NOTES ON MACROCHELIDS ASSOCIATED WITH MANURE AND COPRID BEETLES IN ISRAEL. II. THREE NEW SPECIES OF THE *MACROCHELES PISENTII* COMPLEX, WITH NOTES ON THEIR BIOLOGY [1]

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INTRODUCTION.

A large number of mites of the genus *Macrocheles* Latr. was collected in Israel from the following coprid beetles of the genus *Scarabaeus* : *S. puncticollis* Latr., *S. saceri* L. and *S. cristatus* Fabr. The short palmate J5 setae of all the specimens showed immediately their affinity to *Macrocheles pisentii* (Berl.), but a closer examination and their comparison with specimens of *M. pisentii* from *Scarabaeus semipunctatus* Fabr., made it necessary to describe three new species, each one specific for its host. Recently an additional species, *M. pyriformes* Evans & Hyatt was described from *Mnematium ritchei* McLeay (EVANS & HYATT, 1963) and it seems to me that there exists a group of closely related mites, all bearing short palmate J5 setae and all being phoretic on the large, pill rolling scarabaeids. The relation between the phoretic mites and their hosts is apparently highly specific. In view of this and in view of the superficial similarity between these species, it seems advisable to re-examine records of *M. pisentii* from hosts other than *Scarabaeus semipunctatus* Fabr.

Mites of all the three species were collected alive and reared in the laboratory. The rearing methods have been described in an earlier paper (COSTA, 1966 *a*). Males as well as all the juvenile stages have been obtained.

The structure and the possible function of the *sacculus foemineus* and associated structures have been described for *Macrocheles robustulus* (Berl.) (COSTA, 1966 *c*).

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In the present study some of the more important parts of these structures are described and figured.

The holotypes as well as paratypes of all three species have been deposited in the collections of the British Museum (Natural History).

Macrocheles parapisentii n. sp.

Egg : The egg is pearly white and has a smooth shiny shell. Its dimensions are 375 μ by 305 μ.

Larva : The white larva is weakly sclerotized and no shields are discernable. The idiosoma is 450 μ long and 275 μ wide. The dorsum bears 14 pairs of simple setae and as in *Macrocheles robustulus* two pairs of additional dorsal setae are inserted ventrally. The distribution and the relative lengths of the setae are shown in fig. 1.

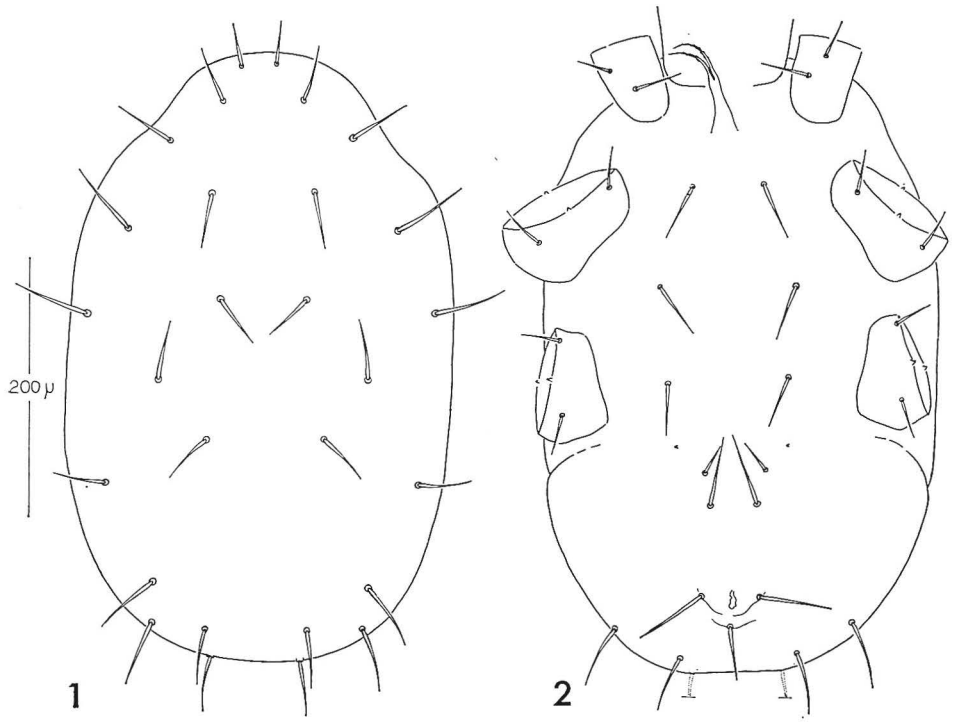


FIG. 1-2. — *Macrocheles parapisentii* n. sp., larva.
1 — Dorsum. 2 — Venter.

The venter (fig. 2) bears three pairs of sternal setae and two pairs of long opisthogastric setae. The setae of the anterior pair are about half the length of the setae of the posterior pair. The nonfunctional anus is represented by a slit ; the paranal setae are much longer than the postanal seta. The tritosternum has an

elongate base of about the same length as the pilose laciniae. The gnathosoma and the chelicerae are only weakly sclerotized (the larva is non-feeding) ; five rows of minute deutosternal teeth are present.

The legs are short and stumpy, their approximate lengths (excluding pretarsi) are : I — 370 μ ; II — 330 μ ; III — 320 μ.

Protonymph : The white protonymph is only weakly sclerotized, its dorsum is covered by two shields (fig. 3). The podonotal shield (335 μ long and 310 μ wide) bears 11 pairs of long needle shaped setae. The smaller opisthonotal shield (185 μ long and 205 μ wide) bears 8 pairs of setae. The posterior marginal setae of the shield (S4, S5) are markedly pilose. Setae J5 are very robust and pilose, they are still fairly long (15 μ) at this stage.

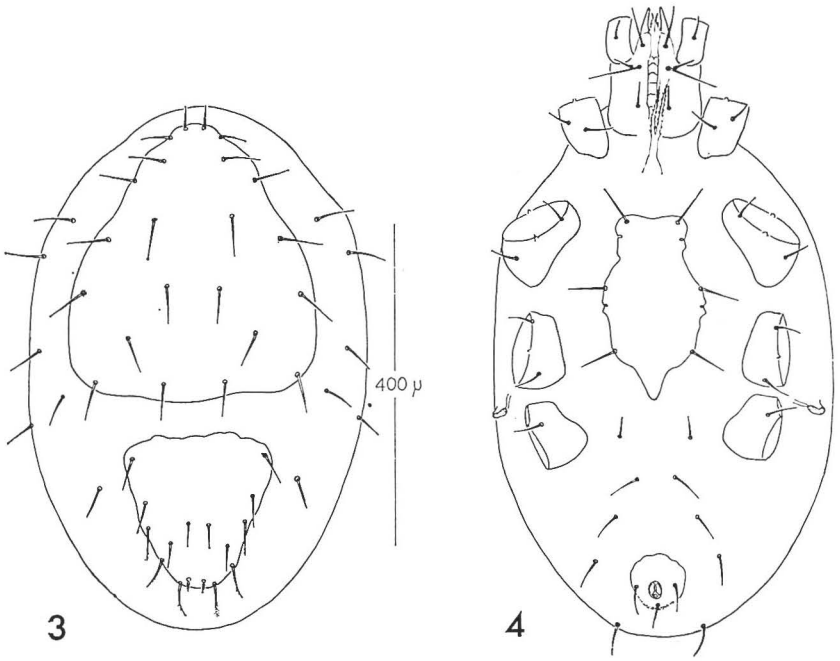


FIG. 3-4. — *Macrocheles parapisentii* n. sp., protonymph.
3 — Dorsum. 4 — Venter.

The sternal shield (fig. 4) is constricted between the first and second sternal setae and is widest at the level of the second pair of sternal pores. The shield has a narrow posterior projection which extends beyond the posterior margin of coxae III.

The gnathosoma is normal (fig. 4). The approximate lengths of the legs (excluding pretarsi) are : I — 515 μ ; II — 440 μ ; III — 445 μ ; IV — 585 μ. The leg chaetotaxy is identical to that of *M. robustulus*. The presence of only 7 setae ($1 - \frac{2}{0}$; $\frac{2}{1} - 1$) on genu 1 of the larva and protonymph seems to be characteristic

for the Macrochelidae, as has been shown also for the larva of *Neopodocinum caputmedusae* (Berl.) (COSTA, 1966 *b*).

Deutonymph : The deutonymph has a well defined, weakly sclerotized dorsal shield (fig. 5) ; wide incisions separate the podonotal and the opisthonotal parts. The shield is 630 μ long and 360 μ wide (at the level of r5). The shield bears 18 pairs of podonotal setae and 10 pairs of opisthonotal setae. Setae J5 approach the characteristic shape attained in the adult and they are considerably shorter than in the protonymph (6-8 μ).

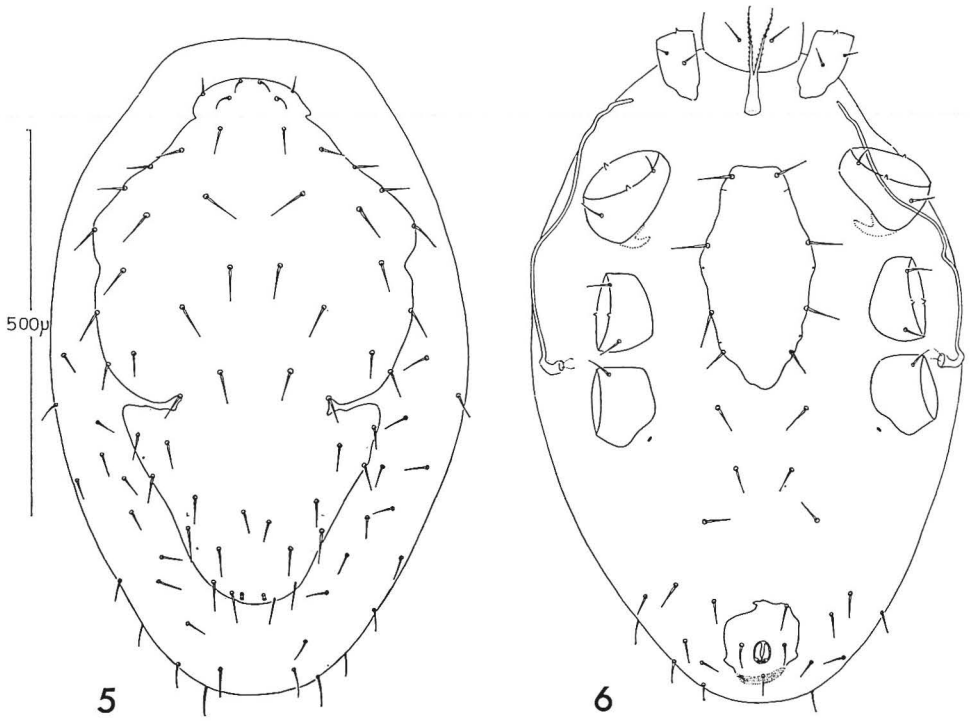


FIG. 5-6. — *Macrocheles parapisentii* n. sp., deutonymph.
5 — Dorsum. 6 — Venter.

The sternal shield is slightly irregular (fig. 6), being widest slightly in front of the second sternal pores. The peritreme is much longer than in the adult and may extend as far as coxa 1. The anal shield is large and sometimes a ventral seta is inserted on it in addition to the regular anal setae.

The approximate lengths of the legs (excluding pretarsi) are : I — 565 μ ; II — 445 μ ; III — 485 μ ; IV — 670 μ. The chaetotaxy is normal for the Macrochelidae (EVANS, 1963), genu IV bearing six setae.

Female : The dorsal shield (912-984 μ long and 528-576 μ wide) is finely punctured and is ornamented mainly on its anterior part. The shield bears 28 pairs of setae

of which 27 pairs are smooth and needle-shaped ; setae J5 are short and palmate. The distribution and the relative lengths of the setae are shown in fig. 7. The tectum (fig. 13) has the characteristic tripartite shape of the genus *Macrocheles* ; its outer lobes are rather variable in form.

Ventrally the sternal shield (160-180 μ long and 204-219 μ wide at the level of the second sternal setae) is weakly ornamented and minutely punctured ; it is darkly tinted and more heavily sclerotized in its anterior part (fig. 8). The metasternal setae are inserted on small irregular metasternal shields. The large ventro-anal shield (295-355 μ long and 245-290 μ wide) bears 9 setae and is minutely punctured. The peritrematal shield is anteriorly fused with the dorsal shield ; the peritreme is relatively short (fig. 15) and barely reaches the posterior margin of coxa III.

The gnathosoma (fig. 10) bears five rows of deutosternal teeth in front of which are two additional faint transverse ridges without teeth. The chelicerae are shown in fig. 9. The *sacculus foemineus* (fig. 12) is globular and 60-68 μ in diameter. The external opening funnel of the *tubulus annulatus* (fig. 11) is widened and shows a characteristic constriction.

The approximate lengths of the legs (excluding pretarsi) are : I — 760 μ ; II — 735 μ ; III — 810 μ ; IV — 1105 μ. Although in older specimens the distal setae of tarsus II may be spinelike (fig. 14), young specimens have distal tarsal setae with a long attenuated tip which seems to wear off during the lifetime of the mite.

Male : The male is considerably smaller than the female, the dorsal shield (695 μ long and 415 μ wide) covering the whole dorsum (fig. 18). The shoulders are very pronounced. The dorsal chaetotaxy as in the female.

The venter (fig. 19) is covered by a sternito-genital shield (270 μ long) and a separate ventro-anal shield (240 μ long and 180 μ wide) which is similar to that of the female. Both shields are devoid of any ornamentation. The peritrematal shield is fused throughout most of its length with the dorsal shield (fig. 22) ; the short peritreme does not reach the posterior margin of coxa II. The gnathosoma (fig. 21) is similar to that of the female. The movable digit of the chelicera (fig. 20) bears the slightly curved spermatophoral process which is shorter than the digit.

The approximate lengths of the legs (excluding pretarsi) are : I — 650 μ ; II — 545 μ ; III — 575 μ ; IV — 830 μ. Leg II (fig. 23) bears a thumb-like protuberance on the femur and a smaller tubercle on the genu and tibia.

Material : Holotype — 1 ♀, ex *Scarabaeus puncticollis* Latr., Na'aman Dunes, Israel, 29.10.1963. Many female paratypes with the same and similar data. All the ♂ paratypes were laboratory reared. This species is extremely common on *S. puncticollis* througout the year and in various parts of the country. The maximal infestation was 20 ♀ on a single beetle. Often this species is found in association with *Macrocheles vernalis* and *Alliphis* sp.

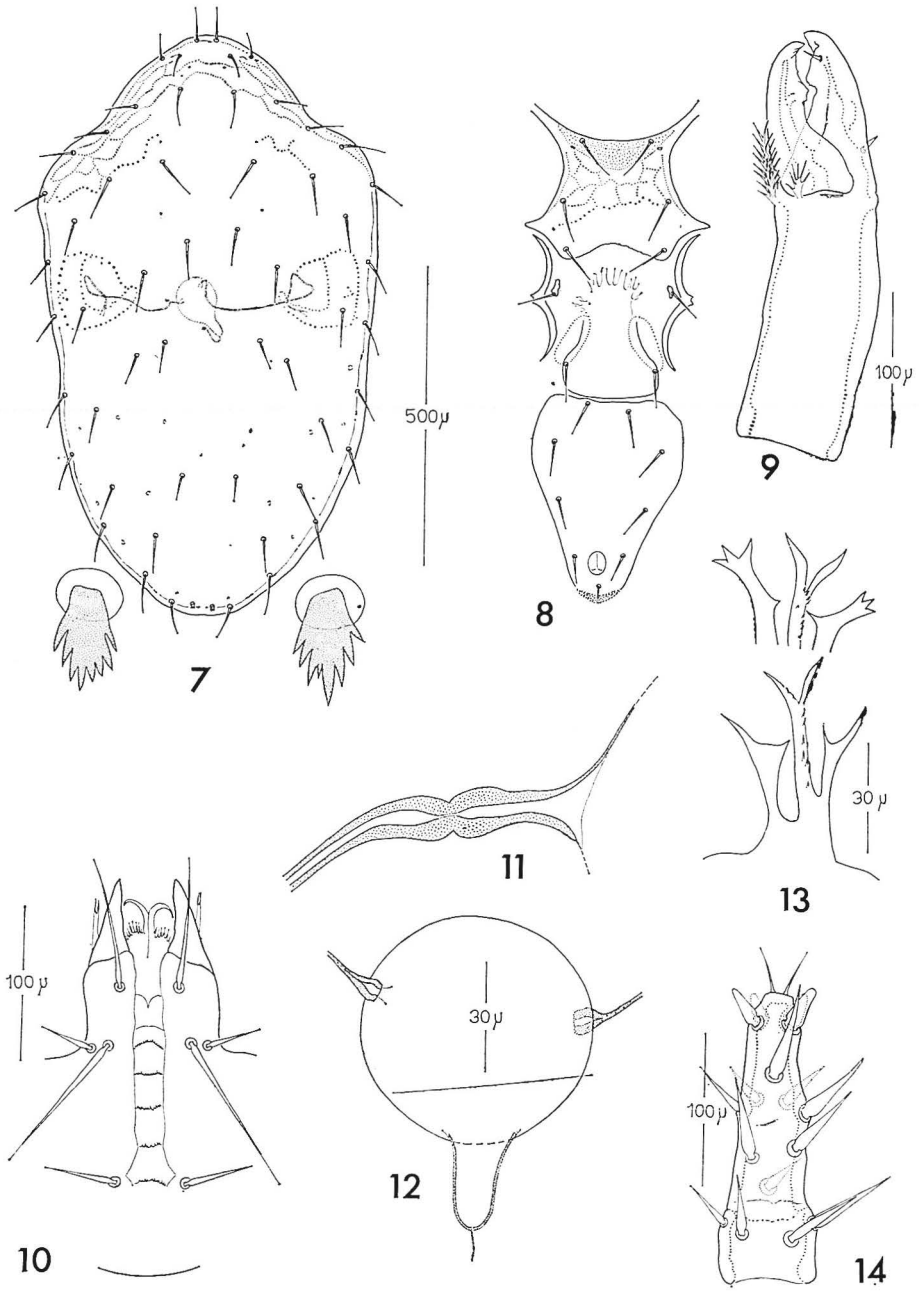
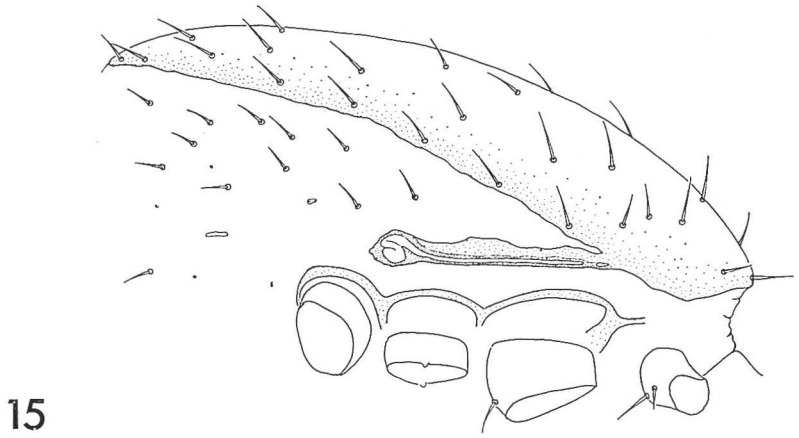


FIG. 7-14 : *Macrocheles parapisentii* n. sp., female.

7 — Dorsal shield. 8 — Ventral shields. 9 — Chelicera. 10 — Gnathosoma, ventral view. 11 — Opening funnel of tubulus annulatus. 12 — Sacculus foemineus. 13 — Tectum (with variation). 14 — Tarsus II, dorsal view.



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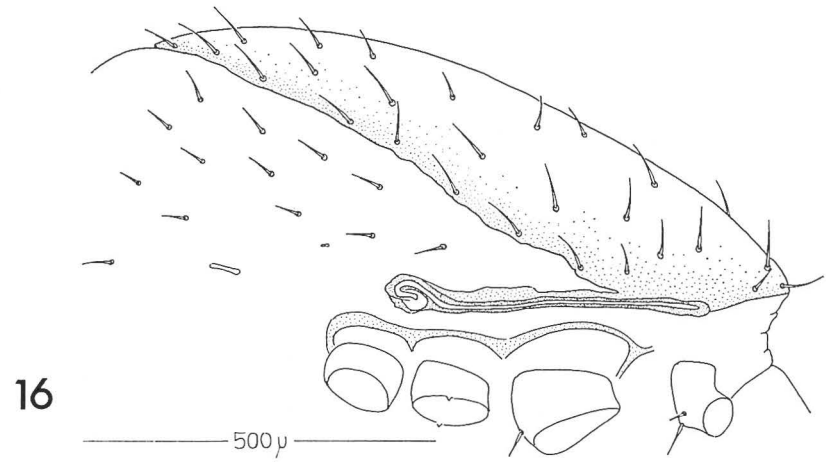

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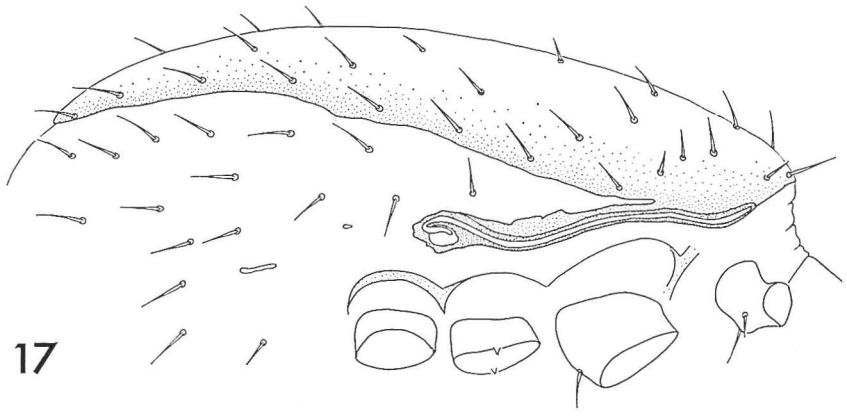

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FIG. 15-17 : Lateral views.
15 — *Macrocheles parapisentii* n. sp. 16 — *Macrocheles cristati* n. sp.
17 — *Macrocheles saceri* n. sp.

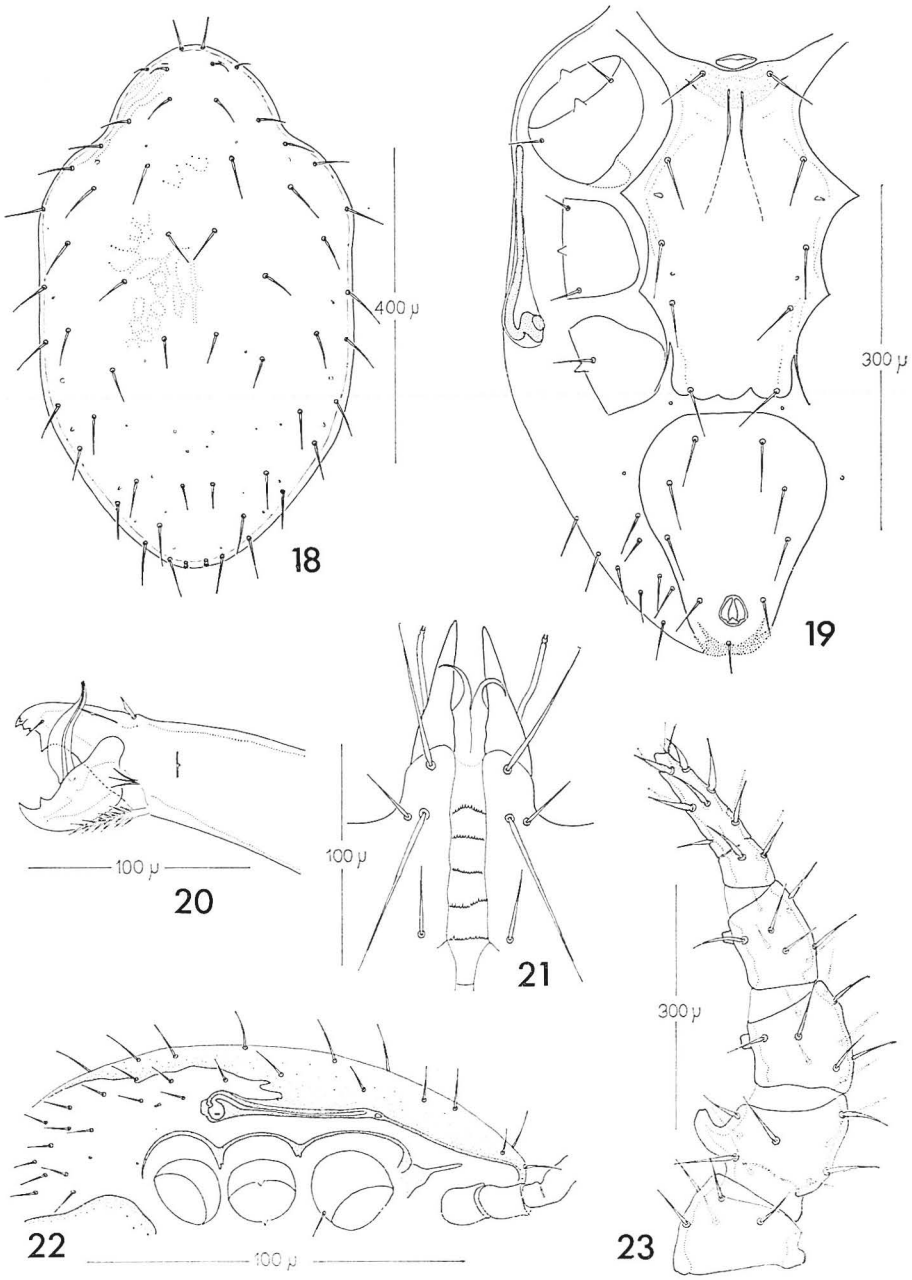

FIG. 18-23 : *Macrocheles parapisentii* n. sp., male.
18 — Dorsal shield. 19 — Venter. 20 — Chelicera.
21 — Gnathosoma, ventral view. 22 — Lateral view. 23 — Leg II, lateral view.

Notes : The new species can be confused with *M. pisentii* (Berl.) which it resembles in having 28 pairs of dorsal setae and a similar habitus. *Macrocheles parapisentii* n. sp. however, is larger (all the specimens are well above 900 μ) and the two species can easily be separated by several characters. *M. parapisentii* has short peritremes, whereas in *M. pisentii* they are long, extending to the posterior margin of coxa I ; the sternal shield *of M. pisentii* is much shorter than that of *M. parapisentii*. Additional differences are found in the shape of the short palmate J5 setae and in the size of the *sacculus foemineus* which is larger in *M. pisentii*. For easier comparison a specimen of *M. pisentii* (ex *S. semipunctatus* Fabr., Savoy, France ; collection of the British Museum (Nat. Hist.) ; det K. H. HYATT) has been figured (figs. 24, 25). The specimen was rather flattened. Its dimensions are : length of dorsal shield — 865 μ ; sternal shield — 132 μ long and 215 μ wide ; ventro-anal shield — 295 μ long and 220 μ wide. *M. pisentii* (Berl.) has ben described and figured recently by EVANS & BROWNING (1956) and EVANS & HYATT (1963).

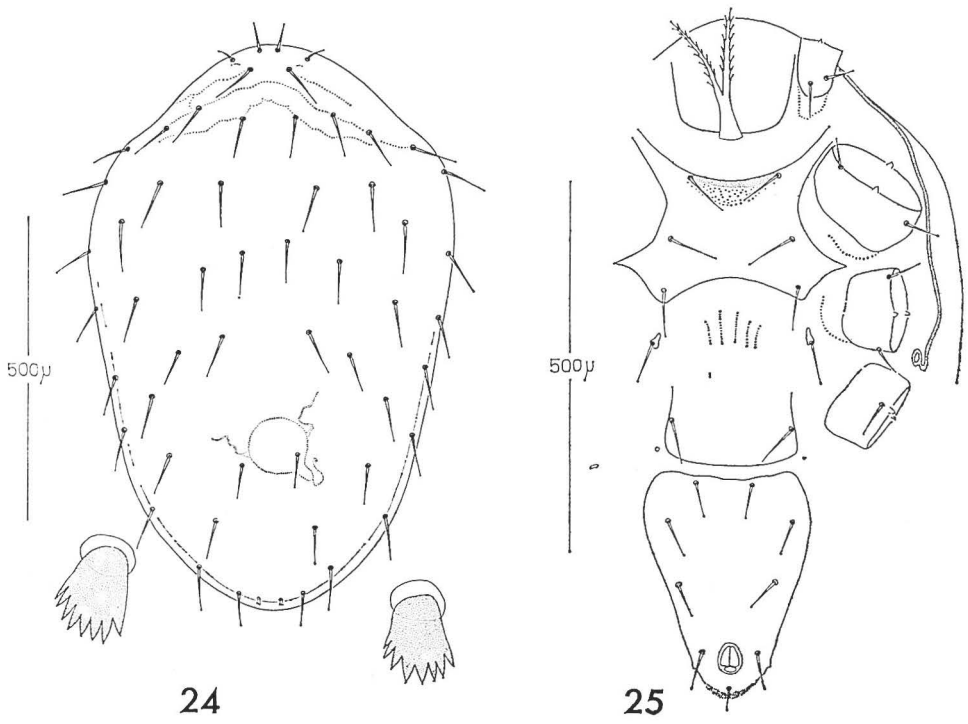

FIG. 24-25 : *Macrocheles pisentii* (Berl.), female.
24 — Dorsal shield. 25 — Venter.

Macrocheles cristati n. sp.

Female : The dorsal shield (948-1045 μ long and 495-565 μ wide) is finely punctuated and bears 29 pairs of dorsal setae. The shield is narrow anteriorly and has pronounced shoulders (fig. 26). The posterior margin of the shield is not rounded but angular and almost forms a right angle. Setae J5 are extremely short and comb-like, as many as twelve teeth being visible in the " comb ". The remaining setae are smooth and needle-like, except the vertical setae (i1) which may be slightly divided distally. The tectum is shown in fig. 30 ; it has the characteristic tripartite shape, but its outer lobes are more divided than in *M. parapisentii.*

Ventrally the sternal shield (fig. 27) (145-165 μ long and 205-230 μ wide) is rather short. Its posterior margin being weakly concave and its posterior corners rounded. The metasternal setae are inserted on minute shields which are sometimes missing. The ventro-anal shield (350-400 μ long and 250-295 μ wide) is usually rather narrow and bears the regular 9 needle-shaped setae. The ventral shields are minutely punctured, but otherwise without ornamentation. The peritrematal shield is fused anteriorly with the dorsal shield ; the peritreme extends anteriorly to the middle of coxa I (fig. 16). The gnathosoma (fig. 31) has seven transverse ridges of which usually the first and the last five bear small deutosternal teeth, whereas the second ridge has no teeth. The stout chelicerae are shown in fig. 28.

The *sacculus foemineus* (fig. 32) is globular ; in most cases its diameter is about 65 μ, but in one large specimen it reached 85 μ. The opening of the *tubulus annulatus* is shown in fig. 29.

The approximate lengths of the legs (excluding pretarsi) are : I — 775 μ ; II — 750 μ ; III — 810 μ ; IV — 1090 μ. Tarsus II of a young female is shown in fig. 33. Leg chaetotaxy normal, genu IV bearing 6 setae.

Male : The dorsal shield (755-890 μ long and 445-530 μ wide) has pronounced shoulders and parallel sides (fig. 34) ; it does not cover the dorsum completely. The chaetotaxy is similar to that of the female, but the dorsal setae of the male are considerably longer.

The venter (fig. 35) is covered by a sternito-genital shield (330-360 μ long) and a separate ventro-anal shield (320-360 μ long and 260-280 μ wide). Both shields are devoid of any ornamentation. The peritrematal shield is fused with the dorsal shield throughout most of its length ; the peritreme extends nearly to the anterior margin of coxa II (fig. 38).

The gnathosoma (fig. 39) is similar to that of the female but only 5 rows of deutosternal teeth could be observed. The stout chelicera (fig. 37) and the spermatophoral process are similar to those of *M. parapisentii.* The approximate lengths of the legs (excluding pretarsi) are : I — 780 μ ; II — 725 μ ; III — 750 μ ; IV — 1020 μ. Leg II (fig. 36) bears a protuberance and tubercles which are similar to those of *M. parapisentii.*

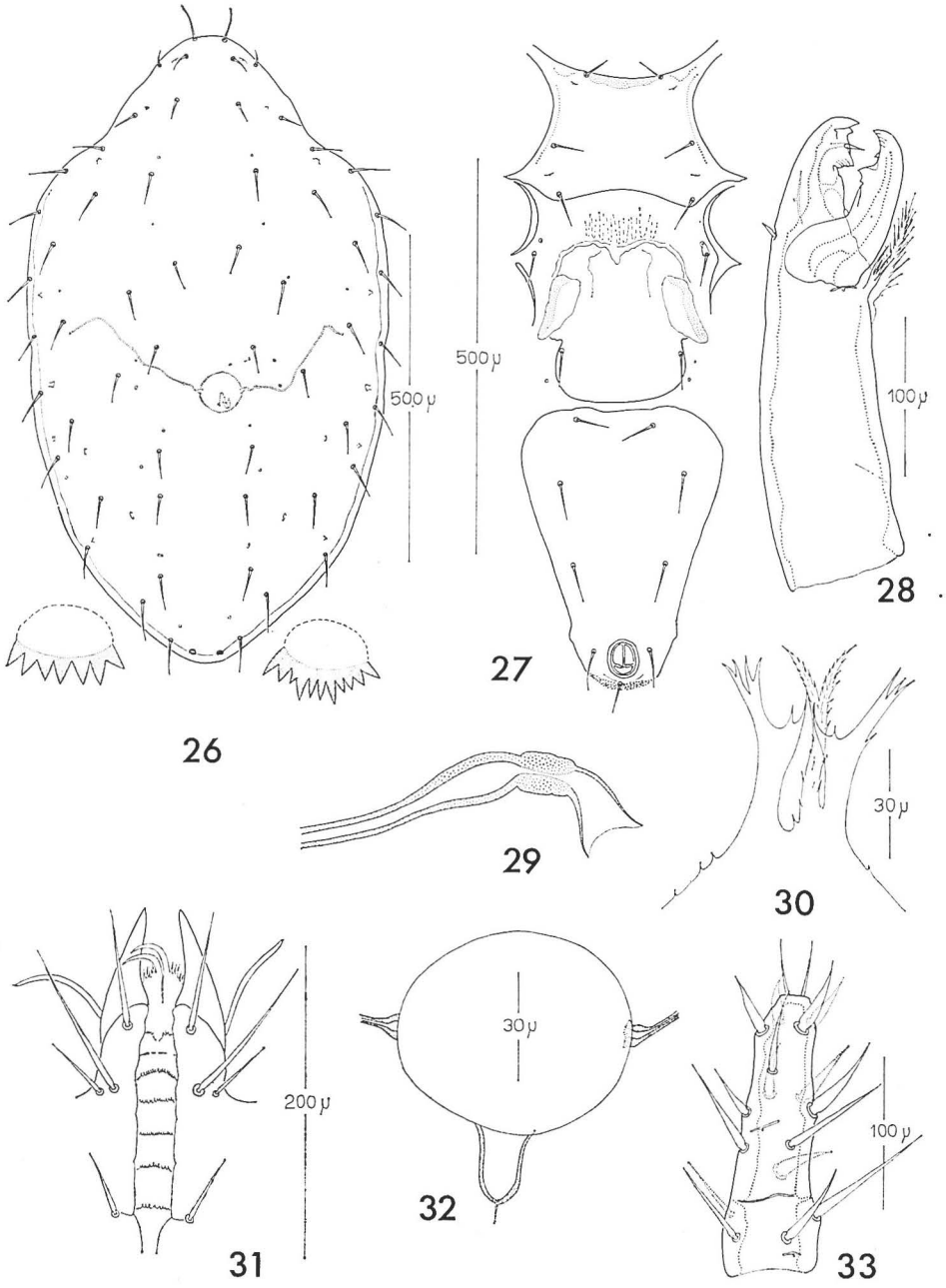

FIG. 26-33 : *Macrocheles cristati* n. sp., female.

26 — Dorsal shield. 27 — Ventral shields. 28 — Chelicera. 29 — Opening funnel of tubulus annulatus. 30 — Tectum. 31 — Gnathosoma, ventral view. 32 — Sacculus foemineus. 33 — Tarsus II, dorsal view.

Material : Holotype — 1 ♀, laboratory reared. Numerous paratypes with the same data. Originally 10 ♀ were collected from 3 specimens of *Scarabaeus cristatus* Fabr., which were attracted to night traps ; Na'aman Dunes, Israel, 12.7.1965. All the laboratory colonies and the paratype material were reared from this source and numerous females and males as well as immature stages were obtained.

Notes : Live specimens are very distinct on account of their reddish-brown tint, their elongate form and the angular shape of the posterior part of the dorsal shield.

Macrocheles saceri n. sp.

Female : The dorsal shield (985-1080 μ long and 540-615 μ wide) is oval in shape and shows a very fine granulation. Anteriorly it is slightly striated. The shield bears 29 pairs of setae. Setae J5 are short and palmate ; the remaining setae are smooth and short, usually not reaching the bases of the consecutive setae. The distribution and relative lengths of the setae are shown in fig. 40. The tectum (fig. 44) is tripartite, its lateral lobes having divided apices.

Ventrally the sternal shield (105-140 μ long and 215-245 μ wide at the level of St2) is finely granulated ; its anterior margin is more darkly tinted and strongly sclerotized. The shield (fig. 41) is deeply concave behind and its posterior corners are distinctly angular. The metasternal setae are inserted on small metasternal shields. The ventroanal shield (365-410 μ long and 295-335 μ wide) is very finely granulated and bears the usual 9 setae. The peritrematal shield is fused anteriorly with the dorsal shield ; the long peritreme extends beyond coxa I, almost reaching seta r1 (fig. 17).

The gnathosoma (fig. 45) usually has 7 ridges of deutosternal teeth, the 2nd ridge sometimes being smooth. The chelicerae (fig. 42) are robust. The *sacculus foemineus* (fig. 46) is globular ; its diameter always exceeds 70 μ and may reach 90 μ. The opening funnel of the *tubulus annulatus* is shown in fig. 43 ; behind the constriction, the inner surface shows small projections into the lumen.

The approximate lengths of the legs (excluding pretarsi) are : I — 830 μ ; II — 760 μ ; III — 790 μ ; IV — 1100 μ. Tarsus II is shown in fig. 47 ; its ventral distal setae have already attained the short, spine-like appearance (through wear and tear) whereas the dorsal setae are still acute.

Male : The dorsal shield (790-970 μ long and 480-600 μ wide) has pronounced shoulders and does not cover the dorsum completely. The chaetotaxy is similar to that of the female. The distribution and relative lengths of the setae are shown in fig. 48.

The venter (fig. 49) is covered by a sternito-genital shield (270-370 μ long) and a separate ventro-anal shield (295-350 μ long and 230-305 μ wide). In several cases the shield is so expanded anteriorly that one or two ventral setae are inserted on it in addition to the regular 9 setae. Both shields are devoid of any ornamen-

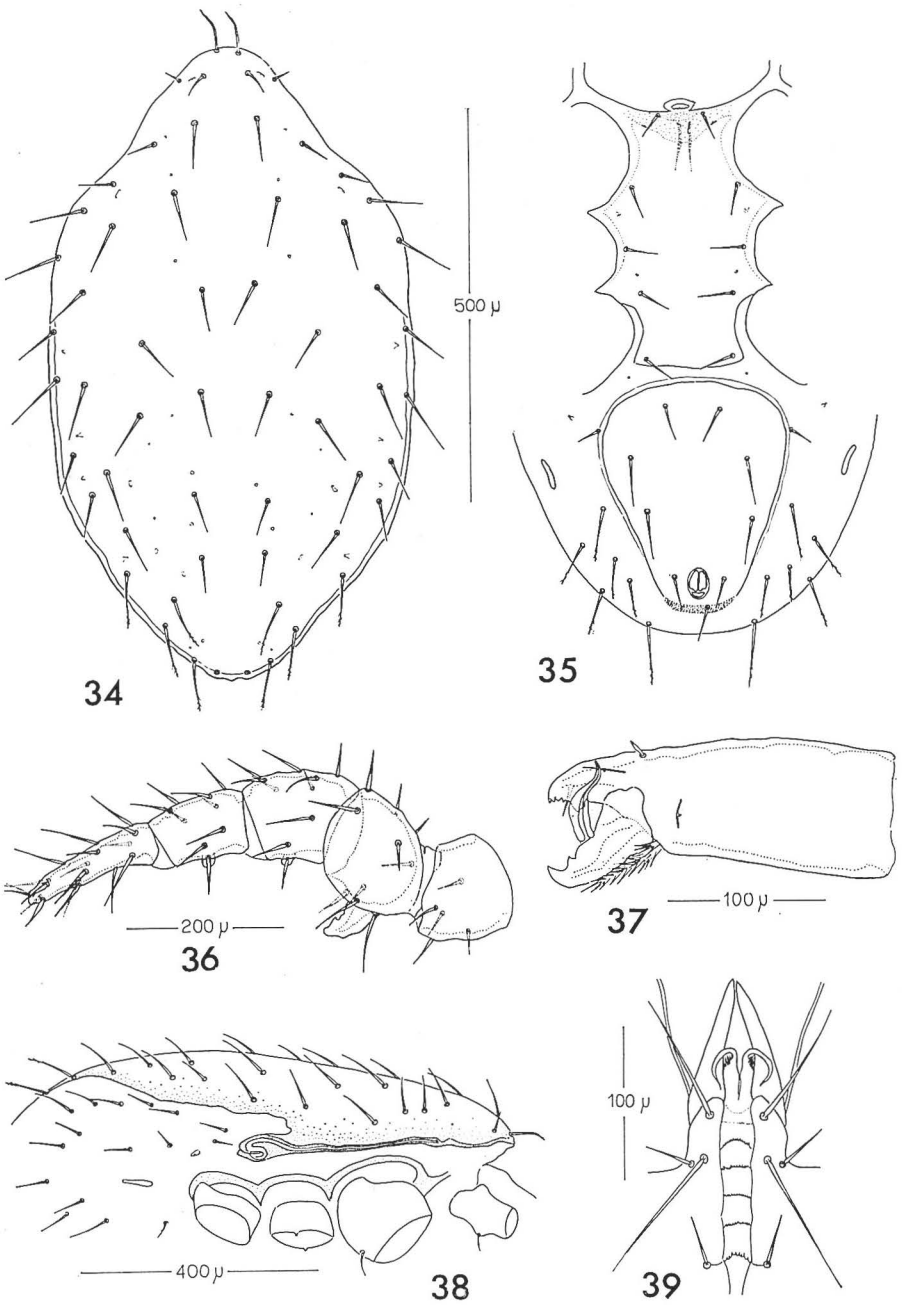

FIG. 34-39 : *Macrocheles cristati* n. sp., male.
34 — Dorsal shield. 35 — Ventral shields. 36 — Leg II, lateral view.
37 — Chelicera. 38 — Lateral view. 39 — Gnathosoma, ventral view.

tation. The peritrematal shield is fused with the dorsal shield throughout most of its length (fig. 52) ; the peritreme extends anteriorly nearly to seta r1.

The gnathosoma (fig. 53) has narrow elongate corniculi. Only five rows of deutosternal teeth could be discerned. The robust chelicerae are shown in fig. 51 ; the brush-like seta at the base of the movable digit is longer than in the preceeding species and reaches 3/4 the length of the digit. The approximate lengths of the legs (excluding pretarsi) are : I — 885 μ ; II — 840 μ ; III — 860 μ ; IV — 1150 μ. Leg II (fig. 50) bears a large thumb-like protuberance on the femur and small tubercles on the genu and tibia.

Material : Holotype, 1 ♀ ex *Scarabaeus sacer* L., Na'aman Dunes, Israel, 13.7. 1962 ; Paratypes : 3 ♀ ex *S. sacer*, Ein Yahav (Wadi Araba), 20.4.1963 ; and many laboratory reared females and males. The source of the laboratory colonies were 1 ♂ and 3 ♀, *S. sacer*, Na'aman Dunes, 12.7.1965. The ♂ was the only male of an insecticolous *Macrocheles* ever collected by me in the field from an insect.

Notes : Bregetova & Koroleva (1960) describe and figure this species, erroneously identified as *M. pisentii* (Berl.). In the description the authors state : " On the dorsal shield are inserted 27 pairs of needle-shaped setae and 1 pair of extraordinarily peculiar short setae ". However, on the figure of the specimen (fig. 105, 1) 28 pairs of needle-shaped setae can be counted. The chaetotaxy of the dorsal shield, the characteristic shape of the sternal shield (fig. 105, 2) and the armature of leg II of the male show clearly that the species described by Bregetova & Koroleva is conspecific with *Macrocheles saceri* n. sp. The Russian material was collected from *Scarabaeus sacer* and rodent burrows.

Diagnostic features of the three species.

It is often fairly easy to differentiate closely related species when looking at living specimens. *M. cristati* for example, can be easily recognized by its reddish tint and by the fact that the females often carry larvae on their venters (see below), whereas *M. saceri* caused me considerable trouble by always climbing up the brush used to transfer them from cell to cell.

Looking at cleared specimens the separation sometimes becomes more difficult. While screening various characters for their usefulness, I plotted the lengths of various structures against their widths, partly with the intention of assessing the value of ratios as diagnostic criteria (vide Costa, 1966 *a*).

An inspection of fig. 54, shows that the dimensions of the sternal shield are a good character with the minimum of overlapping between the species (there might occur some overlapping if the sample had contained more extreme-sized individuals). Only the sternal shield of *M. cristati* shows an indication of a relatively constant length/width ratio. In the other species, however, the shortest shields are often the widest ones and vice versa. One sometimes gets the impression that

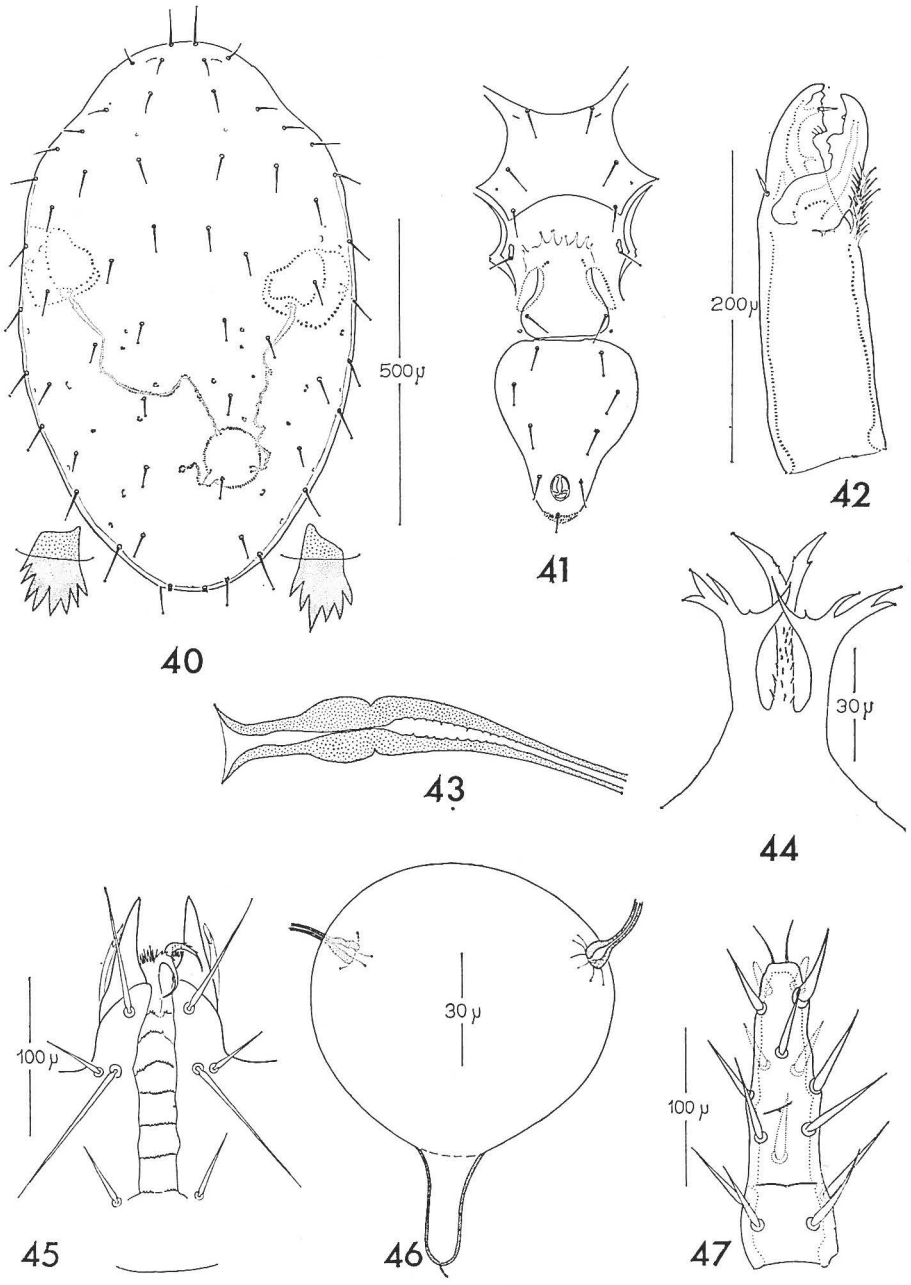

FIG. 40-47 : *Macrocheles saceri* n. sp., female.

40 — Dorsal shield. 41 — Ventral shields. 42 — Chelicera. 43 — Opening funnel of tubulus annulatus. 44 — Tectum. 45 — Gnathosoma, ventral view. 46 — Sacculus foeminеus. 47 — Tarsus II, dorsal view.

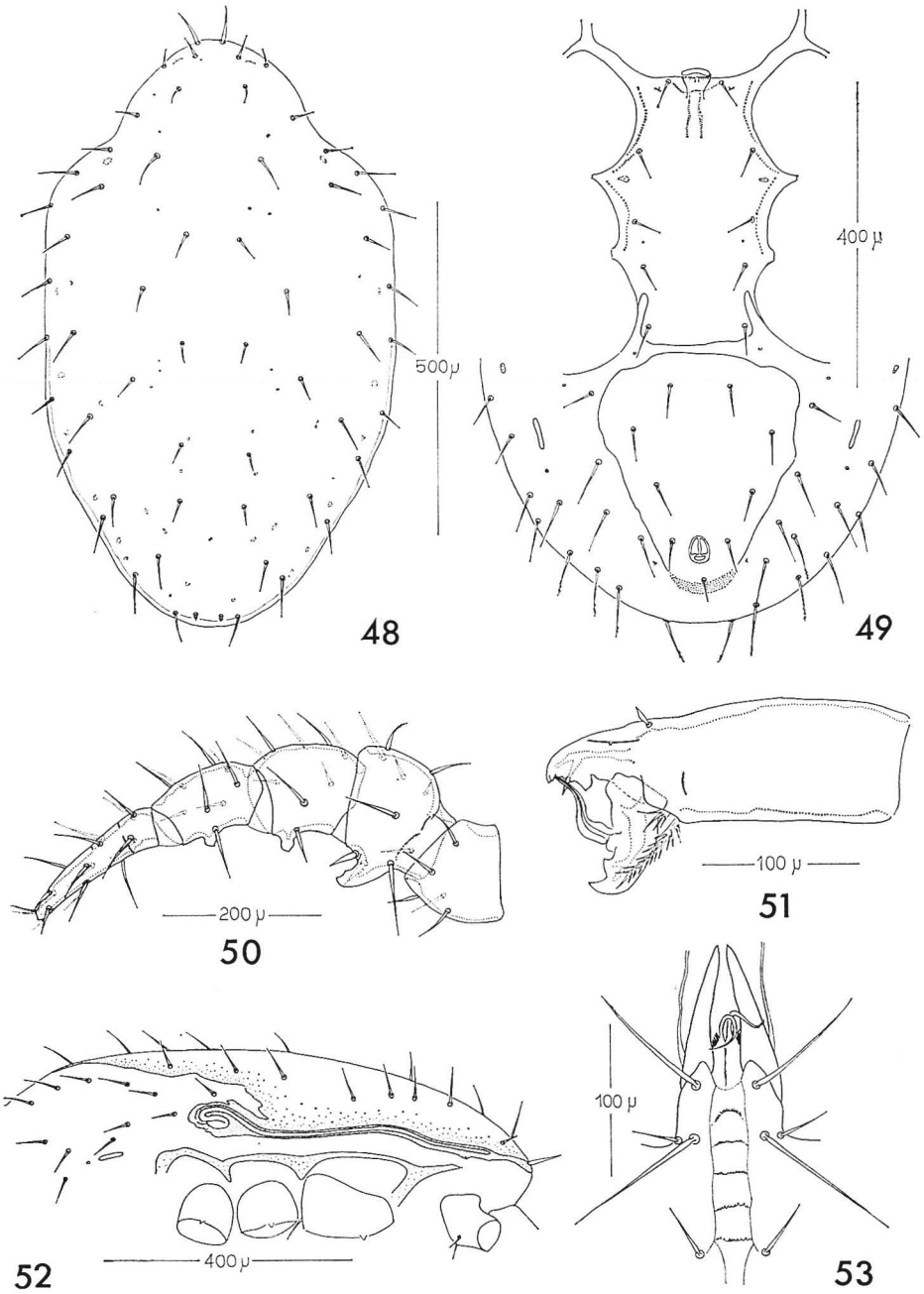

FIG. 48-53 : *Macrocheles saceri* n. sp., male.
48 — Dorsal shield. 49 — Ventral shield. 50 — Leg II, lateral view.
51 — Chelicera. 52 — Lateral view. 53 — Gnathosoma, ventral view.

there is some tendency towards a constancy of sclerotized area, with the result that the length/width ratio becomes very variable.

Length against width plotting has also been done for the ventro-anal shield (fig. 55) and there shows considerable overlap in the three species. On the other hand, the diagram shows that there is no specific constancy of length/width ratio of the ventroanal shield.

The allometry-associated variation in the macrochelids has been discussed by FILIPPONI (1964).

The best character for the separation of the three species is the dorsal chaetotaxy and the length of the peritreme, a character shared by both sexes of the species.

Below the most important measurements (14 specimens of each species) are recorded and include : average, standard deviation and range (all measurements in μ) :

		Dorsal shield.		Sternal shield.	
M. saceri	Length	1028 ± 23.2	984-1080	120 ± 7.8	105-138
	Width	581 ± 23.0	540- 612	236 ± 8.2	215-246
M. cristati	Length	978 ± 31.3	948-1044	151 ± 7.0	144-165
	Width	545 ± 16.5	496- 564	214 ± 5.9	207-231
M. parapisentii	Length	965 ± 30.2	912- 984	169 ± 7.0	159-180
	Width	551 ± 11.4	528- 576	209 ± 4.2	204-219
		Ventro-anal shield.		Distance between 11 setae.	
M. saceri	Length	387 ± 12.3	366- 408	38 ± 4.7	33- 45
	Width	298 ± 15.3	270- 336		
M. cristati	Length	371 ± 14.7	348- 402	46 ± 3.5	39- 51
	Width	269 ± 13.6	252- 294		
M. parapisentii	Length	328 ± 15.6	294- 357	32 ± 2.8	27- 39
	Width	264 ± 11.1	246- 288		

BIOLOGICAL NOTES.

Copulation : Although the copulation of macrochelids has been described in an earlier paper (COSTA, 1966 *c*) for *Macrocheles robustulus*, I should like to add some observations on the copulation of *M. saceri*, a much larger species. In general copulation follows the way described already. During a routine checking of the cultures, a female deutonymph was observed with her legs attached to the glass-cover of the rearing cell and hanging dorsum downwards preparatory to moulting. Suddenly a male jumped upon her, his venter turned towards her back. The male " danced " nervously on her back, around and around, grasping at her integument with all his legs as if trying to strip off her old skin. The integument split and moulting was completed within 30 seconds. Immediately after the female had freed her legs from the deutonymphal skin, the male approached her from the ventral side, and pressed his chelicerae strongly against the base of the posterior side of coxa III. After about a minute the male changed sides and

the process was repeated at the base of the opposite coxa III. No attempt was made to introduce the chelicerae into the genital orifice of the female. After this the male left the female without paying any further attention to her. The whole process from the approach of the male until his leaving lasted about eight minutes.

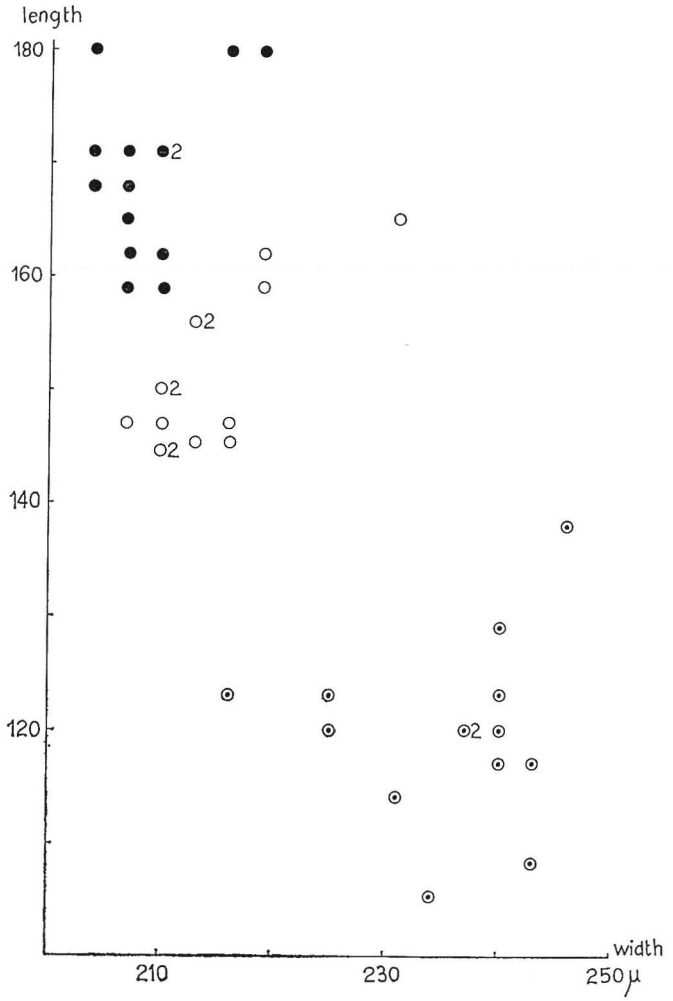

FIG. 54. Length/width ratio of sternal shield. ● = *Macrocheles parapisentii* n. sp., o = *Macrocheles cristati* n. sp., ⊙ = *Macrocheles saceri* n. sp.

The copulation was observed under the 50 times magnification of a dissecting microscope with strong illumination. No spermatophore was seen.

Oviparity and Larviparity : In *M. parapisentii* both oviparity and larviparity were observed with about equal frequency under the same condition. However,

both *M. cristati* and *M. saceri* were strictly larviparous under these conditions. Only once or twice in each case a fully developed larva was born while still in its egg skin. In *M. cristati* the " egg " was 480 μ long and 340 μ wide ; in *M. saceri* the dimensions were 440 μ by 355 μ. In both cases the fully developed larva was

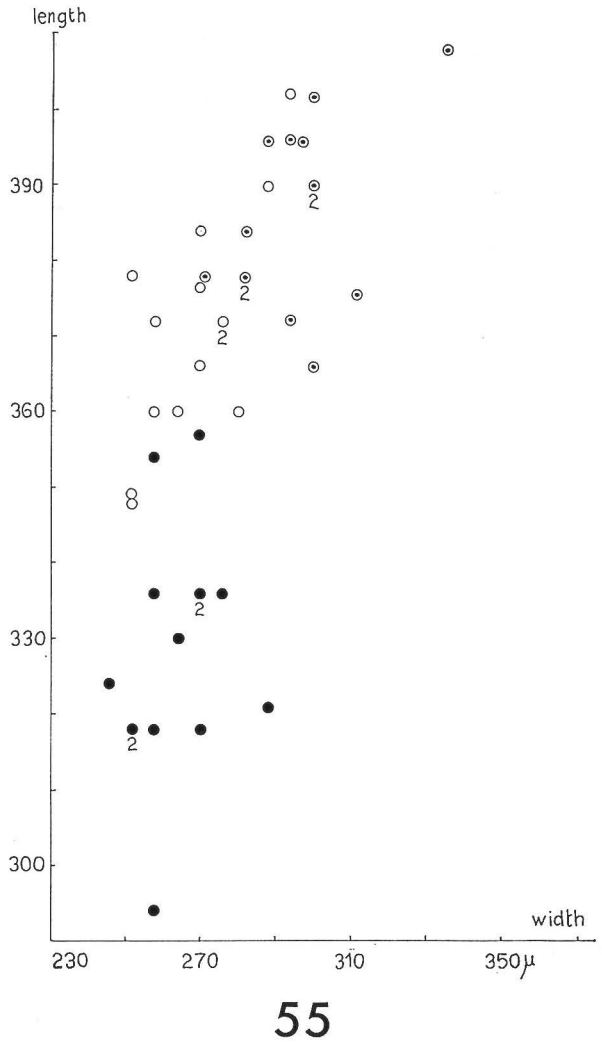

FIG. 55. Length/width ratio of ventro-anal shield. ● = *Macrocheles parapisentii* n. sp., o = *Macrocheles cristati* n. sp., ⊙ = *Macrocheles saceri* n. sp.

moving inside the skin, trying to break free. In *M. parapisentii* on the other hand, the egg is often laid with a still undeveloped embryo, having an incubation time of 24-48 hours before hatching. The problem of oviparity and larviparity has been discussed extensively by FILIPPONI & FRANCAVIGLIA (1963, 1964).

Rudimentary broodcare : In the rearing cells of *M. cristati* females were often seen with larvae and sometimes protonymphs clinging to their venters or backs. At first I attributed this to the density of mites in the rearing cells, but later on it turned out to be a fairly regular phenomenon. During a morning check of the cultures, my attention was drawn to an apparently cannibalistic female, trying

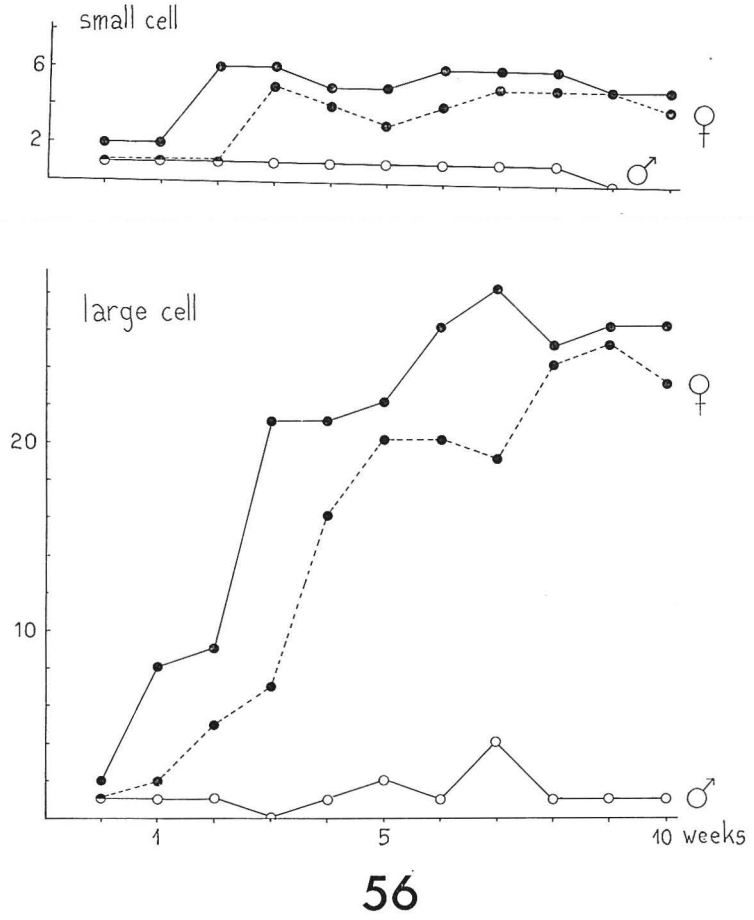

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FIG. 56. *Macrocheles parapisentii* n. sp. The development of a population in a small cell and in a large cell. Upper curve in each figure : total number of mites, including juveniles (further explanations in text).

to devour a juvenile. Closer examination under higher magnification, proved that the female was helping a larva to hatch from its egg skin. The larva hatched very quickly and after a moment of rest it mounted the female with its venter towards the female's venter. The position of the larva is usually in the same direction as the longitudinal axis of the female, the larva attaching its legs II between coxae II and III of the female, with legs III of the larva resting between

her coxae III and IV. Legs I of the larva point straight forward. The larva is usually carried around in this position for 90-120 minutes. After this the female tries to get rid of the larva by gently pressing her abdomen against the glass roof or the floor of the cell. The larva either leaves immediately or tries to change position by climbing from the ventral position to the female's back, but even than the larva leaves shortly afterwards. At this time the posterior margin of the larva shows clearly the two bulges of the protonymphal legs IV forming inside its skin. For several hours the non-feeding larva rests in a typical ' moulting position ' with gnathosoma and legs I lifted off the ground.

The progeny of ' wild ' females : In order to examine the progeny of ' wild ' *M. Parapisentii*, seven females (ex *S. puncticollis*, Na'aman Dunes, 17.5.1965) were isolated in a rearing cell (P1). Batches of eggs and/or larvae produced by these females were also isolated every second day and reared to maturity in separate cells. The first five batches were kept separately (P2-P6) and their progeny were also reared to maturity. As the females in each cell died at different dates, the total of ' female days ' for each colony was calculated and formed the basis for the remaining data, summarized in Table 1 (the interval during which no eggs were laid is excluded from the productivity calculations).

TABLE 1. The progeny of ' wild ' females of *M. parapisentii* and the progeny of their F^1 generation (further explanations in text).

		Total female days	Progeny			Eggs per day	Days per egg	Non-reproductive interval	Maximum longevity	
			Eggs and larvae	♂	♀				♂	♀
P1	7♀	326	108	48	29	0.33	3.0			88
P2	1♂,4♀	318	92	30	48	0.29	3.5	12.7–16.8.1965		154
P3	1♂,1♀	163	78	18	50	0.48	2.1	10.7–13.8.1965	24	163
P5	3♂,3♀	397	119	6	79	0.30	3.3	10.7–7. 8.1965	36	165
P6	5♀	210	32	26	—	0.15	6.6	25.7–13.8.1965	69	89

The high proportion of males produced by the ' wild ' females is striking, out of 77 mites reared to maturity, 48 (62.3 %) were males. This is of course in marked contrast to the rarity of males collected in nature, a problem that will be discussed below.

The longevity of both sexes is also fairly high : the maximum longevity of a male was 69 days, of a female 165 days. During the whole life span the mites are active and reproducing. For *M. peniculatus*, FILIPPONI & DI DELUPIS (1964) found a longevity (for the female) of 65.7 ± 29.1 days with a mean adult progeny of 85.38 ± 7.70 per female.

Equally interesting is the influence of population density on the reproductive rate. All the mites were reared in cells of approximately 1 square cm. The highest number of eggs per day (0.48) was found in the cell with a single pair of mites ; the lowest number (0.15) in a cell that harboured five virgin females. In

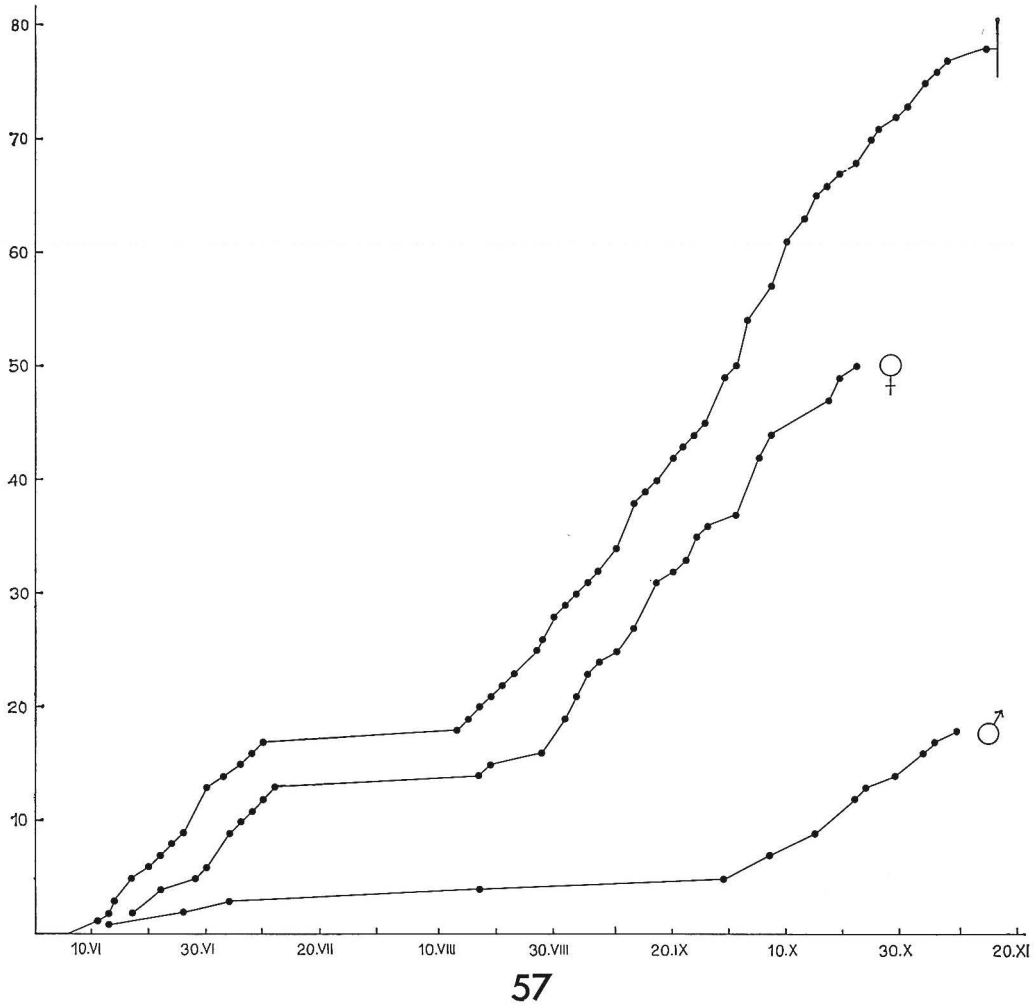

FIG. 57. — *Macrocheles parapisentii* n. sp. The progeny of a single mated female. Upper curve : cumulative number of eggs and/or larvae (further explanations in text).

the cells that harboured 5-7 mites of both sexes the reproductive rate was about 0.3 eggs (or larvae) per day. This phenomenon was separately investigated in the following experiment.

The influence of population density : In the colonies described above, the eggs and/or larvae were taken out every second day and had, therefore, no influence

on the population pressure. All the cells were of the same dimensions, namely 1 square cm, with a depth of 2-3 mm. In the following experiment two differently sized cells were used : a regular cell of 1 square cm and a cell of 5 square cm. Into each of the cells a single young pair of *M. parapisentii* was introduced. The population was counted every week when the mites were tranferred to clean cells. The results of this experiment are summarized in fig. 56. In both cells the equilibrium density reached, is about 5-6 mites per square cm. Food (nematodes of the genus *Panagrellus*) was always available in abundance. It is also fairly obvious that in the restricted territory apparently only one male can survive, a problem which will be discussed further below.

Progeny of a single pair of M. Parapisentii : On the 30.5.1965 two eggs of *M. parapisentii* were introduced into a regular rearing cell. A male emerged on the 4.6 and a female on the 6.6. The first egg was laid on the 11.6, after a preoviposition period of five days. The male died after 36 days and the female after 163 days, producing during her lifetime 78 eggs and larvae. The eggs and larvae were isolated every second day and reared to maturity. The results are summarized in fig. 57.

Several interesting facts can be inferred from the figure. Except for a non reproductive interval (10.7-13.8) reproduction was at a fairly constant rate of an egg or larva about every two days. A similar non reproductive interval was observed in all the cultures which were kept at room temperature. This can probably be explained by the high temperature prevailing during July-August in Israel.

Out of 78 eggs and larvae, 68 were reared to maturity. Several juveniles died and the last six eggs were not viable. The nonviable eggs had a wrinkled surface and were slightly shrunken.

One of the problems which had bothered me was the possibility of the dying out of a culture once only fertilized females were present. Theoretically there might come a period when no male would be available to fertilize freshly emerged females. Older females with a hardened skeleton cannot be impregnated successfully. I was afraid that I might end up with colonies of virgin females which would produce males only.

An inspection of figure 57 shows that arrhenotokous females seem to be wonderfully adapted to this danger : a few males are produced by the impregnated female at the beginning of the reproductive period when several unfertilized eggs are laid. At the end of the reproductive period male producing eggs are laid at the same time as fertilized eggs, so that males and females emerge simultaneously. It is interesting to note that after the non-reproductive interval one of the first eggs laid was unfertilized and produced a male.

At 27°C the whole development from egg to adult is very short. If the females produce larvae these develop into males within 2-3 days and into females within 4-5 days. If eggs are laid an additional day is necessary for the incubation period.

The problem of the rarity of males : It is a well known fact that of most of the insecticolous species of the genus *Macrocheles* only females are collected in nature whereas males are found extremely rarely. Although the males have a considerably shorter life-span than the females, this can hardly be the explanation. The most important factor sems to be the non-phoretic behaviour of the males. Not being concerned with brood-care or the colonization of new habitats, the males unlike the females, do not attach to the coprid beetles. It may happen that, if the mites are collected from a suitable habitat (with a funnel), many males may be found. In a recent collection from Gazella manure heaps (In Kfar Giladi, Northern Galil) the following macrochelids were collected :

	9.1.1966	1.2.1966
Macrocheles robustulus	—	50 ♂, 110 ♀
Macrocheles merdarius	numerous ♂ and ♀	290 ♂, 870 ♀
Macrocheles muscaedomesticae	39 ♂, 4 ♀	3 ♀

In the heap, coprid beetles that acted as transport hosts (*Copris hispanus*, *Onthophagus* spp) were active and many juvenile stages of the *Macrocheles* spp. showed that reproduction was actively taking place in the manure heap.

During the rearing experiments an additional fact was observed. Older males usually killed the freshly emerged males or even the male deutonymphs. Often a dead deutonymph was found in a rearing cell. Many times this was cleared and examined and usually it turned out to be a pharate male. This explains the fact shown in fig. 56 that only one male was usually present in the culture, and that the presence of four males in one week was reduced to one male in the consecutive week. Older well sclerotized males do not kill one another and may be kept in the same cell without harm.

The rarity of males seems also to be the natural result of reproduction in arrhenotokous species : as one male can successfully impregnate several females, these naturally produce an abundance of females.

Experimental taxonomy : In order to test the degree of relatedness between the three species of the *pisentii* group, the following crosses were attempted between freshly emerged females and males which were several days old :

♂ *cristati* × ♀ *saceri*
♂ *cristati* × ♀ *parapisentii*
♂ *saceri* × ♀ *cristati*
♂ *saceri* × ♀ *parapisentii*
♂ *parapisentii* × ♀ *saceri*

The results were extremely surprising : in all cases except the last one, the females were invariably killed by the males. In one case (1 ♂ *cristati* × 2 ♀ *parapisentii*) the first female was found dead after 30 minutes and the second after 45 minutes. The same happened in most other crosses, although females survived sometimes for as long as 24 hours.

Several times, before the females died, attempts at copulation with all the characteristic attitudes were observed. In some cases the females were separated from the males after ' normal copulation ' was observed. The females were never fertilized and produced males only. In a cross between ♂ *parapisentii* × ♀ *saceri* the male was ' outsized ' by the female and did not kill her. Typical copulation was observed but no fertilization took place. The male died after 37 days and the female lived for 82 days, producing male offspring only.

In a cross of ♂ *cristati* × ♀ *parapisentii* the female seemed to be more inclined towards copulation than the male. On encounter the female ' froze ' on the spot, lifting her two hindlegs (legs IV) from the ground. The male passed her several times without showing any interest. This female too was found dead on the following day.

It is apparent that mites of the *pisentii* group have solved the problem of a genetic barrier between related species in a rather unique way.

Summary.

The following three new species of the genus *Macrocheles* Latr. are described and figured : *M. parapisentii* (ex *Scarabaeus puncticollis* Latr.), *M. saceri* (ex *S. sacer* L.) and *M. cristati* (ex. *S. cristatus* Fabr.). All the stages have been described and figured in the first species, male and female only in the remaining ones. The biological notes include observations on the behaviour, copulation, oviparity and larviparity and the progeny of ' wild ' females and a single pair of mites. The rarity of males is discussed. The three species could not be crossed and no mixed F_1 offspring has been obtained.

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