The harvest mite, Leptus autumnalis, in Denmark.
Observations made in 1949.

By
S. L. Tuxen.

Thisted is the name of a town in Jutland distinguished among other Danish towns by a stock of harvest mites, *Leptus* or *Trombicula autumnalis* Shaw. Already in 1875 the then physician of the town P. V. Heiberg published a paper with the title: Om Leptus autumnalis (in Danish). He mentions the endemic disease in Thisted in late summer, which he called "Augustknuderne", and he also discovered the cause, the harvest mite, which he found in a papule. He points out that it is only found in the town; in the country it is unknown he says. It is a curious fact that the harvest mite since then has spread only very little out into the country north and east of Thisted. Till now it has been found nowhere else in Denmark, Thisted, as it seems, forming the northern limit of its European distribution. Since 1874, however, it has become a real plague to the 10.000 inhabitants of Thisted, who are virtually forced to live in-doors in August. In 1948 I was asked to investigate the phenomenon. That year, owing to pressure of work, I was only able to confirm the statement of Heiberg as to the cause of the disease. I 1949 I went a little more thoroughly into the matter; on account of the shortness of the Leptus season, however, my observations had to be rather scattered, my main purpose being, of course, to help the people to get rid of the plague, or at least to

diminish its effects. Since I do not know whether I shall be able to go further into the life-history of the harvest mite in Thisted in the next few years, and since this occurrence, the only one known in Denmark and the northernmost in Europe — is rather curious, it seems desirable to publish now such scattered observations as I have been able to make.

The occurrence of Trombicula autumnalis in Thisted and its environments.

Thisted lies in West Jutland, on the northern shore of Limfjorden, and covers a rather steep slope, rising 35 m in little less than one km, with chalk to the very surface. There are very many gardens, about one

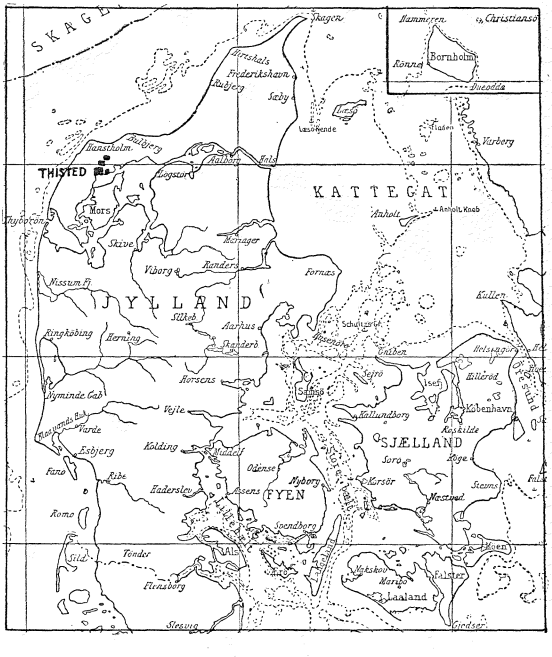

Fig. 1. Map of Denmark. Black spots mark the distribution of the harvest mite.

thousand, and nearly all of these teem with Leptus, to such a degree that people avoid them in the season, which lasts from the latter part of July to the beginning of September, because they will get numerous pustules after only crossing their garden, to say nothing of the numbers obtained when picking berries or lying on the

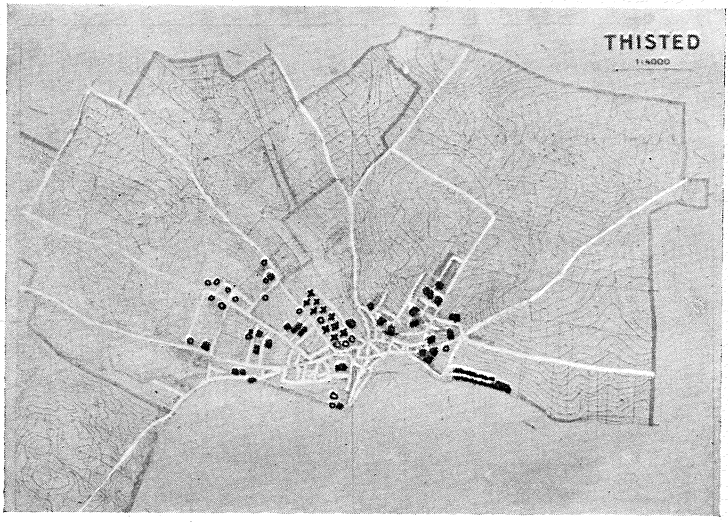

Fig. 2. Map of Thisted. Black spots mark the occurrence of the harvest mites, open rings their non-occurrence and black crosses the small wood in the middle of the town. The streets are shown in white.

lawn. 2-3-400 pustules may be the result of a fine sunday.

In infested gardens the harvest mites occur all over the garden, on bare soil as well as under herbage and on lawns. This last fact I used to obtain a fairly rough estimate of the abundance of Leptus according to the situation of the garden, the time of the day, weather conditions etc. When crossing a lawn it was evident that harvest mites gathered on one's shoes, and if these were white tennis-shoes the red mites could easily be

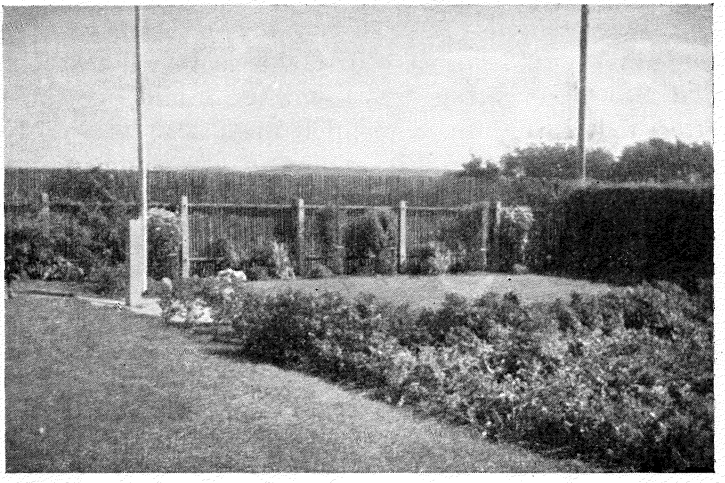

Fig. 3. The open lawn. Thisted August 24th 1949.

Fig. 4. The shady lawn. Thisted August 24th 1949.

seen and counted. After one minute's slow walking on the lawn I therefore took off both my shoes and counted the mites on them. Of course this is rough evidence and may be only suggestive, but the results agreed so often that I venture to mention them. The mites live at the surface of the soil, grass and low plants, on the uppermost end or edges of fallen leaves, stalks of pears and apples, small stones etc., yet I never found them more than about ten centimeters above the soil, and never on stems or leaves of the shrub (as commonly supposed by the local people). On the tips of such objects a little red lump may be seen consisting of many hundreds of mites.

Not all the gardens are equally infested by mites. The town is divided by a small wood, in which I have never seen Leptus, and stony buildings into a West town and an East town (fig. 2). In the East town nearly all gardens were highly infested, a minute's stroll resulting in 2—500 mites; in the West town, however, only small numbers, up to about 20 mites, were counted in most of the gardens, probably owing to the west wind prevailing almost throughout the season this year; in other years the contrary is said to have been the case. Some gardens in the West town, however, were highly infested and those were always gardens with lawns shaded by trees with a more or less dense foliage. Also in the East town there was a distinct difference between shaded and open lawns. A garden in the East town, which I had under steady observation, contained two such lawns (figs. 3—4) and the difference between the mites counted in these two lawns was marked.

Once I tried to see whether it was possible by the rough "shoe method" to form an idea of the density of the mites during the twenty-four hours of the day, so I took a stroll three times every second hour, each time a minute, one day from 9^h—19^h, another one from 19^h—17^h.

Figs. 5—6 show the results, which should be read with every reservation on account of the rough method. The mite numbers are averages of "six shoes", but it was remarkable that the numbers occurring on the two shoes in each stroll agreed fairly well. The upper line gives counts from the shaded lawn with sunshine only

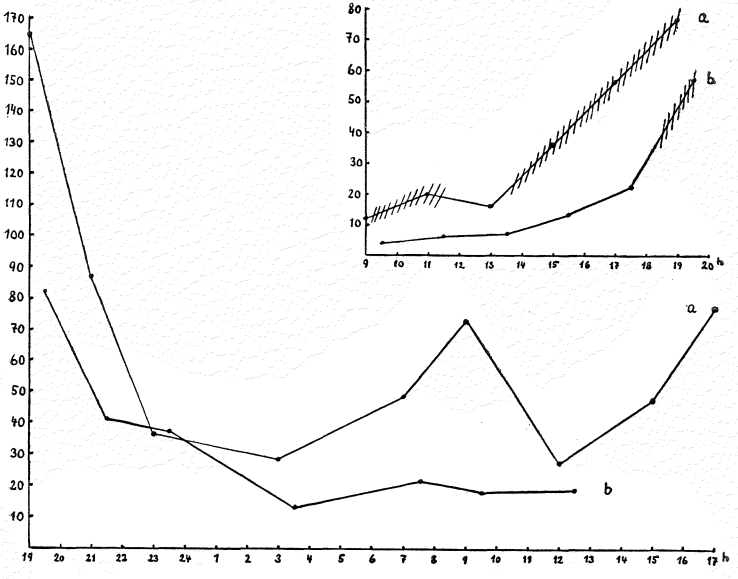

Fig. 5 (above). Number of harvest mites on the shady lawn (a) and the open lawn (b); Thisted August the 12th, 1949, from 9 a. m. to 8 p. m. The oblique shading mark the time of the day when the lawns were shaded.

Fig 6. Number of harvest mites on the shady lawn (a) and the open lawn (b); Thisted, from August the 13th at 7 p. m. to the 14th at 5 p. m.

at mid-day, the lower line shows the open lawn, in shade from 18^{h}. Both curves unambiguously show that the mites are most frequent just before dusk, their frequency otherwise depending on the humidity and the light, mainly on the humidity.

Though I was not able to measure the humidity of the atmosphere just above the surface of the soil it seems evident that this would be highest on shaded lawns, highest in the evening and highest on calm days, which quite agrees with the frequency of the mites as observed by me in different gardens and on different lawns: the frequency being highest on warm, calm afternoons and evenings on shaded lawns. The highest number obtained, about 300 mites on each shoe after a minute's exposure, was counted under such circumstances. Even the small drop in the frequency at mid-day on the shaded lawn (see the curves) — but not on the open lawn — if it is real, may be explained by the desiccating effect of the mid-day sunshine. Apart from the humidity the light seems to be effective in lowering the frequency after sunset, and also the temperature may be effective, because on cold days the frequency was much lower than on warm days. — I repeat that these considerations are based only on my observations and not on elaborate measurements.

On man the harvest mites may penetrate the skin in great numbers forming itching pustules. The mites presumably assemble on the places on the body where the humidity is highest, at least this seems to me to explain why they accumulate between the waist and knees, preferably around the waist, further in the armpits, around the neck etc.; wearing sandals I once got many pustules forming a cross under the buckle. Though I have had many pustules myself and did not scratch them I found few harvest mites in them, so I am forced to think that one mite may try to bite in many places, thus forming pustules, before finding a satisfactory place. Not all people are equally liable to get pustules, in most families some members may go free; as will be known the same is the case with stings of mosquitoes, fleas etc., but it is remarkable that immunity against

these last-named creatures does not coincide with immunity against Leptus, in fact the opposite seems to be the case. It thus looks as if the poison of the harvest mite has a composition different from that of the above-mentioned insect poisons. This fact as well as the cause of the stylostome formation ought to attract the attention of physicians and biochemists.

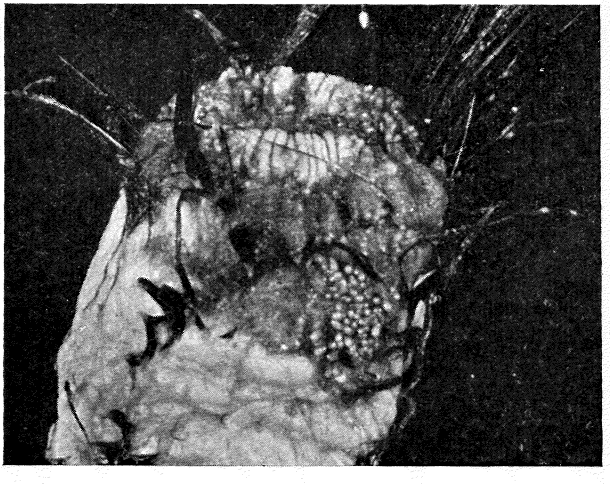

Fig. 7. The anal region of a blackbird, Thisted August 9th, 1949, with many harvest mites. Originally 700 were counted. U. Møhl-Hansen phot.

Man is not the only host of the harvest mite in Thisted, presumably only a "substitute" host, on which the parasites will be lost. People told me that also cattle, horses, dogs and cats may have "Augustknopper" as the pustules are called by the inhabitants, and personally I have seen them on mice (Apodemus sylvaticus L. and Mus spicilegus Pet.), Guinea-pigs, hens, chaffinch (Fringilla coelebs coelebs L.), linnet (Carduelis cannabina cannabina L.), gold-hammer (Emberiza citrinella citrinella L.), and above all on the blackbird (Turdus merula

merula L.). I have seen four specimens of this last-mentioned bird, all with many harvest mites round the anus; in one instance I counted 700 mites on that little space, in all stages of sucking, such a crowd that many newcomers ran to and fro without being able to find space. This, of course, agrees well with the habit of this bird

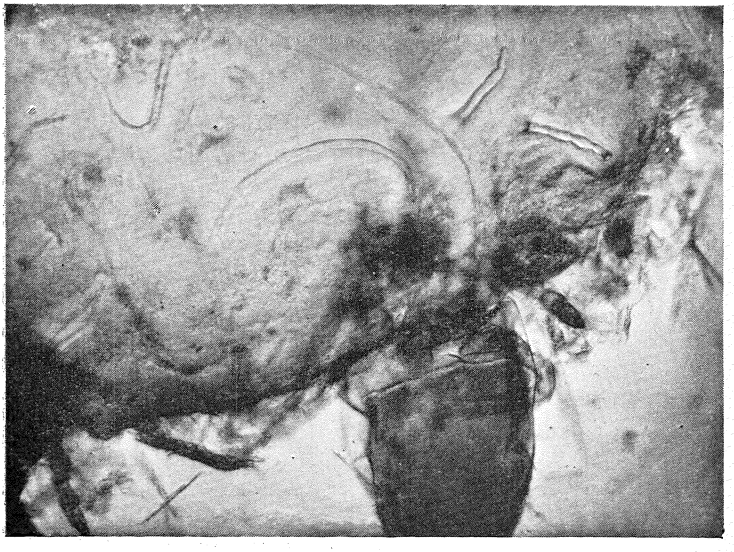

Fig. 8. A piece of skin from the same anus showing the stylostomes. U. Møhl-Hansen phot.

of seeking its food on the ground in contrast to other birds. — Figs. 7—9 show the crowding of the mites around the anus of a blackbird, though before the photograph was taken most of the full-fed mites and the newcomers had dropped off. Figs. 8 and 9 show a small part of the skin cut off; the stylostomes of the sucking mites and of those which have disappeared are seen.

In 1874 the mites were restricted to the town proper and as recounted by old inhabitants especially to the

southern part. About 1900, I was told, they also occurred in the country just north of the town, and now they are to be found north and east of Thisted in the villages of Brund, Hillerslev, Kaastrup and Faarup. The areas are shown black on the map fig. 1. The mites are thus spreading, but it is curious how slowly this spreading takes place considering birds to be the hosts preferred.

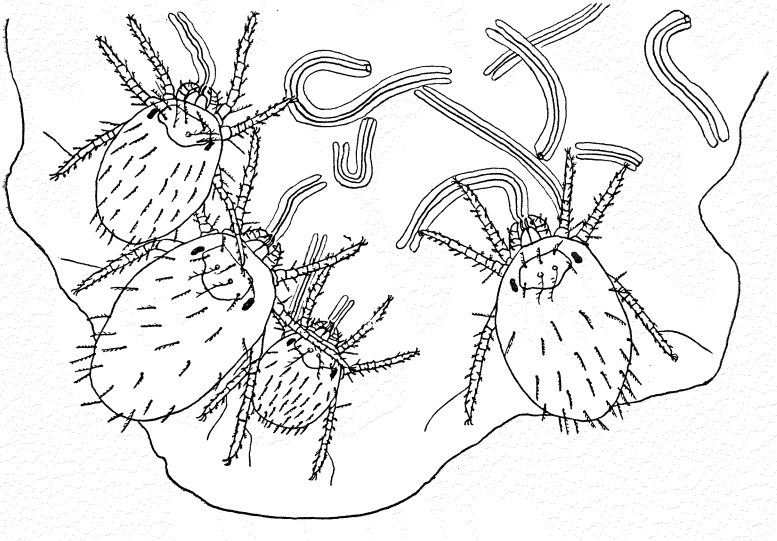

Fig. 9. The same as fig. 8, drawn.

However, the main occurrence of the mite sets in at a time when the birds are rather stationary, the impulse of migration not having set in.

The Control.

As repellents against Leptus I tried 30 % solutions of dimethyl phthalate and dibutyl phthalate in alcohol produced by A/S Ferrosan, Copenhagen; they were applied directly on the body, one large drop rubbed on each leg from hip to toes and another for the arms and

the neck. Used every morning dibutyl phthalate was absolutely effective whereas dimethyl phthalate would sometimes fail to work. I was therefore much astonished at the result of the following experiment.

A piece of filter paper, 20×40 cm., was soaked with the two liquids, one to each half, and then with a brush a cluster of Leptus as already described from pearstalks etc. was swept down upon the paper, several hundreds thus being spread at random over the surface. The result was that the creatures rapidly fled from the dibutyl phthalate, but were killed by contact with the dimethyl phthalate, after some few seconds becoming more and more stiff-legged and slowly moving, eventually stopping and dying. The cause of this unexpected result may be that dibutyl phthalate has a higher boiling point than dimethyl phthatale and therefore lasts for a longer time on the skin of the host, whereas the smaller viscosity of dimethyl phthalate allows it to penetrate faster into the Leptus.

I also tried to eradicate Leptus in the gardens. The problem was to kill Leptus without disturbing too much the balance of the other microarthropods in the soil. The firm of "Midol" of Copenhagen therefore placed at my disposal a spray, called Midol-Azo of the following composition:

Azobenzene	4 %
Trichlorethylene, Methylcellulose and water	96 %

The point was that Azobenzene from experiments with red spiders had shown a selective effect on the eggs of these mites. By means of a fire-engine I sprayed 4 gardens of a total area of 3500 square metres with a 1 % watery solution (as much liquid as would cover the surface in a layer of 1 mm if not absorbed by the soil) in June when I thought Leptus might be in the egg stage (I have never found its eggs); the result was ab-

solutely negative, it disturbed neither the Leptus content nor the other microarthropods.

I then tried another spray called Midol-Thio from the same firm and composed of:

Hexachlorcyclohexane (666).	2.7 %
Azobenzene	4 %
Parathion	0.3 %
Trichlorethylene etc. as above	93 %

As it was a tedious task to spray the liquid with a fire-engine I got help from a spraying firm called "Gartnernes Motor-Sprøjter I/S", which used a jeep-syringe of 50 athmospheres' pressure. By means of this I succeeded in spraying 23 gardens covering obout 20.000 sq. m. on the 15th and 19th of August. In seven of these gardens I had often counted mites by the "shoe method"; I checked them for three weeks after spraying; the result is shown in Table I. Concerning the other 16 gardens I know that

TABLE I.

Number of harvest mites ("shoe method") at about 5 p. m. in some gardens in Thisted before and after spraying with Midol-Thio (marked by a heavy black line).

	August															Sept.
Garden	4	6	9	10	11	15	16	18	19	20	22	23	24	25	26	5
A	—	—	56	68	—	0	0	—	—	—	0	—	—	0	—	0
B	—	179	—	—	—	0	0	0	—	3	—	—	—	1	—	0
C	59	79	—	335	—	—	—	37	—	0	—	0	—	1	1	0
D	—	45	—	—	—	—	—	—	—	—	—	—	—	—	8	7
E	—	—	—	—	—	—	—	23	—	0	0	—	—	0	—	0
F	—	—	—	—	—	—	—	254	—	1	2	—	2	—	—	0
G	—	—	—	—	508	—	—	—	—	4	8	—	—	2	2	3

they were highly infested; I checked them on the 23rd, 25th, 26th of August and Sept. 5th and found no harvest mites or only 1—4 specimens. A garden, which was not sprayed, was examined at the same dates and was highly infested, although showing a definite decline in numbers on Sept. 5th. It goes without saying that counting always took place at the same time of the day, be-

tween 4 and 5 p. m. The results seemed to be equally good whether a 1 % or a $^1/_2$ % solution was used. And the results were in fact so encouraging that the spraying experiments will be repeated and extended in 1950.

As this liquid contained 666, there was of course the risk that many of the microarthropods in the soil would be killed, thereby seriously disturbing the balance in the soil. To find this out I examined Berlese samples of the soil, a column of the soil, $^1/_{1000}$ m^2 in 5 cm's depth, being placed in a Berlese funnel, lighted from above. In two of the gardens which I sprayed 8 samples were taken in each before spraying, 8 in each afterwards and sorted out under the binocular at 32 times' magnification. I do not intend to give all the numbers here as the samples were only taken to be indicative and a thorough investigation of the effect of 666 (as well as of DDT) on the microarthropods of the soil requires all the investigator's time for a longer period than I could spare; but the results looked better than I had expected.

TABLE II.

Number of microarthropods in samples of $^1/_{1000}$ sq. m. before and after spraying. Average numbers of 7 or 8 samples.

	Garden 1 sprayed $^{15}/_8$		Garden 2 sprayed $^{19}/_8$	
	$^{12}—^{13}/_8$	$^{15}—^{16}/_8$	$^{14}—^{18}/_8$	$^{23}—^{24}/_8$
Sminthurids	14	1	3	0
Tullbergia krausbaueri..	6	2	5	4
Onychiurus armatus	—	—	2	3
Isotoma viridis	4	2	6	1
Pseudosinella alba	2	1	1	1
Trombidiids	5	2	5	0
Others	9	5	12	3
Totel....	40	13	34	12

The numbers are given in Table II, each number being the average of 7 or 8 samples. It is evident from the few numbers that there is a distinct fall in the total number, a fall to about one third or one fourth of the original number. The decline is greatest for the orga-

nisms living on the vegetation or in the uppermost layers of the soil, diminishing with the distance beneath the surface. This, of course, means that the liquid has its greatest effect in the uppermost layers of the soil and that the microarthropods, when touched, will be killed; it seems, however, that part of the microarthropod fauna will be spared, and if the more lively Leptus specimens will be killed to a comparatively greater degree than most of the other microarthropods these may perhaps after some time reestablish the balance in the soil, without Leptus. I am quite aware that the use of such unselective sprays containing 666 is dangerous, because it is impossible to foresee the effect of a disturbed balance. The plague which Leptus is in Thisted, I feel, will, however, justify the application of such means of control even if other inconveniences may be involved.

The systematic position of the mite.

As to the species of Leptus in question I have no doubt that it is *Trombicula autumnalis* Shaw, the common European species. I have drawn it in fig. 10. Examining the chaetotaxy in detail I found that it differed a little from the beautiful figures given by Marc André (1930) in the chaetotaxy of the tarsus and the patella of the first leg and of femur 1 and 2 of the hind leg. Prof. André, however, most kindly sent me some of his specimens for comparison, and it appeared that the chaetotaxy agreed in every detail, André having overlooked one hair on each of these joints and a spine on tarsus I. In fig. 11 I figure the chaetotaxy of these joints according to my observations; besides the hairs mentioned three very small spines may be noticed on the patella, tibia and tarsus of the first legs; a similar spine is present on the tarsus of the second leg. They always seem to be situated near one of the larger spines on the joints. They may be sense organs.

I have also compared my specimens from Thisted with the varieties in chaetotaxy described by W. S. Richards (1950) and with some of his own slides kindly sent me by Prof. P. A. Buxton of London. Richards mentions no less than six distinctly different types according to

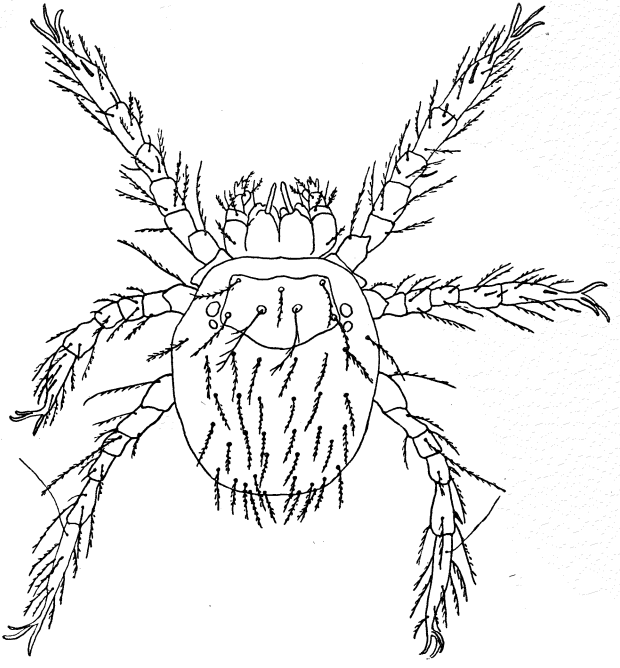

Fig. 10. *Trombicula autumnalis* Shaw, type *b* larva Richards 1950. Thisted August 24th, 1949.

the chaetotaxy (1950a); all these he considers to be phenotypical varieties of one species, the common *T. autumnalis* Shaw. Besides some truly abnormal (though common) types with ciliated galeal hairs or with duplicated humeral or scutal setae three types occur according to the number of setae in the second and third dorsal rows (the two humeral setae forming the first "row"): type *a* with 8,8 setae, *b* with 6,6 setae, and *c* with 8,6 setae.

Of these types *a* and *b* do show some constancy in their local and seasonal occurrence, type *a* occurring farthest to the north; and in the south, where type *b* (and *c*) are also met with, it appears later in the season than these types. He also mentions that larvae of type *b* were "very abundant only on the chalky Chilterns" though fairly numerous also in other soils, and larvae of type *a* "were

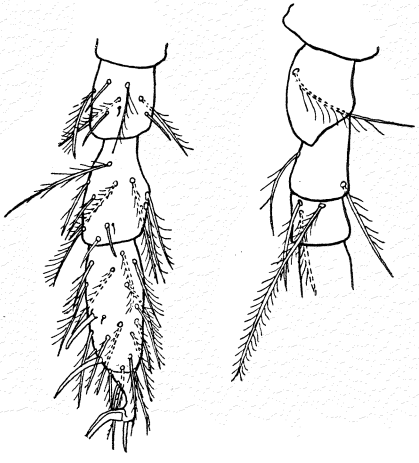

Fig. 11. *Trombicula autumnalis* Shaw, Thisted July 31st, 1948, showing the patella, tibia and tarsus of the first leg (to the left) and the trochanter, femur 1 and 2 of the hind leg (to the right).

responsible for the very heavy infestations recorded away from the chalk" (1950b p. 123).

In view of the above it is very interesting to note, that all Leptus larvae which I have seen from Thisted were larvae of type *b*. None of the aberrant types and none of the types *a* and *c* were ever found. As mentioned above the chalk in Thisted rises to the very surface of the soil nearly all over the town, and the inhabitants have always been anxions to correlate this fact with the occurrence of their tormentors (though they are not known to occur in other places in Denmark where

chalk reaches the surface). Judging from the nature of the soil, therefore, type *b* would be expected in Thisted, and likewise its occurrence mainly from the end of July to early September would lead one to expect this type of larva. The occurrence in Thisted, therefore, seems to confirm the supposition of Richards (1950a p. 115) that "the differences are determined by the nature of the environment during larval development".

On the other hand, it should be borne in mind that there is no explanation so far of the peculiar occurrence of the mite in Thisted of all Danish towns, so that the possibility exists that it may have been introduced by man. In that case the originally introduced creatures may have belonged to type *b* as genetically different from type *a* and more southern in its occurrence (the specimens which I have seen from France also belonged to this type). If, however, thirdly, types *a* and *b* are genetically different and their occurrence at Thisted indigenous we might have expected type *a* to be the form present. Thus the Danish mites can throw no light on the problem of the possible occurrence of more than one species of Trombicula in Great Britain.

Acknowledgments.

My thanks are due to Overlæge Dr. med. Holger Nielsen, Thisted, who directed my attention to this very curious plague and helped me in every way, as well as to nearly all citizens of Thisted who eagerly supported my investigations, Borgmester Chr. Iversen at the head of them all. A/S "Ferrosan", Direktør Rasmussen, "Midol", and Gartner Hartvig Jensen, all of Copenhagen, as well as Bestyrer Krog, Thisted, facilitated my controlling experiments. By providing me with French, English and American specimens of harvest mites Prof. Marc André, Paris, Prof. P. A. Buxton, London, and Dr. Corn. B. Philip, Hamilton Montana, gave me invaluable help. Financial support was granted by Thisted Byraad (1948) and Kong Christian X's Fond (1949). I extend my warmest thanks to all of them.

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[1]) A large number of papers on Trombiculids were consulted but have not been used in connection with the present investigation.