bureau received from Mr. D. S. Bliss, Bureau of Plant Industry, a bag of paddy rice-heads from Java in which this species was living. Many of the kernels showed where the beetles had escaped.

August 10, 1905, Mr. D. A. Brodie, also of the Bureau of Plant Industry, sent specimens in rice from a rice mill at Charleston, S. C., where the insect was associated with the common *Tribolium navale* Fab. and *Læmophlœus minutus* Oliv. and was evidently established. During the same month Mr. Samuel G. Stoney, Charleston,

S. C., sent specimens of this species, and in a letter of August 22 reported that millers in that vicinity had some years previously received rice from Siam and other points in the Orient as well as from Honduras.

It was reported, October 20, 1906, from El Rancho, Guatemala, by Mr. E. E. Knight, who furnished living specimens, as injuring grain, together with the so-called corn weevil (*Calandra oryza* L.). Living examples also occurred among some infested black beans.

During 1909 the species came under observation on several occasions, especially in different localities in Texas, the records being furnished chiefly by Mr. D. K. McMillan. June 26 of that year specimens were obtained in various materials from a flour mill in Galveston. June 28, Mr. J. G. Sanders, then of this bureau, found adults in eggplant and gourd seeds, and beans from Siam. Of its occurrence at Brownsville, Tex., Mr. McMillan wrote that the beetles were very abundant in old rye from the bottom of a bin, and that they were scattered throughout the mill inspected. He observed that they were much more sluggish than most mill insects, and clung closely to the flour sacks and to wood and paper upon which they were resting. They also have the habit of accumulating, or crowding, into small groups, thus showing the gregarious habit common to most herbivorous insects found in stored material. At one mill it was the most abundant species found among rubbish. October 25, Mr. F. A. Stockdale sent this species in paddy rice imported from India and traced to Georgetown, Demerara. December 6, Mr. McMillan sent specimens from Houston, Tex., where the insect occurred in rough Japan rice. At New Braunfels, Tex., it occurred in old rye, flour, and rubbish.

DESCRIPTION.

THE ADULT.

The genus Lophocateres was characterized in 1883 by Olliff, who referred it to the subfamily Peltini of the family Trogositidæ, a group which includes the well-known genera Peltis and Calitys, beetles having flattened, more or less oval, bodies with much flattened thoracic and elytral margins. Olliff's description is as follows:

Genus LOPHOCATERES Olliff.

Head nearly quadrate. Eyes rather small, lateral, not prominent. Antennæ 11-jointed, basal joint large, with the inner angle much produced, 2nd joint short, 3rd rather longer, 4th to 7th transverse and very short, last four forming a gradually elongated club, of which the joints increase in breadth as they approach the apex. Mandibles robust, inner margin straight, the apex slightly incurved. Maxillæ with both lobes narrow and sharply jointed, the inner much the shorter. Maxillary palpi 3-jointed, the basal very small, the 2nd rather longer, the 3rd longer than the 1st and 2nd together, rounded at the apex. Labium with the anterior margin rounded. Labial palpi 2-jointed, of which the apical is somewhat the longer. Prothorax transversely quadrate, rather strongly margined laterally. Elytra about the same width as the prothorax, depressed, covering the abdomen, subparallel, with fine costæ. Legs short and slender; tibiæ armed on their outer margins with short, sharp spines, the posterior tibiæ with a row of blunt teeth at the base, slightly projecting over the 1st joint of the tarsus, tibial spurs short; tarsi 5-jointed, the basal very short, the 2nd and 3rd rather longer, the 4th shorter, and the 5th nearly as long as the other four together; claws simple.

The fine but distinct costæ on the elytra, the gradual 4-jointed club of the antennæ, and the peculiar structure of the posterior tibiæ, are characters which will serve at once to distinguish this genus.

The antennæ in the present species (fig. 2, *a*, *b*) have the basal joint much enlarged and produced on the inner surface, the terminal joints forming a three-jointed club instead of a four-jointed one as is in the type species. The strongly produced apices of the thoracic margin form a strong character, common to the group, but not found in other forms of beetles known to attack stored cereals.

Klug's original description of the species is as follows:

PELTIS F.

81. *Peltis pusilla* n. sp.

P. elongata, ferruginea, capite thoraceque punctatis, elytris punctato-striatis. Long. lin. 1⅓.

Statura fere *P. oblongæ*. Depressa, fere linearis, dorso ferruginea, subtus rufo-testacea. Caput et thorax confertim punctata. Elytra thorace duplo-longiora, marginata, striata, ad strias punctata. Pedes rufo-testacei.

The species may be further recognized by the following description:

Lophocateres pusillus Klug.

Elongate, flattened; dorsal surface glabrous, ferruginous brown, with elytral margins paler ferruginous, strongly punctate. Head deeply, closely, and coarsely punctate. Thorax transverse, finely and distinctly punctate like the head, sides subparallel, narrowed anteriorly. Elytra parallel, each presenting seven costæ which bear on each side a row of close and deep punctures. Apices of elytra rounded. Legs ferruginous.

Length 2.7–3 mm.; width 1.0–1.2 mm.

THE LARVA.

M. Claudius Rey[6] gives a description of the larva (fig. 2, *c*), of which the following is a translation:

Body subelongate or oblong, somewhat attenuate at the extremities, subdepressed or a little convex, obsoletely pilose at the edges; dirty white, somewhat shiny, with the head and last abdominal segment fulvous, the latter armed at the apex with an angular median tooth, and with two strong hooks with points recurved upward and slightly toward each other.

Head nearly round, a little narrower than the prothorax, somewhat divided by a median channel into two smooth and somewhat convex discs, flattened, biimpressed and subrugulose in front, decided fulvous yellow, provided on the sides with four or five long, pale bristles. Labrum transverse, ruddy. Mandibles ferruginous, with black points, bidentate. Palpi small, testaceous; eyes rather distinct; antennæ slightly projecting, testaceous, the joints narrowing gradually.

Prothorax in the shape of a transverse rectangle somewhat out of proportion, pale and shiny. Mesothorax and metathorax transverse, wider than the prothorax but both together hardly exceeding it in length. Pale, more or less unequal, the sides somewhat curved.

Abdomen more or less enlarged, somewhat rounded at the sides of segments, and narrowing to the rear. Of the nine segments, the first eight are shining dirty-white, short, more or less uneven, folded transversely and surmounted by four longitudinal rows of swellings or scars, the lateral rows of which are less pronounced. The ninth is a little narrower, provided on the back with a large flattened plate, which is received in a broad hollow on the eighth segment, fulvous, rugulose or folded transversely for about the first third, and broadly hollowed upon the summit, the deepest part of the hollow armed with a median angular or conical tooth, and limited by the two strong hooks, darker in color and with the points recurved upward and inward.

Beneath the body is pale, subdepressed, sparsely hairy, more or less uneven, with the underside of the head and the last ventral arch fulvous.

Feet short, pale, terminating in a small hard hook, almost straight, brownish.

Length 5.35 mm.; width 1.07 mm., of head 0.50 mm.

Measurements from fully mature, freshly killed specimens extended full length.

THE PUPA.

The pupa has not been described and no material is at present available for descriptive purposes. The general appearance of the pupa, however, is well shown in the accompanying illustration (fig. 2, *d*). In life it is of the same whitish color as the larva and like the larva, also, its last segment terminates in two processes, slightly incurved.

It measures about 2.7 mm. in length and 1 mm. in width.

DISTRIBUTION.

There is now practically no doubt that the species is firmly established in this country, both in North America and in South America, and that it is cosmopolitan in a somewhat narrow sense, apparently being restricted to the tropical and to the warmer temperate zones corresponding to the Lower Austral of North America.

Since this species was first observed by the writer in a Siamese grain exhibit, and as it appears to be well established there, it may be known as the Siamese grain beetle.

HABITS.

Writing of this species in 1888, M. Claudius Rey stated that he discovered the larvæ in company with the adults in a shipment of soy beans (*Soja hispida*), which were in most part reduced to powder, and which came from Saigon, Cochin China. He remarked that M. Valery Mayet had collected the same species at Marseille, France, in peanuts, and that the beetle had been captured flying on the maritime coast where he surmised it would probably some day become naturalized. He expressed the belief that the larva obtained its nourishment from animal substances or products after the supposed habits of other species of Trogositidæ, basing this opinion on its resemblance to them in structure and to the attendant circumstances that the larvæ were not actually found in the seeds of these two plants.

Experiments conducted by the writer, on receipt of living material in 1903, show conclusively that this species will breed in stored grain. A small number of beetles were confined in a jar of uninfested wheat, corn, and meal in February, and in March of the following year, when examined, larvæ from these as well as living beetles and many dead ones were found. There is no evidence as yet of predaceous habits of this insect, as is the case with the related cadelle.

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   Description of Lophocateres, n. gen. Type, *L. nanus* n. sp. from Borneo.

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   Synoptic table of genus with mention of *L. yvani* as being referred to this genus.

6. Rey, Claudius.—Annales de la Société Entomologique de France, 1888, pp. xxxviii, xxxix.

   Description of the larva, mentioned as *Ostoma Yvani* Allibert.

7. Riley, C. V.—Insect Life, Div. Ent., U. S. Dept. Agr., vol. 6, pp. 219, 223, February, 1894.

   Found at Chicago World's Fair in cereal exhibits of Siam, Liberia, and Ceylon. Economic status doubtful.

8. Chittenden, F. H.—Yearbook of the United States Department of Agriculture for 1905, p. 630 (separate).

   Mention of destructive occurrence in stored rice at Charleston, S. C., where it has evidently become established.

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U. S. D. A., B. E. Bul. 96, Part II. T. C. & S. P. I. I., March 31, 1911.

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

THE BROAD-NOSED GRAIN WEEVIL.

(*Caulophilus latinasus* Say.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

NOTES ON OCCURRENCE IN THE UNITED STATES.

Receipts, in recent years, of stored products infested by the cossonine weevil *Caulophilus latinasus* Say (fig. 3) appear to indicate that it is permanently established as an enemy of dried cereals and other food materials in the United States.

In December, 1895, the Bureau of Entomology received from the Cotton States and International Exposition, held at Atlanta, Ga., that year, specimens of this weevil found living in chick-peas (*Cicer arietinum*) from Mexico.

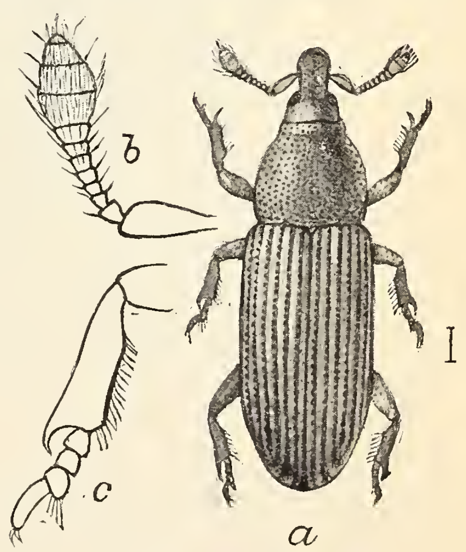

Fig. 3. The broad-nosed grain weevil (*Caulophilus latinasus*): *a*, Beetle; *b*, antenna; *c*, hind leg. *a*, Much enlarged, see size line at right; *b* and *c*, highly magnified. (Original.)

February 3, 1899, living beetles were found in about equal numbers with the rice weevil in shelled corn and chick-peas purchased by Mr. August Busck from a store at Arroyo, Porto Rico.

December 3, 1902, Mr. A. L. Herrera, City of Mexico, Mexico, sent a sample of stored corn from Tlaxiaco, State of Oaxaca, infested with this species, which had been previously identified with injury of this nature in Central America.

During February, 1909, the Bureau of Entomology received from Mr. P. J. Wester, Bureau of Plant Industry, several seeds of avocado, or alligator pear (see fig. 4), obtained at Miami, Fla., via Jamaica, infested with numbers of this weevil.

By April 28 the seed centers had become reduced to powder by the weevils and were filled with larvæ and pupæ, while the adults were swarming on the sides of the jar. In order to furnish them with food some shelled corn was placed in the jar. By May 5 they had riddled it, and by May 21 it was reduced to meal, and the beetles had perished.

DESCRIPTIVE.

Superficially this species bears some slight resemblance to the grain weevils previously treated. Belonging to the same family of Rhynchophora, the Calandridæ, it has the same slender depressed form and measures about one-eighth of an inch in length (3 mm.). It is of

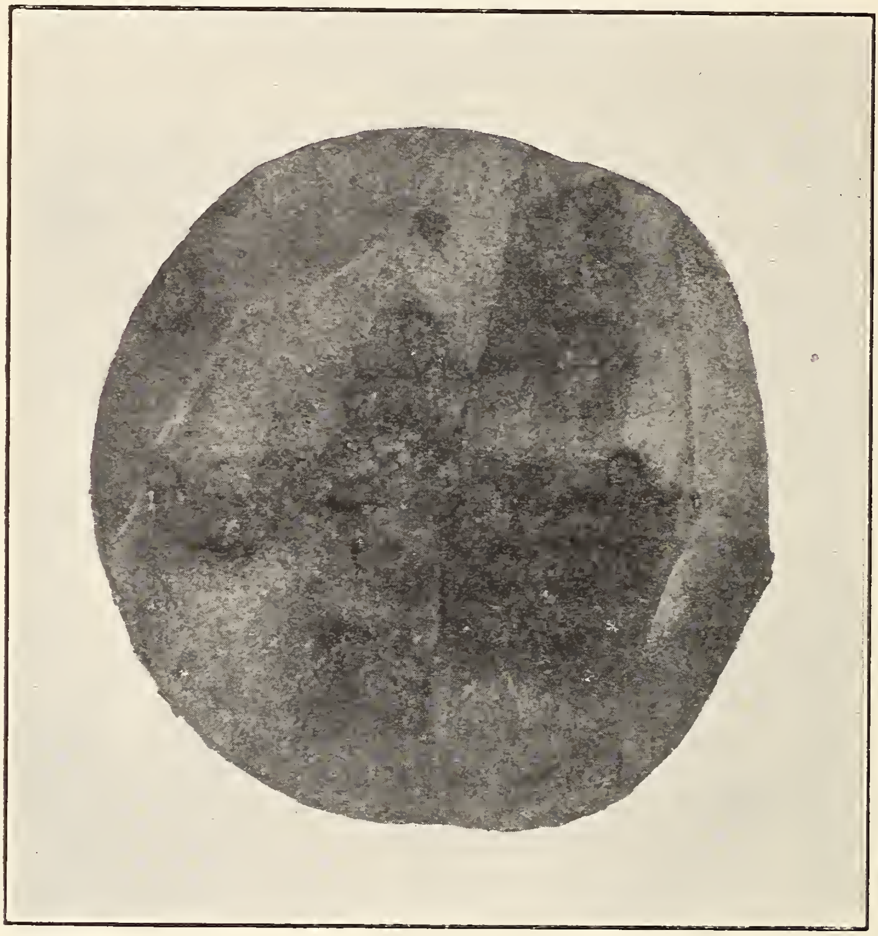

FIG. 4. Seed of avocado (*Persea gratissima*) injured by the broad-nosed grain weevil. (Original.)

a similar dark-brown color, but may be readily distinguished from either of these species by characters which are well shown in the illustrations of the two genera. Of these characters the most obvious are the much broader rostrum and mucronate tibiæ of Caulophilus.

A technical description follows:

Reddish brown or piceous, feebly shining, form moderately robust. Rostrum longer than half the thorax, cylindrical, feebly arcuate, sparsely punctured, between the eyes an elongate impressed point. Thorax as broad as long, anteriorly moderately constricted, sides strongly arcuate, base slightly narrowed, feebly bisinuate and with an obsolete impression in front of the scutellum, surface moderately and evenly punctured. Elytra not wider than the thorax, moderately convex, striæ moderately deep, at base punctured but neither coarsely nor closely, punctures at apex obsolete, intervals moderately convex, indistinctly punctulate. Body beneath sparsely punctured. Anterior tibiæ sinuate within. [Horn.]

The eighth stria, as pointed out by Horn, is slightly oblique and joins the seventh slightly behind the humerus. The interval between the ninth and marginal striæ is reduced to an extremely narrow carina. The union of the seventh and eighth striæ is an unusual character in the genus Cossonus, but is the usual form in the genus Rhyncolus. According to Champion's table this species may be separated from the other three, which he describes, by the elytra being more than twice as long as the thorax, with the elytral intervals simply convex at the apex and closely punctate.

Caulophilus sculpturatus Woll. was described from a single specimen and Wollaston, when writing in after years, remarked that the type was still unique. LeConte,[7] writing of the probable identity of this species and *latinasus,* said that, except that the punctation of the thorax is coarser in the figure furnished by Wollaston than in the three specimens in his collection, he should not venture to declare them different species.

Wollaston compares *Caulophilus sculpturatus* to the European *Rhyncolus cylindrirostris* Oliv. (=*lignarius* Marsh.), but structurally it differs from this and allied genera. From Phlœophagus, with which it is most likely to be associated, the genus Caulophilus is said by Wollaston [3] to be distinguished by its linear outline, depressed, deeply sculptured surface, and comparatively large eyes and scutellum. It differs from indigenous species of Phlœophagus by only the last two of the characters mentioned. It should be stated that it resembles also Pentarthrinus, a genus closely related to Phlœophagus.

If, in addition to what LeConte says of the difference between his specimens and the figure of the Madeira specimen, we consider the likelihood of Wollaston's find having been a wanderer from some merchant ship returning from one of the then Spanish-American colonies to the home country, is it not more than probable that we have here one and the same species? If a comparison of types should prove such to be the case, Say's name would take precedence, since Wollaston's description did not appear until 1854.

At present the writer is inclined to believe in the specific identity of the Madeira and American specimens, for the indications are that the illustration furnished by Wollaston, although attributed to Westwood, does not agree, as so often happens, with the description. The punctation of the prothorax in the figure is extremely coarse, while in the text Wollaston expressly says "head and prothorax (especially the latter) deeply and *closely punctured.*" (The italics are the writer's.)

Assuming the truth of these remarks, the following would be the synonymy;[a]

Caulophilus latinasus Say.

Rhyncolus latinasus Say, Curculionides, p. 30, 1831 (LeConte edition, vol. 1, p. 299, 1859).

Caulophilus sculpturatus Wollaston, Ins. Mad., p. 315, 1854.

Cossonus pinguis Horn, Proc. Amer. Phil. Soc., vol. 13, p. 442, 1873.

Caulophilus latinasus Say, LeConte, Proc. Amer. Phil. Soc., vol. 15, p. 340, 1876.

DISTRIBUTION.

The known distribution of this species is limited, and it is quite evident that it is not as yet cosmopolitan. There is no reason to believe that it is other than native to America, and, from what is at present known of it, it is safe to consider it as neotropical. The type of the species was from Florida. It is also recorded or has been received at this office from Georgia (Horn), South Carolina, Jamaica, Porto Rico, Mexico, Guatemala, and Madeira.

LITERATURE.

Say's original description appeared in 1831.[1] None of the writers who treated of this insect in after years had anything to say in regard to its habits until 1878, when Mr. E. A. Schwarz[8] mentioned it as being beaten from dead twigs in Florida.

In 1894 Mr. C. H. T. Townsend[10] noted its occurrence in a can of "scraped ginger" in the Museum of the Institute of Jamaica at Kingston, together with the cigarette beetle (*Lasioderma serricorne* Fab.). The ginger was stated to be riddled with holes, especially the terminal, slightly bulbous ends of the rhizomes. The pest, according to Mr. Townsend, appears always to attack the rhizomes at the terminal ends and work toward the proximal portion. The fine clay-yellow frass was dustlike or powdery. The paper under consideration included a brief description of the species and mention of a parasite doubtfully referred to Meraporus, which Mr. Townsend thought to be parasitic upon the weevil.

In 1896 the writer[11] mentioned this species and its occurrence in grain at the Atlanta Exposition, and the following year he[12] gave a somewhat more detailed account of the species with a brief review of its biologic literature and some notes on its structure.

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[a] Recently Mr. G. C. Champion[13, 14] has brought together the bibliography and synonymy of this species, pointing out that it is identical with *C. sculpturatus* Woll., a conclusion reached by the writer some years ago by comparison of descriptions. Mr. Champion, however, has had the opportunity of comparison of types. He cites the occurrence of the species in Mexico in three localities and in Guatemala, as well as in Madeira and North America. Evidently, however, he missed the writer's reference to the occurrence of the insect at Kingston, Jamaica, in an article published in 1897.[12]

In June, 1909, Mr. G. C. Champion [13] published a note on this species, having particular reference to its synonymy and distribution. In October of the same year [14] he furnished a synoptic table of four species of the genus, figured the species under consideration, and gave the full synonymy and a list of known localities in which it occurs, notes on variation, etc.

SUMMARY OF LIFE HISTORY AND HABITS.

In addition to what has been said in the introductory portion of this article, it may be added that in Insect Life [9] the species of Caulophilus [a] are stated to have similar habits to other Cossonini, which live under bark and in decaying wood. Doubtless this was the original habit of the genus, and perhaps even at the present time it bores in dead roots and perhaps even in twigs, but there is at hand no evidence that such is the case.

To distinguish this species from the granary and rice weevils it may be called the broad-nosed grain weevil, the descriptive adjective being a translation of the specific name *latinasus*.

BIBLIOGRAPHICAL LIST.

As the literature of this species is limited and the references have not hitherto been brought together the systematic papers as far as known are included in the following list. References to *C. sculpturatus* are also included on the strong probability of its specific identity with *latinasus:*

1. Say, Thos.—Descriptions of North American Curculionides, p. 30, July, 1831. (LeConte edition, 1859, p. 299.)
   Original description as *Rhyncholus latinasus*, from Florida.
2. Boheman, C. H.—Schoenherr's Genera et Species Curculionidum, vol. 4, p. 1068, 1837.
   Latin description as *Rhyncolus latinasus* Say.
3. Wollaston, T. V.—Insecta Maderensia, p. 315, pl. 6, fig. 4, 1854.
   Description of genus Caulophilus and of *C. sculpturatus*, with distinctions from Phlœophagus and Caulotrupis. Original colored figure of *C. sculpturatus*.
4. Wollaston, T. V.—Transactions of the Entomological Society of London for 1861, p. 368.
   Notes on affinities of the genus and a brief remark on the species.
5. Horn, G. H.—Proceedings of the American Philosophical Society, vol. 13, pp. 442, 447, 1873.
   Description as *Cossonus pinguis;* Boheman's description of *R. latinasus* quoted and the species doubtfully referred to Stenoscelis.
6. Wollaston, T. V.—Transactions of the Entomological Society of London, 1873, pp. 499, 586.
   Characterization of the genus; notes on *C. sculpturatus* with reason for its separation from *Rhyncolus cylindrirostris* Oliv. (*lignarius* Marsh.).

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[a] The generic name Caulophilus, from two Greek words meaning literally a stalk lover, was applied by deduction from analogy, since Wollaston, writing later, says nothing of the habits of the species from observation, his type having been picked up under a stone.

7. LeConte, J. L.—Proceedings of the American Philosophical Society, vol. 15, p. 340, 1876.

Synonymy (after Horn). Systematic notes.

8. Schwarz, E. A.—The Coleoptera of Florida. <Proc. Amer. Phil. Soc., vol. 17, p. 468, 1878.

"Rare, beaten from dead twigs."

9. Riley and Howard.—Insect Life, Div. Ent., U. S. Dept. Agr., vol. 1, p. 198, 1888.

The genus stated to live under bark of dead and decaying wood, or to bore into decaying wood of deciduous or coniferous trees.

10. Townsend, C. H. T.—Institute of Jamaica, Notes from the Museum No. 78, 1894.

Occurrence in a can of "scraped ginger" with *Lasioderma serricorne*. Brief description of insect and its work, and of a parasite.

11. Chittenden, F. H.—United States Department of Agriculture, Division of Entomology, Technical Series 4, pp. 29–30, 1896.

Notes on its receipt from the Atlanta Exposition in Indian corn and chick-peas in Mexican exhibit.

12. Chittenden, F. H.—United States Department of Agriculture, Division of Entomology, Bulletin 8, new series, pp. 30, 31, 1897.

One-page article on the occurrence of the species in corn and chick-peas from Mexico, with a review of its biologic literature and notes on its structure.

13. Champion, G. C.—Entomologists' Monthly Magazine, vol. 45, p. 121, June, 1909.

Notes on synonymy and distribution.

14. Champion, G. C.—Biologia Centrali-Americana, Coleoptera, vol. 4, pt. 7, pp. 39, 40, October, 1909.

Bibliography, distribution, and synopsis of species in genus.

THE LONG-HEADED FLOUR BEETLE.

(*Latheticus oryzæ* Waterh.)

By F. H. Chittenden, Sc. D.
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

The long-headed flour beetle (*Latheticus oryzæ* Waterh.), one of our most strongly marked flour beetles, was noticed affecting stored rice prior to 1880, but no description was given until that year, when it was recorded by its describer as occurring in rice from Calcutta and elsewhere, including England. It was also known at that time from Arabia.[1] In following years it received notice at times on account of its graminivorous habits.

Quite recently it has been introduced into the United States, being thus far found in Texas, where it is established, and in Michigan, where a similar establishment seems probable. Since the species in question bids fair to become a pest in time, occasion is taken to furnish an account for the benefit of American entomologists, millers, and others, together with an illustration, and to point out the characters which separate the species from other forms of flour beetles previously recorded and described as occurring injuriously within our borders.

DESCRIPTIVE.

This insect may be readily separated from other flour beetles by several characters, especially by the curious antennæ (see fig. 5). The head protrudes far beyond the eyes, and behind each eye is a minute but distinct canthus, such as we see in the genus Silvanus. It is the slenderest and the palest of the flour beetles. Its color is pale yellow, and it measures less than one-eighth of an inch (2.5–2.75 mm.) in length.

Before proceeding to the specific description Waterhouse's definition of the genus is repeated:

Genus LATHETICUS Waterhouse.

General form of *Tribolium*. Mentum transverse, the anterior angles rounded, the front margin gently emarginate in the middle, the ligula not much projecting, transverse, emarginate in the middle; the labial palpi short, the apical joint very large, one third longer than broad, subparallel (but narrowed at the base), truncate at the apex. The inner lobe of the maxillæ terminating in a very slender, acute hook, with a broad fringe within; the outer lobe slender, terminating with curved stiff hairs;

the palpi stout, the penultimate joint subquadrate, the apical joint about twice and a half as long as broad, cylindrical, narrowed at the apex. Labrum extremely short. Epistoma trapeziform, emarginate anteriorly, the ocular canthus not projecting laterally beyond the eyes. Eyes moderately prominent, very coarsely granular. Antennæ nearly as long as the head; the two basal joints not visible from above; the third joint the narrowest, about as long as broad; the fourth, fifth, and sixth joints transverse, each a trifle broader than the preceding, the seventh joint distinctly larger than the sixth; the eighth the largest (still transverse), the ninth and tenth a little narrower than the eighth; the eleventh still narrower, somewhat flattened, obliquely truncate at its apex. The rest as in *Tribolium*.

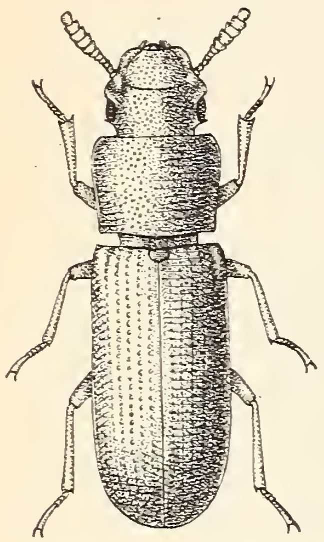

FIG. 5.—The long-headed flour beetle (*Latheticus oryzæ*): Adult, much enlarged. (Original.)

The species is characterized as follows:

Latheticus oryzæ Waterh.

General form of *Tribolium ferrugineum*, F., but rather narrower, and with the head relatively larger and broader and more square in general outline. Forehead and middle of the epistoma gently convex; the former not very thickly but very distinctly punctured; the epistoma less distinctly punctured, about twice as broad as long, obliquely (but not much) narrowed anteriorly, declivous in front, impressed at the sides, emarginate in front; the ocular canthus not much encroaching upon the eyes. Antennæ rather short, thickest at the eighth joint, so that their general outline is somewhat fusiform. Thorax very little broader than the head across the eyes, a little narrower behind; very distinctly but not very thickly punctured; the angles obtuse; the sides somewhat straight, very finely margined. Elytra as wide as the broadest part of the thorax, parallel, their surface somewhat uneven or wrinkled; each elytron with four or five scarcely impressed lines, with somewhat large punctures, the lines somewhat irregular, or here and there interrupted. Legs rather slender. [Waterhouse.]

Length 2.5–2.75 mm.; width 0.65 mm.

The genus, as might be readily inferred from the illustration, is closely related to Tribolium; in fact, it is placed near the head of the tribe Ulomini, directly after Hypophlœus and Doliema, thus bringing it above Cænocorse (Palorus) and Tribolium.

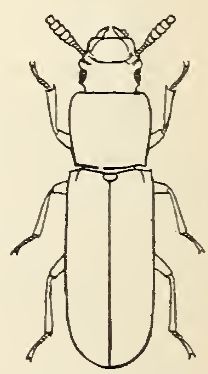

FIG. 6.—*Latheticus prosopis:* Adult. Greatly enlarged. (Original.)

The species is perceptibly shorter than our native *Latheticus prosopis* Chttn., shown in figure 6, a trifle more robust, the thorax being a little shorter, as are also the antennæ. The eyes are strikingly larger and the mandibles are less prominent, the inner tooth being strongly developed.

FOREIGN DISTRIBUTION.

The type of the species was from Calcutta, India. It is also recorded from Arabia, Norway, and England. Champion has added its occurrence in Italy and in a London granary in samples from Bussorah, Persia, and Odessa, Russia.

OCCURRENCE IN THE UNITED STATES.

The occurrence of this genus in the United States was recorded only a few years ago, and the species was not recognized here until 1908. January 16 of that year Mr. D. K. McMillan found this species in corn in a mill at Houston, Tex. It was not observed in abundance and was associated with other mill and grain insects. Later the same species was received from various points in Texas, viz, from New Braunfels, July 3, in flour; from San Antonio, July 25, in rye and elevator sweepings in mill material; from Galveston, in grain; from Fort Worth, in wheat and mill material; from Lyons and Wichita Falls, in wheat, grain, and refuse; and at Dallas, June 22, 1910, in refuse flour and dust in a mill basement. Practically all of these specimens were collected by Mr. McMillan.

In February, 1910, Prof. R. H. Pettit sent several specimens of this species from wheat which came from a mill in Detroit, Mich., but which had doubtless been shipped from elsewhere. It was in this case associated with three or four other common species. The source of infestation could not be learned, nor is it known if the species is established so far north, although such is probably the case.

This insect has a considerable literature for a species which was not described until 1880. Several references are at hand, omitting mere catalogue lists. It is not possible to tell what will be its future economic importance. It has shown its capability of holding its own with other flour beetles like Tribolium and also with Rhizopertha, Calandra, and Læmophlœus—all grain feeders. It is now becoming acclimated indoors and may even make its abode out of doors in tropical and semitropical regions such as are afforded by Texas, portions of Kansas, Mexico, and other sections of the South; hence it would not be beyond the bounds of possibility for it to assume considerable economic interest in America.

HISTORY AND LITERATURE.

The species was described by Charles O. Waterhouse in 1880.[1] He mentions the fact that Mr. G. C. Champion had specimens found in rice (locality not stated), and that the species had been for some time represented by specimens in the British Museum and other collections.

In 1894 Mr. G. C. Champion[8] published a note on this species and its occurrence in barley in a London granary from a sample from Bussorah, Persia, and one from Odessa, Russia. He noticed that the species is very active, and when the samples were placed in the sun or warmed the beetles rapidly emerged from the grain. He was informed that the insects soon spread from one bulk to another in granaries and expressed the opinion that the species was of eastern origin, although the real habitat was of course unknown, and that it would soon rank with such cosmopolitan forms as Gnathocerus, Alphitobius, Palorus [Cænocorse], etc., and be carried to all parts of the world.

In 1904 the writer [9] quoted Waterhouse's description of the genus Latheticus and compared *L. oryzæ* with *L. prosopis*, the latter being described as a new species. More recently, in 1910,[10] he recorded the occurrence of the species in the United States and gave a description, the distribution, and a brief table separating the two species.

Several other notes have been published on this species in addition to those which have been mentioned, ten being the total in hand by the writer. They are all listed below and no further mention need be made of them.

BIBLIOGRAPHICAL LIST.

1. Waterhouse, Chas. O.—Annals and Magazine of Natural History, vol. 5 (5th ser.), p. 147, February, 1880.
   Original description of genus and species. Type locality, Calcutta, India.
2. Perkins, V. R.—The Entomologist, vol. 13, p. 95, 1880.
3. Billups, T. R.—The Entomologist, vol. 13, pp. 209–210, 1880.
   Mention of occurrence in a London grain warehouse.
4. Waterhouse, Chas. O.—Aid to the Identification of Insects, vol. 1, plate 15, 1880–82.
   A colored plate of the beetle and brief reference.
5. Fowler, W. W.—Entomologist's Monthly Magazine, vol. 19, p. 269, 1883.
   Included in a list of Coleoptera new to the British fauna.
6. Fairmaire, L.—Revue d'Entomologie, vol. 11, p. 111, 1892.
   Description of the species under the name *Lyphia striolata* (cf. Champ., Ent. Mo. Mag., vol. 33, p. 146).
7. Seidlitz, Geo.—Naturgeschichte der Insecten Deutschlands, Coleoptera, vol. 5, pp. 572–573, 1894.[a]
   Bibliography, definition of genus and species, and distribution in Europe.
8. Champion, G. C.—Entomologist's Monthly Magazine, vol. 30, p. 259, November, 1894.
   A note on this species and its occurrence in barley in a London granary, received originally from Bussorah, Persia, and Odessa, Russia.
9. Chittenden, F. H.—Journal of the New York Entomological Society, vol. 12, pp. 166–167, 1904.
   Quotes Waterhouse's characterization of the genus Latheticus and gives comparison of *L. oryzæ* with *L. prosopis*, n. sp.; 1 original figure.
10. Chittenden, F. H.—Proceedings of the Entomological Society of Washington, vol. 12, pp. 135–137, 1910.
   Description, distribution, occurrence, and table for separating this species from *L. prosopis*.

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[a] Seidlitz gives reference also to his "Fauna baltica," second edition, page 517, 1891, and "Fauna transsylvanica," page 554, 1891.

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U. S. D. A., B. E. Bul. 96, Part III. T. C. & P. I. I., March 31, 1911.

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

THE LESSER GRAIN-BORER.

(*Rhizopertha dominica* Fab.)

By F. H. Chittenden, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

Among insects which inhabit granaries and storehouses, and which feed upon dry cereals, are two species of beetles of the family Bostrychidæ, which are of considerable importance in tropical climates, but are fortunately seldom seriously injurious in colder countries.

On account of their boring proclivities, the writer has termed these species, for convenience, grain-borers. The commonest and best known species is *Rhizopertha dominica* Fab. (fig. 7), and the less known species is *Dinoderus truncatus* Horn. From their different sizes we may call these, for convenience, the lesser grain-borer and the larger grain-borer, respectively. The former is cosmopolitan and attacks different cereals and several other substances; the latter is tropical and though also a general feeder, at least in its adult stage, is by virtue of its larger size apparently restricted, in the cereals, to maize.

The former species will receive consideration in the present paper. It has already obtained a footing in this country and is frequently brought to our shores from outside sources in stored cereals and other seeds and similar material, and is of considerable economic importance, especially in warm or tropical regions.

So far as known, it appears to prefer grain to other dry products, but shows an inclination to be omnivorous, feeding also upon drugs, and boring into the wood of packing boxes and casks.

Mr. E. C. Cotes has said that this species and the rice weevil "are the two insects that do most of the injury to stored wheat in India." Owing to its minute size several individuals inhabit even smaller seeds.

No common name, with the exception of "the wood bug," which is probably local, appears to have been applied to this insect other than the German one used by Taschenberg. He calls it the "Getreide-Kapuciner"—the significance of which name is apparent to anyone familiar with the appearance of the insects of this and related genera. The object of the likeness is the hoodlike prothorax covering the insect's head.

DESCRIPTION OF THE SPECIES.

This is one of the smallest of the beetles which are injurious to grain in the kernel, being considerably shorter and narrower than the grain weevils. The beetle is about one-eighth of an inch long and about one-thirty-second of an inch in width, quite narrow, being therefore, approximately, four times as long as wide. The form is nearly cylindrical; the head is comparatively large and prominent, and bent down under the thorax in the manner peculiar to most members of the family Bostrychidæ; the antennæ are also prominent, as are the eyes and the mandibles. The antennæ are ten-jointed and terminate in a prominent three-jointed club. The color is dark brown or castaneous and polished throughout.

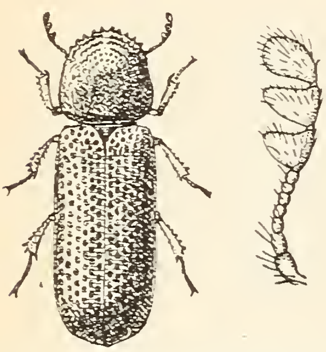

FIG. 7.—The lesser grain-borer (*Rhizopertha dominica*): Beetle, with enlarged antenna at right. Beetle about 12 times natural size. (Original.)

The beetle is shown in figure 7, with the antennæ, much enlarged, at the right.

The original description of this species, according to M. P. Lesne, was published by Fabricius in 1792, antedating the *Synodendron pusillus* of the same writer, by which specific name (*Rhizopertha pusilla*) the insect has generally found mention until very recent years. The description reads as follows:

S[ynodendron]. læve nigrum obscurum elytris striatis, pedibus piceis. Habitat in America meridionali Dom. Pflug.

The more important synonyms, according to M. Lesne and others, are as follows:

Synodendron dominicum Fab., Ent. Syst., vol. 1, pt. 2, p. 359, 1792.
Synodendron pusillum Fab., Suppl. Ent. Syst., p. 156, 1798.
Ptinus piceus Marshal, Ent. Brit., vol. 1, p. 88, 1802.
Rhyzopertha pusilla Fab., Stephens, Illus. Brit. Ent., vol. 3, p. 354, 1830.
Apate rufa Hope, Trans. Ent. Soc. London, vol. 4, p. 17, 1845.
Apate frumentaria (Nördlinger) Motschulsky, Études Entomologiques, p. 78, 1857.
Dinoderus pusillus Fab., Horn, Proc. Amer. Phil. Soc., vol. 17, p. 550, 1878.
Rhizopertha dominica Fab., Lesne, Ann. Soc. Ent. France, vol. 66, p. 332, 1898.

For convenience the description of the earlier stages will be given in a later chapter (pp. 35–36).

DISTRIBUTION.

As with many other cosmopolitan insects, the original habitat of this species does not appear to be known. The type specimens were from South America, but the species is apparently not of very common occurrence on that continent. On this head the Rev. Dr. Gorham [15] has remarked: "It does not appear to have been met with in any numbers in Central America."

Evidently the species is neither European nor American. According to published records, it is, or at least was for years, most injurious in India, and until we know more of the distribution of insects, it is safe to assume it came originally from India, or from some adjacent tropical country.

In the United States it seems to be well established in some southern ports but to have a more or less insecure footing northward, except in large seaports like New York City, and it is not improbable that it occasionally dies out in the smaller inland places to which it is carried in foreign material or in that which has been exposed to infestation at the seaports.

A list of localities from which it has been reported in our country, besides what are recorded in this paper, includes: New York City; Brooklyn, N. Y.; Washington, D. C.; Chicago, Ill.; Keokuk, Iowa (Casey); Charleston, S. C.; Atlantic County, N. J. (Wenzel); Philadelphia, Pa.; Arizona (Horn); and Canada (Hamilton).

It should be remembered that there is strong probability that the species has died out in some of the localities mentioned, e. g., it is positively not a permanent pest in the District of Columbia.

The date of original introduction into this country can not be surmised, even approximately. LeConte [8] has expressed the opinion that it was first introduced into the United States in Persian wheat distributed by the Patent Office. This must have been prior to 1861, the date of the publication in which this opinion was given.

In Europe, according to Redtenbacher,[9] this species is seldom found outside of London, Trieste, and a few other large seaports. Its abundance in London is to be attributed to the large quantities of grain that were brought, at least formerly, from India to that port. Fitch [11] found it in London in abundance in two out of three samples of wheat. Nördlinger has recorded Lorraine and Stuttgart as localities. In nearly all cases in which this insect has been reported in numbers sufficiently numerous to attract attention in European cities, the grain in which it has occurred has been stated to have come from India, Egypt, or even America.

Other localities in the East in which this species has been found include Hawaii, Madeira, and Algeria, in all of which countries it is believed to have been introduced from elsewhere.

In Central America it is recorded by Gorham from Vera Cruz, Mexico, and Belize, Honduras. According to Motschulsky it occurs also in Cuba.

LITERATURE, KNOWN HISTORY, AND HABITS.

The biologic literature of this species, although it has been known for a century, is limited to short notices, usually in connection with its technical description or records of its occurrence in new localities.

It was from seeds and roots imported from India that the species was redescribed by Fabricius.[2] Stephens [4] and others have also remarked that it is found in this manner. Kirby and Spence [3] wrote of this species in 1822 that it fed upon the roots of rhubarb, in which it was detected at the East India Company's warehouses in London.

Wollaston, writing in 1854,[6] found this insect in great abundance in England in powdered arrowroot, and refers to the record of Lucas [5] of its existence in Algeria "beneath the bark of *Quercus suber* and *Cytisus spinosus*."

In 1857 Motschulsky [7] states concerning what is without doubt this species, which he calls *Apate frumentaria* Nördlinger, that it is very common in grain in Egypt, whence it has been introduced into Europe, being listed in the Dejean Catalogue under the name *Apate castanea* Ulrich. Incidentally he notes its occurrence in Cuba, and states that *Dinoderus frumentarius*—evidently another synonym—was found in a single specimen in a cargo of rice from East India.

During the years from 1874 to 1879 brief mention was made by different persons of the occurrence of this species in wheat and in granaries.

In the year 1882 Dr. C. V. Riley published a note [14] on its occurrence as a museum pest. The previous year it was found at this department in insect boxes which had not been used for many years, appearing suddenly in large numbers and perforating the paper lining and evidently feeding on the cork with which the box was lined. The source of this introduction was not ascertained, the whole occurrence being designated as a mystery.

Writing in 1883, Rev. H. S. Gorham [15] noted the occurrence of this species commonly in wood of sugar casks.

In the next few years Mr. E. C. Cotes made frequent mention of its occurrence in different products in India in Indian Museum Notes.[61–19] It was observed injuring ship's biscuits, the seed of wheat, and "cholum seed" (*Sorghum vulgare*).

OFFICE NOTES AND CORRESPONDENCE.

During the winter of 1880–81 this species appeared in great numbers in a glass-covered insect box in this office, boring into the cork-pith lining. This matter has been previously mentioned in referring to Dr. Riley's article.[14] April 20, 1881, beetles and larvæ were found in the museum of this department, where they were infesting wheat from Peru, sorghum, and edible bulbs, as well as bread made from them and used as food by Indians, and in wild prairie turnip.

During the World's Fair in 1893 the writer obtained specimens of the beetles which had bred from a jar of some product of Abyssinian banana (*Musa ensete*) from Mexico.

February 3, 1896, beetles were received from Mrs. Lucy P. Love, New York City, who found them in graham flour. October 8, specimens were received from the writer's sister, Mrs. E. C. Jones, Brooklyn, N. Y., found in a box of rice in an importing house in New York City. The information was elicited, by inquiry, that this species is known to the trade as "the wood bug" from its frequent importation in the wood of boxes used in the shipment of rice. The exact origin of this lot of rice could not be ascertained. It seems probable, however, when we take into consideration the habits of the genus, that this grain-borer is quite as often introduced into new localities in the wood of rice boxes as in the grain itself. November 11 specimens were detected in a soft variety of Indian corn purchased at this department and said to have come from Peru.

June 11, 1898, specimens were found in Carolina rice received from Mr. J. L. Sheppard, Charleston, S. C., and in September and later in that year this bureau received several lots of "pearl millet" (*Pennisetum typhoideum*) through the then Division of Agrostology, with report that the seed was originally from India.

There are other records of receipt of this species in rice and other grains which need not be mentioned here.

During 1901 the Bureau of Entomology received specimens in a consignment of seed Japan rice from Mr. W. W. Bamberge, who remarked as follows:

Honduras rice in the vicinity of infested Japan rice did not show the insects' presence. It was noticed that the insects were flying, and their flight, though short, being coincident with the growth of new rice, our correspondent was alarmed lest they attack rice in the field, and that they might prove a scourge.

July 6, 1903, Mr. G. H. Harris sent a large section of a horse collar (fig. 8) infested by many specimens of this beetle from Calvert, Tex. The dealers in saddlery and in leather goods stated that the beetles do not attack goods unless they have been kept in stock for three or four years. They dispose of such stock at a loss of from 10 to 20 per cent.

Later a saddlery firm at San Antonio, Tex., wrote in regard to injury to horse collars as follows:

Complying with the esteemed request of yours of the 12th inst., 1908, I am forwarding you by today's mail, under separate cover, specimens of the bug mentioned to you in our favor of August 6. I am also inclosing a portion of a horse collar showing the stuffing as the collar is made. My collars are

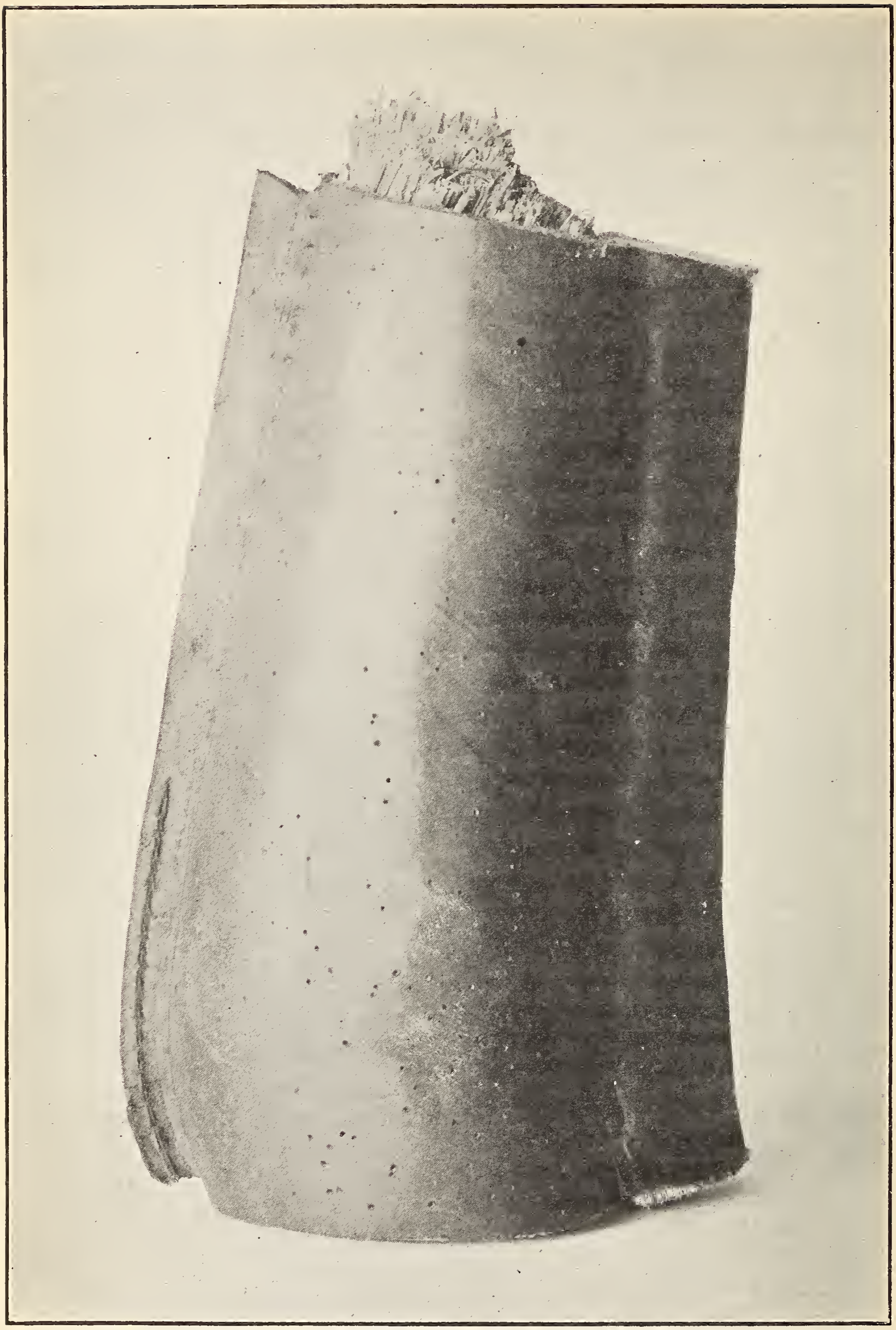

Fig. 8.—Section of horse collar showing holes bored by the lesser grain-borer (*Rhizopertha dominica*). One-half natural size. (Original.)

stuffed with rye straw. Of course this straw contains some few loose grains of rye; however, I am at the present time cutting the heads off of the straw to try and eliminate any grain entering the collar. The grain has been previously threshed from the straw. You will find live specimens in a box in the package. Trusting that through your office I may gain such information as will enable me to exterminate this bug or its egg before or after the collar is stuffed, and thanking you for any information that you may be able to furnish me, I remain, * * *.

In addition to the notes and records which have just been furnished, the Bureau of Entomology has reports of the finding of this species in cereals and waste material in mills in different portions of Texas; in flour at Denison, Tex.; in rice at Crowley, La.; in corn from Houston, Tex.; in mill material generally throughout the State of Texas, and there is one record of the occurrence of the insect from Georgetown, Demerara, where it was imported in paddy rice from India.

July 8, 1908, Mr. D. K. McMillan reported this insect very common in samples of grain from an old mill in Sherman, Tex., which was unused for 15 months. It was also very common in samples of rubbish from a milling company in the same place. The adults bored holes through the cotton sacks, the cloth of which had a starch and whiting filler, thus liberating Cænocorse, Calandra, and other grain insects in the sample bags.

During February, 1910, Prof. R. H. Pettit, entomologist of the Michigan Agricultural Experiment Station, sent specimens found in wheat from a Detroit mill, and associated with other species.

The bureau has also a note from Mr. Knight, of the Bureau of Plant Industry, United States Department of Agriculture, who brought seeds of white lotus in which this species was at work.

BIOLOGIC NOTES.

From a lot of insects obtained in 1881 observations were made by Mr. Th. Pergande, whose notes have been of assistance to the writer in the preparation of this chapter.

From eggs deposited April 27 larvæ were obtained on May 11, or in fourteen days after egg deposit. All the eggs were lying loose among the excrement of the insects at the bottom of the jar.

The egg.—The egg is white, of elongate pear-shaped form, one end forming a rather narrow stem or neck, bearing on one side at its base a transverse impression or suture causing the egg to bend somewhat to one side. Both ends of the egg are rounded; the surface is slightly polished and apparently somewhat rough. The length of the egg is 0.6 mm., and across its thickest portion a little over 0.2 mm.

The newly hatched larvæ.—The newly hatched larvæ were described as white, slightly yellowish toward the head; head yellowish, ocelli reddish-brown, arranged in a triangle, mouthparts brownish, antennæ very short, the head beset with a few long hairs; legs tolerably long, slightly yellowish, with long claws. Each of the abdominal segments bears ventrally a number of long hairs, and similar hairs are also on the dorsal side of the segments 7 and 8. The last segment bears a slightly curved, yellow horn, directed backward. Length a little less than 0.3 mm.

The fully developed larva.—The larva when fully developed is of the characteristic bostrychine form similar to that of *Dinoderus truncatus*, shown at *b* of figure 9. It is rather more elongate than usual in the Ptinidæ, and more constricted at the middle. The ground color is white, the head is light brown, and the mandibles dark brown, nearly black. The claws of the legs are light brown. The body is covered with minute, slender, pale-brownish hairs, which are denser and somewhat longer on the first thoracic and last two abdominal segments.

The larvæ when lying on their sides resemble somewhat, on a smaller scale, those of the lamellicorns, the body being curved in the same manner. Locomotion in this position is possible, but very slow.

Full-grown larvæ measured about 2.8 mm. in length.

Examination of the pellets of excrement made by the beetles shows a somewhat remarkable method of deposition. The pellets are placed in strings of from two to six and sometimes more.

The exact time consumed by this species in its development has not been ascertained to the writer's knowledge. From a lot of fresh corn in which eggs were deposited April 27, however, several beetles were observed August 12.

EXPERIMENTS WITH REMEDIES.

For a long time the writer has desired that a series of experiments be conducted with the standard fumigants, to ascertain if this species is in any degree more, or less, resistant than other insects which injure stored products, such as the grain weevils, the grain beetles, flour beetles, and others. Opportunity for experiments with hydrocyanic-acid gas was offered in December, 1910, at Beaumont, Tex., where Mr. M. M. High, an agent of this bureau, working under the writer's special direction, conducted a series of experiments. Coincident with these experiments another series of experiments with bisulphid of carbon was being carried out in the Department of Agriculture. A still longer series of experiments was also carried on by Mr. D. K. McMillan, at Houston and Beaumont, Tex., both with hydrocyanic-acid gas and with bisulphid of carbon under various conditions and strengths.

The results show that this grain-borer appears to be possessed of a lower degree of vitality, or at least of less resistant power to both of these gases than are the other classes of grain-feeding insects which have been mentioned. These series of experiments are also of value as bearing out the writer's experience in the experimental and practical fumigation of inclosures against insects in low temperatures, substantiating conclusions made years ago, that insects in general are not so susceptible to poisonous gases while torpid as when they are exposed to a higher temperature and are consequently normally active.

Experiments by D. K. McMillan.

BISULPHID OF CARBON.

Experiments Nos. 1 and 2.—At Houston, Tex., December 2 and 3, a bin of Japan rough rice badly infested with the lesser grain-borer and other species was treated in a mill with carbon bisulphid by pouring the liquid upon a large mass of empty sacks within another sack and hanging in the bin just above the grain. The bin contained about 2,500 bushels and was about one-third full.

The top could not be closed in any practicable way.

A short time after putting in the carbon bisulphid the fumes were coming out of the cracks in the sides and out of the bottom, which was 8 feet above the floor of the mill. Two experiments were made, with an exposure of 24 hours, as follows:

1 gallon of carbon bisulphid to 2,500 bushels of grain.
2 gallons of carbon bisulphid to 2,500 bushels of grain.

A large quantity of grain from the bottom of the bin showed practically all insects alive. As the bin was not tight enough and the weather was below 45° F. during this time, these experiments were unsuccessful.

A series of experiments with carbon bisulphid was conducted at Beaumont, Tex., December 5 to 7, upon various rice-mill products infested principally with this species. The tests were made with 50-gallon glucose barrels, which were very tight from the sirup, and tight covers of car paper were fitted over the tops and tied firmly.

Carbon bisulphid in the following proportions was used:

Experiment No.	Proportion.	Exposure.
		Hours.
3	2 pounds to 1,000 cubic feet	24
4	4 pounds to 1,000 cubic feet	24
5	5 pounds to 1,000 cubic feet	24
6	6 pounds to 1,000 cubic feet	24
7	8 pounds to 1,000 cubic feet	24
8	10 pounds to 1,000 cubic feet	24
9	15 pounds to 1,000 cubic feet	24
10	20 pounds to 1,000 cubic feet	24

No insects appeared to be affected until the sixth lot was examined, and only a small percentage, if any, was killed. About 35 per cent were killed with 15 pounds to the 1,000 cubic feet, and 75 per cent with the highest strength used. The temperature ranged from below 32° F. to 68° F. outside the building, which was a shed with sheet-iron sides, and the temperature of the rice was about 48° F.

This follows closely the results of experiments by Hinds and Turner [a] with Calandra during cold weather.

Experiment No. 11.—A three-day exposure was planned to treat between 200 and 300 sacks of infested screenings containing principally this species, with a quantity of rough rice and brewers' rice piled in loose stacks, and in more compact stacks as in the regular storage room. With the same formula and 15 pounds to 1,000 cubic feet the room was left closed from 5.30 p. m. October 29 until 11 a. m. November 2, or a period of about 90 hours, although about 2 hours additional were required to allow the room to free itself of the gas.

When the door was opened after this long exposure the rush of fumes was very strong and the sacks gave up gas for at least 24 hours afterwards. A long search through all the sacks failed to discover any living Rhizopertha; and after giving a sack from the interior an airing, together with material from different places, a half-dozen adult *Tribolium navale* Fab. were seen in motion. All other insects were evidently dead, though of course the entire lot could not be examined in detail.

This seems to give good evidence that with a long exposure the insects can be killed in a tight room. If the room had been closed for another day doubtless the Tribolium adults would not have recovered.

HYDROCYANIC-ACID GAS FROM SODIUM CYANID.

Experiment No. 12.—In the first fumigation with cyanid of soda, the 1–2–3 formula (1 pound cyanid, 2 pints sulphuric acid, and 3 pints water) was used for an exposure of 24 hours at the rate of 15 ounces to 1,000 cubic feet to test the penetrative powers of an increased dosage.

After airing the room sufficiently samples were taken from all parts of the room and from all parts of the piles and exposed to the open air in the bright sunshine for an hour, and examined carefully. The piles of bags were covered with dead insects of all species, and especially with *Rhizopertha dominica.* There were many dead within the sacks, but probably 50 per cent of this species were alive at 4 inches depth in the rice and screenings, while in the lower sacks and those with sacks surrounding them very few were dead except on the outside.

Experiment No. 13.—Another exposure of 48 hours with the same formula and dosage was given to over 200 bags of materials similar

[a] See Hinds and Turner, Journ. Econ. Ent., vol. 3, pp. 47–56, 1910.

to the first lot, giving a complete range of mill products, all badly infested with *Rhizopertha dominica* except the clean rice and bran.

Fully 95 per cent of the Rhizoperthas were dead in all the bags except those having two or more between them and the outside of the piles. In the well-protected sacks about 25 per cent were living, which showed that the gas was beginning to penetrate deeply.

Tribolium and Calandra resisted the gas much better than Rhizopertha, and a longer exposure and probably increased dosage would be necessary to destroy all the insects in the center.

A space between two partitions near the center of the system of storage was boarded up on four sides and ceiled with planed boards without grooves or lap, but solid and suitable as a foundation for the three-ply heavy roofing tarred paper which formed the lining of the room. This was carefully put on with a good lap at each seam, all of which were fastened with a good application of roofing cement before being lapped and nailed, so that a very tight room was the result. The floor was of tongue-and-groove lumber and appeared very tight. Special care was taken with the door and frame, which were beveled and faced with strips from an old rubber belt. The door was held shut after charging by a heavy bar sliding into iron hooks. The door itself was of two thicknesses of good boards, with an uncut sheet of the roofing felt between. That the leakage was very slight was proved by the faint odor of gas, noticeable only after fumigation had been in progress some time, and this came out almost entirely through the floor.

The room was the most nearly gas-proof structure possible under the circumstances and better than many nursery fumigating houses which have come under the writer's observation. There was no leakage through the walls while the experiments were being carried on, and the loss of gas through the floor and around the door was slight. An objection, consisting in the absence of ventilators other than the door, was obviated by leaving the door open all night at the end of the experiments, as the material could not be immediately moved out. The room was not rectangular as to shape of the ground floor, but the sides averaged 14.25 feet, and the height of ceiling was 13.50 feet, making the cubic contents 2,741 cubic feet.

For generators two stoneware jars or "churns" holding 3 gallons each were used.

Several wooden trestles, 2 feet high, with planks laid across them, were placed in the room on which to pile the sacks, so that the gas could have access to them from beneath as well as from all sides.

As the room was in a dark part of the sheds, it was necessary to have an electric light on an extension hung in the room in order that the sacks could be properly arranged.

For the first experiment about 100 pockets of screenings, rough and clean rice bran, brewer's grain, and the various materials about the mill were put in the room; some upon the trestle, others on the floor in loose and compact stacks, to represent the different conditions found in the mill and warehouse.

The most abundant species was *Rhizopertha dominica*, as stated above, but an effort was made to have all other species around the premises represented in larval and adult stages at least, and these were placed at various depths in the sacks and in piles of materials contained in them.

When a visit was made to this mill early in December, 1909, the manager became interested in the idea of having a special room or chamber constructed in the mill or warehouse in which to place infested material for treatment. He agreed to have such a room built according to directions given by the writer. Efforts were made at several other rice mills to have a practical gas-proof chamber built by the owners as a permanent adjunct to their plants, but without success.

Later one of these firms constructed a room for fumigating and used it for treating clean rice with sulphur fumes. It was built in the corner of the clean-rice warehouse by erecting two partitions of tongue-and-groove flooring, single thickness, and had become cracked and warped in some places.

It required considerable work and time to line and make it gas tight. When another visit was made to this mill carpenters had built a fumigating chamber in the rough-rice warehouse for convenience in treating screenings from the rough rice and also the brewer's grain and other infested material which was stored in the rough-rice building. The next experiments (Nos. 14–17) were made by Mr. M. M. High.

Experiments by M. M. High.

HYDROCYANIC-ACID GAS FROM SODIUM CYANID.

Experiment No. 14.—December 16, 1910, the fumigating room just described was carefully inspected for outlets for the escape of the gas. Two holes about the size of one's finger, which had evidently been made by the careless use of trucks, in one wall and a rat hole in one corner of the room were covered and 120 sacks of infested rough rice were placed in the room, care being taken to stack closely. In this the most numerous insect pest was the lesser grain-borer (*Rhizopertha dominica*). Four other species were present in smaller numbers.[a]

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[a] Of these the rust-red flour beetle (*Tribolium navale* Fab.) was second in abundance, followed by the rice weevil (*Calandra oryza* L.), the cadelle (*Tenebroides mauritanicus* L.), a few individuals of the saw-toothed grain beetle (*Silvanus surinamensis* L.), and the fig moth (*Ephestia cautella* Walk.).

Sixty-five sacks of chicken feed, in which this grain-borer was decidedly the most numerous pest, were also placed in the fumigating room. Everything needed to charge the room with hydrocyanic-acid gas was put in place, and at 5.20 p. m. fumigation was begun. The cubic capacity of the room was approximately 2,600 feet. The rate of application was 20 ounces to 1,000 cubic feet of space, using the 1–1–3 formula, i. e., 1 ounce sodium cyanid, 1 fluid ounce sulphuric acid (commercial), and 3 fluid ounces water. After the bags of cyanid had been placed in the jars the door was closed immediately, taking care to make it as tight as possible. The door remained closed until 5.20 p. m. on December 17, thus making a period of 24 hours' exposure. After the door had been opened a short time the room was entered to ascertain results. The fumigating room had only one door and no windows, so an electric globe was used. Samples were taken from sacks in different parts of the room, from the middle of the stack, and from the sacks on the floor. Nearly every one was examined with a trowel, so as to reach the middle of the sack. Dead bodies of Rhizopertha almost completely covered the sacks of the chicken-feed rice and were nearly as abundant over the sacks of the rough rice. Beetles of this species were dead all over the room, with the exception of a few individuals taken from the middle of a sack that lay at the base of one of the jars used. On the interior of this sack, which was probed deeply a number of times, a few beetles were struggling between life and death, while the outside of the sack was covered with their dead bodies.[a]

Experiment No. 15.—As Silvanus and Tribolium appeared more abundant in the clean rice, the manager of the mill was asked for 150 pockets of clean rice to be placed in the fumigating room; but as the mill where the clean rice was stored and the fumigating room were some distance apart, a wagon had to be used. This was rather slow with a limited number of men, so that only 25 pockets of the clean rice were transported to the fumigating room. This, however, was placed with the rough rice, so as to make results the same as they would have been had a greater amount of clean rice been secured. On December 19 at 3 p. m. the charge was liberated. The amount of cyanid was the same as used in the previous charge, i. e., 20 ounces to 1,000 cubic feet of space, but the room was to remain closed 48 hours instead of 24.

December 21, at the same hour, the fumigating room was opened and an examination begun. Out of the first lot of samples taken, which were from pockets near and upon the floor, a few individuals

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[a] *Tribolium navale*, which was not nearly so numerous in the rough rice as the Rhizopertha, was yet quite active. No live specimens of Calandra or Tenebroides were found.

of Tribolium were found still alive. The number of live specimens was estimated at about 5 per cent. The examination was continued for two hours, taking samples from all parts of the room, when the number that failed to succumb seemed to decrease somewhat, for sample after sample was taken from the more exposed pockets and no live specimens were observed, with exception of grain from sacks taken from the interior of the stack of pockets. From near the center of these pockets a few specimens were yet fully active. No other species was observed alive, but all appeared dead with the exception of *Tribolium navale.*

Experiment No. 16.—At 5 p. m. December 21 another charge was made, using the same amount of sodium cyanid and sulphuric acid as in previous experiments (20 ounces of cyanid to 1,000 cubic feet), and left until December 24. The door was opened at the same hour and the inspection begun, paying special attention to the clean rice and the bran where Tribolium was most abundant. At this time no live specimens were found at all, but the dead bodies were numerous.

The conditions for fumigation work were not the most favorable; the temperature was too low to secure the best results, ranging from 49° F. to a little above 60° F. the whole time the experiments were on. It has been demonstrated that better results are obtained at a temperature upward of 65° F. At this time the weevils are more active and succumb more readily to the fumes.

Experiment No. 17.—Later, December 26, at 67° to 71° F. a sample of rough and chicken-feed rice treated with hydrocyanic-acid gas for a period of 24 hours had yet alive one specimen of *Calandra oryza*, two specimens of *Rhizopertha dominica* (hundreds of dead bodies), and several of *Tribolium navale.* On the same date samples of rough rice, chicken-feed rice, rice bran, and clean rice were examined to ascertain if any living weevils were yet present. From one cigar box of rice bran and rough rice 5 beetles of the Tribolium were found, quite active.[a]

Experiments by the Writer and by Messrs. Popenoe and Jones.

BISULPHID OF CARBON.

Experiment No. 18.—December 31, 1910, at Washington, D. C., a lot of *Rhizopertha dominica* in cracked rice, together with other insects, was placed in a bag and exposed to the fumes of bisulphid of carbon in one of the fumigating boxes of the type much used in the Department of Agriculture for fumigating seeds, the reagent being used at the minimum strength for such purpose, or at the rate

[a] Among this same material three of Silvanus were alive, while there were a number of dead bodies each of Tribolium and Silvanus. In the clean rice, where both species were more numerous, all were dead.

of $1\frac{1}{2}$ pounds to 1,000 cubic feet of air space. Exposure was for 48 hours, at the end of which time, when the box was opened, no odor whatever remained of the bisulphid, showing that the exposure had been complete. The box was made approximately air-tight, but seemingly not so tight as was supposed, by pasting over the apertures of the cover with paper. The result was a failure. *Rhizopertha dominica* was apparently unharmed. As there were many dead beetles present with the living individuals in the rice, the precise percentage could not be accurately determined.[a] Average temperature, about 65° F.

Experiment No. 19.—The failure of the first experiment with bisulphid of carbon at the rate of $1\frac{1}{2}$ pounds to 1,000 cubic feet of air space—which was not unexpected—led to the doubling of the strength (3 pounds to 1,000 cubic feet) for the next series of experiments.

In this experiment, started January 7 at 4.30 p. m., the temperature was 68° F., with a minimum of 46° and an average of about 62° for an exposure of 40 hours.

When examined 24 hours after the end of the exposure the insects were all dead.[b]

Experiment No. 20.—Conditions the same as for Experiment No. 5 and a duplicate fumigating box. Starting temperatures 55° F., and at the end of 24 hours 58°; average 56°.

Twenty-four hours after the insects were removed from the fumigator and thoroughly aired, many living specimens could be found, showing the experiment to be imperfect. The beetles of *Rhizopertha dominica* were mostly dead, but a very few were alive, although not very active.[c]

Experiment No. 21.—The fourth experiment was conducted in a special air-tight fumigating box, the temperature being 45° at the start and 42° at the end of 40 hours. There was, however, a minimum of 36°, and the average temperature was estimated at 42° F.

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[a] In another bag, in which were specimens of the Indian-meal moth (*Plodia interpunctella* Hübn.) and *Silvanus surinamensis* L., the larvæ of the former and the beetles of the latter were not affected, so far as could be observed, 24 hours after having been removed from the fumigating box. A week later the meal-moth larvæ were found entirely unaffected. *Tribolium navale* Fab., both beetles and larvæ, survived, as did also the larvæ of *Tenebroides mauritanicus* L.

[b] Other insects were also exposed, including the adult of *Tenebroides mauritanicus* L., and great numbers of the rice weevil (*Calandra oryzæ* L.) in wheat.

[c] The few individuals of Silvanus that were on the outside of the dried figs in which they were working were killed, but those which were protected in the interior were apparently unharmed. The same was true of Plodia, all of which were unharmed. Adults of *Tenebroides mauritanicus* were unaffected. Some Calandras were the same, and probably no strong individuals were killed.

While a few dead insects could be found, in the main they appeared to be unharmed by the fumigation 24 hours later.

The nonsuccess of this experiment is attributed to the temperature, which kept the insects torpid while exposed to the gas, and bears out the writer's experience, which he has frequently expressed in correspondence for several years.

Experiment No. 22.—Conditions the same as for Experiments Nos. 5 and 6, but strength 2 pounds of bisulphid of carbon to 1,000 cubic feet of air space. Starting temperature, 70° F.; at end of 48 hours, 58° F. During this time the temperature ranged as high as 72° and as low as 50°. The average could not be determined, but at the beginning of the experiment it was probably high long enough for the gas to take effect, while the low temperature occurred probably at a time when it was somewhat immaterial. When the fumigating box was opened at the end of 48 hours the odor of bisulphid was sufficiently strong to attract the attention of several persons in the neighborhood. In this case the beetles of this species, which were living in ground rice for poultry feed, were all destroyed. A number of other insects, six species in all, was confined under the same conditions, and all were killed.

Experiment No. 23.—Conditions the same as in Experiment No. 8, a duplicate fumigating box being used and 2½ pounds of bisulphid of carbon liberated, with same temperature, and exposure the same, namely, 48 hours. Every insect was killed.

Conclusions.—These experiments show conclusively that in inclosures made approximately air-tight, 2 pounds of bisulphid of carbon, with a full exposure of 48 hours in a temperature approximating 65° to 70° F., will prove fatal to the lesser grain-borer, as well as to practically any other stored-product insects.

Summary of experiments.

Experiment No.	Reagent.	Proportions.	Conditions.	Temperature (°F.).	Exposure.	Results.
					Hours.	
1	Bisulphid of carbon	1 gallon to 2,500 bushels of rice.	Loose rice in bin; bin not tight.	45	24	Failure.
2	do	2 gallons to 2,500 bushels of rice.	do	45	24	Do.
3	do	2 pounds to 1,000 cubic feet.	50-gallon glucose barrels used as containers; very tight.	About 48	24	Do.
4	do	4 pounds to 1,000 cubic feet.	do	do	24	Do.
5	do	5 pounds to 1,000 cubic feet.	do	do	24	Do.
6	do	6 pounds to 1,000 cubic feet.	do	do	24	Do.
7	do	8 pounds to 1,000 cubic feet.	do	do	24	Do.
8	do	10 pounds to 1,000 cubic feet.	do	do	24	Small percentage killed.
9	do	15 pounds to 1,000 cubic feet	do	do	24	35 per cent killed.
10	do	20 pounds to 1,000 cubic feet.	do	do	24	75 per cent killed.
11	do	15 pounds to 1,000 cubic feet.	Sacks of screenings, rough, and brewers' rice in loose and compact stacks in regular storage room.	do	90	All insects killed.
12	Cyanid of soda	15 ounces to 1,000 cubic feet.	do		24	Insects dead on outside of sacks. 50 per cent dead at depth of 4 inches in rice. Few dead in lower and interior sack.
13	do	do	do		48	95 per cent dead in all bags except those having two or more bags between them and outside of pile. 75 per cent dead in well-protected bags.
14	do	20 ounces to 1,000 cubic feet.	Chicken-feed rice in sacks in tight fumigating room.	49–60	24	All dead, except a few in middle of sack that lay at base of fumigating jars.
15	do	do	Clean and rough rice in pockets in tight fumigating room.	49–60	48	All killed.
16	do	do	do	49–60	72	Do.
17	do	do	Rough and chicken-feed rice in tight fumigating room.	67–71	24	Two living adults. Hundreds killed.
18	Bisulphid of carbon	1½ pounds to 1,000 cubic feet.	Adults placed in bag in tight fumigating box.	65 average	48	Failure.
19	do	3 pounds to 1,000 cubic feet.	do	62 average	40	All killed.
20	do	do	do	56 average	40	Mostly dead.
21	do	do	do	42 average	40	Apparently unharmed.
22	do	2 pounds to 1,000 cubic feet.	Adults in bag of chicken-feed rice in tight fumigating box.	50–72	48	All killed.
23	do	2½ pounds to 1,000 cubic feet.	do	50–72	48	Do.

GENERAL CONCLUSIONS.

The results of the series of experiments performed with bisulphid of carbon and hydrocyanic-acid gas against the lesser grain-borer, and incidentally against other insects, are of considerable value and show in brief the following:

That the lesser grain-borer possesses less resistant power to both gases than do most other stored-product insects.

That fumigations in low temperatures, and especially below 50° F., are practically ineffective unless an excessively large amount of bisulphid of carbon or of a cyanid be used, and that it is still more desirable that from 48 hours to 3 days be the length of exposure in order to kill all insects in even tight inclosures.

Experiment No. 8 shows that even with 10 pounds of bisulphid of carbon to 1,000 cubic feet of space in a tight receptacle only a very small percentage of grain insects were killed in an exposure of 24 hours and with a temperature of about 48° F., and Experiment No. 10 shows that even with 20 pounds of carbon bisulphid to 1,000 cubic feet, or 10 times what may now be accepted as a standard, only 75 per cent of the insects present were destroyed in a 24-hour exposure.

It may be safely assumed that under ordinary conditions, in moderately high temperatures, between 65° and 75° F., 1½ pounds of bisulphid of carbon to 1,000 cubic feet of air space is insufficient even for 48 hours' exposure, and that we may adopt as a general standard 2 pounds to 1,000 cubic feet for 48 hours or more, or until the odor of the gas has become entirely dissipated.

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21. Lesne P.—Annales de la Société Entomologique de France, vol. 66, pp 332–333, figs. 13, 21, 27*b*, 1897 (1898).

Technical description, full bibliography, distribution, and biologic review, with three original illustrations.

THE LARGER GRAIN-BORER.

(*Dinoderus truncatus* Horn.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTORY.

Brief mention has been made in a preceding article of the larger grain-borer (*Dinoderus truncatus* Horn) (fig. 9), in connection with the lesser grain-borer (*Rhizopertha dominica* Fab.). The larger grain-borer has without doubt been brought into this country from Mexico, Guatemala, and elsewhere on many occasions, but there are only a few published records of such importation. So far as the writer knows, the species has never found permanent lodgment in the United States, but is apt to be introduced into tropical Texas as well as elsewhere. It is not probable that it will be a very serious pest, provided its identity is known and efforts are made to stamp it out wherever it appears. From present knowledge of the insect's habit, it would seem to differ but slightly from the lesser grain-borer, preferring corn to other grain, if indeed it even feeds on any other cereal, and it also has the wood-boring habit strongly developed. Corn in the ear is preferred to shelled corn, and edible and other tubers and roots serve as natural breeding places.

Attention has been called by the writer in correspondence to the difficulty of eradicating this species from a barn, if this should happen to be constructed of wood or, what is worse, adobe.

DESCRIPTION.

Dinoderus truncatus is elongate cylindrical in shape and dark brown or castaneous in color, with paler legs and fulvous antennæ. It measures one-sixth inch or less in length and is about two and a half times as long as wide.

The genus Dinoderus (from two Greek words signifying *large neck*), in which this and the succeeding species are retained in our American works, was originally characterized by Stephens[a] as follows:

[a] Illustrations of British Entomology, Mandibulata, vol. 3, p. 352, 1830.

Genus DINODERUS Steph.

Antennæ inserted in front close to the eyes; the basal joint short, robust; the second subglobose; the five following minute, nodose, subcoarctate; the remainder forming an elongate perfoliated club, of which the two basal joints are conic-trigonate, slightly produced within, and the terminal one subglobose, compressed. Palpi short, terminal joint minute, conic; mandibles exserted, acute; head short, transverse, with the neck thick; eyes globose; thorax short, rounded, very gibbous, and rugose in front; elytra retuse posteriorly; body elongate, cylindric; tibiæ compressed, denticulated externally; tarsi short, simple.

For the further identification of this species Horn's original description is quoted.

Dinoderus truncatus Horn.

Rufopiceous, moderately shining, surface sparsely clothed with very short hair. Front moderately, densely punctate. Thorax as wide as long, gradually arcuately narrowed from base to apex, margin very finely serrate, disc anteriorly, roughly granulate, posteriorly, feebly but densely muricate. Elytra with coarse, deep, closely placed punctures, arranged in moderately regular striæ, except near the scutellum, intervals not elevated, declivity abrupt, flat, densely punctate, acutely margined. Body beneath opaque, obsoletely punctate. * * * The marginal ridge of the declivity encloses an exact semicircle, while the face of the declivity is nearly vertical to the axis of the body.

Length 3–4.3 mm., width 1.2–1.8 mm.

With the related species *Rhizopertha dominica*, which has been treated in the preceding paper, the present form, *Dinoderus truncatus*, is not at all likely to be confused. The former is a much smaller insect, proportionately more slender and with a rough surface, whereas the species now being considered is comparatively smooth and somewhat shiny. It has several times been confounded with *D. punctatus* by entomologists. These last two species are alike in form, size, and color, the difference being in minute but distinct structural details. *D. punctatus* appears to confine itself to dead roots and stumps and has not attracted attention, so far as known, by its occurrence indoors.

In some way *truncatus* was entirely overlooked by Gorham in his consideration of the Ptinidæ (including Bostrychidæ) in the Biologia Centrali-Americana, but *pusillus* (*dominica*), *substriatus*, and *punctatus* are included. In the United States National Museum are two specimens of *truncatus* labeled, respectively, "In rice, Guatemala, March 11/84," and "*Apate dubius* E. Dug." The species is obviously common enough in Central America, and it is not impossible that Gorham failed to separate *truncatus* from *punctatus*.

The accompanying illustration (fig. 9) shows the characteristic structure of the beetle at *a*; *b* represents the larva which, it will be noted, strongly resembles better known bostrychids, such as the redshouldered hickory beetle and the apple twig-borer;[a] *c* represents the pupa, ventral view. The larva and pupa are white.

Unfortunately, at the time that the illustration was drawn neither larva nor pupa was described, and the material preserved is not now in fit condition for a technical description.

HISTORY AND LITERATURE.

Dinoderus truncatus was described as a new species in 1878, from specimens accidentally found in California.[1] It was accidentally brought to this country with corn for exhibition in the Mexican section of the New Orleans Exposition in 1885. In 1893 the writer obtained specimens of this insect in corn and edible roots from the Mexican and Guatemalan exhibits at the World's Columbian Exposition, held in Chicago that year.[2] [3] [4] In 1894 about half a peck of samples of Mexican corn that had been ruined by this insect was received in this department. The samples in both cases, as well as in many others that have come to the notice of the writer, were fairly reduced to powder. In the case of corn, the insects bore through and through the kernels, the cob, and the husk, and where paper wrappings and labels are used they also perforate these. Since that time this insect has been received from other sources.

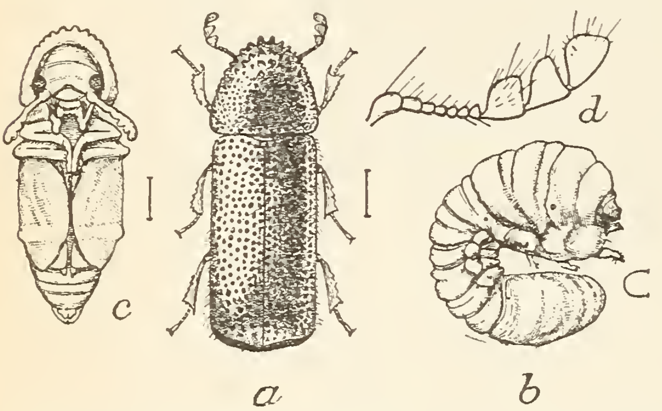

FIG. 9.—The larger grain-borer (*Dinoderus truncatus*): *a*, Adult of beetle; *b*, larva; *c*, pupa; *d*, antenna. *a*, *b*, *c*, About six times natural size; *d*, highly magnified. (Original.)

December 3, 1902, Mr. A. L. Herrera, of the City of Mexico, sent a sample of stored corn from Tlaxiaco, State of Oaxaca, infested with this and other species of insects which are identified with injury of this nature in Central America.

Specimens were also received, November 19, 1909, from Mr. G. C. Beckmann, Parral, Province of Chihuahua, with report that they, with *Silvanus surinamensis* L. and *Tribolium confusum* Duv., were injurious to the ears of maize.

OFFICE EXPERIMENTS.

Owing to the fact that it was known at the time of receipt of living specimens that the insect had not been introduced into the United States, only a limited number of experiments were made lest the

[a] *Sinoxylon basilare* Say and *Amphicerus bicaudatus* Say.

insect might have an opportunity to escape from confinement. A number of adults, 14 in all, were placed, on June 21, in a rearing jar containing an ear of corn. At the end of two months the ear, including the cob, was fully half destroyed, and later the bored ear was converted into dust and other débris.

A similar number of beetles was confined in a rearing jar with shelled corn, June 25. Late in the afternoon and the following morning three kernels of corn were found to have been entered, two having been bored entirely through. Figure 10 shows the work of the beetle in a kernel of corn.

These experiments show the rapidity with which the adults work, as also partiality for corn in the ear, the insect scarcely being at home in shelled corn, while in other material with which it was fed in other experiments the insect did not breed at all.

There seems little doubt that the grain-feeding habit of this species is an acquired one of comparatively recent times, and that it normally, or under natural conditions, breeds in roots and tubers.

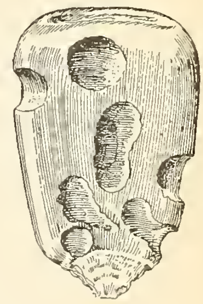

FIG. 10.—Kernel of corn showing work of beetle of larger grain-borer (*Dinoderus truncatus*). Enlarged. (Original.)

During the course of these experiments it was ascertained that the pupal stage varied from about four and one-half days in the very hottest weather to six days in a little cooler weather during June and July, while in October the pupal period lasted twelve days, from October 17 to 29. The egg was not observed, but the egg period is with little doubt about the same as for the pupa under the same atmospheric conditions. By experiment it was learned that the entire life cycle from the placing of beetles in corn until the issuance of the new generation, i. e., from August 25 to October 9, was forty-five days, or about six and one-half weeks. The temperature was moderately warm during this period.

Still another experiment was made with this species by confining it with some others in a superheated atmosphere, which was also very dry. As evidence of its tropical nature this species thrived better than any of the other insects exposed to the same conditions. Indeed, it appears to be the only insect that did not suffer from the extreme dryness to which it was subjected. The temperature in this case was upward of 100° F. and ran as high as 115° F.

The limited supply of this species did not permit of any experiments with remedies. As has already been briefly pointed out in the introduction, it is an insect which should be carefully watched if it once gains access to a granary or other storehouse, as it is apt to do considerable injury to the woodwork, perforating it with holes even when grain is available for food. Undoubtedly bisulphid of carbon, hydrocyanic-acid gas, and other fumigants will destroy this insect in the same manner as they kill the lesser grain-borer, grain weevils, grain beetles, and flour beetles.

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3. CHITTENDEN, F. H.—Insect Life, Div. Ent., U. S. Dept. Agr., vol. 7, p. 327, March 29, 1895.

   The species identified by material found in grain from the Mexican and Guatemalan exhibits at the World's Columbian Exposition, 1892–93.

4. CHITTENDEN, F. H.—Technical Series 4, Div. Ent., U. S. Dept. Agr., p. 28, 1896.

   Some additional notes are given on the occurrence of this species in Mexico.

5. LESNE, P.—Annales de la Société Entomologique de France, vol. 66, pp. 342, 343, figs. 14*b*, 25, 26, 1898.

   Technical description and assignment of the species to *Prostephanus* n. gen.

U. S. D. A., B. E. Bul. 96, Part IV. T. C. & S. P. I. I., October 12, 1911.

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

CARBON TETRACHLORID AS A SUBSTITUTE FOR CARBON BISULPHID IN FUMIGATION AGAINST INSECTS.

By F. H. Chittenden,
In Charge of Truck Crop and Stored Product Insect Investigations,
and
C. H. Popenoe,
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INTRODUCTION.

A representative of a chemical company in Baltimore, Md., suggested to the senior writer as early as 1905 the use of carbon tetrachlorid (CCl_4) as a possible substitute for carbon bisulphid (CS_2), since the tetrachlorid is known to be noninflammable. A sample was kindly furnished and was thoroughly tested in the open and found, as claimed, to be noninflammable. No opportunity, however, was afforded at that time to make a detailed series of tests of its insecticidal properties.

A druggist of Washington, D. C., also suggested the substitution of this chemical for carbon bisulphid, and as others had made similar suggestions a series of experiments was begun on a small scale at Washington, D. C., under the senior author's direction, by the junior author and by Mr. D. K. McMillan.

Carbon tetrachlorid, when pure, is a thin, transparent, colorless, oily fluid, with a pungent, aromatic odor—not powerful, however, as in the case of carbon bisulphid, and not nearly so disagreeable. It is manufactured by the combination, in a heated tube, of the vapors of carbon bisulphid and chlorine. It has a specific gravity about one-third greater than carbon bisulphid, and is similar in other properties, with the exception of being noninflammable.

There are records of experiments made with this chemical as a fumigant for nursery trees in 1908, but tests for stored products affected with insects were made more recently. One of the former records is by Dr. W. E. Britton,[1] who states that carbon tetrachlorid was used at rates of from 1 to 8 ounces in a fumigating box containing 10 cubic feet of space, the fumigating period varying from 2 to 6 hours. All scales were killed, and no trees were injured, where

[1] Journ. Econ. Ent., vol. 1, p. 111, 1908.

30 ounces or less of the liquid to 100 cubic feet were used, with a fumigating period of two hours. Greater quantities of the liquid caused injury and killed some of the trees. In these experiments the liquid was also volatilized by means of heated pans. In conclusion Dr. Britton states that in his experience it proved noninflammable, but that it is not very poisonous to the *higher* forms of animal life.

This compound seems first to have been employed as a substitute for carbon bisulphid as a fumigant for structures containing grain and similar products infested by insects by Prof. Albert P. Morse, Wellesley, Mass., who published an account of the result in February, 1910.[1] He used it against Attagenus, presumably *A. piceus*, as this is the only species of the genus commonly found in the United States. It was employed in a standard museum case which closed tightly, and the strength was 1 quart to 50 cubic feet, which Prof. Morse claims is only twice the strength at which carbon bisulphid is used. In practical use, in perfectly tight inclosures, 1 pound of pure carbon bisulphid to 1,000 cubic feet of space will destroy some insects, but perhaps not the dermestids which affect stored products.

EXPERIMENTS AT WASHINGTON, D. C.

Experiment No. 1.—July 27, 1908, a quantity of rye was subjected to treatment with carbon tetrachlorid at the rate of 1½ pounds to each 1,000 cubic feet. The grain, which was infested with the rice weevil (*Calandra oryza* L.), the saw-toothed grain beetle (*Silvanus surinamensis* L.), and a smaller grain beetle (*Læmophlœus minutus* Oliv.), was closed and left for 48 hours. It was then opened and the insects of the different species were found to be living and in good condition. The experiment was therefore a failure.

Experiment No. 2.—A similar quantity of the same grain with the same insects was fumigated 48 hours with carbon tetrachlorid at the rate of 3 pounds to 1,000 cubic feet. At the end of this time all the beetles present were alive and in good condition.

In these two experiments a closed tin receptacle with air-tight top was used and quantities of the chemical greater than the ordinary amounts of carbon bisulphid for air-tight inclosures were applied. It seems, therefore, that the insecticidal quality of this liquid, if present, is decidedly less than that of carbon bisulphid.

Experiment No. 3.—October 6, 1908, a quantity of grain practically equivalent to that used in previous tests was subjected to treatment with carbon tetrachlorid at the rate of 6 pounds to 1,000 cubic feet, or double the amount used in experiment No. 2. Living specimens of the confused flour beetle (*Tribolium confusum* Duv.), with a few rust-red flour beetles (*T. navale* Fab.), *Silvanus surinamensis* L., *Calandra oryza* L., and *C. granaria* L., the cadelle (*Tene-*

[1] Journ. Econ. Ent., vol. 3, p. 104, 1910.

broides mauritanicus L.) present as larva, and the larva of the Indian-meal moth (*Plodia interpunctella* Hbn.) and of the Mediterranean flour moth (*Ephestia kuehniella* Zell.) were included, as well as adults of the related fig moth (*Ephestia cautella* Walk.). The flour-moth and the fig-moth larvæ were working in a small mass of bran and flour well matted with silk. The quantity of material was about 1 pound, loosely inclosed in a cheesecloth bag.

The fumigating box was closed at 3 p. m. October 6, and calked around the edges of the lid with cotton wadding. After being closed for half an hour no escape of fumes could be noticed. The box was opened at 3.30 p. m. October 7. The fumes of the tetrachlorid were very strong; hence the escape of fumes must have been slight.

The material was all taken out and exposed in the fresh air in the outside insectary until the following day, but immediate superficial examination showed all insects motionless except the larvæ of Tenebroides, which moved slowly when touched. Final examination showed: Flour-moth adults dead; a few examples of their larvæ dead, but the greater number living. The Tenebroides larvæ were unharmed. The flour and grain beetles and the two grain weevils were nearly all living but moving their antennæ or legs very feebly, seeming to be in a paralyzed condition. Numerous examples were placed in a vial with a small amount of flour and stoppered with cotton. On October 16 a few of these were still moving legs or antennæ slightly, but seemed paralyzed and not able to recover.

Experiment No. 4.—This was a repetition of No. 3 in most of the details, except that 10 pounds to 1,000 cubic feet were used. The four-spotted bean weevil (*Pachymerus quadrimaculatus* Fab.) was included in a small sack of beans. About half the quantity of material containing the flour-moth larvæ was taken.

The box was closed at 3 p. m. and carefully calked with cotton. October 17, at 3 p. m., or 24 hours later, the box was opened and the contents freely exposed to the air. All of the bean weevils and other beetles seemed to be dead, but the cadelle larvæ moved slightly when touched, though they were not active. Forty-eight hours after opening all were dead except a few larvæ of Tenebroides.

If the material were a cheap product it might prove a substitute for carbon bisulphid if used in strengths greater than 10 pounds to 1,000 cubic feet. Possibly fumigation for a longer time might increase the effectiveness, but it is most obviously not so fatal as is carbon bisulphid.

EXPERIMENTS AT BALTIMORE, MD.

Experiment No. 5.—October 25, 1910, a quantity of shelled corn stored in a new concrete elevator in Baltimore, Md., was reported by Dr. J. W. T. Duvel, of the Bureau of Plant Industry, to be quite badly attacked by weevils which had worked to such an extent that the temperature had increased from 76° to 90° F. An examination of the corn showed extensive damage by the granary weevil (*Calandra granaria* L.), while *Cænocorse ratzeburgi* Wissm. and *Læmophlœus minutus* Oliv. were also present in some numbers. Since the bin was of concrete and capable of being tightly closed, the opportunity was taken by the junior author for a thorough trial of carbon tetrachlorid as a fumigant. The bin was a trifle over 6 feet square and 75 feet in depth, giving a capacity of approximately 3,000 cubic feet. A dose of 15 pounds of tetrachlorid was poured over the grain from the top of the bin, the grain, 1,300 bushels in all, extending nearly to the top of the bin. The bin was closed and left for four days. October 29, when opened, a slight odor of gas remained. The grain was run over a No. 8 screen and the estimate of mortality made from the insects found. No living Cænocorse or Silvanus were observed. About 50 to 60 per cent of the Calandras were killed, the remainder being very stupid after the screening and thorough airing.

The weevils in this case were left in separate jars for a number of days afterwards in order to ascertain if recovery took place later, but no difference in the number killed was noted.

Experiment No. 6.—A second fumigation was applied early in November, the fumigant being used in the same bin, but at the rate of 9 pounds to 1,000 cubic feet. At this rate the poison was applied in five layers, 250 bushels of corn being run into the bin between applications of 5 pounds each of carbon tetrachlorid. The bin was closed 5 days, then the corn was run over a No. 6 screen, and specimens of weevils collected from the screenings. In this treatment about 90 per cent of the weevils, which by this time consisted almost entirely of *Calandra granaria*, were killed.

Specimens were exposed for recovery but failed to do so. The odor of carbon tetrachlorid was strongly noticeable while the corn was being screened and the gas was apparently well distributed through the corn. This experiment would indicate that carbon tetrachlorid is much less valuable as an insecticide than the bisulphid. The tetrachlorid used was purchased in the open market in Baltimore, at a cost of 28 cents a pound.

COMPARATIVE COST OF CARBON TETRACHLORID AND CARBON BISULPHID.

Inquiry of the Bureau of Chemistry in regard to the comparative cost of these chemicals elicited the reply that the contract prices for supplies for the Department of Agriculture for the year ending June 30, 1909, quoted carbon bisulphid at $0.11 a pound (quality not designated) to $0.28 a pound (chemically pure), while carbon tetrachlorid was quoted from $0.45 to $1 a pound. Prices in the Oil, Paint and

Drug Reporter December 1, 1908, were carbon bisulphid 5 to 7 cents a pound, and carbon tetrachlorid 9½ to 16 cents a pound wholesale. These last quotations represent prices in bulk, and variation is evidently dependent upon the quantity desired.

CONCLUSIONS.

For all practical purposes it will readily be seen that carbon tetrachlorid at the rate of 28 cents a pound costs fully three or four times as much as carbon bisulphid and, in the case of purchase at retail drug stores, probably on an average of two to three times as much. Considering the strength at which it is to be used, it is very obvious that this chemical, unless it can be manufactured at a much lower price, can not be as economically employed as a remedy for insects injurious to stored products in warehouses, mills, or in any other depository, but might be used for choice seeds or in office rooms and dwellings, which can be very tightly closed and where the use of inflammable materials is prohibited or is for other reasons undesirable.

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U. S. D. A., B. E. Bul. 96, Part V. T. C. & S. P. I. I., August 6, 1912.

PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

THE BROAD-BEAN WEEVIL.

(*Laria rufimana* Boh.)

By F. H. Chittenden, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

[With Reports by Wm. B. Parker, *Agent.*]

INTRODUCTORY.

This species, which is commonly known as the bean beetle or bean-seed beetle in Europe, where it has been a pest for a great many years, has frequently been brought to the United States and Canada in its food supply. Until the year 1909, however, there was no positive proof known to the writer of its ever having been introduced into North America. This is most remarkable considering the number of times that it has been imported living—almost yearly in all probability—and that the species is so well established in Europe, where it is a common and destructive pest. It especially infests broad beans, and, it is said, peas and some other legumes. Broad beans, it might be explained, are also known under the names of horse, Windsor, tick, and "English Dwarf" beans. During 1909 and since, this species has become established in several localities in California, and bids fair to become a most formidable drawback to the cultivation of broad beans in that State, if not in the entire country where this crop is raised.

DESCRIPTION.

THE ADULT.

The species under consideration, *Laria rufimana* Boh., although very closely related to the pea weevil (*L. pisorum* L.), is readily separable by the following characters, expressed in tabular form:

Posterior femora acutely dentate; thorax broad; pattern of elytra well defined; pygidium with a pair of distinct apical black spots............................*pisorum* L.

Posterior femora obtusely or obsoletely dentate; thorax narrow; pattern of elytra more or less suffused; pygidium with black apical spots lacking or illy defined, *rufimana* Boh.

While there is no great difference in the size of the two species, *pisorum* averages a little larger. The following technical description of *rufimana* is adapted from Horn:

Oblong oval, black, subopaque. Head black, densely punctulate, sparsely clothed with ochreous pubescence. Antennæ black, four basal joints rufous. Thorax wider than long, sides moderately rounded in front of tooth, sinuate behind it, tooth at middle obtuse, moderately prominent; surface opaque, densely punctate, and with a small whitish triangular space in front of scutellum. Scutellum subquadrate, emarginate at apex, sparsely clothed with cinereous hairs. Elytra longer than wide, feebly convex, sides moderately rounded, surface more shining than the thorax, moderately striate, intervals flat, densely punctulate, and with the basal margin, base of suture, and two irregular transverse bands of whitish hairs. Pygidium clothed with cinereous hairs and with two nearly obsolete oblong black spots. Body beneath black, densely punctulate, and clothed with cinereous hairs. Anterior legs rufous, except their tarsi, apex of tibiæ, and base of femora, which are piceous. Middle and posterior legs black.

Length: 0.14–0.18 inch (3.5–4.5 mm.); width: 0.8 inch (2.4 mm.).

The synonymy of this species is as follows:

Laria rufimana Boh.

Bruchus rufimanus Boh., Schœnherr, Gen. et Spec. Curculionidum, vol. 1, p. 58, 1833.
Bruchus granarius auct. (*non* Linnæus), Westwood, Curtis, Ormerod, Wood, Riley, Fletcher, Lintner, *et al.*
Mylabris rufimana Boh., Baudi, Deutsch. Ent. Zeitschr., 1880, p. 404.
The *Bruchus granarius* L. is *Laria atomoria* L.; Syst. Nat., 12th ed., p. 605, 1766–1768.

The beetle is shown in figure 11, and figure 12, representing the pea weevil, is introduced for comparison.

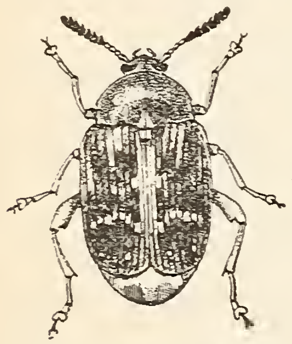

Fig. 11.—The broad-bean weevil (*Laria rufimana*): Adult or beetle. Enlarged. (Original.)

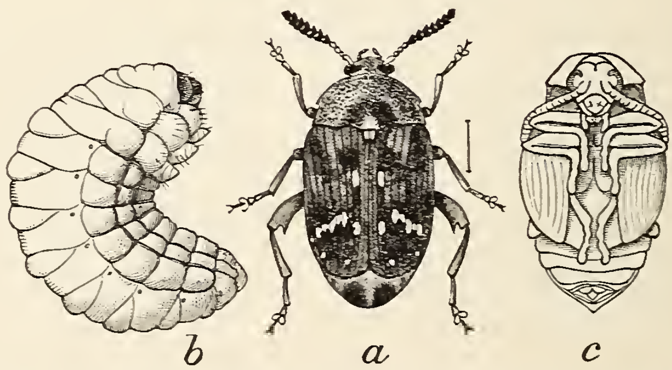

Fig. 12.—The pea weevil (*Laria pisorum*): *a*, Beetle; *b*, larva; *c*, pupa. Enlarged. Author's illustration.

From Mr. I. J. Condit, San Luis Obispo, Cal., under date of April 18, 1911, were received the eggs of this species found on young pods of the broad or horse bean (*Vicia faba*). The pods were just beginning to form in many cases, some being as long as 2 inches. In some cases as many as nine eggs were found on one small pod and one was observed on the withered calyx lobe of the flower. Few beetles were observed and none was detected in the direct act of oviposition. Evidently this is accomplished mainly at night.

THE EGG.

The eggs are deposited upon the outside of the pod, usually without reference to the position of the young beans, and are firmly attached to the epidermis by a glutinous, adhesive secretion, which usually remains as an enveloping border or fringe, as shown in figures 13 and 14. They are deposited singly over the surface of the pods. As many as nine may be deposited upon a single pod, although from four to six appear to be more usual in the cases observed.

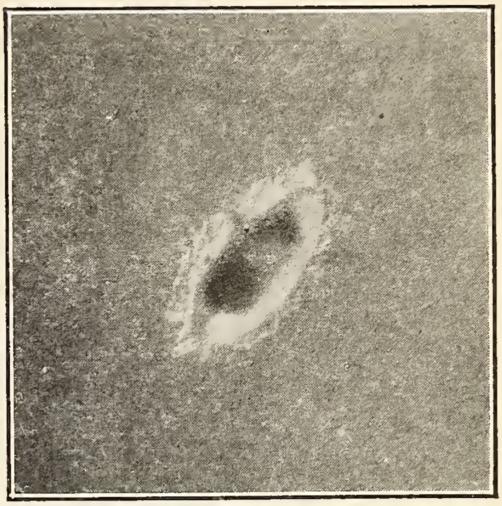

FIG. 13.—The broad-bean weevil: Photomicrograph of egg. (Original.)

The egg is elliptical-ovate, about twice as long as wide, rounded at the extremities, and somewhat more pointed anteriorly. The surface is smooth and polished, without visible sculpture. In color it is clear greenish yellow when fresh, but just before hatching the dark head of the embryonic larva becomes plainly visible through the thin shell. It is 0.55 to 0.60 mm. in length by 0.25 to 0.28 mm. in width.

The description of the egg was made from specimens just before hatching and the greenish color may have been absorbed from beneath, since Mr. Condit states that the egg when first seen is watery white, glistening in the light. It is large and, like the eggs of our other injurious Lariidæ, plainly visible to the unaided eye.

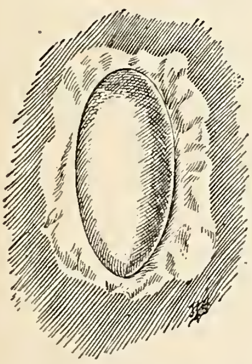

FIG. 14.—The broad-bean weevil: Egg. Greatly enlarged. (Original.)

THE POSTEMBRYONIC LARVA.

The young larva emerges through a round hole in the underside of the egg and bores at once into the young beans, going directly through the pod.

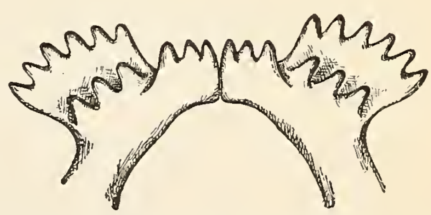

FIG. 15.—The broad-bean weevil: Apical crest of head of postembryonic larva. Greatly enlarged. (Original.)

When first hatched it is pale yellow, with brownish or blackish head and mouth-parts. Except in the shape of the prothoracic spinous processes, it differs little from the larva of the pea weevil (*Laria pisorum* L.). These processes are shown in figure 15.

DISTRIBUTION.

The distribution of this weevil in Europe is given by late authority as middle and southern. The species is also known to be established in Austria, Spain, Italy, southern France, Sardinia, the Crimea, Egypt, Syria, Algeria, and Tunis, and it has long been credited with being a pest in England. It is also recorded from Teneriffe, Canary Islands.

During 1893 the writer found this species commonly in many exhibits of broad or Windsor beans at the World's Columbian Exposition held at Chicago, Ill., during that year; indeed, the exhibits of these last two varieties of seed were almost invariably badly infested or showed evidence of attack of greater or less severity. Specimens of the beetles were taken, mostly dead, in the exhibits of Algeria, Tunis, Spain, and Italy, but some beans damaged by this species were taken in other exhibits, for example, some purporting to come from Porto Rico—perhaps a mistake.

Reports have several times been made of the finding of this species in seeds in various portions of our country, from portions of Canada, and southward to Texas.

The following reason why the species has not before been established in America permanently may be deduced. This weevil, like the pea weevil (*Laria pisorum* L.), produces, as does that species, only a single generation a year and hibernates as an adult in the seeds. Thus the chances are that after the seeds are collected and exported to this country the contained insects are subjected to so much handling and agitation in different ways as to interfere with their proper hibernation, so that by the time the bean plant has attained sufficient growth to produce pods, the beetles are mostly dead or too feeble to propagate. At least this seems to be the case in the Atlantic region and Middle States.

RECORDS OF OCCURRENCE.

September 18, 1909, Mr. I. J. Condit, collaborator of the Bureau of Entomology at San Luis Obispo, Cal., sent living specimens of this weevil in horse beans (*Vicia faba*), which are now being grown quite extensively in that region for feeding stock. They are commonly planted early and are ready to harvest in January or February. Some were planted late, about March 1, but did not produce well on account of the dry season following. When ready for harvest they were found to be infested with this weevil; on account of this and the small size of the pods and beans they were not gathered.

This is without doubt the first notice that we have of the establishment of this species in America. All other records, so far as the writer knows, are of the occurrence of the insect in samples of seed introduced, usually from Europe, into the more northern States and seldom farther south than Washington, D. C. Unless the insects are dead when received, the active ones die long before the next crop of seed is ready for harvest; in other words, there is no food supply for them, as they do not breed continuously in dry seed, but produce only a single generation a year, as in the case of the related pea weevil (*Laria pisorum* L.).

Thus it happens that although this weevil has probably been brought to this country in seeds every few years for a very considerable period, it has not hitherto become established in the United States. Western conditions are different, and the above notes furnished by Mr. Condit require no further elucidation.

Among the notes of the Bureau of Entomology are many records, more or less brief, of the receipt of this species in seed beans from a number of localities.

May 14, 1894, this species was received from Prof. R. H. Price, College Station, Tex., in beans.

In 1900 (February 9) Mr. A. J. Pieters, of the Bureau of Plant Industry, received this species in broad beans (*Vicia faba*) from Italy.

In 1907 this species was received, December 17, from Reading, England, in a lot of 30 pounds of broad beans containing also a parasite, *Sigalphus* sp.

In 1909 this species was received from several sources. March 8, horse beans infested by this species were received from Mr. Mortimer D. Leonard, New York City, with inquiry if investigations had been made in regard to the insect, which had evidently been introduced from Italy with the beans. September 18 of that year, as has previously been mentioned, we received the insect from San Luis Obispo, Cal.—a record of actual establishment of the species in America. October 4 it was received from Magyar-Obar, Hungary, in horse beans; October 15, from Mr. H. C. Moore, Watsonville, Cal., in horse beans—a second report of occurrence in the United States. October 5 the insect was taken from the seeds of *Vicia faba* collected in California, and from a lot imported from Italy in samples rejected by the United States customs officials as adulterated. October 30, badly infested beans containing this species were received from Italy through the Bureau of Chemistry. During the same year specimens were received from Valencia, Spain.

April 20, 1910, Mr. M. L. Peairs, of the Maryland Agricultural College, reported that a shipment of horse beans seized at the Baltimore customhouse was infested by weevils. The beans were traced to a firm in Berlin, Germany. The samples were infested to the amount of 50 per cent. Identification in this case was made by an assistant, Mr. C. H. Popenoe. Other seizures have been made of this weevil by the Bureau of Chemistry in New York City. Efforts were made to ascertain whether the species was present in other localities in California, with some success. Thus far indications are that the beans have all been introduced by individuals or firms and not by the Federal or State Governments. Some of these cases have attained considerable newspaper notoriety from the alleged report that the insects were poisonous, a matter which will be taken up later. May 24 this insect was received from Elisanetpol, Caucasus, Russia. In June it was received from Rhodesia, South Africa. Later additional specimens were received from San Luis Obispo, Cal., and February 2, and later in 1911, specimens were received from Sacramento, Cal., collected by Mr. Wm. B. Parker, an agent of this bureau. They were taken in local stores, and were collected in a garden just outside of the city.

In nearly all of these records the insect occurred in broad beans, but in a few cases the records read simply "in beans."

In discussing the introduction of this species into California, and the seizure by the Bureau of Chemistry of horse beans infested by the weevil in New York City, Mr. David Fairchild, of the Bureau of Plant Industry, with whom the writer conferred, desired to know the exact localities other than San Luis Obispo in which the species was known to have become introduced. During the discussion of the advisability of excluding further introductions of the horse bean by firms and private individuals in the Eastern United States, it became apparent that some measure should be enacted, if possible, to prevent the introduction of the beans from California eastward, as there is a greater probability of the introduction of the pest into the Eastern States in beans from California than in beans from abroad.

Altogether, the further introduction of this seed, when infested by living weevils, either from abroad or from California, should be stopped if possible or Federal inspection of all seeds should be made, that the seed stock may be properly fumigated. The California authorities might be empowered to act, but there is no means provided for Federal inspection other than that by the Bureau of Chemistry under the provisions for inspection under the pure food and drugs act of 1906.

NOTES ON OCCURRENCE IN CALIFORNIA.

By Wm. B. Parker, *Agent.*

March 25, 1911, the beetle was first observed and captured on Windsor beans at Sacramento, Cal. The beans ranged in height from 3 to $3\frac{1}{2}$ feet and were in full bloom. Pods of various lengths were present, the longest measuring 3 inches.

By March 30, beetles were active, flying from leaf to leaf or from blossom to blossom and running about on the plants. They were not observed to feed or deposit eggs, although watched closely.

A resident of Sacramento who had some beans in his yard stated that the seed was infested when planted, and that a lot of seed was sent to Mr. Henry R. Russell, Richey, Amador County, Cal., and was planted that spring.

On April 15, the first warm day since April 1, 15 adults were captured on Windsor beans and placed in paper bags over growing beans in order to obtain eggs. While in the bags two pairs were observed copulating and one pair was confined for further observation.

Eggs were observed April 22, cemented to the outside of the bean, and when removed with a camel's-hair brush a fringe of cement was observed attached to the side of the egg.

Many eggs were observed April 25, scattered promiscuously over the pods. Some were nearly ready to hatch, but the greater number were newly laid. No eggs were found on the stems or leaves.

The number of eggs on the various pods were as follows: 4, 8, 5, 15, 2, 3, 16, 10, 6, 3, 2, 4, 2, 8, 2, 5, 6, 7, 5, 10, 11, 34, 11, 14, 25, 10, 6, 20, 27, and 13.

A few adults were observed on the bean pods April 28. They were apparently ovipositing, though the act could not be witnessed. A few seen on the upper leaves were captured, placed in cold storage, and retained for egg laying. Four days later they were removed, and eggs were obtained.

It was observed that the adults, when disturbed, either flew away or contracted their legs and dropped, much as do other weevils when feigning death, but began moving again before they had struck anything in their fall.

May 1, eggs that had undoubtedly hatched were observed to have a dark or black-edged hole under one end, the larva having entered the pod by boring a hole through the side of the eggshell that was attached to the pod and then into the pod itself.

Sixteen eggs were laid May 4. On May 16, distinct dark spots were observed in the ends of the eggs, while the other ends were translucent brownish. The dark spots were very distinct on the 18th, and on the 19th a few eggs had hatched, while others were hatching. All larvæ had emerged by May 20. The egg period in this case was 15 days.

The first hatched egg of those laid May 5 was observed on May 18. Others had hatched May 19. Of the eggs laid May 6 to 7, the first was observed to have hatched on May 18. All but one were hatched on May 19.

These eggs were laid in the field, the adults being inclosed in paper bags which were kept over the eggs as a protection against predaceous insects.

In emerging from the egg the larva was first observed to draw its head back so that the body occupied about three-fourths of the shell. Then it bored down through the side of the shell which was attached to the bean pod, and as the larva entered the pod the end of the egg previously occupied by the abdomen became clear, and finally the entire shell was glassy and transparent in appearance. Just before emerging the head of the larva was quite black and the abdomen seen through the eggshell appeared yellowish.

On July 10, larvæ were observed to be thriving in the beans taken from the vines at Sacramento, Cal., June 20, though the beans were perfectly dry.

August 3, larvæ and pupæ were taken from Windsor beans that were collected in the field at Sacramento June 20. Although some of the larvæ had pupated, they had apparently been in that stage only a very short time. They were pure white and very delicate.

The point where the larva entered the bean was marked by a black dot which had remained from the time that the larva entered.

When the larva was about to pupate a transparent spot appeared on the epidermis of the bean where the larva had eaten out the cotyledon close to the epidermis or seed coat. This transparent spot was not at the point where the larva had entered the bean, but at varying distances from that point.

ALLEGED POISONOUS NATURE OF THE WEEVIL.

The New York Times, under date of September 28, 1909, printed, under the heading "Poisoned Bug Holds Up Imports of Beans," the following "story." The description given shows plainly that *Bruchus rufimanus* is the insect in question.

MANY CUSTOMS LABORERS MADE ILL BY BITE OF LITTLE PESTS FROM ITALY.—INVESTIGATION IS ORDERED.

AGRICULTURAL DEPARTMENT AND BOARD OF HEALTH CALLED IN—VICTIMS OF BITES DEMAND COMPENSATION.

The local pure food office of the Agricultural Department and the board of health have been asked to investigate the coming to this port of a small gray-winged bug that threatens to stop the importation of a certain kind of bean from Italy. This insect has caused so much illness among the laborers and weighers who handle the beans that the matter has been officially brought to the attention of Surveyor Clarkson. He has called for an investigation, and meanwhile has held up a large importation of the beans until a decision shall be reached.

For some time the authorities have received complaint that a small insect brought from Italy with a dried bean, much like our butter bean and called by the men who handle them as "horse" or "fly" beans, was causing the discomfiture of the men handling them. A few days ago three men became so ill that they had to remain at home under the care of physicians. At first the cause of the malady was a mystery, but the men soon became convinced that the bugs were the cause of it. Sixty-three bags of the beans which arrived here on the *Europa* are known to have brought the pests, and the consignment now held up consists of 125 bags, which arrived recently on the *Virginia*.

The insect is of gray color, about the size of half a pea, with wings that fold closely on its back. When first disclosed in the bean the bug is apparently lifeless. It soon revives, however, and begins to crawl or take short flights. It crawls up the trousers of the men who handle the beans and bites them, the effect being a feeling of nausea. In addition to this a rash appears on the affected parts.

The officers of the Pure Food Bureau have taken specimens of the bug, and are now making tests to prove that it is the bug which causes the strange illness.

The men who have the handling of the importations upon the piers and weighers are almost in revolt, and some have petitioned the collector and the surveyor requesting that their doctor's bills be paid, setting up the claim that they are entitled to remuneration as having been infected while in the performance of their duty. They also want pay for lost time, and the matter has been referred to the Treasury Department for decision.

It was said yesterday that the importers to whom the shipments are consigned have protested against the action of the department in holding up their goods.

ALLEGED POISONOUS NATURE DUE TO MITES.

While the writer has not seen any statement to the effect that this weevil is attacked by the predaceous mite *Pediculoides ventricosus* Newport, nevertheless it seems highly probable that the trouble just related may have been due to the presence of this mite in the broad beans affected by the weevil, this supposition being based on the fact that the writer has observed the mite in great numbers attacking and destroying the related bean and cowpea weevils.[a]

A detailed account of this species with particular relation to its proving noxious to human beings is given by Prof. F. M. Webster in a recent publication of this Bureau.[b]

The writer feels no hesitation in stating that this mite is undoubtedly a parasite of the weevil in question and that it has merely been overlooked by observers, since it is known to prey upon insects of several orders.[c]

The Lariidæ (Bruchidæ) are not classified among poisonous insects, but there are many recorded and unrecorded cases of injury due to insects of the same order; for example, the Meloidæ or blister beetles poison slightly and blisters rise on the bitten places. It is seldom, however, that a human being is bitten more than once or twice at the same time. Several genera of the Buprestidæ, another well-known family of beetles, are frequently accused of biting human beings in the same manner as the Meloidæ, usually on the neck, and they even cause some irritation (but no poison whatever, so far as we know) when they are very abundant in lumber camps.[d]

It is more to the point, however, that we received, March 5, 1909, from Messrs. B. F. Ellington & Co., Atlanta, Tex., examples of two lariids, the four-spotted bean weevil [*Bruchus*] (*Pachymerus quadrimaculatus* Fab.) and the common bean weevil ([*Bruchus*] *Acanthoscelides obtectus* Say), with report that when the infested cowpea seed was being handled, the little insects sometimes covered the bodies of the workmen, raising "wheals" or bumps and actually causing fever.

Under the circumstances, it seems quite probable that when any of this group of weevils occur in great abundance and obtain access to many portions of a human body, the bite may cause considerable irritation, but probably not to all of those having the handling of the infested seed. The fact is established that many persons are poisoned by the attacks of certain insects, while others are immune, or practically so, to insects which more or less habitually sting or bite human beings.[e]

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[a] U. S. Dept. Agr., Yearbook for 1898, p. 247, 1899.

[b] Cir. 118, Bur. Ent., U. S. Dept. Agr., "A predaceous mite proves noxious to man (*Pediculoides ventricosus* Newport)," pp. 1–24, Apr. 23, 1910.

[c] After the above was written Mr. Wm. B. Parker reported this species of mite preying upon *Laria rufimana* in California.

[d] Frequent reports have been made of the biting, or more properly speaking, piercing, of exposed portions of human beings by various forms of leafhoppers, and many bugs of the suborder Heteroptera are poisonous when attacking susceptible persons. The list could be considerably prolonged.

[e] Thus, one person whom we may designate as *A* does not suffer more than a momentary inconvenience by the bite or sting of mosquitoes and bedbugs. On the other hand, he practically suffers torture from the attacks of fleas and chiggers, the wheals caused by the two insects being of about the same size, usually about that of a dime and persisting for one or two weeks and sometimes even longer, and causing uneasi-

GERMINATION OF SEED.

The opinion, which was very generally held, that the larvæ of bean and pea weevils avoid the germ or embryo, and hence do not cause serious deterioration of the germinating power of the seed, seems to have been more prevalent in Europe in the case of this species than it is now, by seedsmen in America, in the case of related weevils.

GERMINATION TESTS IN EUROPE.

Having doubts as to the value of infested seed for planting, Mr. Theodore Wood performed some experiments in 1885 [12] with seed beans infested by the broad-bean weevil. Twenty beans were selected and sowed under the most favorable conditions for their general welfare. At first, growth was strong and vigorous, but when the fruiting time approached it was noticed that the blossoms were scanty and small and the foliage faded and withered, while in some cases plants had died outright without producing a single pod. The total production measured by the pods was in direct proportion to the amount of infestation, such beans as contained three weevils producing less than those which contained two, while those containing only one weevil produced more pods, as high as 23 being counted in one case.[a]

Subsequently more detailed experiments conducted by the same writer [15] with a larger lot of material and with different varieties of plants proved that the first experiment was on too small a scale to be productive of decisive results. As an instance, Mr. Wood cites the case of one plant, the seed of which was tenanted by six weevils, which bore no less than nine pods, seven of which reached maturity. Among other things, he states that with the five varieties of infested plants tested, namely, Carter's "Leviathan," Carter's "Seville Longpod," two other unnamed varieties of "Longpod," and early "Mazagan," more than one-fourth of the pods, although large and healthy in appearance, proved upon examination to contain only withered germs of the beans. The early "Mazagan," however, proved to be an exception.

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ness which can scarcely be relieved by any other means than the application of various lotions and vigorous scratching. Many persons claim that after being attacked by "chiggers," which usually cause more irritation than fleas, they finally become immune and are no more troubled. In fact, it may be said that farm hands generally are little troubled by these pests. Many people claim that they are never stung or bitten by fleas; then again we will mention the case of *B*, who is poisoned by mosquitoes as badly as by fleas. To summarize, immunity is secured by experience and there is considerable idiosyncrasy. Nearly all forms of mites which inhabit dwellings and storehouses cause more or less irritation when they become abundant.

This subject is considered somewhat more at length in Circular 77 of this bureau, "Harvest-Mites or Chiggers."

[a] A striking feature in connection with the experiment above mentioned was, according to Mr. Wood, that the plants raised from weeviled seed, with one single exception, altogether escaped the attacks of *Aphis rumicis*, from which scarcely another plant in the same garden was free. From this he inferred that the sap of the weakened plants was of too deteriorated a character to satisfy the fastidious taste of the "colliers."

The final conclusion, however, of both series of experiments is that the presence of the weevils in the seed is highly detrimental, affecting to a very considerable degree the reproductive powers of the future plant and the germinating qualities of the seed, if any is produced. If the germ itself be penetrated the seed naturally is necessarily rendered sterile.

Mr. Wood admitted that the subject was open to further experiment.

GERMINATION TEST OF INFESTED WINDSOR BEANS FROM CALIFORNIA.

March 8, 1912, from a quantity of Windsor beans infested with the broad-bean weevil, furnished by Mr. Parker from California, a number were selected for germination tests.

The beans were classified as uninjured and those showing injury by the presence of from 1 to 5 holes or infestations. These were placed between cloths and covered with moist sand, remaining in this condition for one week. At the end of this time the beans were opened and the number that had germinated were counted. The beans had previously been divided into lots of 50 each.

The percentages of germination as determined by Mr. C. H. Popenoe are as follows:

TABLE I.—*Germination test of infested Windsor beans from California.*

Number of injuries.	Number of beans.	Number germinated.	Per cent germinated.
Perfect	50	37	74
One injury	50	29	58
Two injuries	50	23	46
Three njuries	50	27	54
Four and five injuries	65	21	32.3

Average percentage of injured beans that germinated	47.5
Percentage o uninjured beans that germinated	74.0
Percentage of germinable beans destroyed by weevil	35.8

The above figures show that even in cases where a single individual weevil attacks a broad bean, less than 60 per cent of such infested beans germinate, whereas when four or five beetles find lodgment in a single seed, 32.3 per cent, or about one-third only, germinate. There is no doubt that seeds containing holes made by this beetle are unfit for planting, as, even with perfect germination, the opportunity for the entrance of water into the seeds stimulates decay and the seed frequently rots before germination.

SUMMARY OF NATURE OF ATTACK AND LIFE HISTORY.

The principal injury caused by the broad-bean weevil is due to the operations of its larva feeding within the seeds of broad or Windsor beans and, it is said, peas and some other leguminous seeds, thus

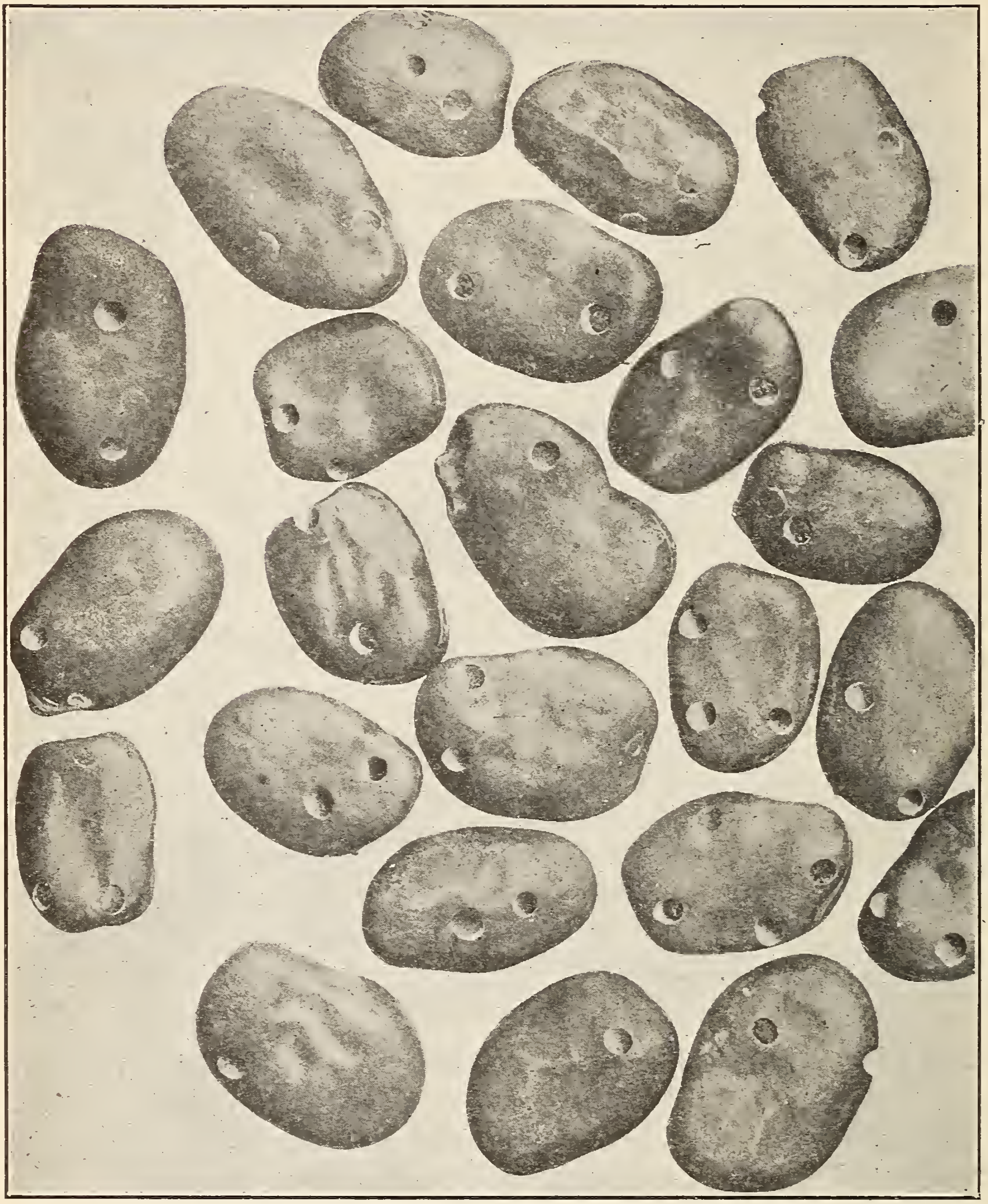

FIG. 16.—Broad beans infested by *Laria rufimana*, showing empty exit holes of beetles, closed exit holes, and open exit holes in which beetles are still present. (Original.)

diminishing their value for sale by loss of weight and by their imperfect or "buggy" appearance (see fig. 16), and also lessening their value as seed material. Where many individuals infest a single seed much of the tissue is consumed and the germinating power reduced nearly one-half, while the growing power of the plant is also diminished, and there is, moreover, in the case of a plant growing, a much lessened yield of seed, which is also apt to be imperfect.

The method of attack is in brief as follows:

The female weevil begins to deposit her eggs on the young seed vessel in the blossom before and after the former has developed into a pod. Here the eggs hatch and the larvæ penetrate into the growing seeds, each gnawing a gallery for itself, which it lengthens from time to time, as needed. (See fig. 17.) When full grown, the larva transforms to pupa within the accumulated frass and develops later into the beetle stage. This development may take place at different periods, the beetles being found afield in some regions as early as February and until May, some leaving the seed as soon as fully developed and others remaining until they have cut through the skin which remains over the cell while the insect is in the larval and pupal stages. When the beetle wishes to emerge it gnaws around this circular piece of skin and forces its way through.

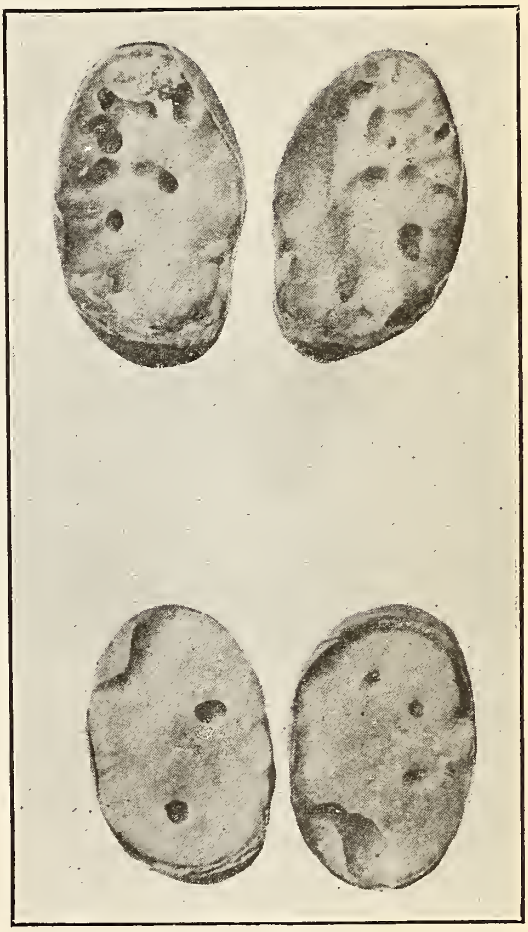

Fig. 17.—Broad beans split to show ravages made by larvæ of the broad-bean weevil above, and by larvæ and adults below, the latter leaving large pupal cases at the ends of the beans. (Original.)

As is the case with the pea weevil, this species hibernates in the adult condition, and a single generation develops each year. Pupæ have been observed as early as August 3, in California, and the probabilities are that in most seasons the beetles will have developed by the middle of August, or a little later; hence, as they are seen in the field toward the end of March and first of April, it can be deduced that the life of the beetle extends from about the middle of August to the middle of April and later—a period of 8 or 9 months.

The separate periods for the egg, larval, and pupal stages do not appear to have been observed.

LITERATURE AND HISTORY.

The broad-bean weevil was first described by Boheman[1a] in 1833, who designated its habitat as Crimea, Dalmatia, Egypt, and France. From the lateness of this description and the fact that the habitat Egypt is mentioned, it is presumed, and with good reason, that the insect was introduced from Egypt, supposedly the natural home of its favorite food plant, the broad bean. In 1860 John Curtis[2] gave a long account of this species, describing it and its habits and injuries, with reference to earlier writings. He also described three of its hymenopterous parasites. It was not until 10 years later that Riley[3] wrote of the supposed introduction of the insect in America. Rathvon,[4] Glover,[5] and Horn,[7] as well as other writers, seem to have taken it for granted that this species was already introduced from Switzerland into America, basing this supposition on Riley's first editorial note. In later years Fletcher[17] mentions the detection of the insect in broad beans imported from England and found in Canada, but neither he, Hamilton,[18] Lintner,[22] or others assumed the establishment of the species in the United States or Canada.

Of important writings on this species may be mentioned the works of Achille Costa, first published in 1857 and again 20 years later,[9] this account including a description of the egg, larva, and adult. and treatment of the biology. Taschenberg,[10 11] who gave similar accounts, Theo. Wood,[12 15] whose articles will be mentioned later, Miss Ormerod,[14 20 21] and Lintner.[22] Lintner's article, while a detailed one furnishing a somewhat complete bibliography, is largely devoted to a discussion of the synonymy of the species and its reported occurrence in America. Other articles and notes on this species are cited in the appended bibliography.

In this connection it might be mentioned that Olivier, in his treatment of "*Bruchus pisi*" in 1795,[1] evidently failed to differentiate the pea weevil from the species in question and the lentil weevil, since in his illustrations, figure 6, *c*, is recognizable as *pisorum*, while figure 6, *d*, is evidently intended for *rufimanus*. In his concluding notes on "*pisi*" he writes that the larva lives in the interior of peas, lentils, "gesse," beans, and some species of vetch. Moreover, his illustration of *Bruchus granarius* is that of a much smaller insect than *rufimanus* (Pl. I, fig. 10, *a*, *b*), and therefore not the latter species.

NATURAL ENEMIES.

Of the natural enemies of this species very little has been written. John Curtis recorded in 1863 three hymenopterous parasites, which he describes.[2] These are *Sigalphus pallipes* Nees, *Sigalphus thoracicus* Curt., and *Chremylus rubiginosus* Nees.

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[a] See Bibliography, pp. 80–82.

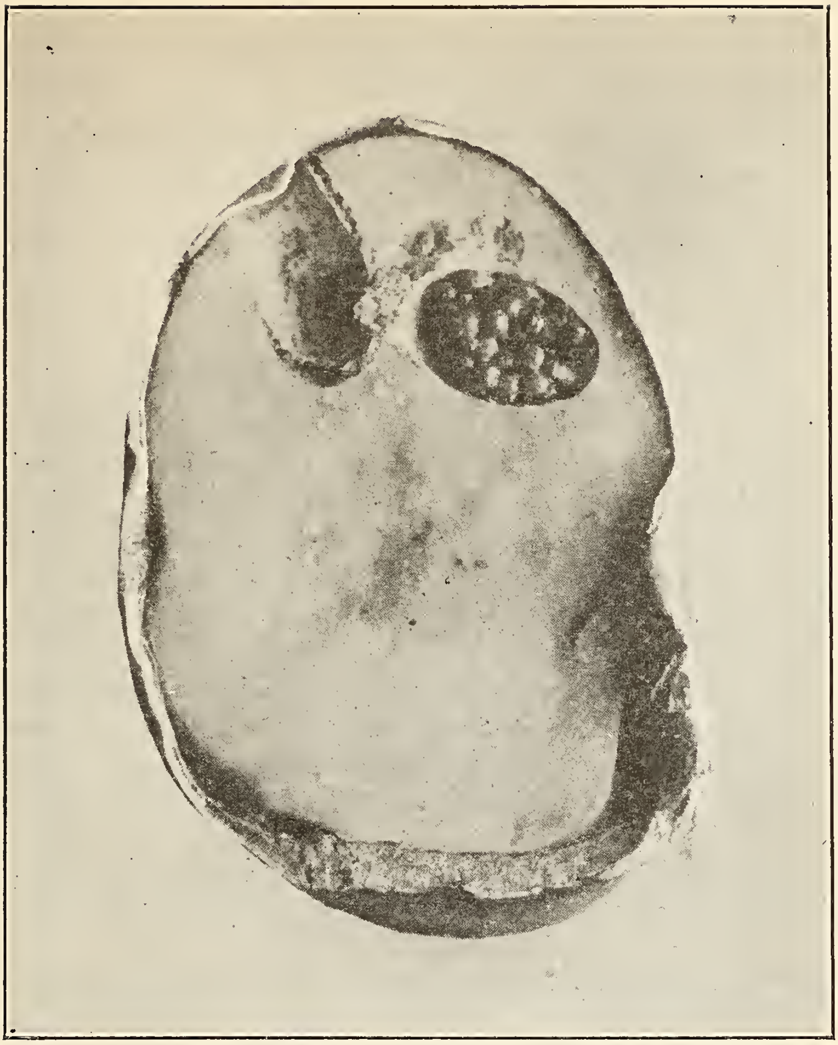

FIG. 18.—Broad bean cut in half to show, at top on left, pupal cell of the broad-bean weevil; at right, cell containing predaceous mite (*Pediculoides ventricosus*). Enlarged. (Original.)

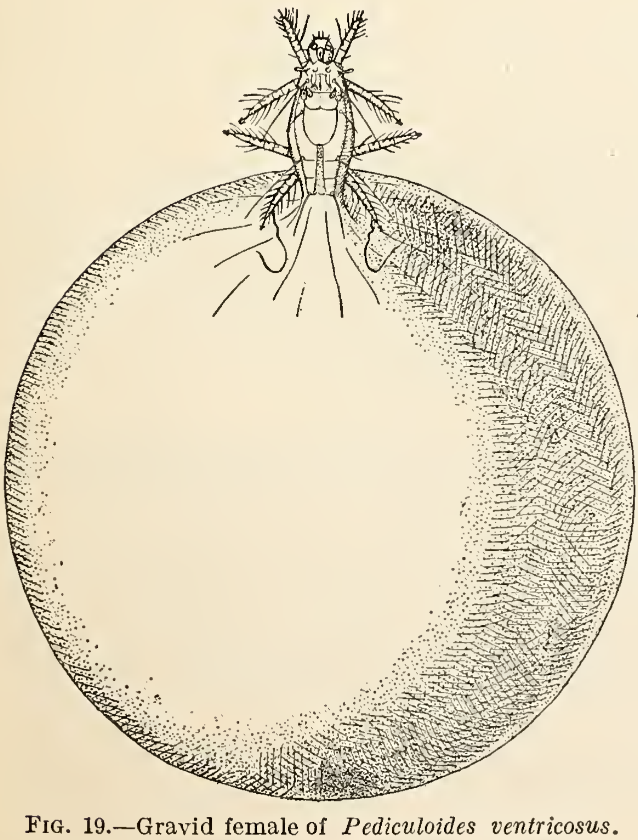

FIG. 19.—Gravid female of *Pediculoides ventricosus*. Greatly enlarged. (Redrawn from Brucker.)

To this list should be added *Pediculoides ventricosus* Newport. Strangely enough, this predaceous mite was not actually observed until 1911, when the species was reported by Mr. Parker at Sacramento, Cal. An illustration is given in figure 18 of a broad bean cut in half, showing the pupal cell of *Laria rufimana* at the left, and at the right another pupal cell showing a mass of females of this mite which have developed within this cell. A gravid female mite is shown in figure 19.

On April 15, 1911, Mr. Parker observed another natural enemy of this species.

A beetle was seen in the clutches of a reduviid bug (*Zelus renardii* Kolen.), which had its beak thrust through the ventral part of the beetle's abdomen.

The probabilities are also that the insect is devoured in the field, at least in its native habitat, by birds of different species.

EXPERIMENTS WITH REMEDIES.

By William B. Parker, *Agent.*

EXPOSURE TO HEAT OF SUN AS A REMEDY.

Experiment No. 1.—At Sacramento, Cal., August 21, 1911, 50 Windsor beans infested by larvæ, pupæ, and adults of *Laria rufimana* were placed in a black rubber tray and set on a white canvas spread on the roof of the State Insectary. In this situation it was exposed to the sun and protected from the wind. The beans were placed in the sun at 10 a. m., and exposed to the following temperatures until 5 p. m.: 10 a. m., 104° F.; 11.30 a. m., 112° F.; 1 p. m., 116° F.; 2 p. m., 118° F. At 5 p. m. the temperature was below 100° F.

September 13, as none of the insects in these beans had emerged, the beans were opened and the number of living and dead noted. There were no living insects in the beans, but the following is a tabulation of the numbers of larvæ, pupæ, and adults which were found. A check of 20 beans was kept.[a]

Table II.—*Heat of sun as a remedy against the broad-bean weevil.*

	Number dead.	Check experiment.	
		Dead.	Living.
Larvæ	20	3	0
Pupæ	25	2	1
Adults	42	1	27
Total	87	6	28
Per cent	100	17+	82+

HOT-WATER TREATMENT.

Experiment No. 2.—At Berkeley, Cal., 133 broad beans infested by *Laria rufimana* were placed in water that had just ceased boiling and were left 5 minutes. When removed they were placed in a pan with moist cotton for a germination test. Of this lot, 116 beans sprouted, or 87.2 per cent. The 26 insects found in the beans were dead.

Experiment No. 3.—Beans to the number of 116 were similarly treated, but were left in the water until cool. Four quarts were used. Eighty-three, or 71.5 per cent, of the beans sprouted. All of the beetles were dead.

Experiment No. 4.—Infested beans were placed in hot water that had just ceased boiling and were removed after 1 minute. Fifty-two beetles were removed from the beans and all were dead. No germination test was made.

During the preliminary experiments just recorded it was observed that the adults in Windsor beans were killed if the beans were dipped in water that had just ceased boiling, while the germinating power of the beans was not injured. As soon as enough infested material was obtained for a moderately large-scale experiment, the following tests were made:

[a] These beans were not tested for germination percentage.

Experiment No. 5—Fifteen pounds of infested beans were dipped in 20 gallons of water which had been heated to the boiling point in an iron caldron. The water had just ceased boiling and the beans were allowed to remain in the water 5 minutes.

Experiment No. 6.—A second lot was dipped for 1 minute. The effect upon the beetles and upon the germinating power of the beans may be expressed in tabular form, as follows:

TABLE III.—*Hot-water treatment against broad-bean weevil and its effects on germinating power of treated beans.*

Temperature.	Time of immersion.	Number beans counted.	Percentage of beetles killed.	Percentage of germination-
°F.	*Minutes.*			
210	5	98	100	2.0
210	1	111	100	38.7

From the preceding data it is evident that on a large scale, at least, the germinating power of the beans is seriously injured. The germination was not injured by the small-scale treatments of a similar nature.

Experiment No. 7.—In another test the infested beans were placed in cold water in the iron caldron and the temperature gradually raised. The first beans were removed when the temperature reached 140° F. and the last at 170° F. The results of these experiments follow:

TABLE IV.—*Hot-water treatment against broad-bean weevil and its effects on germinating power of treated beans.*

Temperature.	Time of immersion.	Number beans counted.	Percentage of beetles killed.	Percentage of germination.
°F.	*Minutes.*			*Per cent.*
130	23	76	94	86.0
140	27	130	100	98.4
150	32	129	100	88.3
160	39	91	100	82.4
170	43	116	100	56.8

It is evident from the foregoing data that 140° F. is the lowest temperature at which all of the insects are sure to be killed and that the germinating power of the bean is not seriously injured until the temperature reaches 160° F. or over.

When removed from the water the beans were somewhat soaked, but were in good shape for planting.

METHODS OF CONTROL.

Possibility of eradication.—The broad-bean weevil is by no means a difficult species to control and if proper action could be enforced there is every probability that the insect could be stamped out in its limited occurrence in this country. This would, however, in all probability require special legislation. By the abandonment, in the infested district, of the culture of broad beans, and possibly other beans and other large legumes which might furnish the insect with food, this result could be accomplished, if at the same time soaking and fumigation of seed, "holding over," and other remedies were practiced. One condition might militate against the effectiveness of a stamping-out process, which is that there is a possibility that the insect might find food in some wild leguminous plant producing a seed large enough for its development, for example, one of the vetches, or other related wild plant, or some plant that has escaped from cultivation. Although this contingency is a doubtful one, still the project is one requiring further study with this end in view. Otherwise the remedies are practically the same as for the pea weevil, allowing of course for different food habits.

The hot-water remedy.—In regard to direct remedies, the late Dr. James Fletcher, experimenting in 1888, demonstrated that soaking broad beans in water for 24 hours drowned every specimen of the weevils present in the samples which he had for the purpose. This expedient, if not applied when the seed is first harvested, should be employed before the time of sowing the seed. The hot-water treatment, with an exposure of, say, 15 minutes, as employed by Mr. Parker in his experiments with cold water gradually heated to 140° F., is obviously a more certain remedy.

Writing of the possibility of the breeding of this species in food plants other than broad beans, Mr. Parker stated, March 18, 1912, that it seems possible that the other leguminous seeds come too late for the beetles to oviposit upon the pods. The Windsor beans are planted in November and ripen very early, while the other legumes are not planted until spring and do not ripen until quite late in the season.

In the practical carrying out of this remedy a piece of burlap is placed in a caldron so that when weighted down with the beans it will not touch the bottom or sides. This keeps the beans from coming into contact with the heating surface and prevents them from becoming overheated. The beans are then placed on the burlap and covered with water and the fire started. The temperature should be raised as rapidly as possible, the beans stirred constantly, and when the thermometer reads 140° F. the beans should be immediately removed. They may then be planted or spread out in a thin layer to dry.

Holding over seed.—As in the case of the related pea weevil, holding over seed for a second year in a tight bag or other receptacle will be found sufficient. The beetles, if kept in a warm room, will emerge prematurely and will die without injuring the beans afterward, as they are unable to breed in dry seed.

Fumigation.—Fumigation with bisulphid of carbon, at the rate of about 2 or 3 pounds of the chemical to each 1,000 cubic feet of air space for 48 hours, is a perfect remedy in an air-tight receptacle, as in the case of other bean and pea weevils.

While a smaller amount of this chemical—1½ pounds to 1,000 cubic feet, with an exposure of 36 hours—is sometimes advised and is theoretically correct, i. e., for absolutely air-tight inclosures, there is great difficulty in securing such a degree of tightness; hence greater strength and longer exposure are desirable. On the other hand the rate advised by many is excessive, especially when three days' exposure is also advised.

In some cases hydrocyanic-acid gas at the usual rate of 10 ounces of cyanid of potash to 1,000 cubic feet will be found useful, where for any reason bisulphid of carbon is considered undesirable. This remedy has not been tested for this species in its occurrence in broad beans, but it has been successfully employed against related weevils and it should not be difficult for this gas to penetrate a mass of these larger seeds.

In the practical fumigation of beans, peas, and similar seeds with bisulphid of carbon it should be first understood that the more nearly air tight the receptacle the more perfect the fumigation. Infested seed should be placed in large barrels, which should then be closed tightly, or in specially made fumigating boxes, bins, or small houses. After filling the receptacles with the seed the bisulphid is poured into evaporators, for which purpose tin pie plates are most valuable, placed on the top of the seed. The gas, being heavier than air, descends through the mass of seed, and, properly applied according to directions, will kill all of the insects contained. At the end of about 48 hours, which is sufficient for perfect fumigation under these conditions, the seed should be removed and thoroughly aired before being packed away for storage. If left in the receptacles, the dead bodies are apt to decay, and thus injure the seed for food or planting.

The usual precautions not to bring fire of any kind, such as a lighted cigar, into the vicinity of the place where the operation is being performed should be observed. Where the covers or doors of the receptacles do not fit perfectly tight, paper should be carefully pasted over.

In any form of leguminous seed the penetrating power of bisulphid of carbon, hydrocyanic-acid gas, and other gases is as nearly perfect as could be wished.

CONSTRUCTION OF A FUMIGATOR.

The extensive pea growers of our Northern States, especially in New York and Michigan, have largely adopted what was known in former years as Tracy houses, named after Prof. W. W. Tracy, now of this department, and also called "bug houses," for the fumigation of peas affected by the related pea weevil. The opinion is somewhat prevalent that in spite of the fact that we can control the broad-bean and pea weevils by means of heating, soaking, and similar mechanical methods, everything considered, fumigation on a large scale, while a little more expensive, is more thorough and requires less labor. The same is true of grain and other material in general affected by weevils and insects of similar habits. The simplest and least expensive remedy consists in the establishment of a quarantine or fumigating building, bin, or box, to be made as nearly air tight as possible, in which the peas, beans, or other infested material can be placed as soon as harvested. After fumigation, if properly conducted, the broad beans or other material can be safely placed in permanent storage without danger of reinfestation from the species which is being considered.

A building, box, or room of about 100 to 200 bushels capacity suitable for the fumigation of a quantity of beans, peas, or grain would contain about 500 cubic feet. A fumigator of this cubic capacity might be built 8 feet square by 8 feet in height. A good, and perhaps the best, preventive for the escape of the gas would be to line the fumigator with sheet tin, with soldered joints, and over sheathing. Another method would be to sheath the room inside, cover the walls, ceiling, and floor with tarred or heavy building paper, with the joints well lapped, and cover the inside with matched ceiling boards. The fumigator should always be equipped with a tight door, in which the joints have been broken, similar to the door of a refrigerator or safe, and should close with a refrigerator catch against a thick felt weather strip, which should render it practically gas tight. Thus constructed it would furnish sufficient space for the fumigation of about 200 bushels of seed material. There would also be sufficient space for the application and diffusion of the carbon bisulphid from the top with a charge of more than necessary for the amount of seed treated.

It is highly desirable to have this fumigating building isolated, because of the danger in the use of bisulphid of carbon, its inflammability, and liability to affect live stock. The writer has had personal experience with several such fumigators in Washington, D. C., and with one in Chicago years ago. The latter was constructed from an iron boiler and was fitted with a metallic door similar to those used in large bank safes. In this fumigator the writer was successful in destroying weevils and other insects in stored grains in 24 hours, using it at the minimum rate of 1 pound to 1,000 cubic feet of air space. In his experience in the use of more loosely constructed fumigators and other containers, peas, beans, and other useful legumes can be satisfactorily fumigated even more easily than can stored cereals. In recent experiments, in specially prepared fumigators which we are now using, it was found best to use 2 pounds to 1,000 cubic feet of air space. It is much better, also, to fumigate at a comparatively high temperature than at a low one, and an exposure of from 36 to 48 hours is better than one of 24 hours. After constructing a fumigator on the lines which have been indicated, the operator will be able to determine the best quantity of insecticide and the length of exposure to his own satisfaction. Perfectly air-tight inclosures are difficult to obtain unless specially constructed with this particular end in view.

A fumigator of the type described is illustrated by figure 20. It has a capacity of 100 cubic feet and is supplied with a pair of tight-closing handles, which are a necessity to prevent warping. Of three fumiga-

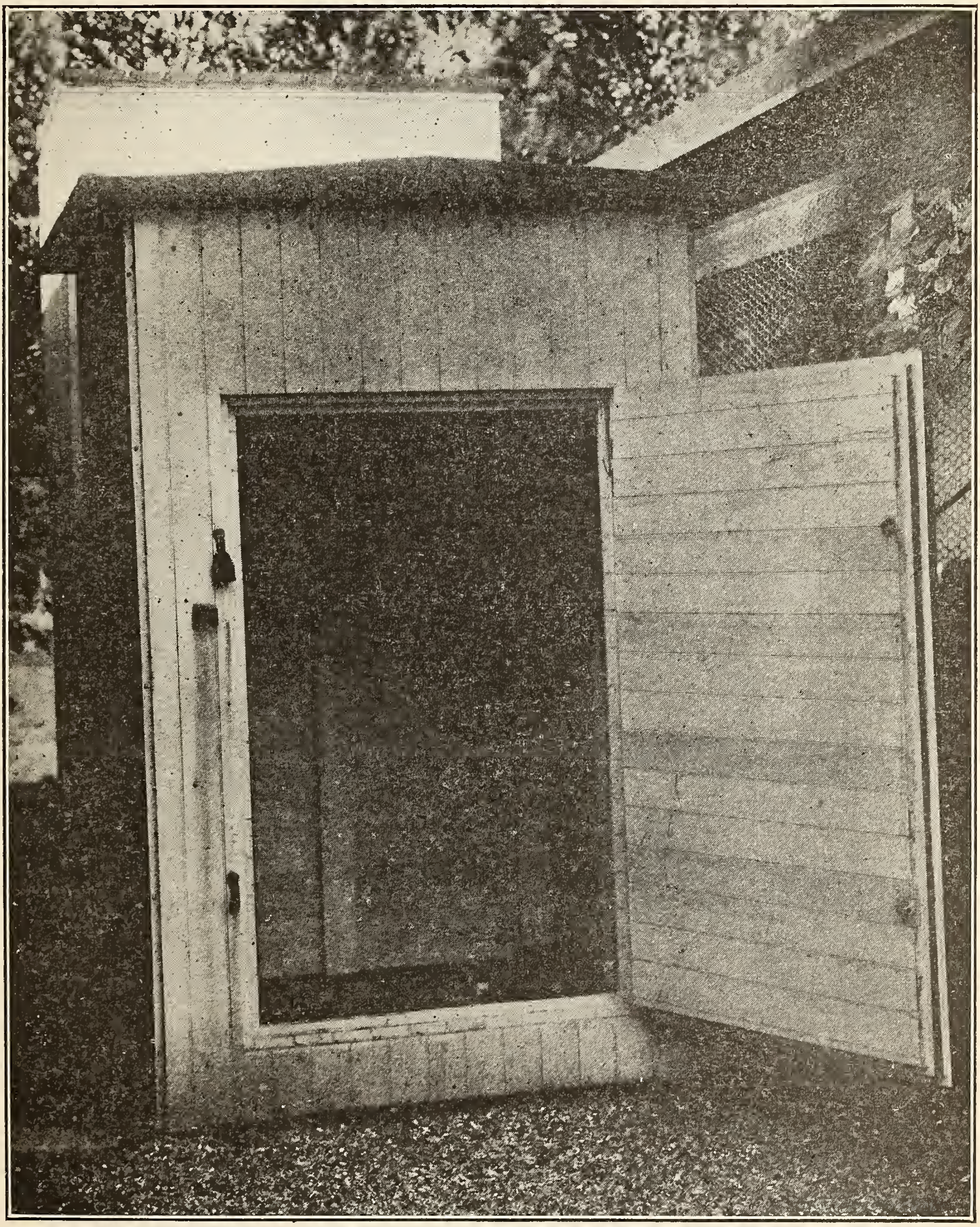

Fig. 20.—Fumigator used for stored products infested by insects. (Original.)

tors of similar pattern one was constructed with a single handle, which was not according to specification, and warped badly in consequence.

It should be added that in order to destroy insects in a fumigator or other inclosure at a temperature much below 50° F. a larger quantity of the bisulphid of carbon is necessary than when the temperature is about 80° to 90° F.

Dry heat.—In the series of experiments made by Mr. Parker in California, the exposure to the heat of the sun as a remedy is significant, but it is not certain what effect this would have if applied on a large scale. A series of experiments along this line should be made, and should also be carried on with other species of weevils in beans, peas, and cowpeas. This remedy has several times been suggested and probably some persons have already made tests of it, but we have no definite records to that effect. One of the best ways would be to place the infested seed on metal, such as roofing tin, especially if the temperature is particularly high, i. e., above 100° F.

Impossibility of prevention.—As in the case of other bean and pea weevils, there is no known method of preventing the ravages of the insect in the field, except the timely application of remedies before the seed is planted. It is not impossible that a certain degree of immunity from injury might be obtained by either very early or very late planting. This remains to be learned. In the case of choice plants grown for experimental purposes protection could be secured by the use of cloth screens as has been advised for such insects as the strawberry weevil and the root maggots.

Importation of parasites.—The insect might be held partly in check at least by the introduction of one or more of three hymenopterous parasites which have been previously mentioned.

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PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

THE COWPEA WEEVIL.

(*Pachymerus chinensis* L.)

By F. H. Chittenden, Sc. D.,
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INTRODUCTION.

The seed of cowpeas are subject to the attack of several species of beetles, of which the cowpea weevil (*Pachymerus chinensis* L.) and the four-spotted bean weevil (*P. quadrimaculatus* Fab.) appear to be specific enemies, injuring the seed in much the same manner as does the common bean weevil. Like that species they begin operations in the field, and continue to breed for successive generations in the stored seed until they entirely spoil it for food and seriously impair its germinating power. Both species are generally distributed and injurious in the South, and are widening their range with the increasing use of their food plant as a soil renovator and as forage.

The cowpea weevil resembles the four-spotted bean weevil superficially in appearance, as in habit, but these two species differ to some extent in various details of their life economy, as well as in structure and distribution. They belong to the same genus of the family Lariidæ (Bruchidæ).

DESCRIPTIVE.

THE GENUS PACHYMERUS LATREILLE.

The genus Pachymerus, as defined by Allard, includes species having the following characteristics:

Posterior femora much thickened, armed on the underside near the extremity with small unequal teeth, and the tibiæ slender and curved.

The following is Schœnherr's definition:

Antennæ somewhat longer than the thorax, becoming wider toward the apex, compressed; joints subperfoliate, half as long as body, last six to eight joints acutely serrate. Head carinate. Eyes sublateral, deeply emarginate, prominent. Thorax in front strongly coarctate, slightly narrower than head; behind deeply bisinuate; in the middle lobed, with acute angles. Elyta subquadrate, the apices separately rounded, above subplanose. Pygidium large, rounded at apex, descendant. Posterior femora strongly incrassate, slightly toothed and serrate about apex. Tibiæ terete [cylindrical], posterior tibiæ arcuate. Body short-ovate, more or less convex.

THE BEETLE.

The cowpea weevil may be readily distinguished from all other species of the family inhabiting the United States by the two large, elevated, ivory-like lobes at the base of the thorax and by the strongly pectinate antennæ of the male (see fig. 21, *a*). The body is more robust than that of other bean and cowpea feeding forms.

The ground color is dull red, sometimes more or less blackish, variegated with black, brown, yellow, and gray or white pubescence. The pattern of the elytra varies, that shown in the illustration being the prevailing form, the combination of colors making, with the somewhat feathery antennæ of the male, one of the most beautiful species of its family to be found in America north of Mexico. The darkest spots at the sides are not round and conspicuous as in the four-spotted bean weevil, and the apical spots are sometimes wanting, while often black is the prevailing color of the dorsal surface.

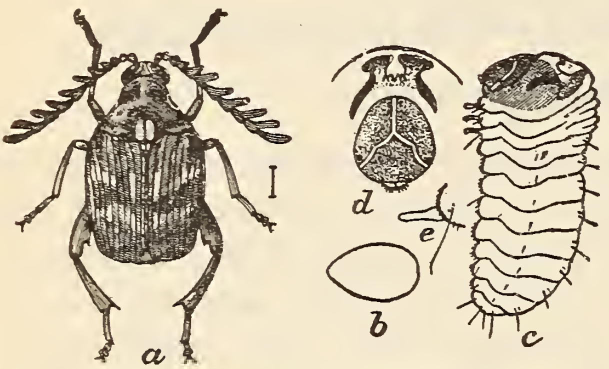

FIG. 21.—The cowpea weevil (*Pachymerus chinensis*): *a*, Adult male; *b*, egg; *c*, post-embryonic larva; *d*, front view of head of same; *e*, thoracic leg of same. *a*, Much enlarged; *b*, *c*, more enlarged. (Author's illustration.)

The following description, under the name *scutellaris* Fab., is from Horn's synopsis, published in 1873: [5]*

Short, robust, brownish, opaque. Hard brown, opaque, densely and coarsely punctured, front subcarinate. Antennæ variable, usually pale rufous, rarely with the outer joints nearly black, as long as head and thorax, male pectinate, female serrate. Thorax trapezoidal, sides nearly straight, base trisinuate, median lobe emarginate at middle; color brownish opaque; surface coarsely punctured intervals rugoso-granulate; median line in front and narrow space at sides sparsely clothed with cinereous pubescence, a small whitish spot on each side of the median line near the middle of the thorax, basal lobe white, ivory-like, clothed with whitish pubescence. Scutellum convex, white. Elytra sub-quadrate, feebly convex, wider at base than thorax; surface striate, striæ punctured, intervals flat, scabrous or finely punctulate; color usually brownish or ferruginous with darker spaces at base and humerus, and a darker space at middle of side connected along the margin. Pygidium nearly vertical, clothed with ochreous hairs, with a whitish line along the middle and a reniform brown spot on each side near the apex. Body beneath brownish, densely punctulate, sparsely clothed with whitish hairs; abdomen paler, with a band of white hairs at the sides. Legs, anterior and middle pairs, pale rufous,

* The small figures refer to the bibliography, pp. 93 and 94.

hind legs dark rufous or brownish. Hind femora armed near the tip with an acute tooth on the outer and inner side.

Length 2.5–3.5 mm.; width 1.5–1.8 mm. Smaller individuals, dwarfed, are frequently seen.

THE EGG.

The egg is ovate in outline, somewhat variable, but usually less than two-thirds as wide as long, rather broadly rounded anteriorly and more narrowly posteriorly, the extreme apex rounded, convex exteriorly and flattened interiorly. The attached surface is variable, but of considerable quantity, flattened upon the seed upon which it is deposited, a lateral view presenting the impression of an egg severed in half. When freshly laid it is clear, translucent. The surface is smooth, shining, with no visible sculpture.

Measurements of five eggs gave the following figures:

No. 1. Length 0.48 mm.; width 0.27 mm.
2. Length 0.49 mm.; width 0.32 mm.
3. Length 0.58 mm.; width 0.31 mm.
4. Length 0.51 mm.; width 0.33 mm.
5. Length 0.49 mm.; width 0.31 mm.

The above show a variation of from 0.48 to 0.58 mm. in length and from 0.27 to 0.33 mm. in width.

The empty eggshells on the seeds or pods in the course of time become opaque gray.

THE POSTEMBRYONIC LARVA.

The newly hatched larva (fig. 21, *c*) resembles somewhat that of the pea weevil. It is of course smaller, the minute temporary legs (see *e*) are apparently not jointed, and the prothoracic plate (*d*) bears blunt rounded teeth instead of acute spines.

SYNONYMY.

Pachymerus chinensis L.

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DISTRIBUTION.

This species is cosmopolitan in the widest sense of the word. Until comparatively recent years there appeared to be a belief prevalent among persons who have observed the cowpea-inhabiting weevils that the cowpea weevil was not so firmly established in the United States as the four-spotted form. It is not only thoroughly acclimated throughout the Gulf region, but appears to be found generally in temperate regions at least as far north as the District of Columbia, where it practically may be taken nearly every year in the field. In the year 1896, when many cowpeas were grown in the District, it was very abundant in the field in September. Since that time it has not been so noticeable, probably because cowpeas are not so extensively grown here. It was the prevalent species in cowpeas in the Norfolk region in 1911. It is fairly certain that it is capable of establishing itself wherever its food plant will grow.

Described from China it was later identified in seeds from many localities and is now widely known through its distribution by commerce, being particularly abundant in tropical countries. Its recorded distribution abroad includes Europe; China, Japan, East India, and Korea, in Asia; Egypt, Sierra Leone, Barbary, Algeria, Rhodesia, Amani, and the Cape of Good Hope, in Africa; Porto Rico, Bermuda, Jamaica, British West Indies; Panama, Brazil, and Chile, in tropical America; Hawaii, Celebes, Java, Dutch East Indies, and Mauritius.

The cowpea is credited with having first been cultivated in this country in the early days of the eighteenth century, and the weevil came with it or soon afterwards, but there is no available record of the occurrence of the insect here earlier than 1853.[1]

LIFE HISTORY AND HABITS.

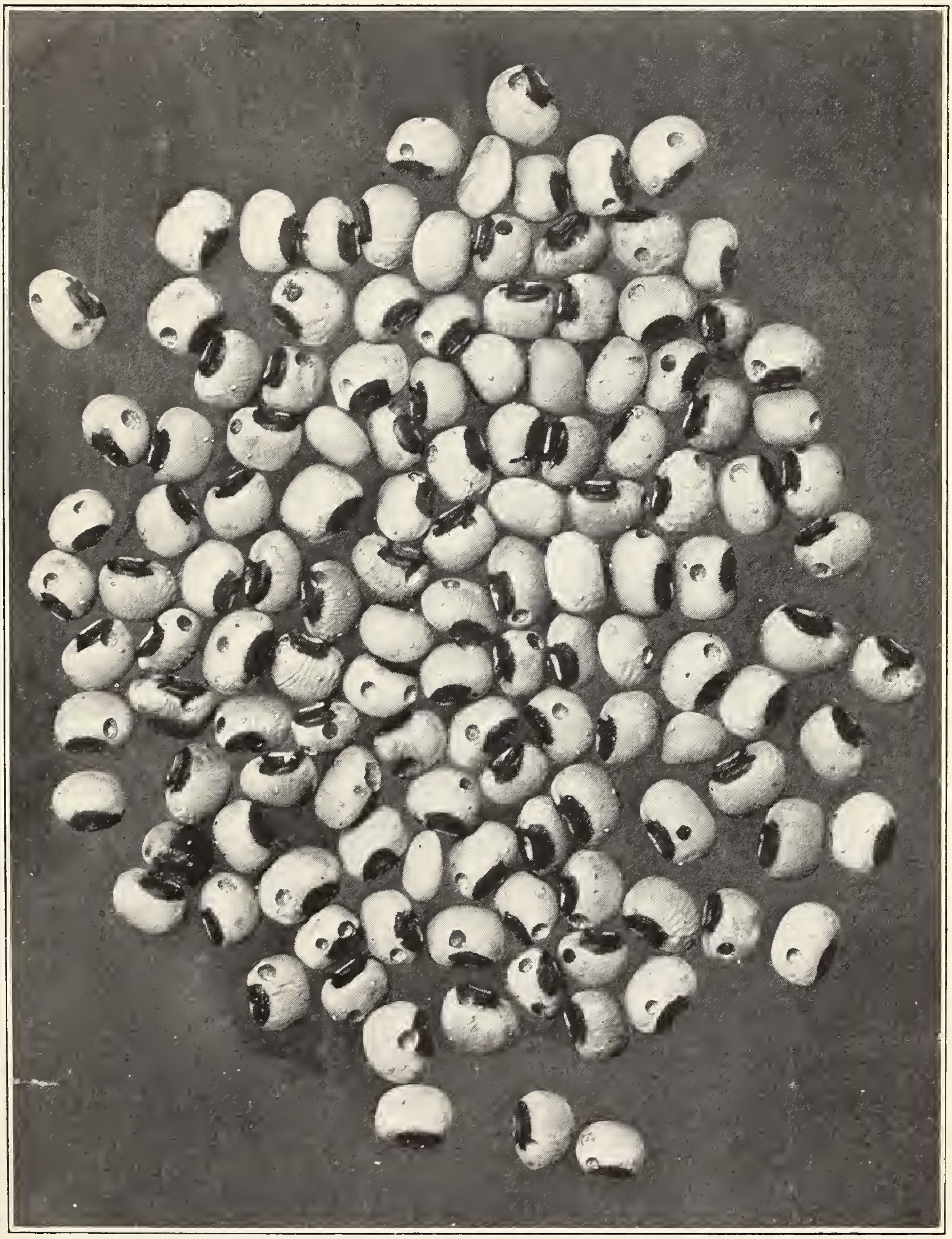
OVIPOSITION.

The usual process of oviposition on dry beans and similar seed as observed by the writer is as follows:

The female crawls about the seed to select a place for deposition; after a few seconds she stops and remains perfectly quiet and in less than a minute, sometimes at once, begins to extrude the egg, completing the operation by a curious and vigorous wriggle from side to side and a short forward motion as the egg is deposited. Within less than another minute, sometimes at once, she turns about and examines the egg with her palpi. Sometimes this is omitted and she rests for a time; again she proceeds at once to repeat the operation in from three to four minutes after the first egg was laid, always crawling about for half a minute or more to select a new place for its reception.

Apparently it is the general rule with this, as well as with related species and with many other beetles, to deposit each egg on a different seed, but sometimes two, three, or even four are deposited on the same seed by the same female, and other females follow until an indefinite number are deposited on one seed. As many as 30 eggs may be counted, in badly infested material, on a single seed of cowpea measuring three-eighths of an inch in length. Plate I shows the eggs of this species on Blackeye cowpeas.

[1] F. E. Melsheimer, Cat. Col. U. S., 1853, p. 99, mentioned as *scutellaris* Fab., synonym of *sinuatus* Schoen.



BLACKEYE COWPEAS INFESTED BY THE COWPEA WEEVIL (PACHYMERUS CHINENSIS), SHOWING EGGS AND EXIT HOLES. (ORIGINAL.)

In a heated period the beetles may be so active as to gnaw their way out from the holes in the seed within 24 hours. The males seek the other sex almost as soon as they emerge from the seed and copulation and egg laying begin very soon thereafter. Copulation has been witnessed within at most four hours after issuance, and eggs have been found the same day.

LIFE-CYCLE PERIODS.

This species was kept breeding throughout the winter in a warm room with an average temperature of about 70° F. During March and April experiments on the life cycle were begun. A number of adult weevils were confined in a rearing jar with fresh beans April 27, and removed after 24 hours, numbers of eggs having been laid during that period. From this lot larvæ began to emerge from the eggs May 5, showing a period of incubation of 8 days or about the same as for (*Bruchus*) *Acanthoscelides obtectus* in about the same temperature, which has been ascertained to be between 8 and 10 days.

A larva, about to transform to pupa on April 9, pupated on April 10, and appeared as imago April 20, or in 10 days, in similar cool weather in April. Five larvæ were removed from their cocoons in the beans and assumed the pupal state April 20, from which two issued as imago April 27, or in 7 days in slightly warmer weather. The remainder failed to transform, and it was noticed that about 25 per cent of the larv, removed from their cocoons when about to transform to pupæ, perished before assuming the adult condition, showing the necessity of the protection of the cocoon within the seed.

A pair of weevils was confined in a rearing jar May 23, with chickpeas, and from this lot the next generation was obtained June 24, or in 32 days.

In another lot of chickpeas, which were still drier than the last, the imago did not develop until 38 days, showing that this species naturally develops in fresh seed more rapidly than in dry seed. In garden peas, beetles developed in 30 days, from June 7 to July 7, in still warmer weather. In other lots kept under different conditions in a cooler room, the entire life cycle in March and April was 45 and 60 days in two experiments.

Another experiment was made in a hot room during the latter part of June and in July and the entire life cycle was passed in 21 days, from egg to adult, showing with the next experiment that in the warmest season of the year in a climate like that of the District of Columbia, where the temperature not infrequently reaches from 90° to 100° F. for prolonged periods, this insect may pass through its transformations in an astonishingly short time.

Finally a lot of fresh beans was placed in a rearing jar containing beetles June 23, and in a few days the beans were removed covered with eggs. The beetles were also removed. On July 12 two males emerged from this lot and the first bean opened disclosed a newly hatched beetle. Allowing at least a day for the beetle to mature sufficiently to gnaw through the outer shell of the bean, we have in this case the completed life cycle in 18 days.

NUMBER OF GENERATIONS.

It will be readily seen that with a species capable of developing in from three to eight weeks according to temperature, we have a possibility in a heated atmosphere of six, seven, or even eight generations annually. Knowing the effect of temperature on the development of insects in general, and of a rapidly breeding species like the present in particular, we may say approximately that throughout the coldest months in the District of Columbia, January and February, in storage in a heated temperature of about 70° F., it is possible for one generation to develop; in the higher temperatures indoors during March, April, and May, two generations; in the still higher temperatures of June, July, and August, one generation in each month; in September and October, one generation; and between the latter part of October and the last of December another generation, making a theoretically possible annual total of eight generations. There is apt to be a resting stage, however, at some point, as was observed on one occasion. During the second week of April, in a heavily infested lot of seeds where the beetles were emerging in large numbers, literally by hundreds almost every day, development suddenly ceased and the beetles did not again appear until about a week later. Two days afterwards they had again become abundant. In cool temperatures the number of generations will be less—three, four, or five—while in colder temperatures the species will probably not survive.

Some other records, the details of which have not been preserved, are available showing that the egg period in the high temperature of midsummer weather may be four or five days and the pupal stage a similar period. A summary of the different periods is shown in the following table. The larval periods are necessarily estimated by subtracting the period of incubation and that of the pupa from the total life cycle. The other periods which are indicated in the table by a star (*) have been estimated in a similar manner; the remaining periods have come under actual observation.

Developmental periods and life cycle of the cowpea weevil.

	March-May.	June-July.	Minimum.	Maximum.
			° *F.*	° *F.*
Egg	8, 10	3*, 4, 5, 6*	3*, 4	10
Larva	17, 25, 40	12, 13, 18	12, 13	40
Pupa	7, 10	3*, 4, 5, 6*	3*, 4	10
Cycle	32, 45, 60	18, 21, 30	18	60

LONGEVITY OF ADULTS.

The beetles of this species have not been noticed feeding. Possibly they feed on the nectar of flowers in the open, but this is not essential to their existence. In experiments to determine the duration of life indoors considerable variation was encountered. May 16, 20 adults recently developed were separated and placed on dried beans. All were dead on May 28, with one exception—a male, which lived until June 21—showing the longevity of 19 individuals to be 12 days and for this one 36 days. Similar experiments were made under perhaps better conditions and some beetles were still living at the end of 17, 18, 19, and, in one case, 25 days.

FOOD PLANTS.

This species is seemingly capable of breeding on most forms of edible legumes, infesting practically all of the cowpeas and beans, and their numerous varieties, "Adsuki" beans (*Phaseolus radiatus*), pigeon peas (*Cajanus indica*), garden and field peas, lentils, chick-peas (*Cicer arietinum*), and the Ceylonese seeds known as "gram" or "mung," and in their native home as "kolu" and "muneta," *Phaseolus mungo*.

We have reared it from *Vigna catjang* and *V. unguiculatus* of many varieties, *V. sinensis*, and *Dolichos biflorus*, and the species has been collected in fields of broad beans. In the case of its attacking lentils, the beetles have, on several occasions, been found in India and in the dry seeds in the District of Columbia. It is not probable that the species can develop in the smallest sized seeds, unless it infests them in the same manner as the lentil weevil does in the field by traveling from one seed to another in the pod. Glycine, a small green variety of soy bean from China, from which we have reared it, appears to be an unrecorded food plant. Of other food plants, Lefroy and Howlett [22] have recorded *Dolichos lablab*, the hyacinth bean.

THE POINT OF EXIT OF THE BEETLE FROM THE SEED.

While examining some Blackeye cowpeas for illustration it was noticed that the majority of the seed showed exit holes of the beetle on the anterior or left half of the seed viewed with the plumule or germ end downward. To learn how general this was, 100 seed were counted out, with the result that 47, or nearly 50 per cent, showed exit holes on the anterior half, 29 on the posterior or right half, 8 near the middle, and 5 near one end, while 11 showed two exit holes. These seed were from the field at Norfolk, Va., where only moderate infestation occurred. In no case was the plumule or germ invaded, the beetles not even attacking the "eye" or black area surrounding the germ. Whether this location of the exit hole, which shows the point at which the larva developed, is constant or not, or whether it is due to the manner of growing, or exposure to direct sunlight, or to shade, remains to be learned. It is not an economic proposition, but is a matter of some interest scientifically.

Another lot of cowpeas infested by the four-spotted bean weevil was examined for comparison and gave similar results. Estimated by percentages of exit holes, on the left side there were 48 per cent, on the right side 26 per cent, near the center 8 per cent, and at one end 6 per cent, while 12 per cent contained two exit holes. It is easy to separate the work of the two species in spite of this fact, however, because of the larger and somewhat more irregular exit holes made by the beetle of the four-spotted species.

SUSCEPTIBILITY OF DIFFERENT VARIETIES OF COWPEA.

From observation of the seed of cowpea grown upon the experimental plats of the department grounds and obtained from other sources it appears that certain varieties are preferred to others by the cowpea weevil as well as by weevils of related habits. When the insect is extremely abundant it is not apt to discriminate between varieties; or, in other words, if the favorite plant is not present in the vicinity where the insect happens to abound, it will not hesitate to attack whatever variety may be ready at hand. There is the best of evidence for the belief that these weevils, like the grain weevils (Calandra), prefer the softest seed because more easily penetrated, and that they experience more or less difficulty in entering harder seed.

The favored variety here, and apparently elsewhere, judging mainly from seed taken direct from the field, appears to be the Blackeye, although all the varieties grown were attacked, the Lee variety less so than any of the others. The different varieties observed are listed in approximate order of infestation as follows: Blackeye, Browneye, Black, Lady, Rice, Manakin, Southdown, Red Ripper, Whippoorwill, New Era, Red Crowder, Unknown, and Lee.

SUMMARY OF LIFE HISTORY.

The cowpea weevil does not differ very strikingly in its life habits and economy from the common bean weevil. A careful study of the biology of each, however, has been rewarded by the development of certain points of difference, which may be briefly summarized.

The eggs are deposited on the outside of the growing pods in the field and upon the dried seeds, and are attached by a glutinous substance which covers the egg and extends somewhat around it. The larvæ hatch from them in four, five, or more days, depending upon the season, temperature, and other circumstances, and burrow into the pods to the developing seed, which they penetrate. In two or three weeks in midsummer weather, and in about two months in cooler weather, they attain full growth, when they present much the same appearance as the larvæ of other bean and pea weevils. The pupal state lasts from about four or five days in warm weather to considerably longer in cooler weather, whereupon the beetle form is assumed. The beetle gnaws its way out of the seed in the same manner as do the related species, by cutting a round flap through the skin of the pod. The first brood which develops in the field attains maturity by about the third week of September, or perhaps earlier, if we may judge by the appearance of the exit holes in the pods and the further fact that certain varieties of cowpea mature sooner than this.

The beetles continue to develop in the stored seed for several generations, in fact until the seed becomes completely ruined for any practical purpose and unfit even for the sustenance of this insect; then decomposition sets in, inviting swarms of mites, and the beetles are forced to other quarters in their struggle for existence.

In a fairly warm indoor temperature six or seven broods probably develop annually in a latitude like that of Washington, D. C.

LITERATURE.

In 1758,[1] Linnæus described this species, giving it its specific name from its known habitat at that time. On this head he wrote "*Habitat in Pisis omnis generis, e China allatis*," showing that its injurious habit was known even at that early date, and that China was evidently the original home of this species.

It will not be necessary to mention all of the references cited in the bibliography which will follow.

In 1890 Dr. J. A. Lintner[9] published the first general account of this species. His published life history was a surmise, and later proved to be incorrect by his own statement. In 1896 Messrs. Osborn and Mally[16] gave a more extended account of this species, based on its occurrence in Iowa, with notes on its life history, effects of fumigation with carbon bisulphid, and results of germination tests to determine the effect of bisulphid of carbon on the fumigated seed. The difference in comparison with a check lot showed practically no injury by this form of treatment, the final conclusion being reached that "the germinating power of the seeds was not impaired." Three new food plants were mentioned—green field peas, horse beans, and soy beans. Unfortunately this species was confused with the related four-spotted bean weevil, both being present in the seeds under observation. The following year, 1897, the writer[17] brought together a summarized account of this species based largely on personal investigations, and the year afterwards[18] gave a more general economic account, together with figures and brief descriptions of the egg and postembryonic larva. In 1909 Lefroy and Howlett[21] recorded three new food plants.

It is interesting to note that it has been noticed of this weevil that material infested by it undergoes marked elevation in temperature, particularly at times when the beetles are undergoing transformation and issuing from the seed. In one instance, the temperature of a small sack of seed infested by the cowpea weevil was found to be 25° F. higher than the surrounding atmosphere.

METHODS OF CONTROL.

General remedies.—The remedies to be employed for the cowpea weevil are practically the same as for the bean weevil and the four-spotted bean weevil, both of which have the same habit of breeding continuously in stored seed. Remedies are fully discussed under "Methods of control" in a previous article on the broad-bean weevil.[a] Bisulphid of carbon and hydrocyanic-acid gas fumigation are the best. The hot water remedy, dry heat, and the introduction of parasites from localities where these are established, into others where they are not known to occur, are all desirable. It should be added that it is impossible to prevent injury in the field or to stamp this species out, since it is already too well established from Maryland southward and westward.

Holding over the seed, as practiced for the pea and broad-bean weevils, is a useless remedy for this species.

Full directions for the application of dry heat and of hot water, and for fumigation with bisulphid of carbon, are given in the article on the broad-bean weevil and instructions for fumigation with hydrocyanic-acid gas are furnished in Circular 112 of the Bureau of Entomology.

Drying the seed.—Frequent inquiry is made in regard to the control of weevils in cowpeas by what is known as "kiln drying," a method which is stated by correspondents in the South to be used in California. Inquiry of several agents of this bureau who have been engaged in work in California fails to elicit the fact that the kiln-drying process is used in that State; indeed, we have no specific knowledge of the use of this practice in any locality. There is, however, a process which is sometimes so termed. It consists of passing cowpeas, grain, and other seeds and foodstuffs over heated pipes, or passing heated air through them in such a manner as to subject the infested material to a temperature of 135° to 140° F., which is fatal to the larvæ and adults of the cowpea and other weevils, as it is also to their eggs. This process is at present used mainly for grain, espe-

[a] Bul. 96, Pt. V, Bur. Ent., U. S. Dept. Agr., pp. 75–80, 1912.

cially for corn stored in elevator tanks, and has proved to be quite efficient. While we have advised this remedy for some time, we have had no opportunity to test it personally and none of our correspondents has written in regard to its value. There is no reason, however, for supposing that it should not prove effective to all insects in cowpeas or other leguminous seed as well as to those in other stored products. This process is simplified by the use of a machine called a "dryer." Several forms of this instrument are in use. They are manufactured by firms in Massachusetts, Chicago, Ill., and New York State.

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