his first specimens on March 23, and on the 30th observed many visits to the flowers of Salix. On March 31 a female was seen looking out from the mouth of nearly every burrow, probably waiting for a warmer temperature, for on April 6, when there was a severe snow squall, no bees were seen flying about the burrows; and a few which had ventured to fly to the willows were numbed by the cold.

Swenk states that he examined a female from Durham, N. H., taken Oct. 5, 1899, and has also seen a few other autumnal specimens of *C. inæqualis*. He regards them as individuals appearing prematurely, which normally would not have come out until the following spring.[1]

Colletes compactus flies in New England from about the first of September to the middle of October. I most commonly find it on the inflorescence of the goldenrod, but have one specimen taken on the flowers of *Aster puniceus*.

THE LIFE HISTORY AND HABITS OF *SPALANGIA MUSCIDARUM* RICHARDSON, A PARASITE OF THE STABLE FLY.[2]

By Harry Pinkus.[3]

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During the summer of 1912, while assisting in the study of the life history of the stable fly (*Stomoxys calcitrans* Linn.), at least two species of parasites were found breeding in large numbers in the puparia of this fly. These parasites belong to the family Pteromalidæ. One has been determined by Mr. C. H. Richardson as *Spalangia muscidarum* Richardson; the others have not been definitely identified. *S. muscidarum* was found most abundant while the other species appeared in smaller numbers. They appear to have similar breeding habits, although little has been done on the undetermined species.

During the investigation of the stable fly a lot of oat straw, placed in a pan and kept moist, was placed in the laboratory yard

[1] ("Specific Characters in the Bee Genus Colletes," Contributions from the Dept. of Ent., Univ. Neb., No. 1, p. 32.)

[2] Published by permission of the Chief of the Bureau of Entomology.

[3] Deceased August 27, 1913, at Dallas, Texas.

near the stable. When the straw began to decay stable flies visited it in large numbers, depositing thousands of eggs. In addition to the stable fly, a number of other species were found to be breeding in this rotting straw, such as Phoridæ, Chironomidæ and Anthomyidæ. No house flies (*Musca domestica* Linn.) or any other species of flies which commonly breed in dung were found although *Musca domestica* was present in the vicinity in considerable numbers. In a few weeks great numbers of Stomoxys larvæ of various sizes, as well as pupæ, were found in the straw. At this time a screened cage was placed over the pan in order to collect the flies as they emerged. Numbers of flies appeared daily for some time but the number was observed to diminish noticeably later. Upon examination of the straw the majority of the Stomoxys pupæ were found rather dark in color, some being almost black. When the cephalic ends of these pupæ were broken off in some cases the pupæ of parasites were found to be contained within, and in others the adult parasites came out as soon as the pupæ were broken. Considerable numbers of the Stomoxys pupæ were dead but no parasites were found within them. These pupæ were in the form of a soft, whitish, malodorous mass. The death of these pupæ appeared to be due, in part at least, to the parasites, as will be explained later.

Spalangia muscidarum Richardson appears to have a wide distribution. It has been bred from the house fly by Mr. C. H. Richardson, Jr., near Boston, Mass., as well as by Doctor L. O. Howard at Washington, D. C., from the same host. During this investigation, adults emerged on October 7, 1912, from Stomoxys pupæ collected by Mr. F. C. Bishopp at Gainesville, Texas on September 6, 1912. Other adults began emerging on October 26, 1912, from puparia collected by F. C. Bishopp and E. O. G. Kelly at Wellington, Kansas, on September 21, 1912, and others appeared on January 15, 1913 from puparia collected October 25, 1912 by F. C. Bishopp at Addis, Louisiana. Numbers have also been bred from pupæ collected at Denison, Texas, December 6, 1912. As has been pointed out, the parasite is undoubtedly very common in the vicinity of Dallas, Texas.

At Dallas the breeding was conducted both in the laboratory and out of doors. In the latter situation some adults emerged at

different times during the winter. These adults were killed when a temperature of 28° was reached on January 2, 1913. The immature stages, however, remained in perfect condition throughout the cold weather, and undoubtedly large numbers will emerge in the spring. In the laboratory, emergence continued throughout the winter. The greatest number appeared from pupæ kept in glass tubes in a well heated room. In another room, in which the temperature ranged somewhat lower, emergence was less rapid. At temperatures from 55 to 60° F. the adults became inactive. Breeding progresses well at 70° and somewhat higher temperatures increase all activities. Adults kept at 110° (in the dry atmosphere of an incubator) died very quickly.

Habits.

The adult parasites are scavengers in habit. In cages no prepared food is necessary for them. They prefer to feed on the remains of the host, and very often crawl back into the puparium and stay there for some time. While within the puparium they have been observed to feed upon the remains of the dipterous pupæ although honey and water were at hand. In no case did the adults pay much attention to artificial foods. They are seldom found anywhere except in and around the breeding places of their hosts. In flight the body is held in a vertical position with head up and wings extended horizontally. When disturbed, both sexes have the habit of "possuming." The legs are drawn together and the insect drops for a few seconds and then quickly resumes activity in order to escape. It appears that the parasites remain in one place as long as they have plenty of fly pupæ to parasitize. Probably dispersion takes place when the parasites become numerous and they do not have a sufficient number of hosts. It has been found that each female requires a considerable number of pupæ in which to deposit her eggs.

After the adults emerge from their pupal skins they have the habit of remaining within the puparia of the host for some time. During this period they gnaw more or less regular, circular holes through the puparia, but in many cases do not issue for some time after the emergence holes have been made.

Copulation takes place very shortly after emergence. The males are ever ready for mating. They seize the females and cling to their backs, caressing them with their antennæ for some time until the female exposes the ovipositor and copulation takes place. This act has been observed to take place a number of times at short intervals. Often two or three males endeavor to secure the attentions of the female at the same time.

Oviposition.

Spalangia muscidarum is a simple parasite[1] and does not usually deposit a second time in a single host. When a female finds a pupa she first makes a thorough examination with the antennæ and then fixes herself firmly on the pupa. She then begins to feel about on the pupa with the tip of the ovipositor, sometimes changing her position if the first spot attacked is too hard for penetration. The ovipositor is usually inserted near the cephalic end of the puparium, generally on a suture. While ovipositing, the female is not easily disturbed. In some cases the puparium may roll over and yet the parasite retains her position. The accompanying figure (Plate I fig. 1.) of the female in act of depositing was drawn from a photograph taken by Mr. H. P. Wood. About ten or fifteen minutes are required for the deposition of an egg.

Repeated efforts to induce the female to deposit an egg in a puparium which had already been deposited in were unsuccessful. In every case the female quickly recognized the fact that the puparium had already been attacked, and left it in search of other hosts. A female which was supplied with fresh pupæ as fast as oviposition took place was observed to deposit in fifteen different pupæ in succession. She would have, undoubtedly, deposited in many more pupæ had they been supplied, as she appeared strong and active after having laid these eggs. Subsequent examination of these fifteen puparia showed that immature parasites were developing in four and all of the others were dead, probably as the result of the insertion of the ovipositor. When numbers of puparia were supplied to parasites in cages, in only one case did an adult fly emerge, the others having succumbed to the attack of the parasites.

[1] Pierce: On some phases of parasitism displayed by insect enemies of weevils. Journ. Econ. Ent., vol. 3, p. 452, 1910.

The female will readily oviposit in many species of dipterous pupæ. Evidently it has no preference. In addition to *Stomoxys calcitrans* the following species have been parasitized experimentally: *Musca domestica* Linn., *Hæmatobia serrata* Desv., *Helicobia quadrisetosa* Coq. and *Pseudopyrellia cornicina* Fabr. In one test a number of puparia of different species of flies were mixed with those of *Stomoxys calcitrans* and all were put under a glass bell jar in the laboratory. A number of parasites were introduced and observations made in order to ascertain if any preference was shown. In this case, as well as when different pupæ were placed in small tubes with parasites, no discrimination between the different species was apparent.

In nature the stable fly is undoubtedly the principal host of the parasite. This is evidently due to the breeding habits of this fly. As has been stated, the stable fly breeds largely in rotting straw or manure which contains much straw. The loose texture of this material allows the parasites to gain access to the puparia with ease. On the other hand, the breeding habits of the species which have been found experimentally to act as hosts of this parasite, are quite different. For example, *Musca domestica*, *Hæmatobia serrata* and *Helicobia quadrisetosa* breed mainly in dung or other matter which is of compact texture. By the time the larvæ are ready to pupate the material in which they are breeding becomes quite compact. This prevents, to a great extent, the adult parasites from entering the substance in order to reach the host, except when the mass of breeding material is accidentally scattered or if some straggling specimens happen to pupate so as to be partially exposed. In nature this condition is not the rule, hence we find the parasite attacking most commonly those species which are readily reached.

Development.

The length of the developmental period of the parasite varies greatly, according to the temperature experienced. An egg (see Plate I fig. 2) which was probably of this species has been removed from the body of a fly pupa. A number of observations have been made to determine various points in the developmental period of the parasite.

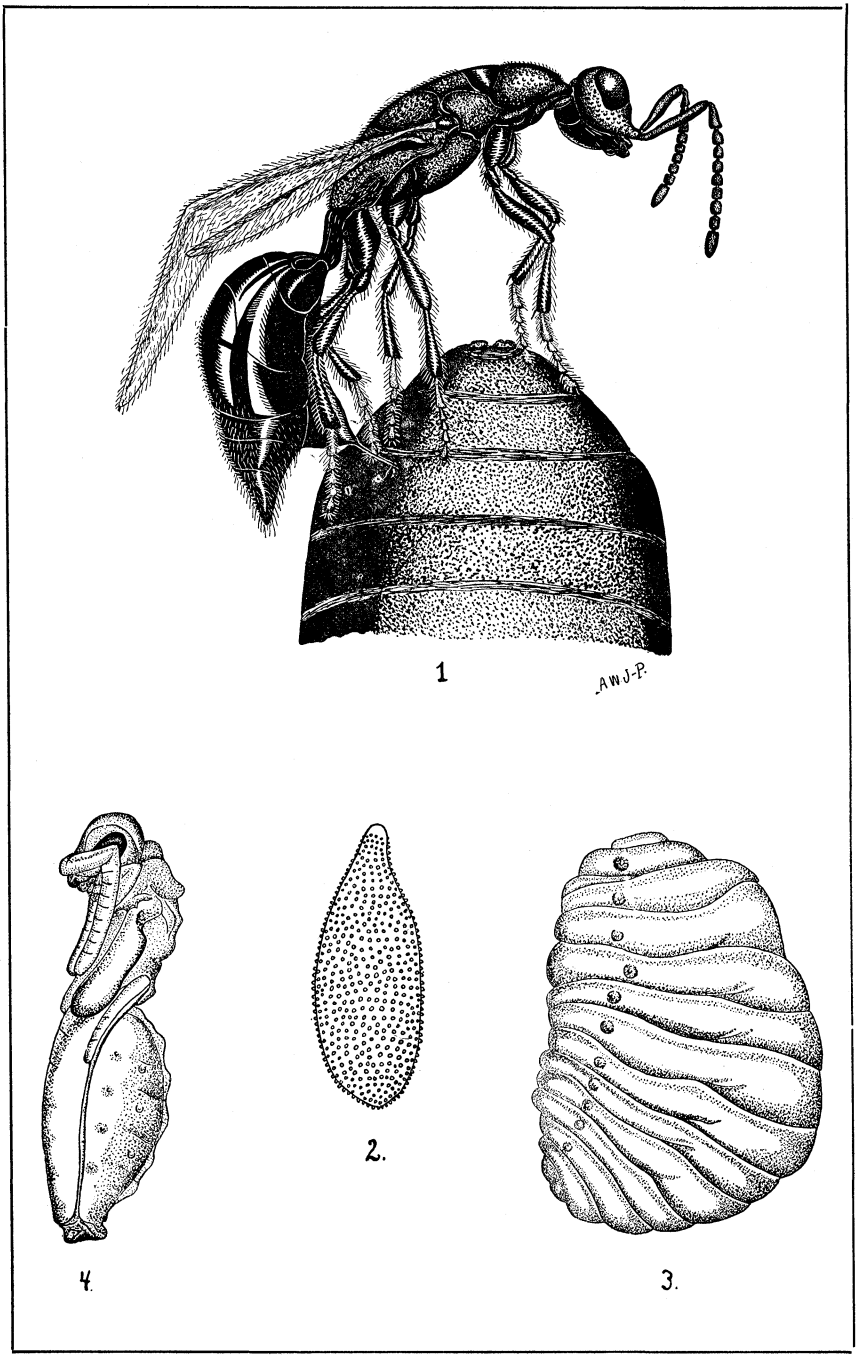

Fig. 1. *Spalangia muscidarum* Richardson. Adult female ovipositing in puparium of *Stomoxys calcitrans* Linn. Fig. 2. Egg of *Spalangia muscidarum*. Fig. 3. Larva of *Spalangia muscidarum*. Fig. 4. Pupa of *Spalangia muscidarum*.

In one series, eggs were deposited on November 7, 1912 within the puparia of *Stomoxys calcitrans*. On November 12 one fly pupa was observed to have a minute larva feeding on its eye. On December 9 full-grown parasite larvæ (see Plate I, fig. 3) were found feeding on the exterior of fly pupæ within the puparia. One parasite pupa (see Plate I fig. 4) was also found on this date. January 30, 1913, one adult parasite emerged, thus having a total developmental period of 84 days. During this period the average mean temperature was 56.58° F.

A number of puparia of *Musca domestica* were exposed to Spalangia adults November 3, 1912. On November 9 the parasites were observed to be ovipositing. In at least two of these the parasites were observed to have pupated when examined December 6. When again examined, on January 9, 1913, the pupæ were becoming black. Three adults had issued on or before February 20, 1913. In this test the total developmental period was less than 109 days. In another experiment, in which *Musca domestica* was used as a host, parasites were placed with the pupæ on November 12, 1912. Oviposition occurred at noon on this date. Full grown parasite larvæ were found on January 5, 1913, and on January 30, some had begun to pupate, thus having occupied 79 days in developing to the pupal stage at about the same temperature which prevailed in the above experiment where Stomoxys pupæ were used. One female parasite issued February 26, 1913, after a total developmental period of 106 days.

Parasites developed from the egg to the adult in 100 days in puparia of *Hæmatobia serrata*. In this test deposition took place on November 12, 1912. Pupation began January 30, 1913 and the first adult emerged February 20, 1913. This experiment was also conducted in the same room as the preceding experiments.

In another room in the laboratory, where the temperature was considerably higher, a number of puparia of various species were exposed to parasites on November 30, 1912. Pupation had begun January 30, 1913, or 61 days after eggs were deposited. This shows that the period from deposition to pupation was shortened 18 days by the higher temperature in which the developing parasites were kept. One adult female and one male emerged February 26, 1913 from a *Hæmatobia serrata* puparium. The total developmental period is therefore about 88 days.

Examinations of puparia kept out of doors during the winter of 1912–13 showed that a few adults emerged during warm weather but the majority of the immature stages appeared to continue developing very slowly and will probably not emerge until the advent of spring.

Methods of Artificial Propagation of Parasites of the Stable Fly.

As has been shown, the habits of the female parasites enable them to destroy a great number of fly pupa. Many of these pupæ are destroyed by the development of the young parasites and others died, apparently from injury caused by the insertion of the ovipositor. Circumstantial evidence also indicates that many fly pupæ are pierced by the ovipositor to cause juice to exude from the punctures for food for the parasites. This view is strengthened by the finding in nature of numerous Stomoxys puparia, the contents of which have completely dried up.

It would seem that if an adequate number of these parasites are present early in the season they would be quite effective in the control of the stable fly. However, under natural conditions it is reasonable to assume that in general there is seldom a sufficiently great number of parasites present to cope with Stomoxys, despite the fact that the fly generally occurs in small numbers early in the spring. The development of the stable fly is considerably slower than that of the house fly and as a consequence it seldom becomes sufficiently abundant to be very injurious until in the fall. The development of the parasites is slower than that of the stable fly, hence under natural conditions the parasites are unable to control it. However, late in the fall the parasite also becomes very abundant as breeding is facilitated by the great abundance of its hosts and the high temperature which prevails at that season. With the advent of cold weather the breeding of both the parasite and host is checked to a great extent and when fatal temperatures are reached nearly all of the adult parasites are killed without having had an opportunity to deposit in the fly puparia which are still present in rotting straw and other places. This condition allows many stable flies to continue to develop through the winter and appear as adults the following spring. Those which were in

the larval stage at the time the adult parasites were destroyed would be entirely exempt from attack as well as some of the pupæ which had not been reached up to that time. Of course the parasites which are in the immature stages would be protected by the same conditions which protect the host and they would pass the winter successfully and emerge along with the flies in the spring. However, their numbers would be much smaller than the stable fly at that time.

By artificial means it is possible to propagate these parasites in large numbers throughout the winter and liberate them early in the spring. By this procedure it might be possible to cut down to a great extent the first generation of flies and the continued development of the parasites during the spring and summer would tend to control the flies throughout the year. In addition to the destruction of the stable fly, house flies and other injurious species would also be attacked whenever the parasites are able to reach them.

Since Spalangia does not discriminate between various species of fly puparia the work of artificial propagation is greatly facilitated. The writer has found it best to collect the larvæ together with the manure or other substances in which they are breeding and after pupation has taken place to separate the pupæ and supply the parasites with them.

The writer has modeled a parasite breeding cage (Fig. 1) which he finds quite practical for the breeding of these parasites. In the construction of this cage an empty honey box (the container of comb honey) size 8 x 14 x $9\frac{1}{2}$ inches in height is used. Glass is closely fitted in the front and top and a hole four inches in diameter is cut in either end. Around the inside edge of each of these holes is tacked one end of a cuff of soft muslin cloth. These cuffs should be about nine inches in length, the outer end being gathered with an elastic so as to closely fit around the wrist of the operator when the hands are inserted into the box. When not in use the cuffs are closely tied with a string to prevent the escape of parasites. At the center of the bottom of the cage a hole one inch in diameter should be cut. The entire bottom of the cage, with the exception of the circular hole, is then covered with oil cloth to protect the wood from the moisture. On top of the oil cloth a

layer of white blotting paper is placed, completely covering the bottom of the cage. A narrow strip of this paper should be sewed to the large blotter in such a position as to extend through the hole in the bottom of the cage into a vessel beneath which contains

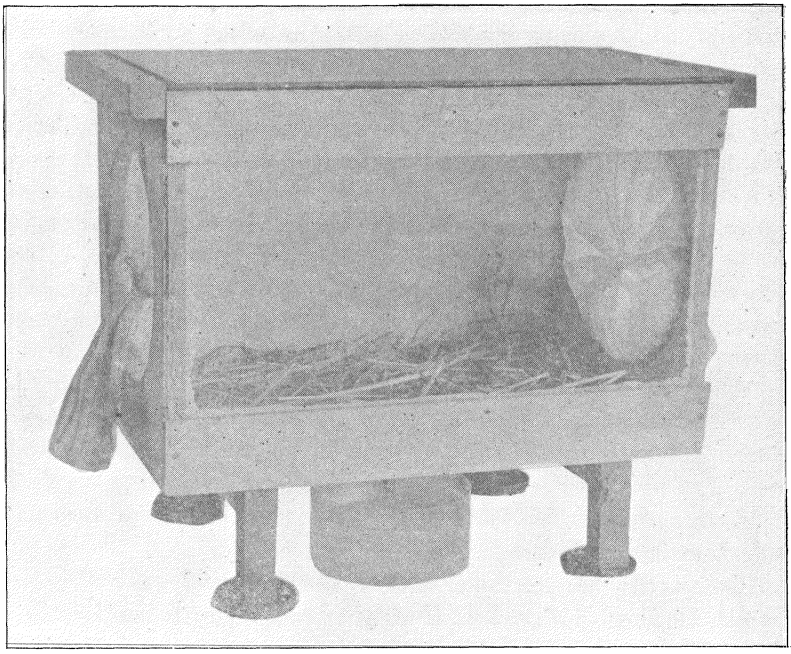

Fig. 1. Parasite breeding box (original).

water. The strip of blotter takes up the water from the container and keeps the large blotter which lies in the bottom of the cage moist at all times. Four legs of a convenient height are attached to the corners of the cage and placed in cups to keep away ants and mites. These legs were $3\frac{1}{2}$ inches long in the cage used in this work. A small amount of damp straw is then placed in the cage on the blotter.

When the cage is in readiness the parasites, either in the adult or pupal stage, are introduced. If adult parasites are put into the cage the pupæ from which they emerged should always accompany them in order to furnish protection and food. Unparasitized

pupæ should then be introduced from time to time to insure having an abundance of fresh material for the parasites to attack. It is very essential that the cage be kept in direct sunlight, for at least part of the day, and in a warm room. A temperature of 75 to 80° F. is desirable. In a week or two after the first pupæ have been exposed to the parasites they should be gathered together and placed in a separate place and more fresh pupæ added. The original stock of parasites should be secured by collecting puparia in localities where the parasites are known to occur in greatest numbers. Where great numbers of pupæ can be obtained they may be placed together. To facilitate the separation of the puparia from the material in which they pupated, and to eliminate the dead pupæ, they may be placed in a vessel of water. All of the living or parasitized pupæ float and may be removed with a section lifter or a skimmer. A parasitized pupa can be quite readily recognized by its being much darker than normal and by one side of the puparium appearing almost black while the other portion is somewhat translucent and of lighter color. These puparia should be placed in glass tubes containing a very humid atmosphere and kept in a warm room. As the parasites emerge they should be transferred into breeding boxes as described above.

When a sufficient number of parasites has emerged to proceed with breeding the other puparia parasitized in the cages should be examined. When it is found that most of the parasites are in the pupal stage the entire lot should be removed to a refrigerator or cold storage room in which the temperature is kept uniformly between 50 and 55° F. These temperatures check development and retard emergence a few weeks before it is planned to liberate the parasites in the field. The puparia should be removed from the refrigerator so they may complete their development. Parasites should always be liberated near barns or straw stacks where flies are known to be breeding.

The developmental period can be shortened greatly, probably less than half the time required in the experiments reported herein, by increasing the temperature under which they are propagated. Under natural conditions breeding must be greatly stimulated by the heat produced by rotting straw and manure which surround the parasitized puparia.

By the plan of artificial propagation herein outlined and liberation of large numbers of parasites early in the spring where it is desired to carry on a campaign against the stable fly, we can reasonably expect them to be an important factor in the control of this pest.

A NEW GENUS OF MALLOPHAGA.[1]

By John Howard Paine.

Bureau of Entomology, United States Department of Agriculture.

Through the kindness of the United States Biological Survey, the writer has been able to make a collection of Mallophaga from bird skins taken in Panama. Among the resulting specimens is a most curious form which is not referable to any of the known genera, and for which, therefore, the founding of a new genus becomes necessary.

Ancistrocephalus gen. nov.

A single male specimen was taken from the skin of a ground dove, *Chæmepelia rufipennis* (Rio Indio, Canal Zone, March 3, 1911). In this specimen the antennæ show but three segments, being most probably due to the loss of the terminal two. This is borne out by the fact that the tip of the third segment, under high magnification, appears unfinished, as though other segments had been attached. The genus therefore, having two-clawed tarsi, falls into the family *Philopteridæ*. Following are given the characters of the genus:

Small species with head broader than long and bearing extremely long hairs on the head and body; these hairs are the longest I have seen on any Mallophagan. Front broad, flattened, almost straight, with lateral angles produced into long, curved, heavily chitinized backward projecting hooklike appendages. Antennæ well developed, in the male at least, and arising from deep lateral emarginations, situated before the middle, affording a certain resemblance to some of the mammal infesting genera. Temples squarish, bearing extremely long hairs; occiput broad, almost straight. Abdomen broad, segments with posterior lateral angles produced into slightly curved, chitinized processes, giving the lateral edges of the abdomen a highly serrate appearance. Last segment in male entire.

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[1] Published by permission of the Chief of the Bureau of Entomology.