THE HAM BEETLE, NECROBIA RUFIPES DE GEER[1]

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INTRODUCTION

The principal species of insects and mites which damage smoked meats fall into two rather distinct groups: (1) Those that infest newly smoked, juicy meats—the cheese skipper (*Piophila casei* L.) and several species of blowflies (*Lucilia sericata* Meig., etc.,); (2) those that infest meats which have become dried to some extent by evaporation during long storage or as a result of prolonged smoking, or both—the ham beetle (*Necrobia rufipes* De G.), the larder beetle (*Dermestes lardarius* L.), the leather beetle (*Dermestes vulpinus* Fab.), and certain mites. The species described in this paper is the most important of the second group, and it is sporadically very injurious where smoked meats are stored for rather long periods. A large part of the expense of protecting cured meats with wrappings, sacks, and washes may properly be charged to this insect.

Riley (*24*)[2], who made the first economic investigation of the insect 50 years ago, cited cases of extensive injury to hams in St. Louis and Boston. In the dispute arising because of the infested stocks at Boston the consignee claimed that the husk paper in which the consignor had wrapped the meat was likely to generate the worm. The referees of the case deposed, however, that "a warm, damp atmosphere and want of free circulation of air on the hams will produce or generate the worm in light-salted sugar-cured hams."

During the summer of 1921 a severe infestation developed in dry-cured Army bacon stored in crates at Baltimore and later at Washington. There were about 220,000 pounds of this bacon, and it was reconditioned by extensive trimming, which in many cases reduced the weight of sides by 75 per cent.

Howard (*16, p. 105–107*) defined the status of the pest as it is at present when he stated, in 1902, that it is hardly a species which causes a constant drain on the trade, but occasionally becomes extremely abundant, ruining large quantities of cured meats.

SYSTEMATIC POSITION, SYNONYMY

This species is the most injurious of the coleopterous family Cleridae, the larvae of which are typically predacious and often beneficial as enemies of economic insects, including the tobacco beetle (*Lasioderma serricorne* Fab.) and many species which attack forest trees.

De Geer (*12, p. 165*) published the original description as *Clerus rufipes* in 1775. In 1796 Latreille (*18, p. 35*) erected the genus Necrobia. Mulsant and Rey (*22, p. 122–124*), who placed the species in the genus Agonolia, listed *Clerus rufipes* De Geer, Oliv., *Dermestes rufipes* Fab., *Corynetes rufipes* Herbst., etc., *Necrobia rufipes* Oliv., etc., as indicating the four genera to which the present species had been referred:

The following specific references (*27, p. 142–143*) are synonymous with *rufipes:*

amethystina Steph., 1832, Ill. Brit. Ent. 5: 417; Klug, 1842, Clerii, Phys. Abh. K. Akad. Wiss. Berlin for 1840, p. 394.
dermestoides Pill. et Mitterp., 1783, It. Poseg., p. 68, pl. 7, fig. 8.
foveicollis Schklg., 1900, Mitt. Nat. Mus. Hamburg 17: 20.
glabra Champollion, 1814, Millin Mag. Encycl. 3: 44; 1902, Schenkling, Bul. Mus. d'Hist. Nat. 8:332.
mumiarum Hope, 1834, Pettigrew, Hist. Egypt. Mum., p. 54, pl. 5, figs. 1–3; Schenkling, op. cit., p. 332.
pilifera Reitt., 1894, Verh. Nat. Ver. Brünn 32: 85; Abeille, 1895, Bul. Soc. Ent. France 1: 208.

COMMON NAMES

The common name "red-legged ham beetle" was given to the insect by Riley (*24*) in 1874. An article in the Yearbook of the United States Department of Agriculture for 1907 (*1, p. 552*) referred to the pest as the "ham beetle." Dealers in meats know the insect by the name "paper worm."

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[1] Received for publication April 22, 1924; issued June, 1925.
[2] Reference is made by number (italic) to "Literature cited," p. 863.

According to Froggatt (*10, p. 26*) *N. rufipes* is known in the Pacific Islands as the "copra bug."

Inasmuch as the other beetles which sometimes attack smoked pork already have well-established common names—"larder beetle" and "leather beetle"—the writers prefer the name "ham beetle" for *Necrobia rufipes* De Geer.

THE ADULT

TECHNICAL DESCRIPTION

Form oval, sides subparallel, widest at apical fourth. Color blue, sometimes with violaceous or greenish luster, legs and first five segments of antennae castaneous, terminal six segments of antennae and the trophi piceous, eyes black, venter aeneous black. Head rather sparsely punctured, the punctures large and small intermingled, median portion of frons and vertex with very few punctures. Pubescence sparse, erect, and black. Eyes finely granulated, with a triangular emargination approximate to the antennal insertion. Labrum emarginate. Both maxillary and labial palpi with subcylindrical, slightly acuminate terminal segments. Antennae each with eleven segments; the first thick, slightly bent; the second about one-third the length of first, equilateral; third almost twice the length of second but of equal thickness; fourth to eighth mutually equal in length, each just perceptibly wider than the one preceding; the eighth is transverse; ninth and tenth strongly transverse, subequal, about one-half as long as broad; the eleventh almost square. Pronotum transverse, sides evenly curved from base to apex, basal and apical angles very obtuse, almost wanting, lateral cariniform margin distinct, finely serrulate. Surface rather sparsely set with moderately coarse punctures; punctures much more dense at sides than on disc; pubescence as on head. Scutellum small, transverse. Elytra long, suture closed, lateral margin finely beaded, each with nine distinct rows of punctures, the normally occurring tenth row being confused with the ninth; rows obsolete just behind the middle, surface between puncture rows and of apical portion rather densely set with fine punctures from each of which a posteriorly-directed subrecumbent black hair arises. Under parts and legs rather finely and densely punctured, clothed with pale fulvous pubescence with a few longer black hairs interspersed. Legs moderately long, femora not greatly enlarged, tibiae straight, tarsi short, of five segments of which the fourth is very small and concealed between the lobes of the third, first three segments with lamelliform pads beneath. Claws rather long, provided at base with a broad toothlike appendage. Length: 3.5 to 7 mm.[3]

In the female each of the elytral punctures, which are arranged in rows, gives rise to a stiff black hair slightly inclined anteriorly; in the male these hairs are subrecumbent and directed posteriorly. Other secondary sexual characters are absent.

ADULT BEHAVIOR

After the transforming insect becomes adult, it gnaws an irregular hole in the wall of the pupal cell, and emergence occurs. The meconium is voided in the cocoon. Sometimes a day or two elapse between the time the adult becomes fully pigmented and its escape, and in the case of adults emerging in vials they often return to the cell for concealment.

Mating usually occurs promptly after two newly emerged beetles of opposite sex are placed together, and is frequently observed during the long oviposition period, especially when the beetles appear frightened during manipulation of the dishes in which they are confined. The forwardly directed elytral spines of the females doubtless materially assist the males, which are usually smaller than the females, in maintaining their position during copulation.

Besides sharing in the attacks of the larvae upon ham and cheese, the adults are markedly predacious and also cannibalistic. It is apparent that the beetles and their larvae can destroy an infestation of cheese skippers (*Piophila casei* L.) in ham,[4] and under some conditions, as in stores of bones, they probably are beneficial to the extent that they help destroy the maggots of skippers and blowflies. In the laboratory experiments fat bacon was a much less favored food for adults than skipper larvae.

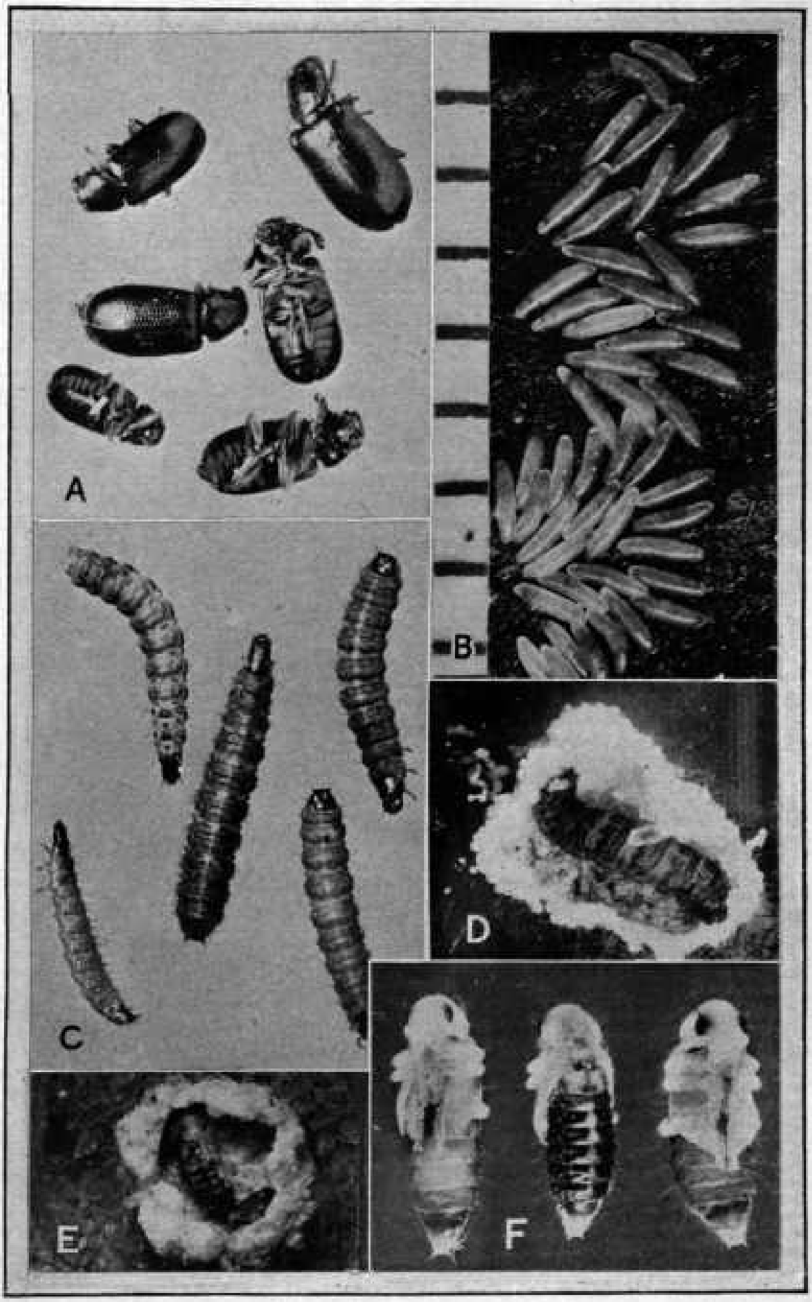
Even when fed daily with skipper maggots, ham beetles sometimes dismember an individual of their own species and then proceed to devour it. Specimens which die naturally are usually promptly eaten. The beetles have also been observed by the writers to eat the eggs and larvae of their own species, and where adults become very numerous, as has occurred in boxes of smoked meat under observation, their cannibalism is apparently responsible for a great reduction in the number of their larvae. Adults which are deprived of food usually die in two or three weeks.

During hot weather the beetles may be seen in slow flight about infested rooms. The usual mode of progression, however, is by rapid running. When roughly handled they feign death for a short time; as a rule they are negatively phototropic and quite wild, but those which are confined and exposed to light during the day and fed frequently become increasingly tame. On being held in the fingers or forceps a strong, very disagreeable, but transient, odor is emitted.

A photograph of several ham beetles is shown in Plate 1, A.

[3] The writers are indebted to Edward A. Chapin for the foregoing technical description.

[4] A similar service in stored products by a clerid has been reported by G. A. Runner (*26, p. 35*), who stated that *Thaneroclerus girodi* Chevrolat apparently at times causes the complete disappearance of *Lasioderma serricorne* Fab. from boxes of infested cigars.



Necrobia rufipes

A.—Adults. ×4
B.—Eggs laid on cardboard. (Showing the edge of a millimeter scale)
C.—Full-grown larvae. ×3
D.—Larva in cell made between plug of black cotton and side of vial
E.—Pupal cell on canvas sack, opened to show pupa and cast prepupal skin
F.—Pupae

THE EGG

The egg of *Necrobia rufipes* is about 1 mm. in length and 0.25 mm. wide, tapered, and roundly pointed at both ends and slightly curved in outline. It is smooth, shining, translucent, and is glued in place. As shown in Plate 1, B, the eggs are usually deposited in clusters. Those laid by old females often partially collapse laterally within a few hours after being deposited, and such shrunken eggs do not hatch.

Toward the end of the incubation period (four or five days in length during warm weather) the four eye-spots of the embryo become visible, followed by pigmentation of the tips of the mandibles. Shortly after hatching, and in some cases before the escape of the larva, the caudal plate, head capsule, and prothoracic shield assume their final color.

HATCHING

The struggles of the hatching larva cause the posterior extremity to move about, with the result that the tubercles on the caudal plate tear the eggshell open at one end, the mandibles accomplishing the same at the anterior end. Thus the eggshell is usually torn open at both ends before the larva leaves it, and the larva often remains in the shell as in a short tunnel for several hours, feeding on the shell.

THE LARVA

TECHNICAL DESCRIPTION (*4, p. 597–599*)

Total length of body, about 10 mm.; extreme width, about 2 mm.; fifth to seventh abdominal segments widest; anterior width of prothorax one-half the width of the seventh abdominal segment; extreme thickness, 1½ mm.; seventh abdominal segment thickest. Corneous parts shiny, brown ocher; delicately chitinized parts shiny, pale clay yellow; membranous parts of thorax and abdomen dorsally mauve or lilac with white muscle attachments, ventrally whitish with bluish pattern. Frons rugose, anteriorly on each side of middle line with a shallow deepening. Labrum three times as wide as long; width about one-third the length of frons. Mandibles half as long as frons; length to width as 4 : 2; retinaculum and tooth same size, well developed, and rather obtuse. Two short mandibular setae. Prothoracic shield two-thirds as long as wide, with parallel sides. Both mesothorax and metathorax are about as long as prothorax, surpassing it one-third or more in width; metathorax a trifle wider than mesothorax; mesothoracic and metathoracic dorsal plates present, small, and about the same size. Basal plate of cerci a trifle wider than the prothoracic shield, length to width as 2 : 3. Cerci one-third the length of basal plate, upward curved, diverging about 60°.

LARVAL BEHAVIOR

The delicate, wrinkled, hairy larva after leaving the shell moves about but little for awhile, confining its activities as it gains strength to feeding on the unhatched eggs in the near vicinity and eating the shells of empty eggs. The shells are usually almost wholly consumed. New-laid eggs of the ham beetle, exposed to very young larvae which were also provided with dead skipper maggots, were all eaten. Eggs of *Dermestes vulpinus* Fab. were also eaten.

The postembryonic larvae are repelled by light, and, for the first day or so, prefer to spend most of their time hidden beneath some object, even when food is provided and light excluded.

The rearing of individual larvae (Table VII) was found to be practically impossible when fat bacon or skipper larvae were used as the only food. By feeding the postembryonic larvae with eggs of the ham beetle for 8 or 10 days after hatching, then giving both eggs and crushed skippers for 4 days and crushed skippers thereafter, single larvae were easily reared. To prevent the very small larvae from escaping or becoming entangled in cotton, the best container was found to be No. 11 veterinary capsules, the food being placed between two pieces of cardboard. The larvae thus reared reached a good size and molted two or three times before pupating. First skins measured 0.08 mm. between the tips of the caudal tubercles, second skins 0.25 mm., and third skins 0.5 mm. The molting skin splits over the thorax, the head is withdrawn from the head capsule and extruded through this opening, and the insect crawls out of the skin. There is much variation between the dimensions of the smallest and largest full-grown larvae, the latter being 100 per cent larger than the former.

Larvae of all instars are repelled by light. Well-grown larvae are able to crawl rapidly and to kill migrant skipper larvae. In their efforts to escape the maggots throw their attackers about with considerable force, but the latter seldom release their jaws until the maggots have become helpless. When touched, ham-beetle larvae protect themselves by thrashing about, bending their extremities together first on one side and then on the other. The full-grown larva is shown in Plate 1, C.

PUPAL CELL OR COCOON

Following the completion of feeding, full-grown larvae infesting smoked meat migrate from the greasy material in which they develop and seek a dark, dry spot in which to build the cocoon. At this time the larvae will not usually eat if skippers are offered to them.

The cocoon (pl. 1, D, E; pl. 2, D) may be completed within 24 hours, and is formed by filling in the open boundaries of the crevice chosen for pupation with a wall of white substance which is vomited at will from the mouth of the larva in frothy droplets. Each droplet appears only after the larva has chosen the location for the next unit of the wall, and it hardens into a vesicular mass immediately it is put in place.

During the process of cell building the larva is usually curled in the cell, although sometimes the inclosure is large enough to allow it to extend its length. At times cocoons are broken into by adults and the occupants devoured. It sometimes happens that two larvae inclose themselves in a common cell. On one occasion a larva was observed to cease construction work and to remain motionless, apparently as a means of protection, for several minutes while another larva was crawling on the outside of the cocoon. Frequently, when collecting immature material for experimental use, the writers secured numbers of larvae by opening cells, and many of these were able to resume normal activity promptly and to secrete without further feeding sufficient froth to construct another complete pupal chamber.

HE PREPUPA AND PUPA

Several days after the cocoon is completed the larva contracts in length, the body consequently becoming more robust; the head assumes a fixed attitude at right angles to the body axis, and the insect becomes a prepupa. The last larval skin is next cast and the pupa appears in the cell.

The pupa is restricted in movement to wriggling of the abdomen, to the tip of which the shriveled cast skin of the larva usually adheres. Unprotected pupae are readily devoured by adults. Pupation occasionally takes place without the protection of a cell. The pupa is illustrated in Plate 1, F.

DISTRIBUTION

In 1804, Latreille (*19, p. 156*) gave the distribution of the species as southern France and Italy. Stephens in 1830 (*32, p. 327–328*) reported it rare about London, though rather abundant in certain years. According to Curtis (*6, pl. 350*) the range of the insect was extensive, including southern France and Africa, although in Britain it was rare. Sharp (*30, p. 254*) stated that it is one of our most cosmopolitan species. Houlbert and Bétis (*15, p. 16*) gave its distribution in Brittany as widespread, but quite rare.

According to Lintner (*20*), the insect was introduced into the United States, and Froggatt (*9, p. 169*) believed the same to be true with respect to Australia.

Reports of injury to smoked meats have been received by the Bureau of Entomology from Texas, Tennessee, Georgia, Virginia, the District of Columbia, Maryland, and Pennsylvania, as shown by Figure 1.

In general, it may be said that *Necrobia rufipes* is a cosmopolitan insect. It is a species commonly

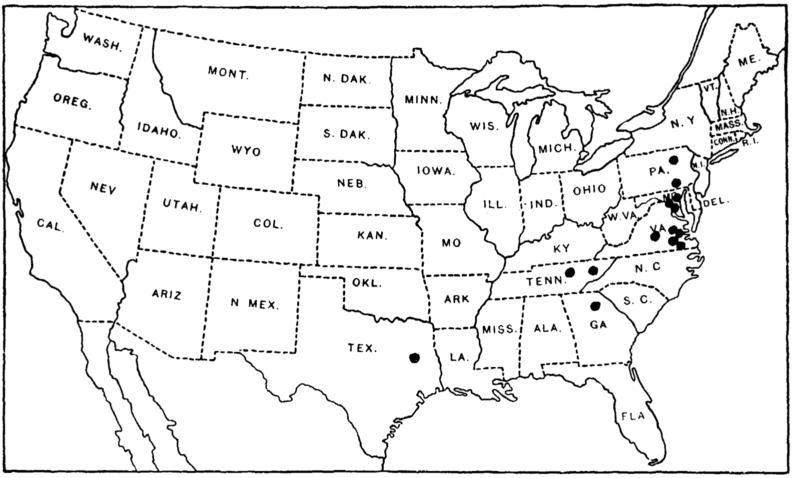


FIG. 1.—Map showing localities from which complaints of damage by the ham beetle (*Necrobia rufipes*) to smoked meats have been received by the Bureau of Entomology. Records of infested cargoes landed at various ports are not included

brought into our ports in cargoes. Records in the Bureau of Entomology show that it has arrived in cargoes in fish "guano" and bone meal from Honolulu, in garlic from New Zealand (probably having developed in other material), in coconuts from Manila, in bones from Argentina, in copra from the Philippines, in palm-nut kernels from British West Africa and Liberia, in herring and whale "guano" from Scandinavia, in dried egg yolk from China, in coconut palm from Ceylon, and in rattan from Japan. In bone storages it is frequently found in company with a closely related but economically unimportant species, *Necrobia ruficollis* Fab.

In the United States, as shown in Figure 1, reports indicate that most of the injury occurs in the Middle Atlantic States and that it is particularly marked in Virginia. Possibly this is due in a measure to the long storage of stocks of "Virginia" hams, which are not considered prime until they are about a year old.

SUBSTANCES INJURED

The first record of injury to human food by *Necrobia rufipes* seems to be that of Glover (*13, p. 97–98*), who reported it on cheese in Maryland. Riley (*24*) gave the earliest account of extensive injury to cured meats, concluding that attacks occur particularly to hams injured by overheating or by exposure to sun and rain. The species, he believed, is attracted by the fatty slime on hams.

Our chief concern in this country is with the infestation of smoked pork, other materials being attacked only on rare occasions.

The following list summarizes the known foods of this insect. The "substances infested but not fed upon" are sought by the migrating, full-fed larvae as suitable materials in which to pupate. Baled cotton and wool are sometimes badly matted with the pupal cells of the insect when these goods are carried in the same ship with bones.

Foods of the larvae or adults of the ham beetle, as recorded from literature, include: Cheese (*25, p. 226; 31, p. 266*), hams, bones (*34, p. 161; 31, p. 266*), fish (*25, p. 226; 31, p. 266*), drying carrion (*31, p. 266*), copra (*10, p. 26; 2*), hides (*5*), salt fish (*7*), bacon, dried egg (*29*), dried figs (*17*), and Egyptian mummies.[5] Bureau of Entomology records include: Dried egg yolk, hams, cheese, fish "guano"[6], bone meal, bacon, copra, bones, palm-nut kernels, and herring and whale "guano."[6] Substances infested but not fed upon, as recorded in published accounts, include: Silk (*28, p. 426*), baled cotton (*21*), and woolen tops (*11*); rattan and salt are given in the files of the bureau. A number of other references to literature, for the most part dealing with infestations of copra, are not included.

NATURE OF INJURY

Both larvae and adults feed upon smoked meats, the latter superficially. The larvae at first burrow beneath the hide, later extending their feeding deeper into the meat, chiefly in the fat portions (pl. 2, C). Frass is extruded from the burrows; this is shown in Plate 2, F. A piece of meat which had been seriously damaged on the flesh side is illustrated in Plate 2, A, and the work of the larvae in perforating a grease-soaked paper wrapping is shown in Plate 2, E. Plate 2, B shows the work of this species in old cheese.

BIOLOGICAL INFORMATION RECORDED BY OTHER WRITERS

The life history and habits of *Necrobia rufipes* have received little attention. Riley (*24*) stated that hibernation takes place solely as the larva and that no adults emerge before the first of May. On the other hand, Fay (*8, p. 197*) listed it among insects secured in winter collections.

[5] See reference to Hope on *Necrobia mumiarum*, under "Synonymy."
[6] Refuse used as fertilizer.

EXPLANATORY LEGEND FOR PLATE 2

Necrobia rufipes

A.—Longitudinal section of an old infested ham. In this case most of the feeding has been on the inside and has extended toward the skin side. Burrows may be seen penetrating the solid fat. Extensive feeding took place under the skin at the shank end, some of which is shown in the photograph

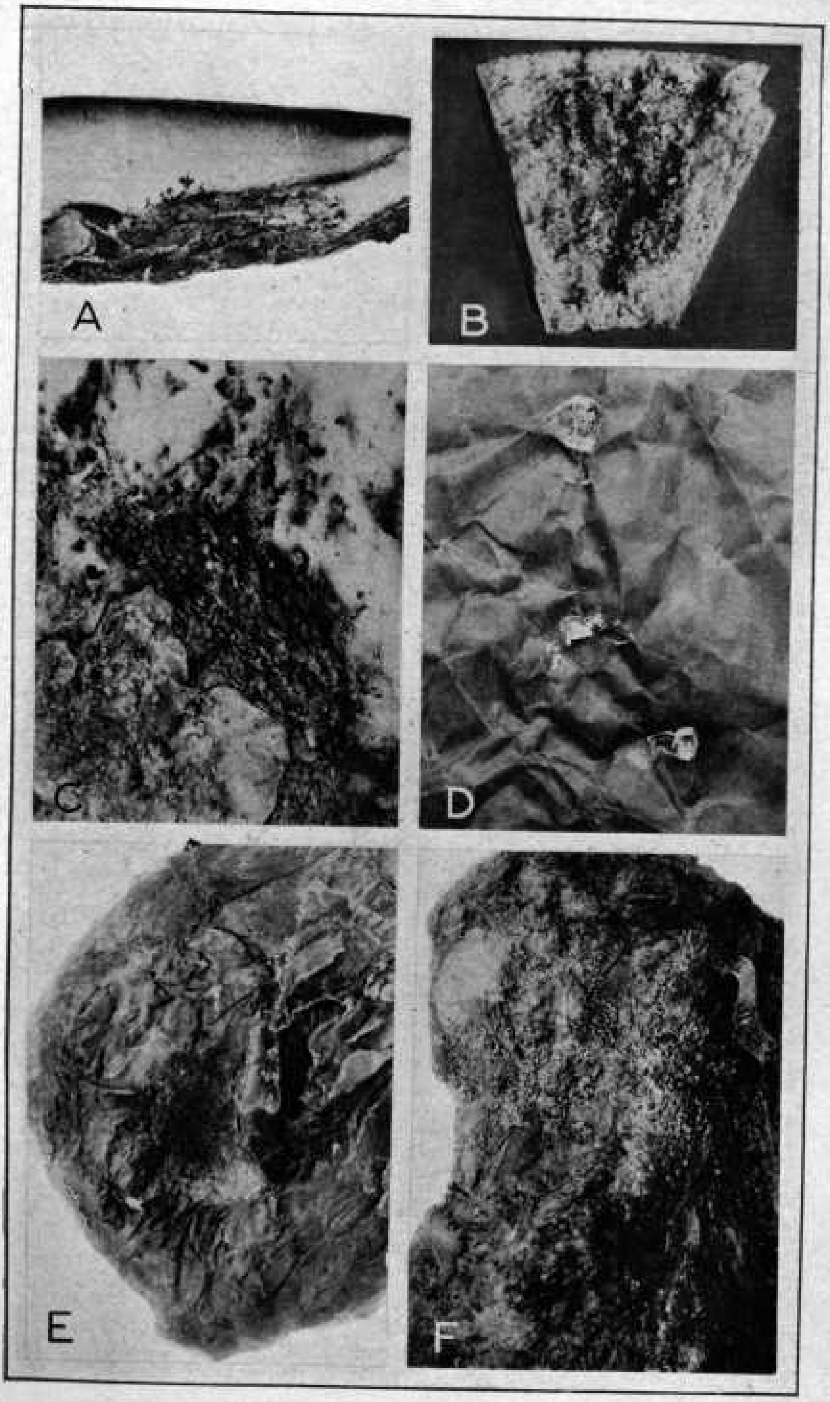
B.—Injured cheese. Several pupal cells are present in the excavated area. The dark spots are the excrement of the adult beetles. In this case the beetles and their larvae superseded an infestation of the cheese skipper (*Piophila casei*)

C.—Feeding burrows of larvae in the fat of an old ham. The cut surface, to the right of the black ink line, slants down into the tissues

D.—Pupal cells formed in creases of paper wrapper on ham. Cells torn open when paper was flattened out

E.—An old ham which had been wrapped for several months. The inner paper had become grease-soaked and the larvae penetrated it in the course of their feeding

F.—An old shoulder infested with larvae, showing the mealy frass from their burrows which has accumulated on the surface



(For explanatory legend see p. 850)

The beetles appear in May and June, according to Howard (*16, p. 105–107*), and never seem to oviposit except where the meat is more or less exposed. He also stated that E. A. Schwarz found adults in midwinter at Detroit, Mich., and Cambridge, Mass.

Herrick (*14, p. 278*) reported that pupation takes place in the more fibrous parts of ham, or sometimes in a near-by beam. The globules of white substance which form the cocoons are emitted from the mouth of the larva.

Of the biology of the ham beetle as a copra pest, Dupont (*7*) wrote that "it is supposed to be a purely predacious insect, feeding on dipterous and micro-lepidopterous larvae," but it was not known whether or not it attacks the larvae of *Oryzaephilus surinamensis* L. (the saw-toothed grain beetle), which are also abundant in copra stores.

LIFE-HISTORY INFORMATION

OVIPOSITION

The act of oviposition has never been observed by the writers; presumably the eggs are deposited when the insects are in darkness. Owing to their carnivorous appetites the beetles devour eggs which are exposed, and the females usually deposit them in crevices inaccessible to the mandibles of roving adults.

Following unsatisfactory oviposition trials with pieces of stale bacon attached to strips of cardboard, Petri dishes were used in which the only suitable place for oviposition was between small squares of dark-colored cardboard held together with a paper clip. In dishes which were greasy throughout, oviposition was sparse until clean dishes and dry cardboard were provided. It

TABLE I.—*Incubation period of Necrobia rufipes, 1922*

Date eggs were laid [a]	Hatching began	Minimum incubation period	Temperatures during each period [b]			Date eggs were laid [a]	Hatching began	Minimum incubation period	Temperatures during each period [b]		
			Max.	Av.	Min.				Max.	Av.	Min.
		Days	°*F.*	°*F.*	°*F.*			*Days*	°*F.*	°*F.*	°*F.*
Mar. 28	Apr. 5	8	79	66	53	Sept. 24	Oct. 2	8	75	68	60
May 9	May 15	6	82	74	70	25	Oct. 3	8	75	68	60
11	May 16	5	82	75	70	26	Oct. 4	8	74	68	60
12	May 17	5	77	74	69	27	Oct. 5	8	77	69	60
15	July 19	4	82	77	69	28	...do....	7	77	70	66
20	July 24	4	84	79	72	29	Oct. 6	7	79	70	65
21	July 25	4	89	81	72	30	...do....	6	79	71	65
25	July 29	4	84	78	71	Oct. 1	Oct. 7	6	79	72	65
Aug. 16	Aug. 20	4	88	81	73	2	...do....	5	79	72	65
19	Aug. 25	6	83	75	66	3	Oct. 8	5	79	73	67
20	...do....	5	80	74	66	6	Oct. 11	5	78	73	67
21	Aug. 26	5	80	74	66	9	Oct. 17	8	77	68	59
23	Aug. 28	5	81	77	68	10	Oct. 18	8	77	68	59
24	Aug. 29	5	81	76	69	11	Oct. 20	9	77	67	59
25	Aug. 30	5	81	76	69	12	Oct. 21	9	77	67	59
26	Aug. 31	5	81	75	69	13	...do....	8	77	67	59
27	Sept. 1	5	80	75	69	14	Oct. 23	9	77	67	58
28	Sept. 2	5	80	74	68	15	Oct. 24	9	75	67	58
29	Sept. 4	6	80	75	68	16	Oct. 26	10	77	67	58
30	...do....	5	80	75	68	17	Oct. 27	10	77	67	58
31	Sept. 5	5	82	76	68	18	Oct. 28	10	77	67	58
Sept. 1	...do....	4	82	76	68	19	Oct. 30	11	77	66	58
2	Sept. 6	4	82	77	72	20	Oct. 31	11	77	65	56
3	Sept. 7	4	84	78	73	25	Nov. 5	11	77	66	56
4	Sept. 8	4	85	79	75	26	...do....	10	77	66	56
5	Sept. 9	4	85	79	75	27	Nov. 7	11	77	66	56
6	Sept. 10	4	85	78	75	28	...do....	10	77	66	56
7	Sept. 11	4	85	78	75	Nov. 3	Nov. 14	11	77	67	58
8	Sept. 12	4	83	78	75	4	...do....	10	77	67	58
9	Sept. 13	4	83	78	75	6	Nov. 16	10	77	67	58
10	Sept. 14	4	83	76	70	7	Nov. 17	10	77	67	58
11	Sept. 15	4	83	76	70	8	Nov. 18	10	77	67	58
12	Sept. 16	4	81	75	70	12	Nov. 22	10	76	66	56
13	Sept. 19	6	81	72	58	16	Nov. 29	13	77	64	49
14	Sept. 20	6	81	71	58	17	Dec. 2	15	79	64	49
15	Sept. 21	6	81	70	58	24	Dec. 7	13	79	64	49
16	Sept. 23	7	80	70	58	28	Dec. 9	11	79	65	53
20	Sept. 28	8	76	68	60	29	Dec. 13	14	79	66	53
21	Sept. 29	8	76	68	60	Dec. 1	Dec. 14	13	79	66	53
22	Sept. 30	8	76	68	60	2	...do....	12	79	66	53
23	Oct. 2	9	76	69	60						

[a] Number of eggs laid each day varied from about 25 to 100.
[b] Average temperatures computed from thermograph readings every 2 hours.

is concluded that a close, dry crevice is preferred by the laying females.

INCUBATION PERIOD

At temperatures of 70° to 85° F. the usual incubation period is four or five days. In early winter, when temperatures became low in the laboratory at night, incubation periods of two weeks were recorded. Batches of eggs hatched with uniformity as regards time; the last eggs to hatch produced larvae about one day after hatching began, in warm weather. Table I shows incubation periods observed in 1922 at Washington, D. C.

FECUNDITY

The results of oviposition in vials containing stale bacon as food for the adults show an average of 137 eggs and a maximum of 312, which does not indicate that the ham beetle is unusually prolific. When the beetles are fed on maggots, however (see Table IV), a far greater capacity for increase is indicated, and it is instructive to compare Table IV with Table II.

The eggs laid by females fed with maggots of the skipper fly in several cases totaled over 1,000 and were obtained in the following manner. Pairs were mated shortly after emergence from the cocoon and were fed daily, except Sunday, with three migrant larvae of *Piophila casei*, maggots in excess of three being usually uneaten. The results of the oviposition of some of the pairs are given in Table III, which includes 20 of the best records from a series of 76 pairs. The discontinuance of another series of 32 pairs, mated in March, 1923, became necessary after six of the females had laid from 444 to 1,110 eggs each.

TABLE II.—*Oviposition and longevity of Necrobia rufipes, 1922*

[Food: Stale fat bacon]

Pair No.[a]	Total eggs laid	Male emerged	Male longevity	Female emerged	Female longevity	Pair mated	Mating to oviposition	Duration of oviposition	End of oviposition to death of female	Laboratory temperatures (° F.)			
										Month	Maximum daily mean	Average daily mean	Minimum daily mean
			Days		*Days*		*Days*	*Days*	*Days*				
1	312	Feb. 23	135	Feb. 23		Feb. 27				Feb	71	67	59
2	10	Mar. 4		Mar. 4	49	Mar. 6	24	6	17	Mar	72	67	59
3	155	Mar. 5		do		do				Apr	80	69	58
4	140	Mar. 6	186	Mar. 3	169	Mar. 8				May	79	73	67
5	78	Mar. 7	160	Mar. 7	160	do	22	107	30	June	86	79	70
6	239	Mar. 9	104	Mar. 9	142	Mar. 10	14	97	30	July	87	79	71
7	68	do	158	do	175	do				Aug	83	76	71
8	109	do	163	do	183	do	26	104	52	Sept	81	73	62
9	38	Mar. 10	85	Mar. 10	90	do	14	35	41				
10	111	Mar. 11	118	Mar. 11	161	Mar. 14	16	111	31				
11	233	do		do	94	do	6	85	0				
12	192	Mar. 13	87	Mar. 10	137	do	6	72	55				
13	94	Mar. 15		Mar. 15		Mar. 18	24	88					
Total	1,779		1,196		1,360		152	705	256				
Average	137		133		136		17	78	32				

[a] These pairs were used in preliminary experiments, but the results clearly show that an exclusive diet of smoked pork is not the most favorable food for adults kept in close confinement. Compare with Table IV.

TABLE III.—*Oviposition of Necrobia rufipes*

[Food: Larvae of *Piophila casei* L. Legend: EM, emerged and mated]

Date of oviposition	Eggs laid by female of pair No																				Daily mean temperature
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1922																					°F.
Sept. 1	EM																				73
6		EM	EM	EM																	80
8	11	18		10																	76
9		31	6	37																	77
10		20	54	25																	78
11		3	38	34	EM																79
12		10	7	32		EM															77
13			36																		73
14			10	14																	74
15	1		16	15																	77
16		13	8	25			EM	EM	EM	EM											76
17			25			17															71
18						12					EM	EM									65
19													EM	EM							68
20		10	17				5								EM						69
21				6												EM					71
22			16	13							22										69
23		26					6				6										70
24		22	21	24		29	3	6			33		12								73
25		44	25			3	6				15		24								67
26						12															62
27							6	1					3								65
28	12	32				31	22				12		19								68
29		8																			70
30		20	17			8	16				5										70
Oct. 1			17								14										69
2	8					22															69
3		16	8			10					14					5					70
4			26			18					11		12								73
5	7	21	9	6		14	5				28										74
6		21	21			3	15	12			13			5			EM				74
7		19	8	20		23	19			14	16			13		3					73
8	6	27	12					10		8	25	10				11					74
9	3	17	23			21				2	8					9					71
10	5	19				20	2	18						6							73
11	2		13	2		16	9			2	16		5	6		16					67
12		33	10				12				14			11							64
13						4															65
14			12	9		19	7	14			6		29	9							68
15				5							23					27					68
16		19	23			31					20							EM			69
17		16	5							2	9			3							70
18		10	11											17				13			68
19		17											17					28			67
20			13			22								13	5	19		20	EM		66
21											10							17		EM	65
22						17															60
23				5		15	3				6			4		7		18			65
24		44	14				6				8							8			68
25			8			3				8		4	23	19			8	13			66
26			4			3					27			6				24			67
27																		6			65
28	7		23			25						12				7	34	3	9		67
29													6	5							62
30	5					8															65
31	8																	19			64
Nov. 1			8			4							14	5		8			9		68
2	9	11						8			8	5		8		8		7	7		68
3	5		21							9	11'			5	6	16		23			68
4			18						13		17			16	14				8		68
5			4									20	9			10		13	15		69
6	3	20	11			31					12					3		9			68
7	8		9											14							69
8			23			28			1	31				21				28			66
9			26			24			14					10	5			26	9		67
10	9		15			16			5	14	18		10	16	11	20		10	14		66
11		24	24	10					6		5		17	12				6			67
12			8			30				9											62
13	23		28								6	8						15	11		67
14			9			17				14	18		25	18		8		16	24		67
15						17					6					3					69
16	13		28	4						6	8			13				5			67
17	12		3			33				10	8			6				21			67
18	16		21				7				13			13					10		67
19	6		18			27								9					7		63
20						12															64
21	7					12										14		55			65
22	14					10					7		10	14	5						63
23	9												11								64

TABLE III.—*Oviposition of Necrobia rufipes*—Continued

Date of oviposition	Eggs laid by female of pair No.																				Daily mean temperature
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	°F.
24			9								13										66
25											7								9		66
27			18											14							63
28	10												21						14		65
29			26							13						9					67
Dec. 1										17	4								6		66
2			27							9	11										68
5	10		38								5			([a])				26			69
6													4			4					65
7	19		12			5				5											65
8			22							5		5									67
9	10																				71
11	19					23				11	6	12	16					13	19		68
12	17					17												15			68
13						13				20		24	3				13	4			67
14									7										5		67
15	5					27							20		12				16		69
16	21		28							19	23	27				16		22	15		69
18			25			12				15	5		22					20	15		66
20																11					68
21	16		24			18			6	4								18			68
23			7							13								16			66
26	28		9			30				24			22			22	3	41			67
28	5		3			9			2								5	14			69
30	22					19			7	21	4	13		14				20	31		69
1923 Jan. 2	32					14							25	5		6	19	30			71
3				5		3															68
5						17								10			15		6		69
8												20		20			20				67
9						16												15			69
10						15				7		18	21				16	15			66
11	17	2	1			9								19				9	20		66
12												25				17	29	17			67
13										11									8		68
14						24							20								62
15	21					26						13		19			21		6		66
16	17									16		15			5		18	12			67
17	6										([b])			8	12				20		66
18	8									24			16	15				14			69
19	6					24			6	3							39		26		72
20						8												8			70
22	14						10		6			20	13				22				67
23	18					23				13		6		14							70
25		10				9				12		17		37		6	8	12			72
26						6				8		8	13						23		72
27										15											71
29										11							12	22	17		68
30	8											14						6	8		68
31	11					10				18					10			16			69
Feb. 1	14	5													4		7				70
2						7				39		19	14	5		11	24				69
3													12	9	4		14	21			71
5						6				19											66
6												10					18				69
7	7					6	4								3			11			71
8										8				9			4	15	8		70
9										8		21			10						70
10												17					2	19	5		67
12	17	42				3						45	22	12							66
13					5		39			15		14		10				5		11	70
14	7	5								17		48			23						68
15							40		5					8						11	69
16		20				5			5			33	16	6				7			65
17	23				7									5	20	9				8	69
18							19														64
19		29					7			12		67			12					3	68
20	14	5				5	4									8		5	8		70
21	18								4			25		9	16						67
22							28			23									27		66
23	20					6						12		20	29						67
24									31								([c])				64
25																39			44		68
26							15					([c])			5				16		70
27	9						27			3				15	17	6		5			70
28	6																		7		70

[a] Male escaped. [b] Female died. [c] Male died.

TABLE III.—*Oviposition of Necrobia rufipes*—Continued

Date of oviposition	Eggs laid by female of pair No.																				Daily mean temperature
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1923																					°F.
Mar. 1	6												6						13		68
2												5	6		26				8		68
3	7	13			9							13		6		26					73
4	14																				73
5					6					28			18	6							71
6		40													13				25		69
7		34			5		7		20				11		24						71
8							3		5					6	7				5		69
9	10						7		32			4							7	6	70
10										25											68
11	17																				62
12	6	32					17								16	21			14		71
13					19		19		23			6							31		74
14					7				23							14			9		71
15	12	50			4				14	20		13			18				12	7	69
16							12					21			8	2			4		68
17		39			3				21				13			5			11	6	68
18									26												61
19	7	47			14							45	19		36					28	66
20							5													6	68
21									17												70
22	2									8					44				22	18	73
23							19														75
24		67							38	34		16			7				43	28	74
26				(a)					8	15		46			7				(a)		66
27		50													19	20				17	68
28									6												71
29										19		6	18								69
30									24												69
31																				2	71
Apr. 1										3											56
2		6			10										42						71
3		42			1		8					8				8					72
4					15											4				12	74
5	9																				73
6	4														50						73
7		54					23		5			26								6	73
9									24												68
10		51			11				7	6		3	9		9	20				9	69
11	15								3												69
12									14	19			18							24	71
13									19												72
14	14								5	21			24			9					69
16					28		7		26	10										37	68
17																8					70
18	15								16			10			9						71
20			(b)		52					10			20								73
21	10				16				28				15							32	75
23		24	(a)							30			8		45						74
24					19			2													65
25					12		5	3							8	12					71
26							(a)	3					17							18	71
27												14									71
28		6					7						16		45	28		(b)		30	74
30		52							27	25						16				47	68
May 1	(a)				32										11					5	70
2	15				14				10											13	71
3		20			27															28	71
5					7			4		19					11	22					74
7						(b)		7		10		11			53					50	73
8					6											6					73
9					20				4	4						16					71
10										3										7	66
12						(a)			(a)				(a)							25	71
14															7	27					72
15																				15	74
16								5	7	9										8	78
17					9					15						34				24	76
18					12											5					73
19					24			14		12					4	22					76
20											(a)										76
21								34		8						19					76
22		(b)													25					23	75
23					11			12								10				20	71
24					13			22		20					26	35				11	72
25					23					12					12	19				5	73
26					17			12		9					7					6	74
28					6			22	13						26	40				36	80
29								11							11	7				7	82
31				(b)	12											12					75

[a] Male died. [b] Female died.

TABLE III.—*Oviposition of Necrobia rufipes*—Continued

Date of oviposition	Eggs laid by female of pair No.																				Daily mean temperature
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1923																					
June 1												(a)									77
2					11										27	42				18	84
4								17		11										15	85
6					20			7		23				(a)	11	22					85
7					43			7		5					(b)	24					84
8					4					11						23				27	81
9					22			24							43	31					75
11					30			26							22	48				29	76
12								16													72
13																24					71
14					11										10	9					72
15					40			11								57				51	78
16					12			10							32	12					79
18					18			24							33	64				34	83
19					10										10	6					84
20					17			22	(a)	(a)						44					87
21					23			15								24					89
23					27			11								51					85
24																				(a)	86
25					26			23								37					88
26					13			11								13					90
28					8			30								33					79
29					13																74
July 2					14		(a)	(b)								28					73
3					40																75
4					(b)			10													78
5																35					81
6								17													82
8					20			6													79
10					12											16					79
11					12			15								45					81
12					16																80
13								17								44					79
16					42			19								43	(a)				82
18					11			20								11					79
20					13			20					(a)			26					81
21					4											8					85
24					10			27								45					73
25																8					76
26								19								16					76
27					22			4								29					77
28																23					80
30								48								18					80
Aug. 1								30													69
2								17								20					72
3					15			27								16					80
4					11			27								38					81
6					26			108								53					84
7								31								13					85
8								37								41					86
9								30								20					78
11								43								32					78
13					5			40								33					79
14								12								14					76
15								8													80
16					5			24								16					77
17					9			28								18					72
18								15													71
20					25			38								19					78
21					7											5					78
22								29								4					75
23					11			25													69
25								19													73
27					6			28													75
30					5			17													75
Sept. 1					22																76
4								42													80
6					8			20													72
10																(b)					69
18								43													67
24					(a)											(a)					78
26								51													76
28								12													75
Oct. 30								(a)													
Nov. 13																			(a)		
20										(b)											
Total	846	1316	1087	301	1197	1088	481	1497	583	1029	576	854	744	598	1042	2131	351	876	706	823	

Average eggs per female 906. Date of death of female No. 15 not recorded.

[a] Female died. [b] Male died.

In Table III the conspicuous features are the large numbers of eggs laid by several of the females, the length of the records, the marked differences in fecundity of the females, and the long rest periods during which no eggs were laid. As the present report appears to be the first detailed account of the biology of a representative of the large family Cleridae, there is no opportunity for comparison of the life history of *Necrobia rufipes* with an allied form.

As shown by Table III, mated females continued to lay eggs for several months after having been deprived of the male through its death or escape. The male of pair No. 14 escaped December 5; eggs laid by the female January 18 and March 5 produced larvae. As previously noted, eggs laid by old females not infrequently collapse and fail to hatch. This occurred, for example, with the eggs of pair No. 2, which were laid April 23 and May 3, and the eggs of pair No. 9, laid on May 2. The records detailed in Table III are summarized in Table IV.

TABLE IV.—*Oviposition and longevity of Necrobia rufipes, 1922 and 1923* [a]

[Food: Larvae of *Piophila casei*]

Pair No.	Male and female emerged and mated	Longevity of male	Longevity of female	Duration of period, mating to oviposition	Duration of period of oviposition	Duration of period, end of oviposition to death of female	Total number of eggs laid
	1922	*Days*	*Days*	*Days*	*Days*	*Days*	
1	Sept. 1	242	([b])	7	236	([b])	846
2	Sept. 6	375	258	2	237	19	1,316
3	...do....	229	226	3	124	99	1,087
4	...do....	201	267	2	119	146	301
5	Sept. 11	296	378	155	205	18	1,197
6	Sept. 12	242	237	5	159	73	1,088
7	Sept. 16	222	289	4	221	64	481
8	...do....	289	409	8	369	32	1,497
9	...do....	238	277	58	196	23	583
10	...do....	430	277	28	237	12	1,029
11	Sept 18	234	121	4	99	18	576
12	...do....	161	256	20	211	25	854
13	Sept. 19	235	304	6	215	83	744
14	...do....	([b])	260	17	153	90	598
15	Sept. 20	229	------	30	------	------	1,042
16	Sept. 21	354	368	12	323	33	2,131
17	Oct. 6	131	283	22	43	218	351
18	Oct. 16	325	194	2	132	60	876
19	Oct. 20	157	389	8	147	234	706
20	Oct. 21	248	246	113	127	6	823

[a] This table is a summary of the records detailed in Table III. Compare with Table II.
[b] Escaped.

DEVELOPMENTAL PERIOD

In the first rearing trials larvae were provided with what appeared to be the preferred food—stale bacon. This was heated to about 120° F. for a day or two in order to extract some of the low-melting-point fat, which was so abundant in unheated pieces of bacon that the larvae were often smothered in it. Although larvae usually become large and vigorous when they develop in whole hams, shoulders, or sides of bacon, the mortality in vials containing small pieces of the same meat was high and development slow, frequently resulting in dwarfed individuals. The results of the rearing experiments in which stale fat bacon was used are assembled in Table V.

Trials shown in Table V were preliminary, but the results, compared with those given in Tables VI and VII, show that an exclusive diet of smoked pork is not the most favorable food for larvae reared in close confinement.

In some of the rearing work done subsequently to that shown in Table V the ham-beetle larvae were fed only skipper maggots. Newly hatched larvae were transferred to Petri dishes, 10 or 20 to a dish, where they were given crushed skippers until nearly full grown, when live skippers were provided. The mortality in these dishes was nearly always high. There was probably cannibalism, and the soft posterior proleg of the very young larvae often stuck to the smooth glass, resulting in their death by starvation.

Records of the development of larvae fed with skippers are given in Table VI. A comparison of this table with Table V shows the advantage to the insects, when closely confined as larvae, of a diet of maggots in the place of stale bacon.

In Table VI the shortest developmental period is shown to have been 30 days, including 17 days as a growing larva and 13 days within the cocoon as larva, prepupa, pupa, and adult. According to the results included in Table I the incubation period may be as short as 4 days; the minimum preoviposition period recorded (Table IV) is 2 days. The life cycle, therefore, is possibly as short as 36 days.

The details of the larval life are given in Table VII. In this set of experiments individual larvae were reared in large veterinary capsules, as explained previously under "Larval behavior." The larval stage is divided into three, sometimes four, instars.

PUPAL PERIOD

Details as to the duration of the pupal period and the prepupal period within the cocoon were secured both by opening cocoons and by examination of the insects in cells that had been built against the glass of the vials. In general, the prepupal stages (resting larva and prepupa) occupied about the same time as the pupal stage. Table VIII gives the results of these examinations.

half-grown larvae were found to be dead, and many full-grown larvae were dead. Seven full-grown larvae survived, however, and eventually transformed into adults.

From these records, full-grown larvae appear best able to withstand such winter temperatures as obtain at Washington.

CONTROL SUGGESTIONS

Riley (*24*) recounted the control measures used by a concern in St.

TABLE V.—*Development of Necrobia rufipes, 1922*

[Larval food: Stale fat bacon]

Date eggs were laid	Number of eggs in vial	First cocoon formed	Emergence began	Minimum period, egg deposition to cocoon formation	Minimum cocoon period [a]	Minimum period, egg deposition to adult emergence	Average daily mean temperature during egg to adult period
				Days	*Days*	*Days*	° F.
Mar. 22	28		Aug. 17			148	75
24	5		July 14			112	74
24	25		Sept. 3			163	75
24	21		July 31			129	75
26	33		July 11			107	74
30	33		July 9			101	74
30	11		Aug. 31			154	75
30	3	July 20	([b])	112		([b])	
Apr. 1	9		July 9			99	74
1	8		do			99	74
9	26	July 3	July 18	85	15	100	75
9	3	July 15	July 29	97	14	111	76
11	4	July 28	Aug. 9	108	12	120	76
15	11	Aug. 15	Sept. 7	122	23	145	76
19	7	July 15	Aug. 4	87	20	107	76
19	11	July 24	Aug. 17	96	24	120	76
28	8	July 12	July 27	75	15	90	77
May 5	24	Aug. 5	Aug. 31	92	26	118	77
13	13	Aug. 3	Aug. 26	82	23	105	77
13	13	do	([b])	82		([b])	
16	10	July 20	Aug. 26	65	37	102	77
June 21	11	Aug. 3	do	43	23	66	78
Total				1,146	232	2,296	
Average				88	21	115	

[a] The figures in this column represent probable but not actually known minimum cocoon periods. In each vial several cocoons were formed in the cotton plugs, and the first adult to emerge did not necessarily come from the cocoon which was formed first.

[b] No emergence.

OVERWINTERING

In an experiment made by the writers to determine the ability of full-grown larvae to survive 48° to 50° F. in a refrigerator, five out of seven lived about six months and one survived for seven months.

On December 21, 1922, an old shoulder infested with adults and various sizes of larvae was exposed to outdoor temperatures. The meat was kept in a fumigating box, protected from rain and snow, until March 24, 1923. After three months of winter temperatures, all adults and small and

Louis. This firm dipped wrapped hams in a mixture of flour, water, a little glue, and chrome yellow, sometimes with "heavy spar" (barium sulphate) added. He suggested that a heavier canvas be used and applied before the first of May. Following the adoption of Riley's suggestions, losses were practically eliminated.

It should be observed that these suggestions were made in the days before artificial refrigeration was widespread, when hogs were necessarily slaughtered in the cool months. Practically all pork for use in summer had to be cured or smoked, or both, during

TABLE VI.—*Development of Necrobia rufipes, 1922* [a]

[Food: Mature larvae of *Piophila casei* L.]

Date egg hatched	Larval period	Cocoon period	Hatching to emergence	Date egg hatched	Larval period	Cocoon period	Hatching to emergence
	Days	*Days*	*Days*		*Days*	*Days*	*Days*
Sept. 5	28	13	41	Sept. 23	25	16	41
5	34	11	45	23	28	15	43
5	35	10	45	23	28	15	43
5	34	14	48	23	28	17	45
5	34	15	49	23	37	15	52
5	35	14	49	23	42	16	58
5	35	14	49	29	24	15	39
5	35	15	50	29	26	14	40
5	41	12	53	29	42	15	57
5	56	16	72	Oct. 2	28	14	42
5	80	19	99	2	28	15	43
12	30	14	44	2	28	17	45
12	30	14	44	3	23	18	41
12	30	15	45	3	41	26	67
12	30	16	46	3	41	29	70
12	36	13	49	3	55	18	73
12	36	13	49	4	26	15	41
12	36	14	50	4	30	17	47
12	36	15	51	4	30	18	48
12	37	14	51	4	48	16	64
12	36	15	51	4	35	52	87
12	36	15	51	6	38	16	54
12	36	15	51	6	41	18	59
12	36	16	52	6	46	16	62
12	36	16	52	6	41	21	62
12	36	16	52	6	46	16	62
12	37	15	52	6	46	17	63
12	36	16	52	6	48	16	64
12	39	13	52	6	46	18	64
12	36	17	53	6	48	18	66
12	39	15	54	6	46	20	66
12	41	15	56	6	48	19	67
12	43	14	57	6	48	20	68
12	44	14	58	6	48	20	68
12	45	17	62	6	48	21	69
12	48	16	64	6	52	19	71
12	48	16	64	6	52	22	74
12	59	16	75	6	52	29	81
12	59	18	77	7	45	16	61
12	65	16	81	7	45	16	61
20	28	13	41	7	45	16	61
20	28	13	41	7	45	17	62
20	28	17	45	7	45	18	63
20	35	19	54	7	47	16	63
20	40	14	54	7	47	18	65
20	54	16	70	7	47	18	65
21	25	11	36	7	45	24	69
21	25	12	37	8	19	17	36
21	25	13	38	11	19	15	34
21	25	14	39	11	38	7	45
21	32	17	49	11	28	24	52
21	32	18	50	11	49	20	69
23	17	13	30	11	49	22	71
23	17	13	30	12	26	15	41
23	23	8	31	15	22	14	36
23	19	13	32	15	39	15	54
23	23	12	35	15	37	17	54
23	23	12	35	15	39	19	58
23	19	16	35	15	47	21	68
23	23	13	36	15	43	29	72
23	23	15	38	15	54	19	73
23	23	15	38	17	35	17	52
23	23	15	38	18	40	22	62
23	25	14	39	20	47	22	69
23	23	16	39	26	36	27	63
23	28	12	40	26	43	20	63

[a] Larvae reared in Petri dishes. Sept. 5 to 26, exposed to laboratory temperatures, average daily mean 76° F.; Sept. 26 to Nov. 3, in incubator at 80° to 85° F; Nov. 3 to Dec. 8, temperatures not recorded but were usually between 70° and 80° F. All cocoons incubated at 80° to 85° F.

the season of low temperatures and stored for future consumption.

According to Perkins (*23, p. 126*) the larvae do not seem to be able to eat their way through any covering, and thoroughly wrapped hams are not therefore exposed to injury.

In the Philippines this species is controlled in copra by fumigation under a tarpaulin with carbon disulphide (*10*).

Herrick (*14, p. 280*) stated that the injured parts of infested meats can often be cut away.

Ashbrook, Anthony, and Lund (*3, p. 25–26*) have given an important control measure, which consists of removing the original string from smoked meats before wrapping them and tying a new string tightly around the outside of the package. This is necessary because it is impossible to make an insect-tight package if a string passes from the meat through the wrappings.

Ordinarily there appears to be slight danger of infestation of newly smoked pork products by ham beetles. If meats are wrapped promptly and tightly, there should be no trouble, but long-stored hams and sides of bacon that are hung up unwrapped or packed in crates accessible to the beetles are likely to become infested during warm weather.

The ham beetle is able to find an entrance to meat which is apparently tightly covered, and in view of the insect's ability to reach smoked meats protected by several overlapping layers of paper it is hardly to be wondered at that the theory of abiogenesis has been used to explain the presence of purple worms in these products.

Careful screening with fine wire cloth (30 meshes per inch), as recommended to exclude the cheese skipper, will also be effective against ham beetles.

Reconditioning by trimming off infested parts with a knife is sometimes resorted to, especially with bacon. The eradication of an infestation will be hastened if the meats and rooms in which they have been stored are fumigated with hydrocyanic-acid gas. The use of this gas for the fumigation of meats has been approved by the Bureau of Animal Industry, United States Department of Agriculture (*33*).

TABLE VII.—*Development of individual larvae of Necrobia rufipes*

[Food: Eggs of *N. rufipes* followed by larvae of *Piophila casei*]

Date egg hatched	Duration					Date egg hatched	Duration				
	First instar	Second instar	Third instar	Fourth instar	Larval stage		First instar	Second instar	Third instar	Fourth instar	Larval stage
1923	*Days*	*Days*	*Days*	*Days*	*Days*	1923	*Days*	*Days*	*Days*	*Days*	*Days*
May 13	8	6	10	13	37	May 15	9	6	10	--------	25
13	10	6	13	--------	29	15	7	8	16	--------	31
14	7	8	15	--------	30	16	6	8	19	--------	33
14	11	4	10	11	36	16	6	8	8	--------	22
14	7	8	8	10	33	16	6	8	8	11	33
14	7	8	8	16	39	16	6	8	19	--------	33
14	9	6	10	8	33	16	6	6	10	--------	22
14	9	6	21	--------	36	16	6	8	19	--------	33
14	9	6	21	--------	36	16	6	8	8	--------	22
14	9	8	19	--------	36	16	8	6	22	--------	36
15	7	8	8	13	36	16	8	6	16	--------	30
15	7	6	24	--------	37	16	6	8	10	--------	24
15	7	8	10	--------	25	16	8	8	14	--------	30
15	7	8	10	--------	25	16	6	8	10	12	---- 36
15	9	6	22	--------	37						

NOTE.—Mean temperatures (°F.): May 13, 73°; May 14, 72°; May 15, 74°; May 16, 78°; May 17, 76°; May 18, 73°; May 19, 76°; May 20, 76°; May 21, 76°; May 22, 75°; May 23, 71°; May 24, 72°; May 25, 73°; May 26, 74°; May 27, 78°; May 28, 80°; May 29, 82°; May 30, 77°; May 31, 75°; June 1, 77°; June 2, 84°; June 3, 86°; June 4, 85°; June 5, 87°; June 6, 85°; June 7, 84°; June 8, 81°; June 9, 75°; June 10, 76°; June 11, 75°; June 12, 72°; June 13, 71°; June 14, 72°; June 15, 78°; June 16, 79°; June 17, 80°; June 18, 83°; June 19, 84°; June 20, 87°; June 21, 89°; June 22, 89°.

SUMMARY

The ham beetle (*Necrobia rufipes* De G.) is widely distributed over the warmer parts of the world, frequently being found as an inhabitant of stores of bones and other inedible animal products. Among the islands of the Pacific it is a pest of copra. In parts of the United States sporadic injury, occasionally of considerable extent, is done to long-stored hams, shoulders, and bacon.

The adult is a shiny, green beetle 3.5 to 7 mm. long; the larva is purplish and about 10 mm. in length when full grown. Both imago and larva are

active and predatory; their habit of infesting smoked pork has probably been acquired rather recently. The larvae are responsible for most of the damage to infested meats. They bore holes in the meat, preferably burrowing into the fat parts. The adults feed chiefly on the surface. Pupation occurs within a white cocoon constructed with drops of froth emitted from the mouth of the larva.

The adult may live for more than 14 months, the female depositing as many as 2,100 eggs during that time. In warm weather the incubation period is four days or more. The preoviposition period is as brief as two days. The period from hatching of the egg to adult emergence may be as short as 30 days, including 17 days as growing larva and 13 days within the cocoon.

TABLE VIII.—*Cocoon period of Necrobia rufipes, 1922*

Cocoon formed	Prepupal period in cocoon [a]	Pupal period	Cocoon period	Average temperature during cocoon period	Cocoon formed	Prepupal period in cocoon [a]	Pupal period	Cocoon period	Average temperature during cocoon period
	Days	*Days*	*Days*	°*F.*		*Days*	*Days*	*Days*	°*F.*
Jan. 17	----------	----------	42	67	Aug. 21	17	4	21	76
17	----------	----------	46	67	21	10	12	22	76
17	----------	----------	55	67	21	9	14	23	76
18	----------	----------	51	67	21	15	8	23	76
19	----------	----------	45	67	21	8	18	26	76
20	----------	----------	47	67	21	5	22	27	76
20	----------	----------	55	67	21	9	34	43	73
21	----------	----------	41	67	21	26	54	80	71
21	----------	----------	47	67	22	10	10	20	76
22	----------	----------	40	67	22	17	31	48	73
22	----------	----------	52	67	23	16	4	20	77
24	----------	----------	36	67	23	16	6	22	76
24	----------	----------	42	67	23	14	10	24	76
24	----------	----------	44	67	23	14	10	24	76
24	----------	----------	45	67	23	14	12	26	76
24	----------	----------	46	67	23	16	12	28	75
24	----------	----------	49	67	24	13	5	18	76
26	----------	----------	46	67	24	15	8	23	76
27	----------	----------	41	67	24	14	9	23	76
28	----------	----------	41	67	24	13	12	25	76
28	----------	----------	58	67	24	13	13	26	76
Feb. 4	----------	----------	46	66	24	15	15	30	75
Mar. 25	----------	----------	32	69	24	19	23	42	73
25	14	21	35	69	24	17	27	44	73
26	12	21	33	69	25	14	8	22	76
26	12	28	40	69	25	15	7	22	76
27	12	21	33	69	25	13	9	22	76
28	12	24	36	69	26	13	8	21	76
31	10	21	31	69	26	12	15	27	75
Apr. 1	10	22	32	69	26	15	13	28	75
3	9	24	33	70	28	9	10	19	76
9	9	21	30	70	28	9	13	22	76
Aug. 14	7	4	11	77	28	13	11	24	75
15	4	9	13	77	28	12	30	42	73
15	9	12	21	76	29	8	10	18	77
15	10	11	21	76	Sept. 1	10	8	18	76
15	14	8	22	76	2	6	8	14	77
16	6	11	17	76	2	8	22	30	73
16	9	12	21	76	2	9	23	32	73
16	13	9	22	76	5	6	9	15	75
16	12	11	23	77	5	6	21	27	72
17	11	5	16	76	5	6	21	27	72
17	11	9	20	76	6	14	13	27	72
17	11	9	20	76	14	22	12	34	70
19	8	11	19	76	14	17	19	36	70
19	8	14	22	76	16	15	15	30	70
19	17	7	24	76	16	14	18	32	70
19	19	9	28	76	16	21	11	32	70
19	17	11	28	76	16	16	19	35	69
21	15	5	20	76	16	32	22	54	68
21	10	11	21	76					

[a] The prepupal period (period from formation of cocoon to appearance of pupa) and pupal period occurring in cocoons formed Aug. 14, et. seq., were determined by opening the cocoons. Prior to Aug. 14 the same notations were made by observations through the glass of vials containing cocoons built against the glass.

An important consideration in the prevention of injury by the ham beetle is the careful wrapping of meats. Probably the most effective method for the eradication of an infestation is a thorough fumigation with hydrocyanic acid gas.

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