TAMARIND POD-BORER, SITOPHILUS LINEARIS (HERBST)[1]

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The literature of North American entomology contains occasional reference to the curculionid beetle, *Sitophilus linearis* (Herbst), but nothing definite has been published regarding the biology of this interesting weevil or the extent of its distribution in the United States.

HISTORY AND DISTRIBUTION

The tamarind pod-borer was described in 1797 by Herbst under the name of *Rhynchophorus linearis*. The specimens described were obtained from the West Indies, where the weevil had been introduced with its food plant, the tamarind. It undoubtedly is native to India but has now spread to all places where the tamarind is grown. In 1815 it was described by Thunberg as the variety *striata*, and again in 1834 by Christy under the name of *Calandra tamarindi*, and finally in 1837 by Dejean under the specific name of *frugilega*. All of these later names have since been reduced to synonymy.

In 1892 Casey[2] noted the occurrence of *Sitophilus linearis* in North America, but in 1895 Chittenden[3] stated that in his opinion *S. linearis* should not be inserted in our faunal list until it could be ascertained that the species actually bred in some plant within our faunal limits. Up to the present time all records of its occurrence in the United States refer to occasional specimens picked up in the southern Atlantic and Gulf States which had undoubtedly been imported in shipments of tamarind pods. The writer has found it to be exceedingly abundant in southern Florida where the tamarind is now grown; therefore there is no longer any doubt that it is well established within our faunal limits.

In 1916 A. H. Ritchie[4] recorded this species as causing considerable damage to the pods of the tamarind in Jamaica, and T. B. Fletcher[5] has recorded similar damage in India.

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[1] The writer was enabled to make a study of this species through the courtesy of the Federal Horticultural Board, whose representative, Mr. O. K. Courtney, intercepted at the port of New Orleans a shipment of infested tamarind pods from Guatemala, which was forwarded for study to the division of Stored-Product Insect Investigations of the Bureau of Entomology. The writer wishes to acknowledge his indebtedness to Dr. Adam G. Böving, of the Bureau of Entomology, for his valuable aid and advice in the study of the larval characters of this weevil.

[2] CASEY, Thos. L. COLEOPTEROLOGICAL NOTICES IV. *In* Ann. N. Y. Acad. Sci., v. 6, 1891-92, p. 359-710. 1892. [*Calandra linearis*, p. 686.]

[3] CHITTENDEN, F. H. ON THE DISTRIBUTION OF CERTAIN IMPORTED BEETLES. *In* Insect Life, v. 7, no. 4, p. 326-332. 1895.

[4] RITCHIE, Archibald H. REPORT OF ENTOMOLOGIST FOR YEAR 1915-1916. *In* Ann. Rpt. Dept. Agr. Jamaica [1915] 16, p. 31-34. 1916.

[5] FLETCHER, T. Bainbrigge. ONE HUNDRED NOTES ON INDIAN INSECTS. *In* Agr. Research Inst. Pusa Bul. 59 39 p., 20 fig. 1916. Weevils in tamarind fruits, p. 10.

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This weevil is now known to occur in the United States, India, Brazil, Mexico, Ecuador, Jamaica, Montserrat, St. Bartholomew, Cuba, and Costa Rica. It occurs, undoubtedly, wherever the tamarind is grown.

NATURE OF INJURY

The injury is confined entirely to the seed pods of the tamarind. The adult weevils feed little, but the larvæ or grubs bore in the seeds or beans and reduce them to powder. The entire crop is frequently completely destroyed unless promptly harvested and protected.

For those not familiar with the tamarind a few descriptive and historical notes are here inserted.

The tamarind, *Tamarindus indicus*, although attributed to India, is positively asserted to be indigenous to Africa and Australia. It was introduced into the West Indies by the Spaniards soon after the discovery of those islands, and was naturalized at an early date in Brazil, Ecuador, Mexico, and other parts of the tropical world. A few trees have been introduced into the United States in Florida and California. Although a tropical plant it does well in southern Florida.

The seeds are borne in large pods and are embedded in a sweet, sticky, reddish pulp. This pulp has mild laxative properties and is found on the market usually mixed with sugar or syrup. In tropical countries the pulp is used extensively for the preparation of a cooling beverage and as a flavoring for ice cream. In European countries it is said that the pods and seeds when roasted are considered a delicacy. The bark, seeds, and leaves are used to a limited extent by natives of the Tropics as therapeutic agents.

The wood is heavy and hard and is used for making furniture on account of its fine grain and color. It is used also in making tools, axles, wagon wheels, and similar articles.

LIFE HISTORY AND BIOLOGY

Since the tamarind grows only in tropical or subtropical climates, the activities of the weevil are not stopped by winter. It breeds throughout the year. In Florida the seeds of the tamarind usually mature in May, but a few may be found maturing in almost all months of the year, thus providing a more or less continuous food supply for the weevils. As the pods mature they quickly become infested.

The adult weevils enter the tough-shelled pods through the stem end. The swaying of the pods in the wind causes small breakages in the pod rind to occur at the juncture of the stem, and through these breaks the weevils find an easy entry. The female weevils bore directly through the pulpy covering and into the tough seeds. In the seeds they excavate a cylindrical cavity about 3 mm. deep and 1.5 mm. in diameter. If the shell of the pod is broken away the weevils may be seen at work, the top

of the abdomen alone showing above the surface of the pulpy covering, the rest of the body being concealed within the cavity. This cavity is usually completed in from two to three days. The individual egg cavities are then bored in the seed all around the interior of this larger cavity, an egg being deposited as soon as a hole is finished. The eggs are all placed as close together as possible, so that the interior of the large cavity has the appearance of being lined with rows of egg-caps. From 12 to 50 eggs are laid in one group, the time taken for the completion of the group varying from one to two weeks, according to the number of eggs laid. By the time the last egg is laid the first eggs have hatched and the grubs have become half grown. This habit of the female weevil of grouping a number of eggs together in one seed exhibits an interesting difference from the egg-laying habits of the grain weevils belonging to this genus. One would naturally conclude that it was developed to save energy, since it would be no mean undertaking to bore through the pulpy covering and the tough seed coat for each individual egg.

The operation of excavating the egg cavities is accomplished by a combined up and down and rotary motion of the proboscis, effected by turning the head from side to side while the thorax is oscillated back and forth. As soon as an individual egg cavity is completed and the sides are smoothed to the satisfaction of the weevil the proboscis is withdrawn. The weevil then reverses its position and, inserting its ovipositor into the cavity, deposits an egg, sealing it in with a plug of opaque, yellowish material resembling faecal matter. In a few days this plug turns to a dark yellowish brown.

It is interesting to note that, so far as observations go, the female weevil does not leave the egg cavity from the time it is started until the last egg has been laid. She works day and night until the operation has been accomplished unless disturbed by outside agencies. Whenever she rests it is without leaving her position in the cavity. As soon as one group has been finished the weevil immediately seeks out another location and begins operations again. For sheer industry and continuous application to the object of perpetuating its kind this weevil would be hard to surpass.

The eggs hatch at the end of three days. Previous to hatching the larva may be distinctly seen through the thin outer shell of the egg. This shell or skin is very flexible and undulates with the movements of the young grub. It becomes somewhat wrinkled and finally breaks at the bottom, allowing the grub to escape. The young larvæ begin at once to feed and bore through the seed, their burrows radiating from the large cavity to all parts of the seed, and usually ending near the shell of the seed, through which, however, they never break.

As in other species of this genus, there are four larval instars, although previous writers have erroneously attributed but three larval instars to

the grain weevils of this genus. The lengths of the various stages are regular and are given in Tables I and II.

TABLE I.—*Life history data of the tamarind pod-borer* [1]

Weevil No.	Egg laid.	Hatched.	First molt.	Second molt.	Third molt.	Prepupa.	Pupa.	Adult.
1	June 19	June 22	June 24	June 26	June 28	July 5	July 6	July 13
2	23	26	29	July 1	July 3	11	12	19
3	25	28	30	2	4	12	13	20
4	26	29	July 1	3	5	13	14	21
5	29	July 2	4	6	8	14	15	21
6	July 2	5	7	9	11	16	17	24
7	2	5	7	9	11	17	18	25
8	4	7	9	11	13	21	22	28
9	4	7	9	11	13	21	22	29
10	11	14	16	18	20	24	25	31

[1] Data included in tables were secured at Orlando, Fla., during June and July, 1919. The mean temperatures for period were as follows: June, average mean temperature 79.4° F., high mean 90.5°, low mean 68.3°; July, average mean temperature 81.4°, high mean 92.4°, low mean 70.3°.

TABLE II.—*Length of stages of the tamarind pod-borer*

Weevil No.	Egg.	First larval stage.	Second larval stage.	Third larval stage.	Fourth larval stage.	Prepupal stage.	Pupal stage.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
1	3	2	2	2	7	1	7
2	3	3	2	2	8	1	7
3	3	2	2	2	8	1	7
4	3	2	2	2	8	1	7
5	3	2	2	2	6	1	6
6	3	2	2	2	5	1	7
7	3	2	2	2	6	1	7
8	3	2	2	2	8	1	6
9	3	2	2	2	8	1	7
10	3	2	2	2	4	1	6

The pearly white larvæ, when full grown, construct pupal cells within the seed by lining the cavities at the end of their larval burrows with a mixture of frass and borings cemented together with a secretion that gives it when dry the appearance and consistency of a dark brown shellac.

As shown in Table II the larval stage usually requires from 12 to 14 days. After a prepupal stage of about 1 day the pupal form is assumed, and 7 days later the adult is formed. The adult does not immediately leave the seed but remains within to harden and feed for a few days. It then makes its way to the original cavity made by the mother weevil when laying her eggs and emerges, rarely if ever forcing its way through the shell at any other point.

After the adults have all emerged little is left of the seed but the empty shell and a mass of powder.

PREOVIPOSITION PERIOD

Copulation takes place soon after emergence, and the females deposit their first eggs in from 7 to 10 days after attaining adult form. Copulation is frequent and often takes place while the female is at work on the egg cavity.

OVIPOSITION PERIOD

The longest oviposition period recorded lasted for 84 days, and during this time 183 eggs were deposited. Toward the latter part of this period fewer eggs were laid than at first, the female becoming more and more feeble and exhausted. Three weeks after the last egg was laid the female died. The male died a few days later.

Other female weevils in captivity deposited from 126 to 165 eggs. It seems probable that under natural conditions with an abundant supply of fresh seed the oviposition period would be longer and the number of eggs deposited would be correspondingly larger.

HABITS OF ADULT

The males are, as a rule, slightly more abundant than the females. Of 488 bred specimens, 258, or about 53 per cent, were males. The males apparently feed but seldom, spending their time in constant attendance on the working females or in fighting among themselves for the females. They are of a very combative nature, and it is not uncommon to see two and sometimes three males fighting together for hours at a time with apparently great ferociousness. As they have no efficient or deadly weapons, however, little damage is done; and long before a decision is reached another male has assumed the care of the female, who, intent only on her work, is oblivious to the struggles of the aspiring males. The males are readily distinguished from the females by their shorter, thicker beaks. The beak of the male is considerably broader at the base than that of the female. The adults in captivity have fed on acorns, sweet potatoes, and various fruits. Normally, however, they do not attack anything but the tamarind seeds.

PARASITES

No parasites have been reared from any of the stages of *Sitophilus linearis*. Larval and pupal stages in the laboratory were attacked and killed by a predacious mite, *Pediculoides ventricosus* Newport. It seems very doubtful, however, that this mite would be able to penetrate to the larval burrows under field conditions.

DESCRIPTION OF IMMATURE STAGES

EGG

The egg is opaque, white, shining, ovoid to pear-shaped, rounded at the bottom; the top is slightly flattened and narrower, fitting into a plug or cap that cements it into place. The shell of the egg is very delicate and flexible, conforming to the shape of the egg cavity. Its length is 0.60 to 0.64 mm., the width 0.31 to 0.35 mm.

MATURE LARVA

The mature larva measures from 2.5 to 3.5 mm. in length and is pearly white in color. It is a footless, fleshy grub, very thick-bodied, the ventral outline being approximately straight while the dorsal outline is almost semicircular. The head is light brown in color, the anterior margin and mandibles are much darker, the head is longer than broad and somewhat wedge-shaped, and the sides are broadly rounded from middle to apex. The apex is slightly angular. The sides are nearly straight from the middle to the anterior angles, and the lateral area has an oblique, longitudinal, lighter stripe or area. The epicranial and frontal sutures are distinct and light in color; there are also two oblique, longitudinal, light stripes rising from the frontal sutures and coalescing with the epicranial suture near the apex. The frons is subtriangular with a distinct dark median line from the posterior angle to the middle, indicating a carina. The sutural margins are irregular or sinuate. The frons is provided with five pairs of large setæ, and each sutural margin bears a large seta. Each epicranial lobe bears the following setæ: One close to the posterior angle of frons and located within the oblique, longitudinal stripe rising from the frontal suture; one very small seta posterior to this and near occiput, two anterior to it on disk of epicranium; two opposite middle of frons; one opposite middle of mandible; one opposite hypostomal angle of mandible; and one on hypostoma near base of mandible. The epistoma is represented by the thickened anterior margin of the front. It is distinctly darker in color, with the anterior margin declivous and slightly curving and the lateral angles slightly produced and elevated where they support the dorsal articulation of the mandibles. The pleurostoma is represented by the somewhat darker declivous area surrounding the mandibular foramen. The mandibles are stout, triangular, with the apex produced into an acute apical tooth. The inner edge toward the apex is provided with a subapical tooth and a small medial tooth, no molar parts present. The dorsal area of the mandible is provided with a pair of bristles set apart. The eye is represented by a well-defined black spot beneath the exoskeleton.

The clypeus is attached in front of the frons and is broadly transverse. It is broad at the base, the sides narrowing toward the apical angles, and is slightly longer and broader than the labrum. It bears on the epistomal margin two fine setæ on each side. The labrum is distinctly broader than long, with two lateral and a larger median lobe. It is provided with six large setæ behind the middle, two marginal, short, thickened setæ on each of the lateral lobes, and six similar marginal setæ on the median lobe.

The cardo is present and distinct in the maxilla; the stipes is not divided into stipes proper, subgalea, and palpifer but is one continuous piece, with the anterior inner angle produced into a single setose lobe.

The palpus is 2-jointed and bears a single seta near the apex of the first segment. There are three other setæ found on the maxilla, two located on the vaginant membrane between the palpus and palpifer, and one stouter and longer seta midway between the palpus and cardo. There is no articulating maxillary area between the maxilla and the mental-submental region.

The submentum and mentum are fused and are represented by a broad lobe bearing three pairs of stout setæ. The stipes labii are posteriorly enforced by a median, trangular chitinization; the anterior median section is produced anteriorly between the palpi into a small lobe-like ligula which is fused with the lingua. Each stipes labii bears a single seta. The short, conical, 2-jointed palpi are situated on the anterior angles of the stipites. The ligula bears four small setæ.

The prothorax is dorsally not divided; but two areas, the praescutal and scutoscutellar areas, are roughly indicated by rows of setæ. The mesothoracic and metathoracic segments are above divided into two distinct areas, the anterior of which represents the praescutum and the posterior the scuto-scutellum and alar area. The thoracic spiracle is located on a lobe pushed into the prothorax from the epipleurum of the mesothorax. It is bifore, elongate, larger than the abdominal spiracles, and placed with the finger-like air tubes pointing dorsad. The metathoracic spiracle is rudimentary.

There are 10 abdominal segments, the first 7 similar, the last 3 smaller and reduced. Each of the abdominal segments 1 to 8 is supplied with a spiracle, that of the eighth being located more dorsally than the rest. Each tergum is divided above into two distinct areas. The first contains praescutal and scutal elements; the second represents the scutellum. Below these two areas and adjacent to the epipleurum is the alar area. The abdominal spiracles are placed anteriorly and in a little separate corner piece, probably of the alar area.

Below a very indistinct and abrupt dorso-lateral suture and above a well-defined ventro-lateral suture is a large, not subdivided epipleurum. The abdominal epipleura are located considerably higher than the thoracic, and the ventro-lateral suture makes an S-shaped line between metathorax and first abdominal segment. Below the ventro-lateral suture is the hypopleurum subdivided into three lobes, one right under the other. Below the hypopleurum is the coxal lobe, and below that is the sternum, consisting of the eusternum and a posterior triangular area representing the parasternum or the parasternum fused with the sternellum.

The setæ on the abdominal segments are arranged as follows: One on the praescutum, a long and two shorter ones on the scutellum, two on the alar area located just above the spiracle, two on the epipleurum, one on the middle lobe of the hypopleurum, one on the coxal lobe, and three on the eusternum. One of the hairs on the scutellum is sometimes missing on the last few abdominal segments.

LARVAL INSTARS

First-instar larva 0.53 to 0.60 mm. long, 0.37 to 0.43 mm. wide; pearly white; head about 0.25 mm. wide, 0.26 long.

Second-instar larva 0.65 to 0.80 mm. long, 0.5 to 0.65 mm. wide; head 0.32 mm. wide, 0.36 mm. long.

Third-instar larva 0.75 to 1.3 mm. long, 0.6 to 1 mm. wide; head 0.42 to 0.45 mm. wide, about 0.52 mm. long.

Fourth-instar larva 1.5 to 3.5 mm. long, 1 to 2.5 mm. wide; head about 0.57 mm. wide, about 0.80 mm. long.

PUPA

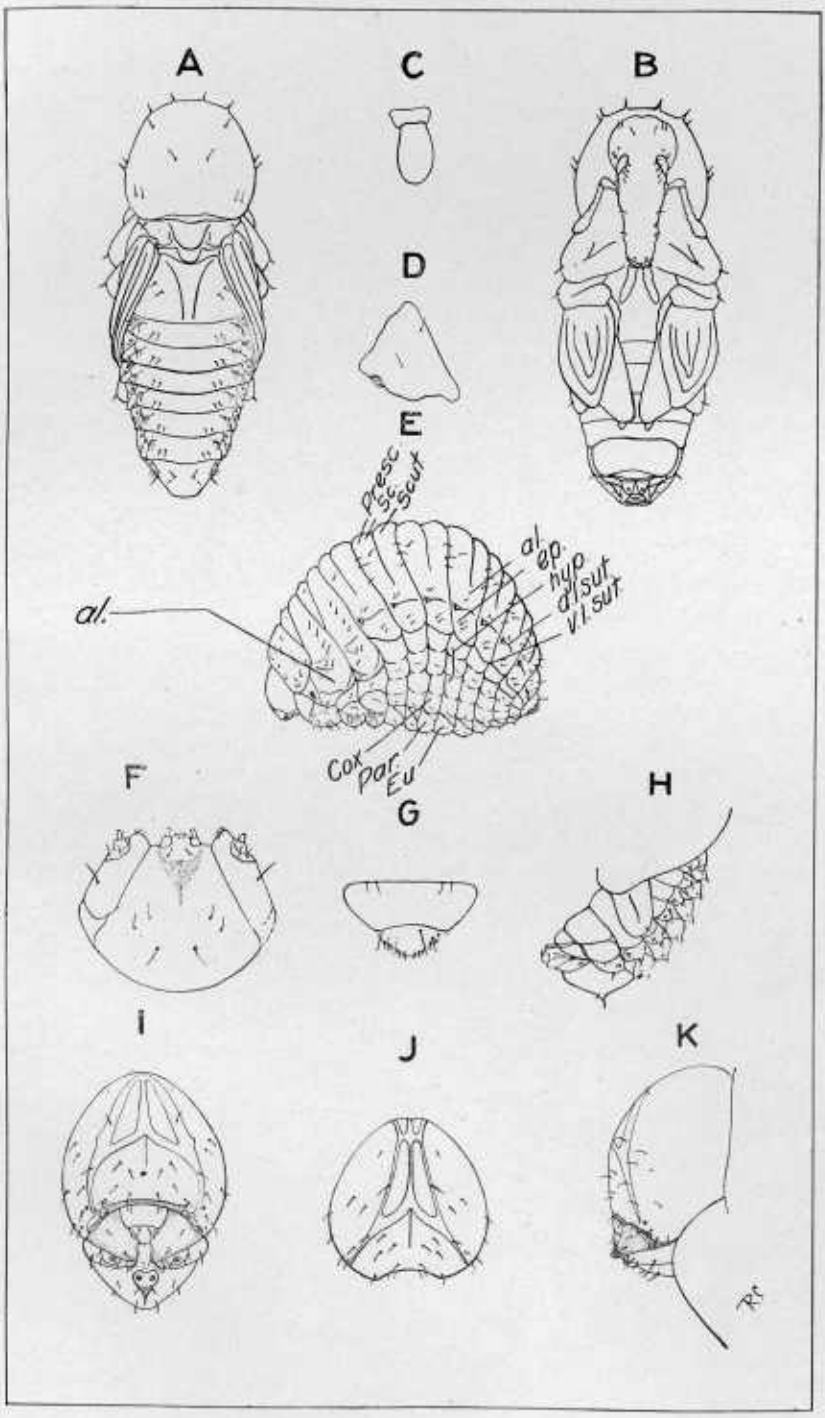
The pupa is uniformly white when first transformed, 3.5 to 4.25 mm. long, and about 1.65 mm. wide. The tips of the wing pads attain the fifth abdominal segment; the tips of metathoracic tarsi extend beyond the tips of the inner wings. The head is oval, the beak elongate and slender. The head has two prominent spines towards the vertex, a group of two spines and two spinules on each side above the eyes, two pairs of small spines near the anterior margin, and a small one on each side of the front between the eyes. There are three pairs of spines on the beak between the frontal ones and the base of antenna, a pair of small ones on the beak midway between the base of antenna and tip of beak, a pair on the sides of the beak between the latter pair and the tip of the beak, and two pairs on the tip of the beak.

The prothorax is provided with one pair of antero-marginal, setigerous tubercles, one pair of antero-lateral, two pairs of medio-lateral, and four pairs of dorsal setigerous tubercles. The mesonotum and metanotum are each provided with two pairs of spines. The abdomen has seven distinct dorsal tergites, the seventh being somewhat larger than the rest. The dorsal area of each is armed with a pair of large spines and a pair of smaller ones. The lateral area of each tergite is armed with a spine at the base of which is a small seta. The epipleural lobes are each armed with two minute setæ. One pair of the dorsal spines of the seventh abdominal segment is much larger than the rest and is usually directed cephalad; the second pair is small and slender and is directed caudad. The ninth abdominal segment is armed with two fleshy processes.

PLATE 61

Sitophilus linearis:

A.—Pupa, dorsal view.
B.—Pupa, front view.
C.—Egg.
D.—Mandible.
E.—Mature larva.
F.—Ventral view of head.
G.—Clypeus and labrum.
H.—Pupa, lateral view.
I.—Head, face view.
J.—Head, dorsal view.
K.—Head, lateral view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