DESCRIPTION OF A NEW SPECIES OF TELENOMUS WITH OBSERVATIONS ON ITS HABITS AND LIFE HISTORY

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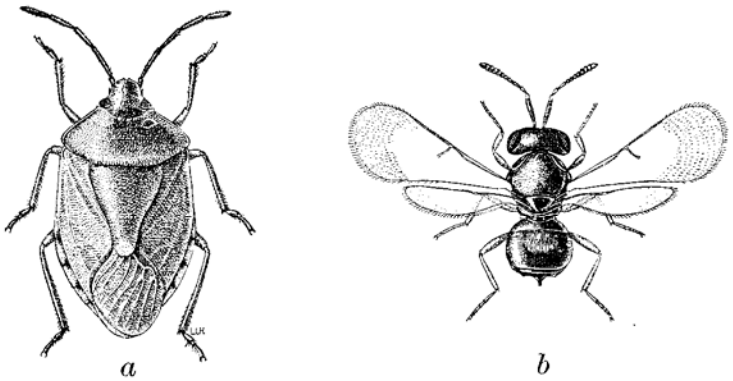
MINUTE egg parasites belonging to the hymenopterous family Proctotrypidæ are known to play an important role in checking the multiplication of certain insects, fluctuations in the numbers of the parasites and hosts usually being intimately associated and resulting in a corresponding benefit or injury to the crops attacked by the latter. Notwithstanding the economic importance of the proctotrypids our knowledge of their life histories is very meager, and the incidental and more or less fragmentary notes upon which this contribution is based seem to point to a fruitful field for the investigator.

The data here presented were obtained in 1905 in connection with the investigation of heteropterous pests of cotton, alfalfa and other crops. The principal insect (Fig. 1, *a*) affected by the parasite here discussed, is a member of the stink-bug family or Pentatomidæ, and is commonly known in Mexico by the name "Conchuela." Only five North American species of proctotrypids known to attack the eggs of these bugs have heretofore been described, but many undescribed forms doubtless exist. All of these five species were described by Ashmead ('93), one belonging to the genus Telenomus and four to Trissolcus.

H. A. Morgan ('97) records that in Louisiana in August, 1896, the eggs of the Harlequin Cabbage Bug, *Murgantia histrionica*, were parasitized by proctotrypids (*Trissolcus murgantiæ* and *Trissolcus podisi*) to the extent of over 60%. The writer has noted ('07) that of 211 pentatomid eggs collected at Barstow, Texas, in September 1905, 148 or 70% produced adult specimens of *Telenomus ashmeadi*, the species hereafter described. During July 1905, 22 batches including 794 eggs were collected in cotton and alfalfa fields at Tlahualilo, Dgo., Mexico. Of these, 18 batches were parasitized and from their 638 eggs, 468 adult speci-

mens of *Telenomus ashmeadi* were produced. The remaining eggs, amounting to 27%, failed to produce adult parasites or to hatch; they were presumably destroyed by parasites which failed to mature or to emerge, for from the four non-parasitized egg batches 155 bug nymphs hatched from 156 eggs. In the case of every parasitized pentatomid egg batch collected at Barstow, Texas, or at Tlahualilo, Mexico, no nymphs hatched, showing that in the majority of cases complete destruction results whenever an egg batch of a host species is discovered by its tiny enemies. Of 41 batches collected, 36 or 88% were parasitized by *Telenomus ashmeadi*. This probably represents more closely



a *b*

FIG. 1.— *a*, an adult conchuela, *Pentatoma ligata* Say, enlarged 2⅜ diameters. *b*, an adult female specimen of *Telenomus ashmeadi* N. Sp., enlarged about 20 diameters. From the author's illustrations in Bull. 64 of the Bur. of Ent., U. S. Dept. of Agriculture.

the economic usefulness of this species than do figures based upon the individual eggs. Although the multiplication of the host species appears to be effectively checked by these beneficial insects by midsummer, the pentatomid bugs affected have already had an opportunity to show the extent of their destructive capabilites. In the case of a large plantation in northern Mexico which comprises some twenty-seven thousand acres of cultivated land mostly devoted to cotton, the damage from the host species, the conchuela, is estimated at from twenty to sixty thousand dollars in single seasons. Without the natural check afforded by these parasites this destruction would doubtless be increased five or six times.

Description and Records of Breeding and Collection.

This parasite having been pronounced a new species of the genus Telenomus by Dr. W. H. Ashmead, the writer takes pleasure in dedicating it to this eminent authority on the parasitic Hymenoptera who has described more than 500 North American representatives of the family Proctotrypidæ.

Telenomus ashmeadi, N. Sp. ♀ (Fig. 1, *b*). Length 1.08–1.15 mm. Black with fine pale pubescence.

Head.— Width, .56 mm., scarcely wider than thorax, marked with impressed reticulations; mandibles black. Antennæ clothed with pale pubescence, dark brown to blackish in color, except pedicel the color of which gradually changes to light brown at distal end. Proportionate dimensions of antennal segments (Fig. 2, *B*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum									
	:	:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*1–9*
Length	105	28	30	18	12	11	17	15	15	16	20	~~124~~ 154
Greatest width	16	12	11	11	13	15	18	18	17	16	13	—

Thorax.— Width .55 mm., length .48 mm. Dorsum marked with impressed reticulations, pubescent; mesoscutum rather roughly longitudinally grooved posteriorly; scutellum smooth and shining with a few pale hairs arising from minute punctures. Legs clothed with moderately dense pale pubescence; coxæ black; trochanters, tibiæ and tarsæ light brown by reflected light, yellowish brown by transmitted light; tarsal segments successively darker to the last; femora dark brown or brownish black by reflected light, dark brown by transmitted light. Proportionate length of segments of hind tarsæ not including tarsal claws, as follows:[2] $\frac{1}{13}$, $\frac{2}{6}$, $\frac{3}{4}$, $\frac{4}{3}$, $\frac{5}{4}$. Wings hyaline, iridescent; venation brownish; length of fore wing 1 mm., greatest width, .46 mm.

Abdomen.— Length .532 mm., width .518 mm.; basal two thirds of first segment striate above; basal two thirds of second

[1] Measurements made with 1 in. eye piece and $\frac{1}{6}$ in. obj.; tube length 160 mm. To obtain dimensions in mm. multiply by .003.

[2] Measurements made with 1 in. eye piece and $\frac{2}{3}$ in. obj., tube length 160 mm. To obtain true lengths in mm. multiply by .0148.

segment striate above except laterally, elsewhere smooth and shining; third to fifth segments punctate. Length of second segment .3 mm., greatest width .518 mm. Second, third and fourth segments fringed with sparse pale hairs posteriorly. Fifth segment finely pubescent. Ventral plates finely punctate and pubescent. Sheath of ovipositor about .044 mm. in length. Ovipositor when fully extended about .1 mm. in length.

♂.— Length .8–1.13 mm. Differs in form from the female principally in the moniliform twelve segmented antennæ and the more abruptly truncate abdomen. Head, .44–.62 mm. wide. Thorax, .38–.55 mm. wide. Length of abdomen .32–.44 mm., greatest width .38–.46 mm. Proportionate dimensions of antennal segments (Fig. 2, *A*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum										
	:	:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*1–10*
Length	100	25	31	24	25	20	19	19	19	19	20	30	226
Greatest width	17	15	17	17	17	17	17	17	16	15	15	14	—

The constricted basal portion of the scape is dark brown; the outer three-fourths is light brown. Pedicel light brown, darker on outer side. Flagellum light brown basally, changing to dark brown distally. Legs except the coxæ light brown in color by reflected light, by transmitted light pale brown to honey yellow.

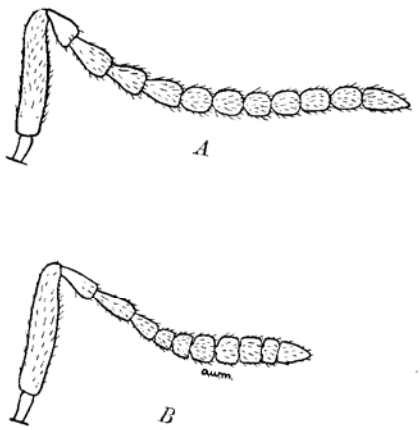


FIG. 2.— Antennæ of *Telenomus ashmeadi*, enlarged 70 diameters. *A*, male. *B*, female.

Described from numerous specimens of both sexes. Cotypes deposited in the U. S. National Museum; Type No. 10364. Type locality Barstow, Texas; also collected at Tlahualilo, Dgo., Mexico.

[1] Measurements with same combination as used for measurements of the segments of the antennæ in the female. Multiplying the figures by .003 will give dimensions in mm. of average specimens bred from eggs of *Pentatoma ligata*.

All of the females were bred from eggs of *Pentatoma ligata* collected at Barstow, Texas, Sept. 12th, 1905. Three of the males were bred from eggs of *Thyanta custator* Fabr. In the foregoing description of the male, the smaller series of dimensions refers to the specimens bred from *Thyanta custator,* and the larger series of dimensions to specimens bred from the eggs of *Pentatoma ligata.* It is probable that this parasite will readily attack the eggs of most or all of the species of pentatomid bugs. In addition to the eggs of *Pentatoma ligata* they have been bred from the eggs of *Pentatoma sayi* Stål collected at Barstow and in the laboratory showed no hesitation in attacking the eggs of *Euschistus servus* Say and *Thyanta custator.* The size of the adult parasites corresponds directly with the size of the respective host eggs. The following table showing the relationship between the size of the host eggs and of the adult parasites is based on five male specimens bred from eggs of each of the three host species:

Host species	Pentatoma ligata	Euschistus servus	Thyanta custator
Host egg, average length	1.33	1.11	.90
" " , average diameter	1.01	.88	.75
Head of parasite, average width	.60	.53	.45
" " " , maximum width	.62	.54	.47
" " " , minimum width	.56	.52	.44

The parasitizing of eggs of pentatomid species representing more than one genus by a proctotrypid was recorded in 1897 by Prof. H. A. Morgan who bred *Trissolcus podisi* from the eggs of *Murgantia histrionica,* the Harlequin Cabbage Bug. The parasite in this case had previously been recorded as having been bred from the eggs of *Podisus maculiventris* Say (= *spinosus* Dal).

Habits and Life History.

Emergence of adults. The adult parasites use their mandibles to make exit holes for themselves at the top of the eggs, i. e., at the end through which the nymphs normally emerge (Fig. 3). When mature, the parasite completely fills the host egg and so far as observed always develops with its head at the end from which the pentatomid nymphs normally hatch. In one instance, one egg of a batch of 28 was deposited wrong side up by the parent

pentatomid (*P. ligata*) and after the batch was subsequently parasitized the adult proctotrypid emerged from the top side of the misplaced egg, *i. e.*, the under side of the egg batch.

Oviposition. On one occasion it was observed that four adult parasites, which had previously been rather quiet at the top of a cage, became very much excited immediately upon the introduction of empty egg shells of *Thyanta custator* and an unhatched egg batch of *Euschistus servus*. The insects were not ordinarily dis-

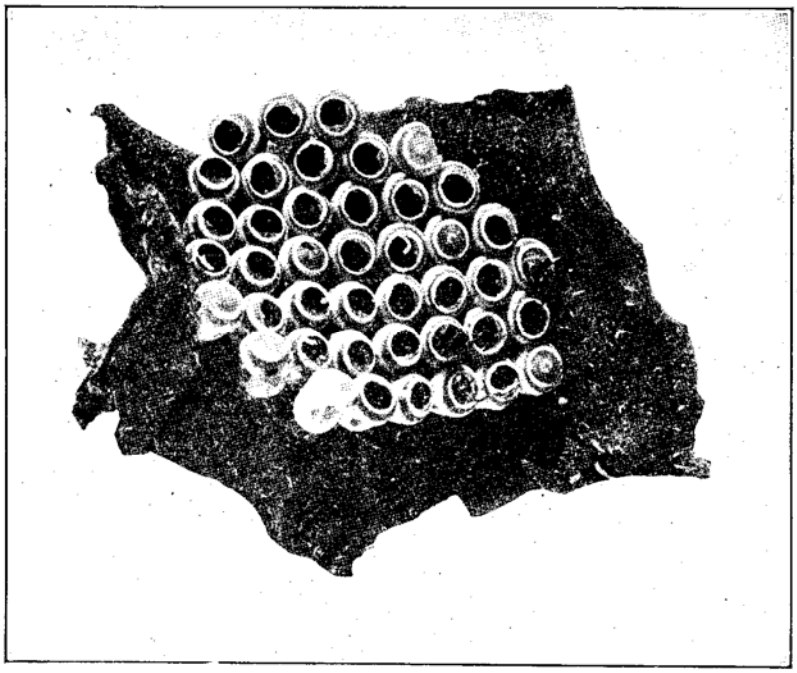


FIG. 3.— Egg batch of conchuela, *Pentatoma ligata*, from which 32 parasites, *Telenomus ashmeadi*, have emerged. Enlarged 6⅔ diameters. The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant. Morrill, Bull. 64 of the Bureau of Entomology, United States Department of Agriculture.

turbed by such a slight movement of the cage as was necessary to introduce these eggs and egg shells, but in this case they dropped almost at once to the bottom and carefully examined the empty egg shells, after which the eggs of *Euschistus servus* were found, and oviposition in these began almost immediately. At another time thirteen parasites, presumably all females, showed similar excitement upon the introduction of eggs of *Pentatoma ligata*.

No attempt was made to ascertain the nature of the tropism or sense which leads to the discovery of host eggs by the adult parasites, but it appears that the attraction is as great for empty egg shells of *Thyanta custator* as for unhatched eggs of *Euschistus servus* in a suitable stage of development for successful parasitism.

When the pentatomid egg batch is found, the adult parasite carefully examines it with her antennæ. If the eggs are satisfactory she sets to work industriously and oviposits in one egg after the other. The process of oviposition in a single host egg requires from two and one quarter to three minutes. The body of the female during this operation is held rigidly by the legs in a position nearly perpendicular to the surface of the host egg at the point of introduction of the ovipositor. The puncture may be made through the egg cap or top end of the egg, or it may be through the side of the egg. The latter is more frequently the case with eggs located on the outside of the batch.

Before leaving the egg the female scrapes it for a few seconds with the tip of the ovipositor, usually moving it around the point of insertion making a nearly complete circle, then reversing and with a shorter radius passing around to or beyond the starting point, then perhaps reversing again and with a still shorter radius making a nearly complete circle. Sometimes a much more irregular figure is traced but it is always curved for the most part, and so far as observed the direction of the movement is abruptly reversed from one to three times. It is difficult to imagine any useful purpose of this instinctive act except to mark the parasitized egg so that it can be detected as unsuitable for further attack by parasites of its own and probably other species.

Egg laying capacity. The largest number of pentatomid eggs positively known to have been successfully parasitized by a single female of the species here considered is 27. The total number of eggs which a female parasite may deposit appears not to be necessarily indicated by the number of adult parasites which may result. In many cases it has been found that the parasite for some reason failed to emerge even after reaching full maturity. In other cases the larvæ of the parasites appear to die when quite young, although accomplishing the destruction of the host egg. The data at hand on the number of eggs deposited by a single female parasite of this species are given in the following table:

NUMBER OF PENTATOMID EGGS PARASITIZED BY SINGLE SPECIMENS OF *Telenomus ashmeadi*.

Date 1905	No. of eggs accessible	No. of eggs from which adult parasites were bred	No. failing to hatch or to produce adult parasites; probably parasitized
July 17	28	27	1
" 28	42	21	7
Sept. 16	127	13	34
" 30	13	13	0
" 30	10	10	0
" 30	22	22	0

Developmental period of the parasite compared with the incubation period of the host. The parasite requires for its complete development about twice the normal incubation period of the host egg at any given temperature. The following table summarizes the data at hand which bear on this point:

DEVELOPMENTAL PERIOD OF PARASITES AND INCUBATION PERIOD OF EGGS OF THE HOST SPECIES.

When parasitized	Locality	Developmental period of parasite days.	hrs.	Aver. daily mean temperature °F	Incubation period of non-parasitized host eggs days.	hrs.
July 17, 6 P. M.	Tlahualilo, Mexico	10	23	80.2	5	1
Sept. 16, 10 A. M.	Dallas, Texas	11		76.	5	11
Sept. 24, 10 A. M.-5 P. M.	" "	11	12	74.	6	—
Sept. 28-29, 4 P. M.-4 P. M.	" "	15	—	—	–	—
Sept. 30, 4 P. M.	" "	14		69.8	7	6
Sept. 30-Oct. 1, 10 A. M.-4 P. M.	" "	14		—	–	–

In the case of the first, second and fifth records the exact time of the beginning of oviposition is given to the nearest hour. In the remaining records no note was made as to the exact time at which oviposition began. The last five records, although made at Dallas, Texas, refer to specimens of host and parasite originally from Barstow, Texas. The short incubation period in the record in Mexico as compared with subsequent records in Texas is probably due to the natural adaptation of the species to climatic conditions within its range. The parasite seems to be equally well adapted to its different environments inasmuch as the relation of its developmental stages to the normal incubation period of

the eggs of the host species remains quite constant as shown in the table.

Condition of host eggs necessary for successful parasitism. In the many cases in which definite records have been made, parasitism by *Telenomus ashmeadi* has been successful with the majority of the eggs of a batch up to the time that the embryos have gone through one half of their development. The failure to produce adult parasites from the remaining eggs in such cases is probably due to some other factor than the developmental condition of the host egg.

In one instance a batch of twenty-two eggs of *Pentatoma ligata* deposited on the morning of September 26th was parasitized by a female *Telenomus* on the morning of September 30th. The normal incubation period of the eggs of the host species at this season was about six and one half or seven days, the embryos therefore at the time of oviposition were slightly more than one half developed. Twenty-one of a total of twenty-two of the bug eggs hatched in a normal manner and the remaining egg failed to produce either a nymph or an adult parasite. A similar experiment with the eggs of *Euschistus servus* deposited four days previously and at a time when the normal incubation period was about seven days resulted in four eggs of a batch of ten producing adult parasites. The remaining six eggs contained parasites which failed to emerge, perhaps as a result of an attempt to delay their emergence by placing the egg batch for a few days in an ice box.

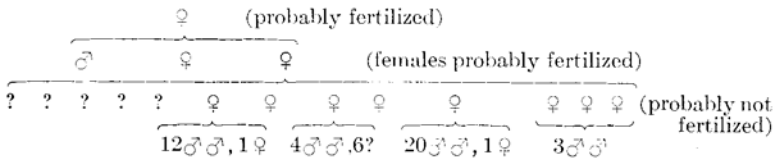
Changes in the appearance of parasitized eggs. During the course of two or three days following oviposition by the parasite the eggs of *Pentatoma ligata, Pentatoma sayi,* and *Thyanta custator* became slightly darker, but as they are subject to a variation in their color during normal development, parasitism cannot be said to produce any characteristic changes in appearance up to the time the adult parasites emerge. In the case of *Euschistus servus,* however, parasitism produces a marked change in color, since the egg membrane in this case is more translucent than with the other species mentioned, and the young nymphs are normally paler in color. Ten eggs of this host species were parasitized on October 1st, beginning at 3:00 P. M. On October 5th at 9:00 P. M. it was noted that seven of the ten were very dark in color, six being very dark gray and one slate gray; the three others had

changed color only slightly if at all. Two days later the eggs which had changed but little up to the time of the previous examination were as dark as the rest and indistinguishable from them as far as appearance was concerned. Parasites developed to maturity in each of these ten eggs and the first one was noted to have emerged at noon on October 16th.

Development in infertile host eggs. It is the writer's observation that shriveling of the eggs of pentatomid bugs indicates infertility although in some species, as in that of the Harlequin Cabbage Bug (*Murgantia histrionica*), a slight shrinking normally occurs just before hatching. With this as guide for the experiment, a batch of ten eggs was selected, which had been deposited by a specimen of *Euschistus servus* which previously had deposited a batch of infertile eggs. Four of these eggs were reserved as controls and a female parasite was given access to the remaining six; after having made the usual examination she was observed to begin oviposition. The four control eggs shrivelled in the course of a few days, but the six eggs into which the parasite had oviposited became dark in color and to all appearances promised to produce adult parasites. None appeared however nor did shrinking occur, and several weeks later when the eggs were opened their contents was found to consist of a very dark colored vitelline membrane together with a small shrivelled blackish mass on one side, which was unrecognizable as insect remains. A similar condition was found occasionally in parasitized eggs believed to be fertile and belonging to a batch from which many adult parasites appeared. The failure to produce adult parasites from the eggs used in the above experiment is therefore not positive evidence that this was due to infertility of the host eggs. The experiment shows however in a fairly conclusive manner that adult females of the species of proctotrypid here considered will readily parasitize infertile pentatomid eggs, and that the resulting larval parasites will develop sufficiently to cause the host eggs to take on the characteristic color of parasitized fertile eggs.

Parthenogenesis and its relation to sex of offspring. No absolute proof of parthenogenetic development of the eggs of *Telenomus ashmeadi* was obtained, but the contributary evidence from the few breeding experiments undertaken furnishes a good basis for the supposition that parthenogenetic development occurs and

moreover has a marked influence on the sex of the offspring. The following diagram shows the history of the offspring of a single female, which was one of a lot of 120 females and 19 males bred from eggs of pentatomids collected at Barstow, September 12, 1905:



The specimens recorded in the diagram by a "?" escaped or were otherwise lost so that their sex is unknown. The last generation included eighteen specimens which are not indicated in the diagram, since they came from eggs laid before the individuals of the preceding generation had been separated from one another. Of these eighteen, fourteen were males, and the others escaped before their sex had been determined. Two females bred to maturity in the laboratory under conditions which allowed of less doubt concerning their supposed infertility, oviposited in eggs of *Pentatoma ligata* and produced 27 and 21 adult parasites respectively; of these 17 and 15 respectively were males and the remainder escaped before their sex was determined. To summarize:— The offspring of the probably fertile females numbered 10 females, 1 male, and 5 undetermined; the offspring of the probably infertile females numbered 93 males, 2 females,[1] and 26 undetermined.

Proportion of sexes in nature. This subject furnishes additional and probably the strongest evidence that the fertility or infertility of the eggs of the parasite determines to a great extent the sex of the offspring. Sixteen females and 8 males were bred from a batch of eggs of *Pentatoma ligata* collected in a cotton field at Tlahualilo, in July, 1905. Another batch yielded 20 females and 2 males. Pentatomid eggs collected at Barstow in the months of August and September, 1905, produced 125 females and 19 males. In all, of 190 adult parasites bred from pentatomid eggs collected in the field, 161 or 85% were females, and 15% males.

[1] The writer has followed his original notes closely, although at present inclined to doubt that the two females referred to above were actually bred from the same egg batches with the males. Owing to their minute size and consequent difficulties met with in handling them it seems not impossible that the two specimens were in some way misplaced.

In the laboratory, where the chances of the females becoming fertilized were much less than in nature, the sex of 106 specimens was determined as above stated; of these 11 % were females and 89% males.

Longevity and Food Requirements. Under laboratory conditions, confined in glass tubes, pill boxes and insect cages, the adult parasites under observation had an average life of 3.8 days. The maximum longevity under these conditions was 8 days. The following table shows the various records in their relation to the season of the year:

LONGEVITY OF ADULTS OF *Telenomus ashmeadi* IN THE LABORATORY.

Period	No. of adult parasites	Approximate total no. of days lived	Average longevity per specimen
July 17–20	1	3	3
" 28–31	19	47	2.4
Sept. 14–16	1	2	2
" 27-Oct. 1	3	12	4
" 27– " 2	3	15	5
" 27– " 3	1	5.5	5.5
Oct. 5– " 13	38	165	4.3

An attempt to produce artificial hibernating conditions in an ice box was unsuccessful although the adult life of each of the 25 parasites used in the experiment was very much prolonged. When subjected to an average and only slightly varying temperature of 48.6° F., one adult lived 22 days, another 21 days, and the remainder between 12 and 20 days. At the temperature mentioned the adults appeared to be entirely inactive.

Adults of *Telenomus ashmeadi* have never been observed to feed. Those upon which the observations recorded in this paper were made had no access to anything that might have been used as food except pentatomid eggs and egg shells, fragments of more or less dried cotton leaves to which such egg batches were attached, and dry cotton lint or cloth which was used to close the tubes or cages in which the parasites were confined. No moisture was accessible to any of those which were used in the breeding experiments. In biting the exit holes from the host eggs the fragments of the egg shells are not eaten by the parasites. The evidence indicates that the parasites are sufficiently nourished

during their larval existence to require no food for carrying on, at least to a certain extent, their reproductive functions. It is not unlikely, however, that their longevity and reproductive capacity is increased by such food as they might obtain under natural conditions.

Summary and Conclusions.

1. A species of the proctotrypid genus Telenomus, believed to be new, is described under the name *Telenomus ashmeadi*.

2. The species, although originally bred from the eggs of pentatomid bugs of the genus Pentatoma, readily attacks the eggs of species of the genera Thyanta and Euschistus and such eggs ordinarily produce adult parasites differing in size from the parent in direct correspondence with the size of the host eggs.

3. The developing parasite invariably occupies a fixed position in relation to the embryo of the host, and emerges from the egg through the end from which the bug nymph normally hatches.

4. Adult female parasites are capable of detecting the presence of pentatomid eggs at some distance; four specimens were as strongly attracted by empty egg shells as by the unhatched eggs suitable for parasitizing.

5. Between two and three minutes are required for oviposition, after which the surface of the host egg is marked by the ovipositor in a characteristic manner, presumably for aiding in its subsequent detection as unsuitable for attack by other parasites.

6. The maximum number of pentatomid eggs known to have been successfully parasitized by a single specimen of *Telenomus ashmeadi* is 27; but there is evidence that this number may be greatly exceeded.

7. The entire developmental period of the proctotrypid parasite here considered is approximately twice the normal incubation period of the eggs of the host species, in Texas and northern Mexico during the summer months of 1905 varying approximately from 11 to 15 days.

8. Pentatomid eggs may be parasitized successfully by *Telenomus ashmeadi* up to the time that the host embryos have passed through one half of their incubation period. After this time the results are uncertain.

9. Pentatomid eggs with translucent membranes containing developing nymphs of a pale color undergo a characteristic darkening as a result of the parasitism. Other eggs with more opaque membranes and dark colored developing nymphs do not exhibit characteristic changes in external appearance.

10. Females of *Telenomus ashmeadi* show no hesitation in ovipositing in infertile pentatomid eggs, and such eggs when parasitized do not show the shrinkage which is usual in infertile eggs. In the case of *Euschistus servus* they undergo the changes in color characteristic of the parasitized fertile eggs of this species. Although no adults have thus far been bred from parasitized infertile eggs, the development of the parasite is at least partial, and the observations here recorded furnish only slight evidence that complete development in infertile host eggs is impossible.

11. Sex of the offspring seems to be controlled to a great extent, if not absolutely, by fertilization. In nature where the chance for a female parent to be fertilized is at a maximum the female sex greatly predominates, whereas under laboratory conditions which artificially reduce the chances for mating of the adults, the male sex predominates in an even greater proportion.

12. In confinement in the laboratory, adult life under ordinary temperature conditions lasts but a few days. The maximum period recorded during the month of July is three days, during September four days, and during October eight days.

13. The adults of *Telenomus ashmeadi* have not been observed to feed and apparently this is not necessary for carrying on reproductive functions.

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