# OBSERVATIONS ON THE HABITS AND LIFE HISTORY OF A CHIGGER MITE, EUTROMBICULA BATATAS

## (Acarina: Trombiculinae)

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### INTRODUCTION

Although chiggers are severe pests in many parts of the world and are important disease vectors in a large area of the Far East, detailed life history studies have so far been published only for the Japanese species. Life history studies of this group have a peculiar importance from the standpoint of disease transmission, since an individual chigger feeds on a vertebrate host only once during its entire life, and in only one stage, the larva. The disease organisms must, therefore, pass from the larva of one generation through all the successive stages, including the egg, to the larva of the next generation. In the present paper the life history of one of the species of chiggers most commonly encountered in Panama is discussed.

From the Western Hemisphere about ninety species of Trombiculinae have been described. Most of these are known only from the larval stage, only about eight from the adult stage, and apparently but two, *Eutrombicula alfreddugèsi* (Oudemans) in North America and *E. göldii* (Oudemans) in South America are known in both larval and adult stages. The observations here described were made in Panama on *Eutrombicula batatas* (Linnaeus), which is the much discussed but little known pattata mite of Surinam. Larvae and adults of a few other species were correlated in Panama by Capt. Roy Melvin, and it is hoped that information on these will be published at a later date.

The classification of the trombiculine mites leaves much to be desired. There are twenty-five named genera in the world, all based on larval characters. About thirteen of these genera are known from the Western Hemisphere. The study of adults has gone quite independently, most of them having been placed in the genus *Trombicula*.

### NOMENCLATURE

The following appears to be the correct synonymy for *Eutrombicula batatas* (Linnaeus):

*Acarus batatas* Linnaeus, 1758, Syst. Nat., 10th Ed., Genus 235, Species 22.
*Thrombidium batatas*, Oudemans, 1905, Nova Guinea, 1903, vol. 5, p. 148.
Gen. ? *batatas*, Oudemans, 1912, Zool. Jahrb., Suppl. 14, Heft 1, p. 3.
*Trombicula batatas*, Ewing, 1931, Proc. U. S. Nat. Mus., vol. 80, Art. 8, p. 6; Schierbeek, 1937, Ann. Parasit. Hum. Comp., vol. 15, p. 329; Schierbeek, 1938, Acta Leidensia, vol. 12-13, p. 269; van Thiel and van Ommeren, 1940, Geneesk. Tidschr. Ned.-Ind., vol. 80, 0. 1638; Radford, 1942, Parasitology, vol. 34, p. 57.
? *Pattata-luis* van Stockum, 1904, Tijdschr. Kon. Nederlandsch Aardr.-kundig Gen. 1904, Verslag. Saramacca-Exp., p. 22.
*Trombicula flui*, van Thiel, 1930, Parasitology, vol. 22, p. 347; Ewing, 1931, Proc. U. S. Nat. Mus., vol. 80, Art. 8, p. 7.

*Eutrombicula flui*, Ewing, 1938, Jour. Wash. Acad. Sci., vol. 28, p. 294; Radford, 1942, Parasitology, vol. 34, p. 66.
*Acariscus flui*, Ewing, 1943, Proc. Ent. Soc. Wash., vol. 43, p. 64; Islas, 1943, An. Inst. Biol., Univ. Nac. Mexico, vol. 14, p. 441.
*Trombicula hominis*, Ewing, 1943, Proc. U. S. Nat. Mus., vol. 82, Art. 29, p. 5; Ewing, 1938, Jour. Wash. Acad. Sci., vol. 28, p. 294; Radford, 1942, Parasitology, vol. 34, p. 66.
*Acariscus hominis*, Ewing, 1943, Proc. Ent. Soc. Wash., vol. 45, p. 63.
*Trombicula pastorae* Boshell and Kerr, 1942, Rev. Acad. Colombiana Cien. Exact., Fisíco-Quím. y Nat., vol. 5, p. 12.

*E. flui* and *E. hominis* have not previously been considered as synonymous. It is evident, however, from a study of specimens and descriptions, that the supposed differences are largely the result of inaccurate observations and descriptions.

The third pedipalpal seta is described as simple for *hominis* (Ewing, 1933, 1943). Van Thiel (1930) failed to see it in *flui*, showing only the fourth but Ewing (1943) describes the third as branched. From Ewing's figure (1933) it seems certain that he, like van Thiel, failed to see the third seta and described instead the fourth, which is simple and is much more conspicuous than the third. In all Panamanian specimens which I have studied including those from the type locality of *hominis* the third seta of the pedipalp is branched, but its position is such that it is often difficult to see. Finally, certain of my Panamanian specimens were sent for comparison with the types of *hominis* to Ewing, his attention being drawn to the branching of the third pedipalpal seta. He identified them as undoubtedly *hominis*.

From a study of Ewing's (1943) descriptions it would appear that the prongs of the claws of the pedipalps are subequal in *hominis* while the outer is the longer in *flui*. However, the original description of *hominis* (Ewing, 1933) states that the outer is longer.

The dorsal abdominal setae are said to be thirty-two in number in *hominis*, thirty-four in *flui*. In unengorged specimens, the number of apparently dorsal setae ranges from thirty-two to thirty-six, depending on slight variations in the positions of the terminal abdominal setae and perhaps on the manner in which the specimen is flattened on the slide. In figure 1 there are indicated thirty-two dorsal abdominal setae not counting the near marginal "b" and "c." This is as in the *hominis* types as indicated in a letter from Dr. Ewing. In many specimens, however, "b" becomes clearly dorsal and "a" marginal or even, occasionally, dorsal, as shown on one side of van Thiel's figure of *flui*. There is no actual difference in the number of setae involved, but merely slight differences in position such as are often observed elsewhere on the body. On other parts of the body, however, such variations do not result in shifting setae from dorsal to ventral in position, and hence have never been considered important. It has not been possible to correlate these variations with other characters, such as the relative

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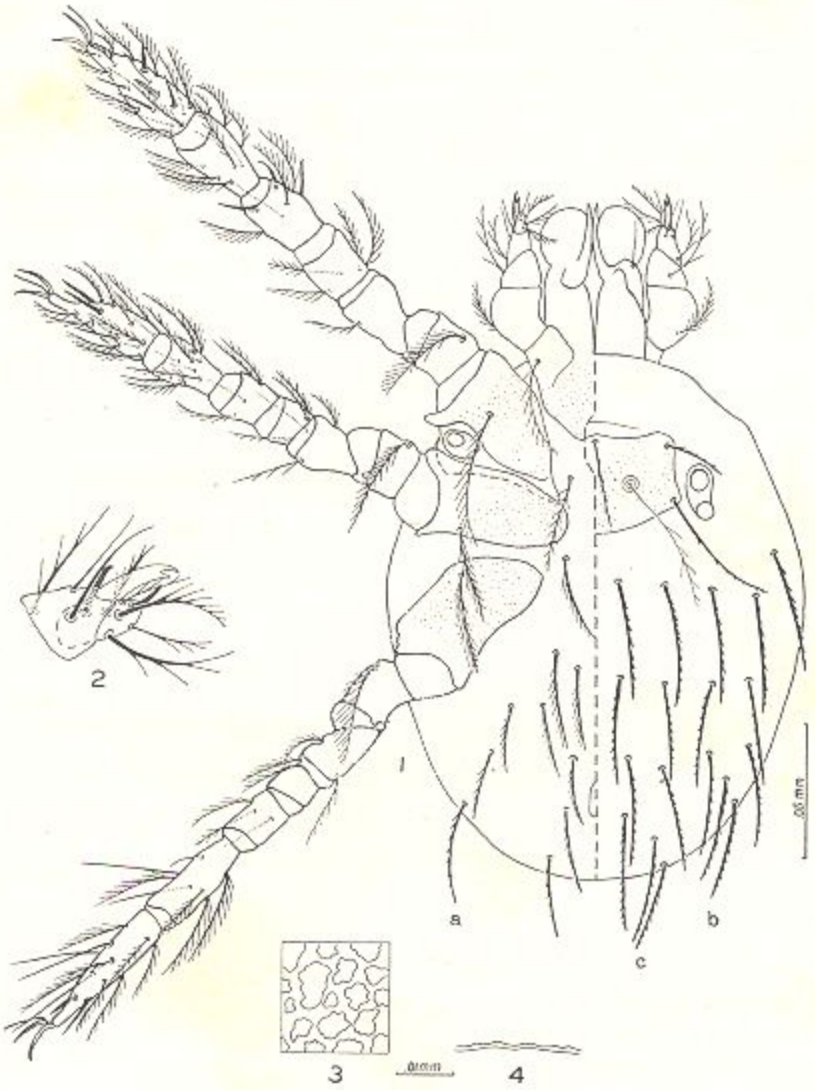
EXPLANATION OF PLATE I

Fig. 1, Larva of *Eutrombicula batatas*, dorsal view on right, ventral view on left. Fig. 2, Apex of pedipalp of larva. Fig. 3, Detail of sculpture of chorion of egg. Fig. 4, Section of same.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sizes of the eyes. (See remarks on the larva for other notes on other variations in chaetotaxy.)

The anterior margin of the dorsal plate is correctly described and figured for *hominis* as biconcave. For *flui* it is described and figured as convex. From a study of van Thiel's (1930) figure of *flui* it is evident that he saw, not the anterior margin of the plate, but an arcuate fold that often develops in the integument in front of the plate. This fold extends between the anterolateral angles of the plate, and is commonly more conspicuous in unstained specimens on slides than is the margin of the plate. The anterior limit of the pitted area shown by van Thiel is actually near the anterior edge of the plate. As shown in figure 1 the pitted area extends almost to the margin of the plate. The excess length thus given the dorsal plate by van Thiel is responsible for the statement that the pseudostigmatic organs are about as long as the plate in *flui*, longer in *hominis*.

In passing it is well to state that in order to avoid similar errors it is desirable to study properly stained mites. A simple method of staining larvae, which because of their small size are troublesome to transfer from one liquid to another in preparation for mounting, is to dissolve a stain in the mounting medium. Both acid fuchsin and iodine crystals dissolve slowly in Berlese medium, giving it a strong color which is taken up by the mite integument.

From the evidence given by Schierbeek (1937, 1938) and van Thiel and van Ommeren (1940) there is very little doubt that *flui* is a synonym of *batatas*. Both were described from Surinam. Although the Linnaean description does not give diagnostic structural characters, the species was stated to attack man in a field. These authors found *flui* to be the only species commonly attacking man in Surinam, and therefore regarded *flui* as a synonym of *batatas*. The fact that both were described from open fields is a further indication that the synonymy is correct. At the earliest opportunity a specimen from Surinam should be designated as a neotype of *Acarus batatas* Linnaeus, in order to leave no further room for argument.

The generic name *Eutrombicula* is here used, *Acariscus* being considered a synonym. When *Acariscus* was named (Ewing, 1943) it was defined to include species previously placed in *Eutrombicula* but having more abdominal setae. Many species of *Eutrombicula* have twenty-two dorsal abdominal setae. The species placed in *Acariscus* have 26, 28, 30, 32, 34, 38, and 50 in the various species. In itself this arrangement is not tenable, there being much greater differences among the species of *Acariscus* than between *Acariscus* and *Eutrombicula*. The discovery in Panama of a species (as yet undescribed) with twenty-four dorsal

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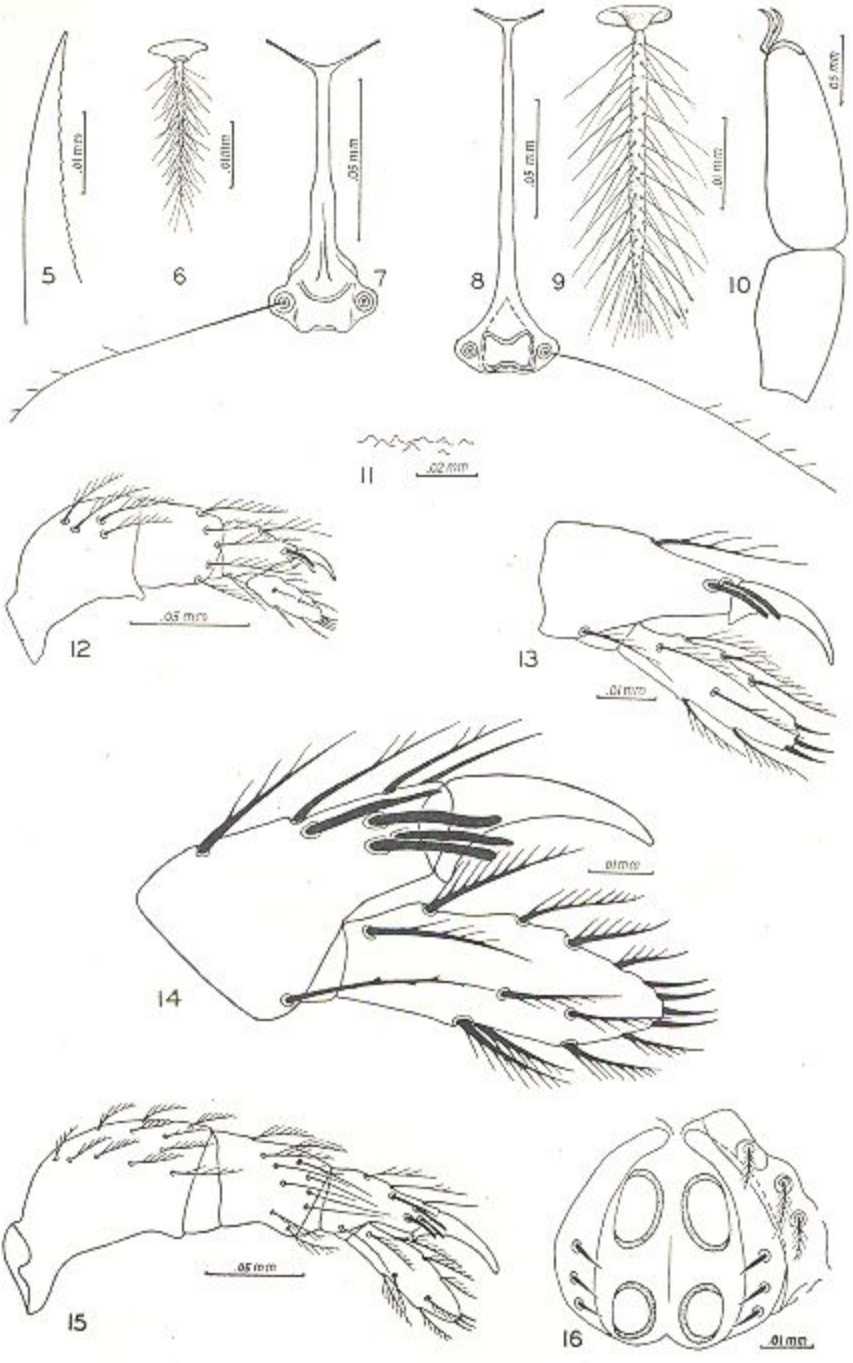
EXPLANATION OF PLATE II

Fig. 5, Apex of chelicera of nymph of *Eutrombicula batatas*. Fig. 6, Hair from posterior part of body of nymph. Fig. 7, Crista of nymph. Fig. 8, Crista of adult. Fig. 9, Hair from posterior part of body of adult. Fig. 10, Last two segments of anterior leg of adult. Fig. 11, Detail of integument of protonymph. Fig. 12, Inner view of pedipalp of nymph. Fig. 13, Inner view of apex of same. Fig. 14, Inner view of apex of pedipalp of adult. Fig. 15, Inner view of pedipalp of adult. Fig. 16, Genital area of nymph.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abdominal setae completely bridges the gap between *Eutrombicula* and *Acariscus*. The ventral abdominal setae are similarly useless in separating these genera.

## OCCURRENCE

As now known, *Eutrombicula batatas* ranges from Dutch Guiana to Colombia and Panama and north to Puerto Rico, Florida, Alabama and the state of Puebla, Mexico. New Panamanian locality records are as follows:

*Canal Zone:* Juan Mina, Summit. *Panama Province:* Panama City, San Francisco de la Caleta, Matías Hernández, Camarón, Chilibre, Las Guacas. *Colon Province:* Santa Rosa, Gatuncillo.

This is a species found in open sunlit places. It has not been collected in wooded or jungle areas. The nymphs and adults live, at least during the rainy season, on the surface of the soil or within one-half inch of the surface in areas of dense but short grass or other herbaceous vegetation. Frequent rains and the shade provided by the grass keep the soil surface moist. Adults of most other local species must be searched for in the leaf mold and debris of the forest or stream banks, or under rocks and logs, but to find the adults of *batatas* it is only necessary to part the grass where larvae are abundant and search for them on the soil surface. Indeed in morning and evening, when the sun does not strike the ground, adults and nymphs of *batatas* may be found walking about on open ground near the grass. At night, however, they become quiescent, often gathering in groups of as many as five or six in favorable small hollows in the soil.

The larvae occur on the grass and weeds sometimes in great numbers. They have not been found on logs, stumps, and the like where larvae of certain other species often occur. This agrees with the observations on this species made by van Thiel and van Ommeren (1940) in Dutch Guiana and indeed with the Linnaean account of the species. Larvae survive heavy rains, clinging to the grass blades or leaves of weeds. When the grass is wet with rain or dew the larvae are relatively inactive, although they are able to walk on the surface film of water. They are easily dislodged from wet grass, however, and will then cling to man or animals walking through the area. Greatest larval activity occurs after the grass becomes partially dry in the morning, usually between 8:30 and 9:30 a. m. on a clear day and continues until the temperature in the vicinity of the tops of the grass blades reaches about 40° C. At temperatures above this the larvae are not in evidence in any numbers, probably disappearing into the shade near the bases of the plants. When the sun is obscured by clouds the larvae are more or less active, but never in the numbers that are seen in bright sunlight in the morning immediately after the dew has dried.

This species apparently becomes abundant only in the grassy areas around houses and in villages where domestic animals, particularly chickens, are numerous. At Santa Rosa, Panama, where most of my observations were made, larvae have been collected attached to man, goat, dog, rat, chicken, ruddy ground dove (*Chaemepelia rufipennis*), ani (*Crotophaga ani*), and striped cuckoo (*Tapera naevia*). Other recorded hosts are horse, guinea hen, southern meadowlark (*Sturnella magna*

*argutula*), brown thrasher (*Taxostoma rufum*) (Ewing, 1943), turkey (Boshell and Kerr, 1942), and lizards (Schierbeek, 1937). The species is evidently rare on reptiles, however.

On children wearing only loose clothing over 80 per cent of the larvae attached in the groin and under the armpits. In one instance 138 attached larvae were found on a twelve-year-old boy who, after being freed of all chiggers, played in chigger infested grass for three hours. On adults many larvae attach on the ankles under socks, in the groin, and about the belt line. But few reach as high as the armpits. On chickens, the most important hosts where I have studied *E. batatas*, the chiggers tend to gather in groups about the vent, under the wings, and elsewhere on the body. They are most numerous on young, partially feathered birds. As many as a thousand have been taken from a single young chicken. Older chickens become equally favored hosts if some of the body feathers are clipped off. On goats the larvae gather in masses under the bases of the legs.

*Eutrombicula batatas* is abundant in favorable localities throughout the rainy season and larvae, at least, can be found during the first month of the dry season. After becoming gradually scarcer for several weeks, the larvae finally disappeared completely near Panama City about February 5, 1945. They reappeared there, after considerable rain, about May 30. At Santa Rosa, where there is considerably more rain, they disappeared about February 15, reappeared about May 10. How the species survives the dry season, when the grass becomes dry and brown, is not known. It has been observed that the soil cracks deeply in drying and it may be that the species passes the dry season from February to April or May deep in the soil where it is relatively moist. Attempts to find these mites by digging, however, have been unsuccessful.

## LIFE HISTORY AND DESCRIPTIONS OF THE STAGES

*Egg:* The eggs are laid singly on the surface of moist soil. Melvin records laying of eggs in masses. This is certainly not the usual thing, but may have resulted from his method of forcing egg production by heat. Thus far, among numerous mounted females, not more than one egg has been found in an individual. Apparently the chorion is formed on only one egg at a time, which is laid before another chorion is formed.

The eggs are spherical, pale dull orange, about 0.15 mm. in diameter, the shell rather thick and with numerous, irregularly shaped depressed areas giving it a reticulate appearance.

Because of their dull coloration and minute size, the eggs must be searched for with a binocular microscope. Failure to find the eggs of *Eutrombicula alfreddugèsi* except in the bodies of females (Ewing, 1944) does not seem to be a good indication of ovoviviparity.

*Deutovum:* About four or five days after being laid, the egg shell breaks into anterior and posterior portions, which become separated from one another as shown in figures 18 and 19, exposing the median portion of a stage called by Miyajima and Okumura (1917) the deutovum. Ewing (1944) calls this the "cast cuticular exuvia of the fully developed embryonic larva." It should be pointed out that

Ewing's opinion was based on the figure given by Miyajima and Okumura which apparently shows the "deutovum" at a time when the larva is already moving about inside attempting to emerge, and does not give a good impression of the organism at this stage. Without expressing an opinion as to the true nature of the structure involved, the word deutovum will be used for convenience here.

The two portions of the egg shell may be easily removed from the deutovum exposing it as shown in figures 20 and 21. It is about 0.2 mm. long, obviously larger than the egg, perhaps having absorbed water. The surface is smooth, without setae or papillae, and the leg and pedipalpal sheaths show no segmentation except that indicated by the developing larval appendages within. It may be noted here that the leg sheaths are much more distinct, and separable from one another in some of the related mites such as *Manriquia*, in which the deutoval stage lasts several weeks. On the dorsum of the deutovum is a single spine.

The posterior part of the body is quite red, and the red ocular areas of the larva show through the deutoval integument. The trochanters of the larval legs extend out into the three lateral projections of the deutovum, the more distal portions of the legs being bent downward and forward into the leg sheaths.

*Larva:* After about six to seven days in the deutoval stage, ten or twelve days after egg laying, the fully formed larva emerges from the deutovum. Its activity begins by moving the legs, which can be seen through the translucent deutoval cuticula, back and forth in their sheaths. In a few hours it works its way free.

The body of the larva is red, the ocular areas deep red, the appendages pale. The newly hatched larva is about 0.19 to 0.2 mm. long.

The characters of the larva are shown in figure 1. Variations in the apparent positions of the apical abdominal setae are described in the portion of this paper entitled "Nomenclature." In addition there are actual variations in the positions of certain setae in unengorged individuals. Noticeable in this connection is the variation in the dorsal sublateral seta immediately behind the third transverse row of eight setae. On one or sometimes both sides of the body this seta often moves forward into the preceding row of setae, so that the dorsal setal formula becomes 2–8–8–9, etc., or 2–8–8–10, etc., instead of 2–8–8–8, etc. In one specimen studied there were nine instead of eight setae in the second row on the dorsum, and in another the same was true of the third row. The ventral abdominal setae often vary in number as well as position on the two sides of the body. The most

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EXPLANATION OF PLATE III

(Figures 17 to 34 are all drawn to the same scale.)

Fig. 17, Egg of *Eutrombicula batatas*. Fig. 18, Dorsal view of deutovum partially covered by broken egg shell. Fig. 19, Lateral view of same. Fig. 20, Dorsal view of deutovum with egg shell removed. Fig. 21, Lateral view of same. Fig. 22, Dorsal view of unengorged larva. Fig. 23, Lateral view of same. Fig. 24, Lateral view of engorged larva in position assumed prior to transformation. Fig. 25, Dorsal view of engorged larva. Fig. 26, Ventral view of protonymph. Fig. 27, Lateral view of same.

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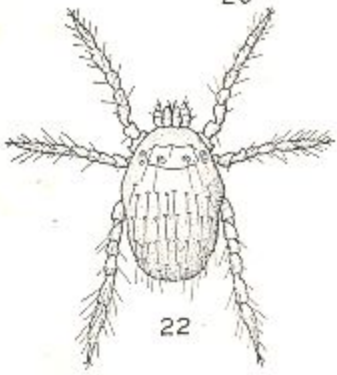

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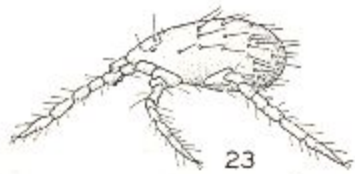

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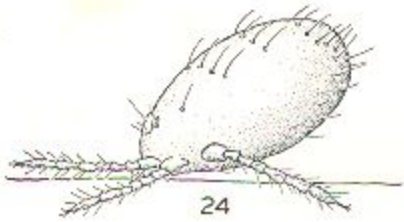

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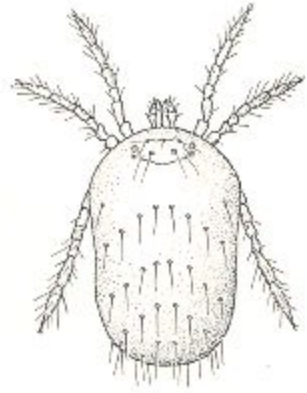

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26

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common variation of this sort is shown clearly by van Thiel (1930). Often there is one, or even two setae on one or sometimes both sides of the body in the vacant spaces midway between the anus and the seta marked "a" in figure 1. In one specimen the posterior sternal seta on one side of the body was absent.

The body setae appear more plumose than in the figure if the specimen is strongly compressed, since then the branches are pressed more nearly into the same plane.

The structure termed the "inner maxillary lobe" by Ewing (1944) is relatively small in most mounted specimens but under certain conditions is large and flat as shown in figure 1. It appears that when specimens are killed in Berlese mounting medium the lobes are large but when killed in alcohol and mounted later in the same medium the lobes are small.

Larvae can live in the laboratory for nearly two weeks without feeding. It may be that under natural conditions they would survive longer.

On finding a suitable host animal the larvae attach and engorge, reaching a length of 0.3 to 0.35 mm. Engorgement begins rather rapidly. On man specimens which have been attached only three hours are noticeably larger than unattached individuals. The length of time which chiggers remain attached to chickens varies from two to ten days. The great majority remain attached three or four days and only very few more than six days. After engorgement is complete the larvae drop from their host. They then crawl about actively for a period of time ranging from a few hours to four days, usually about one day. They then become quiescent, assuming the position shown in figure 24 with the legs commonly straight, the abdomen elevated, and the mouthparts serving to hold the mite in place. This usually takes place in nature in the bases of tufts of grass.

Soon after assuming this position the legs and mouthparts lose the power of movement, histolysis evidently taking place within them.

*Protonymph:* Within the body of the quiescent engorged larva the nymph develops, with its appendages folded up and completely independent of the larval appendages. Surrounding the developing nymph in the same manner that the deutoval integument surrounds the developing larva is a membrane which is considered by some to be the integument of the protonymph. This stage was called the nymphochrysalis by Miyajima and Okumura (1917) but according to Ewing (1944) is apparently homologous with the protonymph of many other mites. The word protonymph seems preferable to nymphochrysalis. The same membrane surrounding the developing nymph was termed the apoderm by Nagayo, Miyagawa, Mitamura, and Imamura (1917), who describe changes in its structure and the development of the nymphal appendages, the apoderma by Henking (1882) and the Zwischenhaut by Claparéde (1868).

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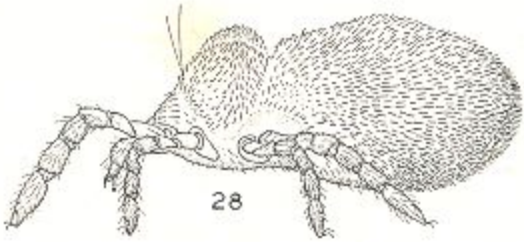
EXPLANATION OF PLATE IV

Fig. 28, Lateral view of newly emerged nymph of *Eutrombicula batatas*. Fig. 29, Ventral view of preadult. Fig. 30, Dorsal view of nymph. Fig. 31, Lateral view of preadult. Fig. 32, Lateral view of preadult within nymphal integument.



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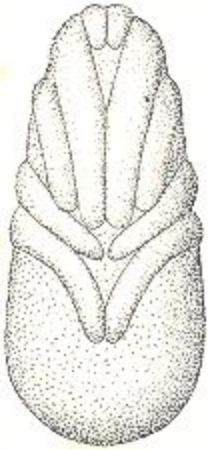

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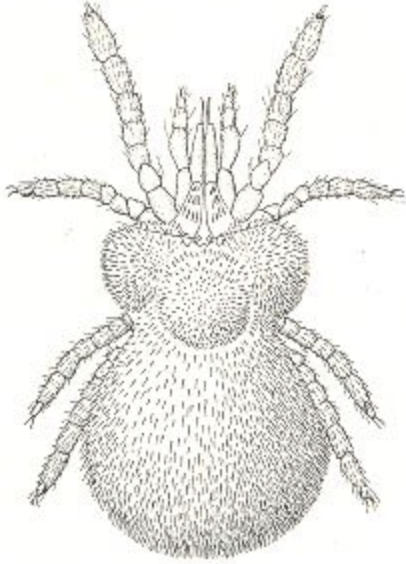

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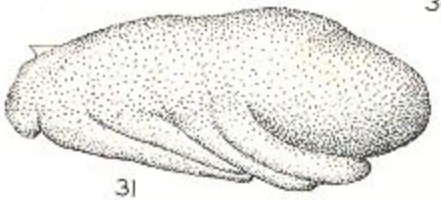

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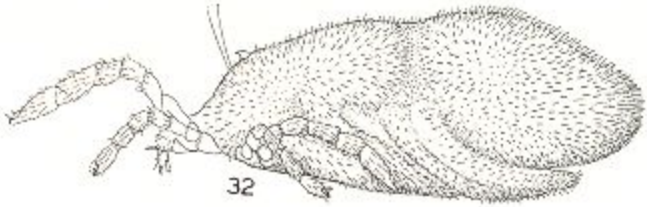

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The protonymph (figures 26 and 27) never emerges from the larval integument, but must be dissected out before the emergence of the nymph. For a few days before emergence of the nymph, the protonymphal body shape and appendages may be seen through the tightly stretched larval integument, just as the preadult may be seen through the stretched nymphal integument (figure 32). The integument of the protonymph is minutely tuberculate. There is a dorsal spine, which according to Nagayo, Miyagawa, Mitamura, and Imamura (1917) is used to pierce the larval skin. The appendages are unsegmented and saclike. The nymphal appendages develop within those of the protonymph.

*Nymph:* The nymph emerges from the protonymphal and larval integuments through a transverse opening in the anterior part of the dorsum from five to seven days after the larva becomes quiescent. On first emerging the nymph seems very small and is dull red but within a few hours at most its body seems to swell and the body hairs become dry and fluffy, giving the characteristic brilliant red color as well as an appearance of larger size.

The nymph or first eight-legged stage closely resembles the adult except for its small size, and such characters as are shown in the illustrations. It is red, with pale legs. When compressed on a slide the constriction between anterior and posterior parts of the body is much less evident than in the figure. The length is about 0.5 mm. on emergence, increasing to 0.55 mm. or more after feeding. These measurements do not include the length of the posterior body hairs. The following characters will be helpful in identifying this species in the nymphal stage.

*Pedipalps* with few setae; claw-bearing segment with two curved, blunt spines on inner side; claw longer than the distance from its base to base of finger; base of claw produced ventrally to a sharp point; finger terminating in three or four simple, short, robust, curved setae. *Crista* rather thick posteriorly; pseudostigmatic area broader than long with a transverse ridge arcuate posteriorly; mesad of each pseudostigma is a longitudinal ridge which at its posterior end curves mesad and forms a projection on the posterior margin of the pseudostigmatic area. Pseudostigmatic organs longer than crista, with three to five short branches in distal halves. On each side of pseudostigmatic area is a smooth convex eye. *Body hairs* slightly longer posteriorly than on shoulders, arising from large disc-like papillae, somewhat elevated medially; these papillae are almost contiguous.

The duration of the nymphal stage was observed to vary from sixteen to forty-five days, probably depending largely on the availability of food. Only starved individuals lived as nymphs for as long as forty-five days. Others transformed in shorter periods.

There is apparently but one nymphal stage. Aside from the evidence provided by rather closely observed rearings of numerous individuals, this is shown by frequency curves based on measurements

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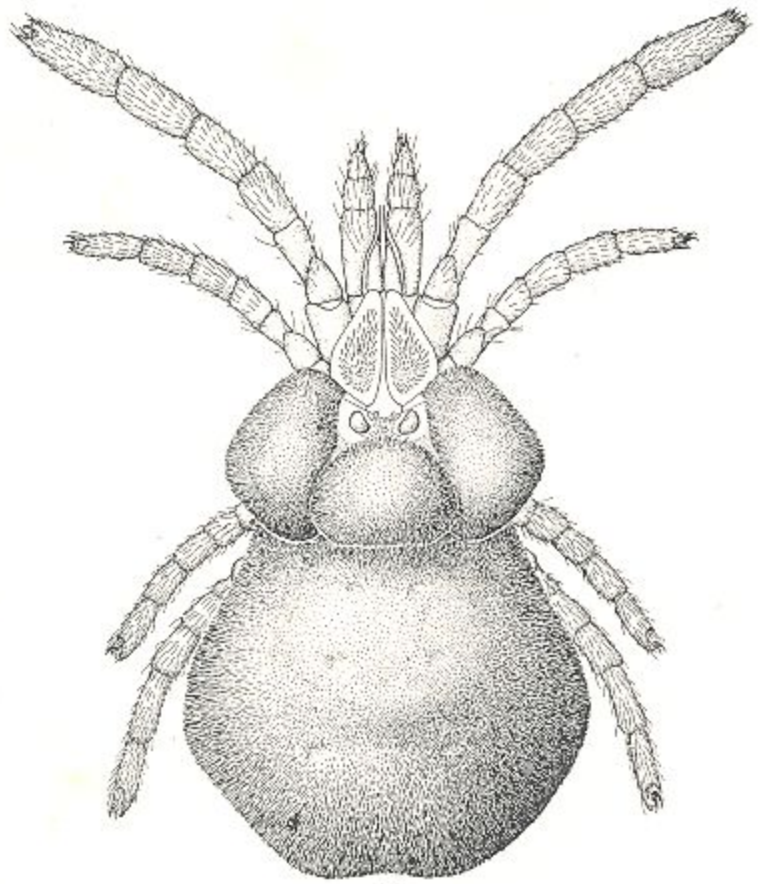
EXPLANATION OF PLATE V

Fig. 33, Dorsal view of large adult of *Eutrombicula batatas*. Fig. 34, Lateral view of same.



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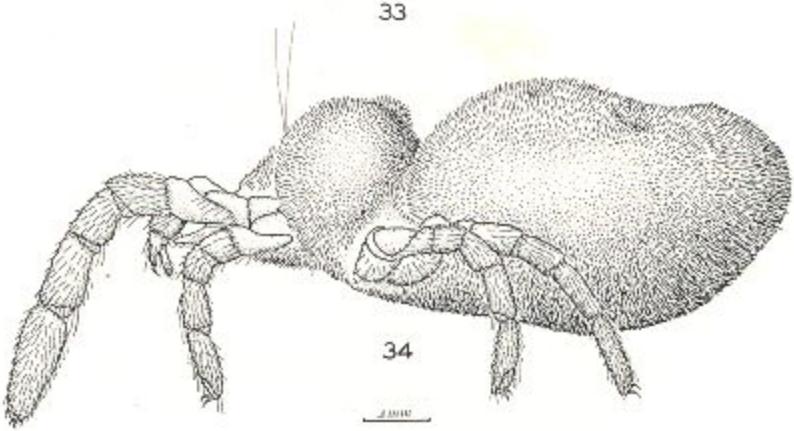

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of portions of the appendages. Such curves are not bimodal for nymphs, nor are they for adults if the sexes are segregated. This is in contrast to certain other genera in the family (e. g., *Manriquia*) in which there are additional nymphal stages having most of the characters (e. g., six genital suckers) of the adult.

*Preadult:* When the nymph is ready to transform to the adult stage, it becomes quiescent and elongate in form, bloated in appearance. In nature this stage is ordinarily found hidden at the bases of tufts of grass, just beneath the soil surface, or inside broken pieces of hollow dead weed stems. Histolysis evidently takes place in the nymphal appendages, which become dry and brittle, and are easily broken off. Within the integument of the nymph is found the thin, tuberculate integument of the preadult, a stage which differs very little, except for larger size (0.55 to 0.66 mm. in length), from the protonymph and which never emerges from the nymphal integument. Through the stretched nymphal integument the form of the preadult can readily be seen (figure 32) and the dorsal spine of the preadult can often be seen to have ruptured the nymphal integument. The adult develops within the preadult integument, its appendages within those of the preadult. The preadult quiescent period lasts for five to seven days.

*Adult:* The adult emerges from the preadult and nymphal integuments through large rents in the dorsal surfaces.

The sexes are easily separated by the characters of the genitalia illustrated by Ewing (1944). The females average larger than the males. Females range from 0.77 to 0.99 mm. in length, the average of fifteen being 0.91 mm.; males range from 0.66 to 0.83 mm., the average of fifteen being 0.74 mm. A comparable difference in size, correlated with sex, was noted in the preadult stage. The body integument of adults, like that of nymphs, is soft and thin and can be stretched to some extent. The smaller adults are those which have recently become adult while larger ones have had some time for feeding. Adults are bright red with paler appendages.

*Pedipalps* with more setae than in nymph; inner surface of claw-bearing segment with three blunt spines arising near the base of the claw and an additional more pointed spine arising near the middle of the segment; base of claw with a blunt ventral projection; finger terminating in three or four short, robust, curved setae. *Crista* slender; pseudostigmatic area broader than long with a transverse curved ridge in front of the pseudostigmata, this ridge bending backward at its ends and extending posteriorly mesad of each pseudostigma to the posterior edge of the area; pseudostigmatic organs as long as crista, with two to eight short branches in the distal half. On each side of pseudostigmatic area is a smooth convex eye. *Body hairs* longer on posterior part of body than elsewhere, each arising from a disc-like papilla; apices of body hairs not thickened.

Adults have been kept alive in the laboratory for periods up to forty-five days. This is considerably less than for certain other species.

The food of nymphs and adults is not certainly known. They were not seen feeding, although considerable time was spent in watching for such action. Nymphs failed to grow and transform into adults, or did so only slowly and in very small numbers, in jars containing sterilized

soil alone, soil with grass or seedling corn growing in it, and soil to which was occasionally added small arthropods (other species of mites, Collembola, etc.), dead insects, small quantities of caterpillar feces, or pieces of potatoes. Nymphs grew well, however, in a mixture of five parts of sterilized soil and one part of chicken manure. Since much mould grows in such a mixture it was thought that the chiggers might be feeding on the fungus. However heat sterilization of the mixture greatly reduced the fungus growth, although it did not eliminate it entirely because of the spores carried on the bodies of the nymphal chiggers. The nymphs grew as well in such jars with reduced fungal content as in jars with much fungus.

From this evidence one may conclude that living animals, portions of living green plants (e. g., rootlets), as well as insect excreta and freshly dead animals and plants are not necessary for the growth of nymphs and adults of *E. batatas*. In all probability fungi are also unnecessary. Since the chiggers have sucking mouthparts, it seems probable that nymphs and adults of this species feed on soil moisture rich in organic matter, sucking such moisture from the interstices of damp soil.

The stages in the life history of *Eutrombicula batatas* are summarized in Table I. It is probable that the "intervening stages" should not

TABLE I

| Major Stages | Intervening Stages | Characteristic Features | Duration |
|---|---|---|---|
| Egg | | Spherical, laid singly on damp soil. | 4–5 days |
| | deutovum | Quiescent, occurring within broken egg shell. With dorsal spine, unsegmented appendages, no setae. | 6–7 days |
| Larva | | Active, with six legs, and with setae on body and appendages. | Up to 14 days before feeding. 2–10 days on host. 1–4 days after leaving host. |
| | protonymph | Quiescent, occurring within dead larval integument. With dorsal spine, unsegmented appendages, no setae. | 5–7 days |
| Nymph | | Active, with eight legs, numerous plumose setae, 2 pairs of genital suckers. | 16–45 days |
| | preadult | Quiescent, occurring within dead nymphal integument. With dorsal spine, unsegmented appendages, no setae. | 5–7 days |
| Adult | | Active, with eight legs, very numerous plumose setae, 3 pairs of genital suckers. | Up to 45 days |

be considered as distinct stadia. The integument of the quiescent, pupalike stages evidently consists of a layer of hypodermal cells and a secreted cuticle which does not dissolve in caustic. It thus resembles the true integument of the active stages. However, in certain other mites of this family (e. g., *Manriquia bequaerti* Boshell and Kerr) there are at least four nymphal stages, each preceded by a protonymph. It thus seems that the formation of an extra integument is associated with each ecdysis and probably does not indicate the existence of another stadium.

The integuments of the intervening stages are delicate and not found as exuviae. According to Nagayo, Miyagawa, Mitamura and Imamura (1917) the integument of the protonymph undergoes "granular degeneration" shortly before emergence of the nymph.

It is probable that the life histories of other species are essentially similar. Apparently the preadult stage has not been previously described, but there can be little doubt that it exists in the species studied by Mayajima and Okumura (1917) for they describe the elongation of the nymph prior to transformation, just as it occurs in *batatas*, and the formation of the adult appendages within the nymphal body.

## REARING METHODS

Since many unsuccessful attempts were made to rear this chigger before successful methods were devised, it seems worth while to record the methods finally used.

Fully engorged larvae were obtained in large numbers and in good condition by placing an infested chicken or other animal in a cage having a coarse wire mesh bottom. The cage was provided with short legs which supported it above the surface of the water in a large shallow tray. As the larvae fell from the chicken they landed in the water, floating helplessly on the surface.

Twice a day the chiggers were collected from the water surface onto small squares of paper, the mites sticking to the paper because of the surface tension of the water. Newspaper was found to have the proper absorptive qualities. As the squares of paper dry the mites are released and walk about.

The squares of paper with the mites on them were then placed in small fruit jars lined with a thin layer of plaster of Paris. The latter serves to absorb any moisture that condenses on its surface. This was important as many of the mites otherwise became stuck in condensed moisture on the glass, and died there.

After transformation to nymphs they were shaken out of the jars lined with plaster of Paris into rearing jars. The best type of rearing jar so far used is a medium sized fruit jar with the bottom removed and replaced by a plug of plaster of Paris. In the jar are then placed soil, sterilized or not according to the need, plants of grass, chicken manure, etc., to simulate the natural environment. Thus far chicken manure mixed with sterilized soil as described by Melvin has given the most rapid nymphal growth. The top of the jar is left open, and water is added daily or oftener. Excess water runs out through the plaster of Paris in the bottom of the jar. The mites are able to take up positions of favorable humidity for there is a gradient from relatively

dry above to very moist below. Evaporation from the soil surface and from the plaster keeps the temperature relatively low. Transformation to adults takes place readily in these jars, and egg laying takes place, particularly if the jars are kept at a temperature higher than usual for a few days. At times when larvae are expected to hatch a lid may be put on the jar.

Larvae were placed on the host animal by removing them from the jar by picking them up on wet pieces of paper. The paper was then placed in a very shallow, wide shell vial the open end of which was appressed closely to the skin of the animal and held in position with adhesive tape. As the paper dried slightly the mites were released from the water and attached themselves to the host.

A small plaster of Paris cell with a cover made of a microscope slide and held in place with a rubber band was found convenient for making special observations, as for example on eggs. Such cells have the advantage that water can be added from the outside through the plaster without disturbing the contents of the cells. Nymphs and adults, however, do not survive for more than a week or two in constant contact with plaster of Paris.

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