DESCRIPTIONS OF THE JUVENILE STAGES
OF *PACHYLAELAPS HISPANI* BERLESE
(ACARI : MESOSTIGMATA) [1]

BY

Michael COSTA [2].

(Kibbutz Mishmar Haemek, Israël).

INTRODUCTION.

Pachylaelaps hispani was briefly described by BERLESE in 1908 and later figured by him (BERLESE, 1913). The adults were redescribed and figured in detail during a mite survey of the scarabaeid *Copris hispanus* (L.) (COSTA, 1963). In the present study the juvenile stages are described and figured and special attention is given to the chaetotaxy of the dorsum and the legs. In the dorsal chaetotaxy I have followed mainly HIRSCHMANN (1957), EVANS (1963) has been followed in the notation of the leg chaetotaxy.
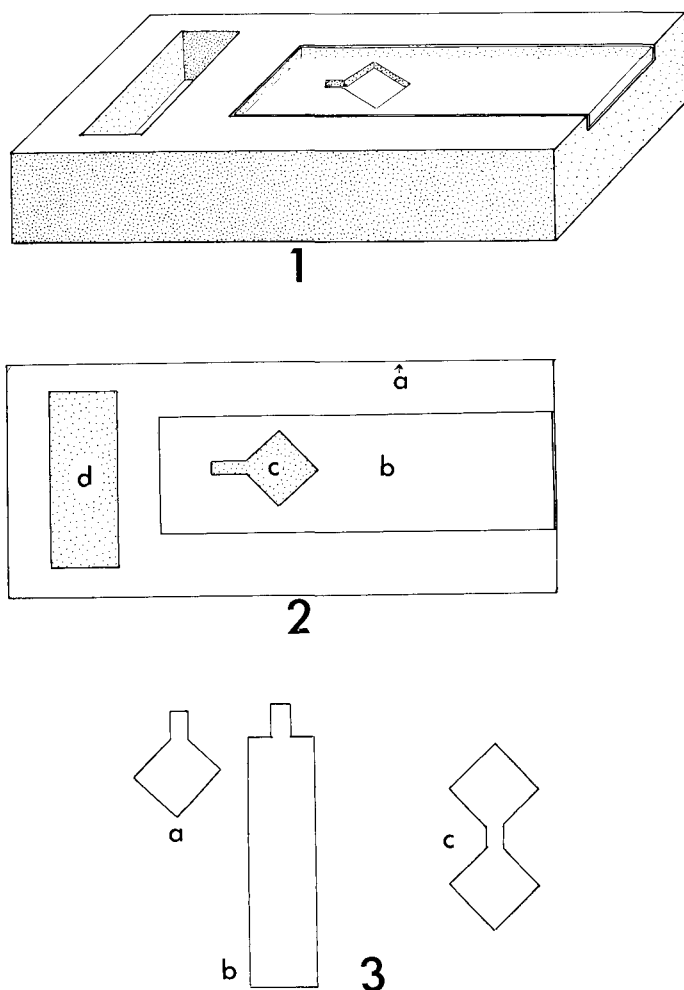
METHODS.

The mites were reared in cells made from Plaster of Paris and regular object slides (0.8 mm thickness). As the rearing method seems to be applicable to many species of free-living mites and is simple, it is described here in detail although many rearing cells have been described in the literature. The finished cell is shown in fig. 1. The main advantage of the cell is, that the rearing cavity can be partially opened by simply moving the slide. In this way food can be introduced into the feeding channel without too much disturbance to the mite colony. The culture can be observed directly under the dissecting microscope and the size of the rearing cavity can be made in accordance with the field of vision. Filling the trough with water once in a while, brings the relative humidity in the cavity to near the saturation point.

The manufacture of the cell is a simple process. The rearing cavity is preformed

in plasticine in the desired shape and depth (fig. 2, c). Although the plasticine does not adhere to the dry plaster, it is advisable to prepare the mould with slanting sides. The plasticine mould is pressed slightly to the glass slide (fig. 2, b) in the desired position. The water trough is also preshaped in plasticine (fig. 2, d). For

FIGS 1-3. — 1. General view of the rearing cell. 2. Diagrammatic arrangement of the moulds : a) tin strip ; b) object slide ; c) plasticine mould of cell ; d) plasticine mould of trough. 3. Cell shapes : a) small cell ; b) large cell ; c) double chambered cell. Further explanations in text.

the outer mould a tin strip of 20 mm width is used, which is bent into a rectangle of 5 cm by 11 cm, its overlapping ends are hold together by a paper clip (fig. 2, a). The whole arrangement is shown diagrammatically in fig. 2.

It is extremely easy to prepare cavities of various shapes. Various cavity sizes were used in order to examine the influence of population density on repro-

ductive or molting behaviour (fig. 3, a, b). A special double chamber, with a blackening of the slide in the appropriate spot has been used for investigating the phototactic responses of mites. Simply by moving the slide, the light conditions in the two connected chambers can be reversed, other conditions remaining equal (fig. 3, c).

Fungi may be troublesome after several weeks, but they may by overcome by using a mixture of active charcoal and plaster (the black background may be desirable for the discovery of eggs etc.) or by using an appropriate fungicide.

In my rearing experiments I use the nematode *Panagrellus* sp. which is easily mass-cultured in quaker-oats cooked in milk. The best results were obtained with fairly thick and dry porridge (using about equal volumes of milk and oats). The porridge is poured into a transparent plastic bowl. Several days after inoculation with *Panagrellus* sp., the nematodes migrate up the slanting sides of the bowl and form a thick and clean layer. Thus, they can be collected directly with a brush without the tedious process of separating them from the culture medium. The nematodes have to be subcultured every 3-4 weeks. One culture produces enough nematodes for about 30 cells of mites. *Panagrellus* sp. is very hardy and stays alive in the humid cell for many days. As it is viviparous it is obtained in a large assortement of sizes.
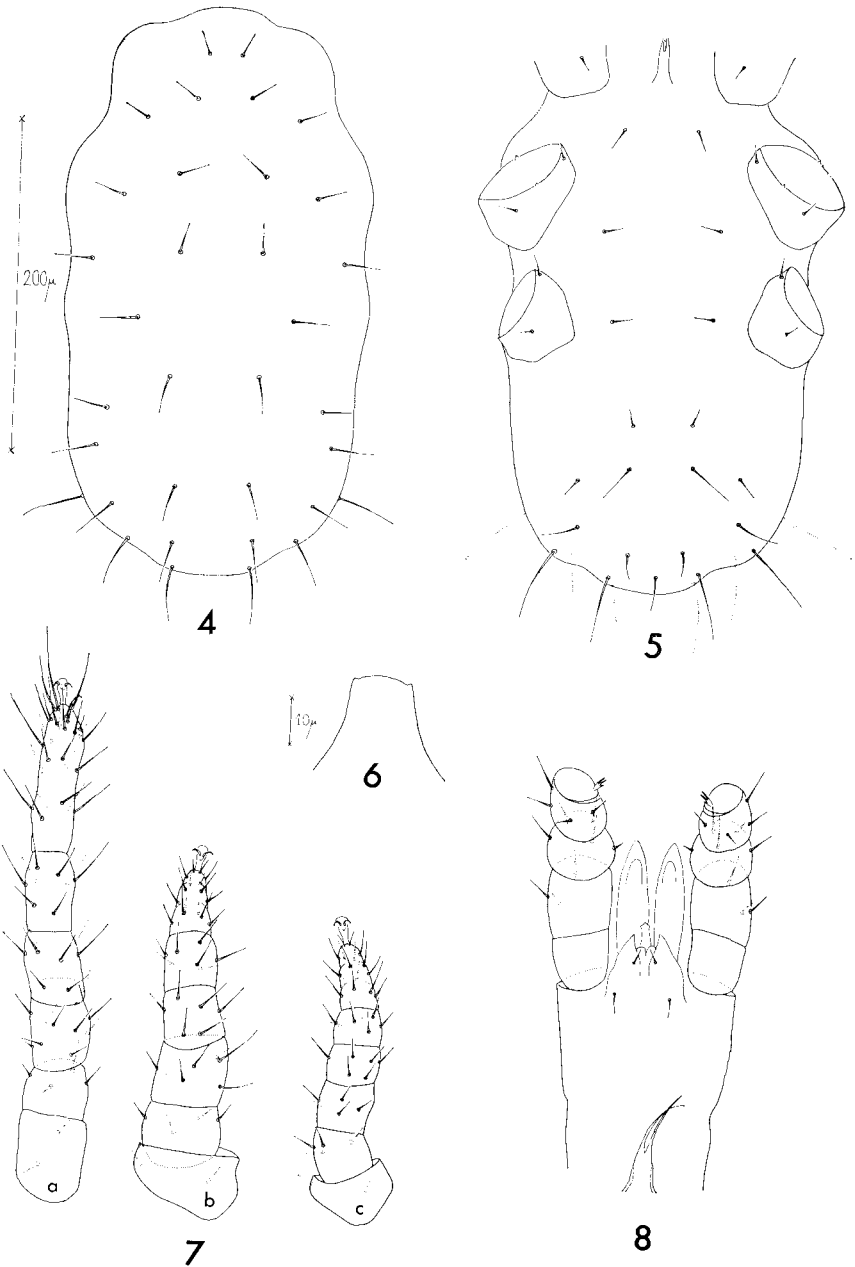
RODRIGUEZ et al. (1962) have described culture methods of *Rhabditella leptura*, extracting the nematodes with Baerman Funnels.

DESCRIPTIONS.

EGG : The egg is transparent white in colour, elongate oval in shape and 275 μ long and 190 μ wide. The egg shell is very delicate and easily ruptured. It is devoid of any ornamentation, the shell being smooth and shiny.

LARVA : The larva is whitish and only weakly sclerotized, it is 360 μ long and 190 μ wide (at the level of coxae III). Sclerotized platelets could not be discerned on the dorsal and ventral surfaces. The dorsum bears 16 pairs of simple setae and 1 pair of rather long postero-lateral setae (S 3). The large podonotal portion of the dorsum bears 11 pairs of setae (i1-i5, z1, z2, s2, s5, s6, s7) and the small opisthonotal portion bears 6 pairs of setae (J2-J4, Z2, S3, S4). Two additional pairs of dorsal setae (S5 and J5) are ventrally inserted in the larva. The distribution and the relative lengths of the dorsal setae are shown in fig. 4 (for setal homologies see the discussion). The tectum (fig. 6) is a short transparent lobe.

The venter (fig. 5) bears 3 pairs of sternal setae, 4 pairs of opisthogastric setae in front of the anal area which bears its usual 3 setae, and 2 pairs of posteromarginal setae. The latter, which I identify as S5 and J5, move to the dorsum during ontogenetic development. No anal aperture is present in the larva which is non-feeding, and no indication of a non-functional anus could be discerned. The gnathosoma (fig. 8) bears 2 pairs of gnathosomal setae, the corniculi are transparent. The chelicerae are only weakly developed.

FIGS 4.-8. — *Pachylaelaps hispani* Berlese, larva. 4. Dorsum. 5. Venter. 6. Tectum. 7 a-c. Legs of the right side, I-III respectively, dorsal view. 8. Gnathosoma, ventral view.

The approximate lengths of the legs (excluding pretarsi) are : I — 315 μ ; II — 225 μ ; III — 200 μ. The leg chaetotaxy of the larva is as follows (notation after Evans, 1963) :

	I	II	III
trochanter	$1 - \dfrac{0}{2} - 1$	$1 - \dfrac{0}{2} - 1$	$1 - \dfrac{1}{2} - 0$
femur	$2 - \dfrac{4}{2} - 2$	$1 - \dfrac{4}{1} - 1$	$1 - \dfrac{3}{1} - 0$
genu	$1 - \dfrac{2}{1} ; \dfrac{2}{1} - 1$	$1 - \dfrac{2}{0} ; \dfrac{2}{0} - 1$	$1 - \dfrac{2}{0} ; \dfrac{2}{0} - 1$
tibia	$1 - \dfrac{2}{1} ; \dfrac{2}{1} - 1$	$1 - \dfrac{1}{1} ; \dfrac{2}{1} - 1$	$1 - \dfrac{1}{1} ; \dfrac{2}{1} - 1$

The leg chaetotaxy (figs. 7 a-c) is identical with that of the larva of *Pergamasus* sp. (EVANS, 1963).
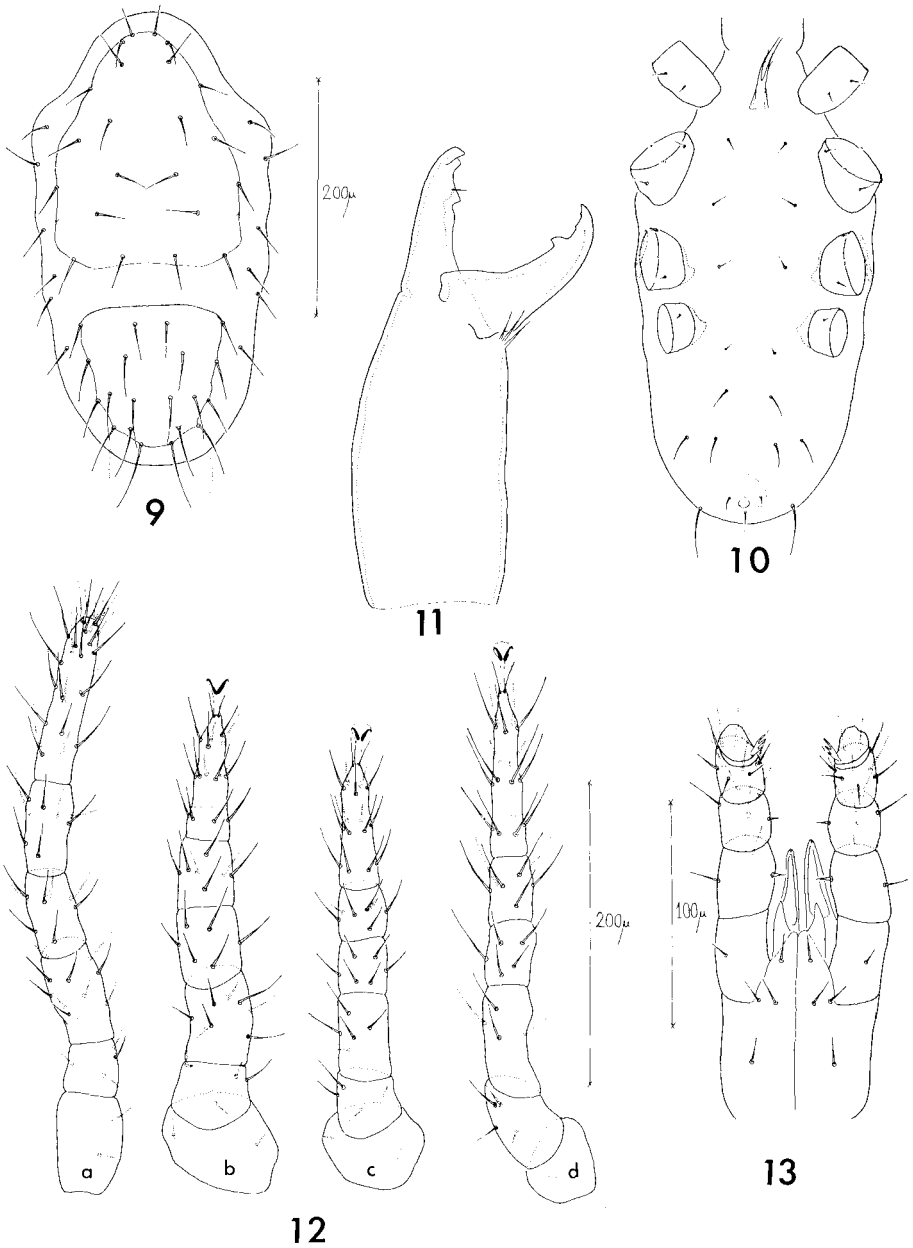
PROTONYMPH : The idiosoma of the whitish protonymph is 430 μ long and 220 μ wide. The two dorsal shield can be discerned only with difficulty. The podonotal region bears 16 pairs of setae, 11 pairs of which are inserted on the podonotal shield. Of the five pairs of setae which are added at this stage s1 and s3 are inserted on the podonotal shield and r4, r5 and r7 on the membrane. 11 pairs of setae are inserted in the opisthonotal region, the opisthonotal shield bears 10 of the pairs. Three pairs of setae, namely J1, Z1 and Z3 that are added at this stage, are inserted on the opisthonotal shield and S5 and J5 have moved to the dorsum.

The weakly sclerotized sternal shield bears the usual 3 pairs of sternal setae. As two pairs of larval postero-marginal setae have moved dorsally, the ventral surface of the protonymph bears actually less setae then in the larva (fig. 10). Only one pair of short genital setae are added. The rudimentary peritreme is situated opposite coxa III.

The gnathosoma (fig. 13) bears the full complement of 4 pairs of gnathosomal setae. The well sclerotized corniculi are elongate and acute. The chelicerae (fig. 11) are well sclerotized, the movable digit bears 2 tiny teeth anteriorly to a large central tooth, and the fixed digit bears 2 median large teeth.

The approximate lengths of the legs (excluding pretarsi) are : I — 365 μ ; II — 280 μ ; III — 265 μ ; IV — 350 μ. The leg chaetotaxy is as follows :

	I	II	III	IV
trochanter	$1 - \dfrac{0}{2} - 1$	$1 - \dfrac{0}{2} - 1$	$1 - \dfrac{1}{2} - 0$	$1 - \dfrac{1}{2} - 0$
femur	$2 - \dfrac{4}{2} - 2$	$1 - \dfrac{4}{2} - 1$	$1 - \dfrac{3}{1} - 0$	$1 - \dfrac{2}{1} - 0$

FIGS 9-13. — *Pachylaelaps hispani* Berlese, protonymph   9. Dorsum.   10. Venter.   11. Chelicera.   12 a-d. Legs of the right side, I-IV respectively, dorsal view.   13. Gnathosoma, ventral view.

genu	$1 - \dfrac{2}{1};\dfrac{2}{1} - 1$	$1 - \dfrac{2}{0};\dfrac{2}{0} - 1$	$1 - \dfrac{2}{0};\dfrac{2}{0} - 1$	$1 - \dfrac{2}{0};\dfrac{2}{0} - 1$
tibia	$1 - \dfrac{2}{1};\dfrac{2}{1} - 1$	$1 - \dfrac{1}{1};\dfrac{2}{1} - 1$	$1 - \dfrac{1}{1};\dfrac{2}{1} - 1$	$1 - \dfrac{1}{1};\dfrac{2}{1} - 1$

The leg chaetotaxy of the protonymph (figs. 12 a-c) is identical with that of the protonymph of *Pergamasus* sp. except for femur IV which in *Pergamasus* sp. is $1 - \dfrac{3}{0} - 0$ (EVANS, 1963).

DEUTONYMPH : The deutonymph is only weakly sclerotized and the outlines of the dorsal shield are only weakly defined. The idiosoma is 550 μ long and 280 μ wide. The dorsal shield covers the idiosoma only partly and its lateral incisions are only weakly indicated. The podonotal part of the shield bears 18 pairs of setae (r1 and r2 are added) and the opisthonotal part of the shield bears 12 pairs (S2 is added, the R series is inserted on the membrane). The distribution and the relative lengths of the setae are shown in fig. 14 (for setal homologies see discussion).
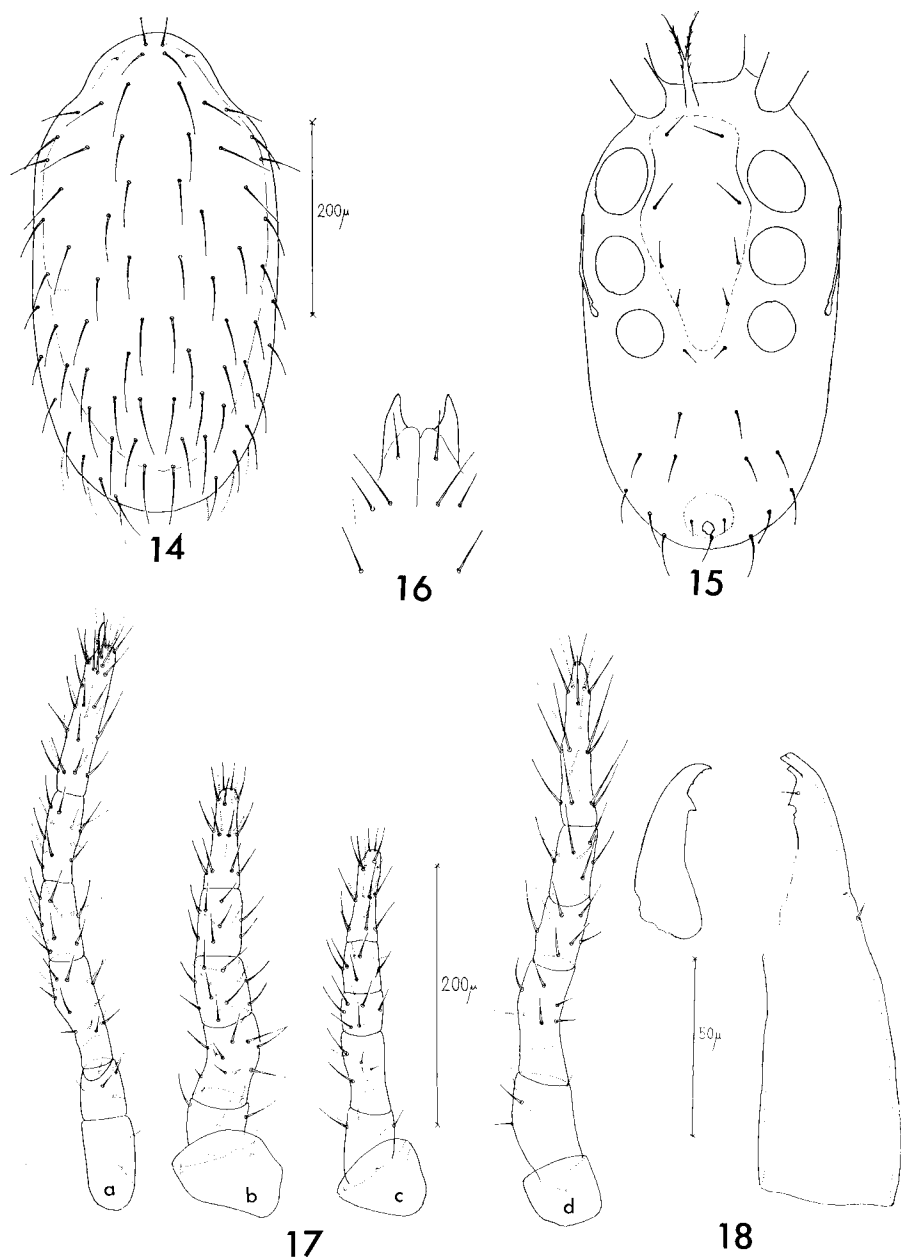
On the ventral surface (fig. 15) the weakly defined sternal shield bears 4 pairs of setae, the metasternal setae being added at this stage. Two additional pairs of opisthogastric setae make their appearance lateral to the anal area. The round anal shield is weakly sclerotized. The postanal seta is markedly longer than the paranal setae which are inserted at the level of the anterior margin of the anal aperture.

The gnathosoma (fig. 16) is similar to that of the protonymph and the deuto-sternal teeth could not be discerned. The chelicerae (fig. 18) are well sclerotized and are similar to those of the protonymph.

The approximate lengths of the legs (excluding pretarsi) are : I — 450 μ; II — 335 μ; III — 305 μ; IV — 445 μ. The leg chaetotaxy is as follows :

	I	II	III	IV
trochanter	$1 - \dfrac{1}{3} - 1$	$1 - \dfrac{0}{3} - 1$	$1 - \dfrac{0}{3} - 1$	$1 - \dfrac{1}{3} - 0$
femur	$2 - \dfrac{4}{5} - 2$	$2 - \dfrac{5}{3} - 1$	$1 - \dfrac{4}{1} - 0$	$1 - \dfrac{4}{1} - 0$
genu	$2 - \dfrac{3}{2};\dfrac{2}{1} - 2$	$2 - \dfrac{3}{1};\dfrac{2}{1} - 2$	$1 - \dfrac{2}{1};\dfrac{2}{0} - 1$	$1 - \dfrac{2}{1};\dfrac{2}{0} - 1$
tibia	$2 - \dfrac{3}{2};\dfrac{2}{1} - 2$	$2 - \dfrac{2}{1};\dfrac{2}{1} - 2$	$1 - \dfrac{1}{1};\dfrac{2}{1} - 1$	$1 - \dfrac{1}{1};\dfrac{2}{1} - 1$

The leg chaetotaxy of the deutonymph (figs. 17 a-d) agrees with that given by EVANS (1963) for the adult Pachylaelaptidae. Only femur I seems to differ

FIGS 14-18. — *Pachylaelaps hispani* Berlese, deutonymph. 14. Dorsum. 15. Venter. 16. Gnathosoma, ventral view. 17 a-d. Legs of the right side, I-IV respectively, dorsal view, pretarsi ommited. 18. Chelicera.

slightly, Evans states $2 - \dfrac{5}{4} \, 2$ whereas my interpretation is $2 - \dfrac{4}{5} - 2$, but one has to admit that the twisted femur may be interpreted with ambiguity.

In the adults of the genus *Pachylaelaps* tarsus II bears one or two terminal spines in the female and the male respectively. It is interesting to note that these spines make their appearance in the adults only and that they are not indicated in the juveniles. This is in marked contrast to *Neopodocinum caputmedusae* (Berlese), where these spines are present in all post-embryonic developmental stages (COSTA, 1965).

<div align="center">BIOLOGICAL NOTES.</div>

In order to obtain the juvenile stages, which are not known from nature, rearing was made in the cells described above. The adult mites were often observed to feed on the nematodes. Specimens of *Tyrophagus putrescentiae* were introduced also into the rearing cells, but they were ignored by *Pachylaelaps* and started to lay eggs and reproduce in the cells side by side with *Pachylaelaps*.
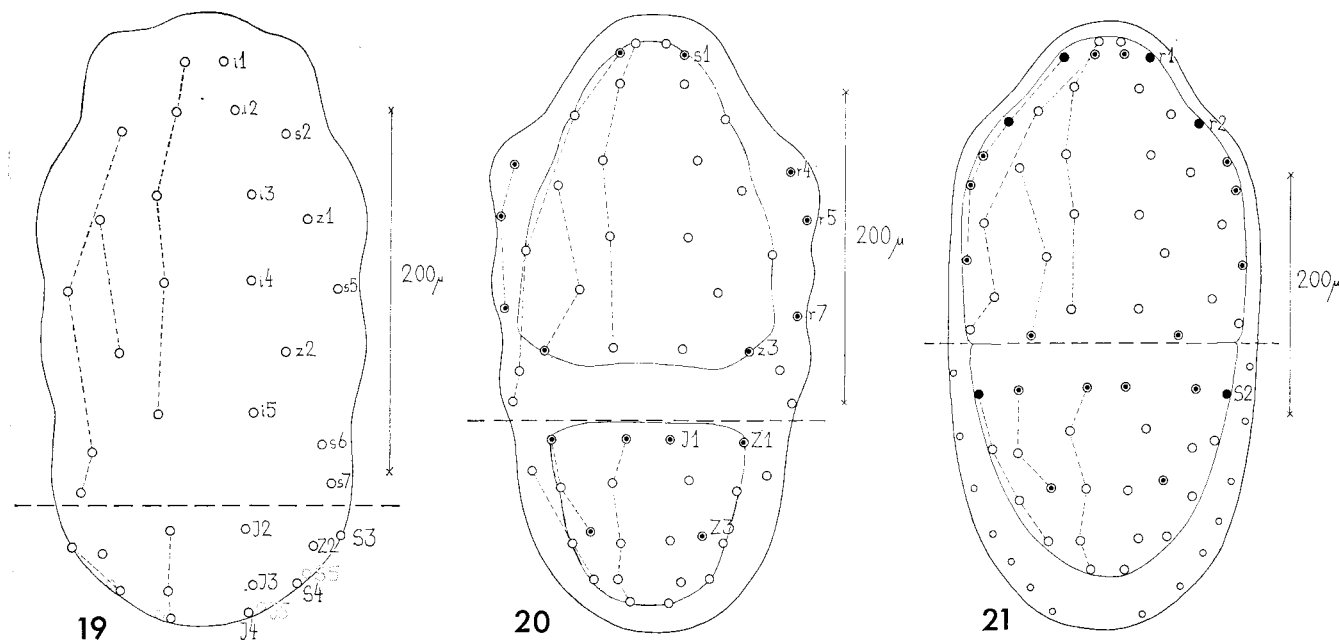
In the first experiment 4 females of *P. hispani* were introduced into the cell. The first egg was observed after 20 days and during 5 weeks a total of only 15 eggs was produced. In a second experiment 2 ♂ and 5 ♀ were introduced into a rearing cell and they produced 17 eggs within 4 weeks. The larva emerges (at room temperature, February) after an incubation period of 2-3 days. The larva is non-feeding and moults within 24 hours into the protonymph. The protonymph starts to feed and moults within 3 days into the deutonymph. The whole developmental cycle took 10-12 days (at room temperature).

<div align="center">DISCUSSION.</div>

The development of the dorsal chaetotactic pattern is shown in the diagrammatic figs. 19-20. 19 pairs of dorsal setae are present in the larva (two of these, S5 and J5, are ventrally inserted). Eight pairs of setae are added in the protonymph and three pairs of setae in the deutonymph, bringing the total to 30 pairs of setae which are inserted on the adult dorsal shield.

Two main centres of the addition of setae can be seen : one at the periphery of the podonotal shield and the other on the anterior margin of the opisthonotal shield.

When speaking of setal homologies, it should be borne in mind that we are speaking of " positional homology " only. There seems to be no evidence that the larval seta i1, for instance, is really homologous to seta i1 in the protonymph or the deutonymph. Homology could be proved only by showing that homologous setae are produced by the same cell-complex — trichogen, tormogen, nerve cell etc. Observing specimens in the premoulting stages, namely a larva with the fully developed protonymph seen through the larval skin or a deutonymph in the proto-

FIGS 19-21. — Diagrams of the dorsal chaetotactic pattern of *Pachylaelaps hispani* Berlese.
19. Larva.   20. Protonymph.   21. Deutonymph.

o = setae appearing in the larva ; ⊚ = setae appearing in the protonymph ; ● = setae appearing in the deutonymph.

nymphal skin, one can see that "homologous" setae rarely arise from the same point. On the contrary, their bases are often quite distant from each other.

In the diagrams the figures are reproduced at different scales and brought to the same length. This emphasizes the shift of the line that divides the dorsum into the podonotal and opisthonotal parts. In the larva the podonotal part occupies approximately four fifth of the dorsum whereas in the deutonymph the dividing line passes through the center of the dorsum. This is of course to be expected if the main function of the podonotal part is to form the attachment sites for the leg muscles. A similar shift is known from other free-living mites of various families (e.g. Macrochelidae, Parasitidae) whose life histories are known.

The development of the leg chaetotaxy shows that the juvenile stages of the free living mites are conservative and the pattern seems to be identical for many families of the free-living Gamasina. Differentiation between the families starts mainly at the deutonymphal stage only (Evans, 1963). The analysis of the chaetotactic pattern of the legs points to the close relation between the Pachylaelaptidae and the Macrochelidae. Both families show also a similar biology with a non-feeding larva that quickly moults into the protonymph.

Addendum.

Since completion of the manuscript of this paper, Hirschmann & Krauss (1965) have proposed a new name, *Pachylaelaps costai*, for *Pachylaelaps hispani* Berlese *sensu* Costa, 1963. This action was taken solely on the basis of the comparison of the type of *P. hispani* with the descriptions and figures of the species given by me in 1963. These authors have not examined my specimens! This is surprising in view of the fact that the distinction between the "species" was made on three criteria (each appearing in three separate keys) based on measurments of certain structures not given by me in the 1963 description. I assume that Hirschmann & Krauss obtained their data from my drawings. In order to validate these authors measurments and ratios I have examined a series of specimens upon which I based my descriptions with the following results :

1. In the key for adults (Rückenhaarbestimmungstabelle erwachsener Tiere (Weibchen und Mänchen) the following couplet separates *P. costai* from *P. hispani* :

56   Z_3 = Abstand Z_3-S_5 = *Pachylaelaps costai* (Nr. 29)
57 (60) Z_3 länger als Abstand Z_3-S_5 bei *P. hispani, pulsator.*

An inspection shows that this is not even true for the copied figure (Tafel 15, 29 RW in Hirschmann & Krauss or fig. 23 in Costa, 1963) were Z_3 is longer than the distance Z_3-S_5. I have rechecked this character in a number of specimens in wet (temporary) mounts as well as in specimens mounted permanently in gum-chloral (Table 1).

TABLE I. — The length of seta Z3 compared with the distance Z3-S5 in females of *P. hispani* Berlese *sensu* Costa, 1963.

wet mount		gum-chloral mount	
Z3 in μ	Z3-S5 in μ	Z3 in μ	Z3-S5 in μ
66.7	55.5	72.2	55.5
74.1	55.5	74.1	66.7
77.8	66.1	74.1	63.0
79.6	63.0	77.8	66.7
81.5	68.4	79.6	66.7
83.2	63.0	85.2	75.9
83.2	68.4	85.2	75.9
85.2	64.8	85.2	59.3

2. In the special key for females, based on :

$$x = \frac{L \text{ (Länge des Genitiventrale)}}{B \text{ (Breite des genitiventrale)}}$$ we find the following :

x = 1.04 bei *Pachylaelaps hispani, regularis, reticulatus*.
x = 1.09 bei *Pachylaelaps costai, denticulatus*.

In general, basing differences between species on the second decimal digit of a ratio, reminds one very much on the typological species concept which was abandoned by taxonomists long ago (*vide* MAYR, LINSLEY & USINGER, 1953). It is commonplace knowledge that within the species linear measurements may vary by as much as 50 % or more. There is no theoretical basis for considering ratioes as being constant (to the second decimal digit !) within the species, especially as in arthropods many of the size relations are allometric. Nevertheless I have checked the length-width ratio of the geniventral shield in a number of specimens (Table 2).

An inspection of the table shows that the length-width ratio varies from 1.00 to 1.13. This range covers in the key proposed by HIRSCHMANN & KRAUSS not less than 25 species out of 43 that are included in the key.

As it can be argued that it is sometimes difficult (or subjective) to define the anterior border of the genitiventral shield, I have measured also the distances between setae v5′ — v5 and VI′ — VI that are inserted on the shield as well as the ratio between these distances. For the distance v5′ — v5 the range was 104-119 μ (15 specimens) ; for VI′-VI the range was 138-168 μ and for the ratio $\frac{VI'-VI}{v5'-v5}$ the range was 1.65-1.99.

TABLE 2. — Measurments (in μ) of the genitiventral shield
of *Pachylaelaps hispani* Berlese *sensu* Costa, 1963.

gum-chloral mount			wet mount		
length	width	$\dfrac{length}{width}$	length	width	$\dfrac{length}{width}$
228	210	1.08	182	182	1.00
225	200	1.13	190	175	1.09
217	207	1.05	207	186	1.11
217	215	1.01	207	191	1 08
217	199	1.09	207	193	1.07
221	215	1.03			
215	201	1.07			
196	188	1.04			
211	197	1.07			
193	187	1.03			

3. In a third key for males the character used is :

$$x = \frac{\text{Sp (Länge des Spermatophorenträgers ab Austritt beweglicher Lade)}}{\text{Bl (Länge der beweglichen Lade)}}$$

at the termination of the key we find :

x = 6.60 bei *Pachylaelaps hispani*.
x = 8.07 bei *Pachylaelaps costai*.

My measurements of 11 males are included in Table 3.

TABLE 3. — Cheliceral measurements (in μ) of the males
of *Pachylaelaps hispani* Berlese *sensu* Costa, 1963.

wet mounts			gum-chloral mounts		
mov. digit	sperm. proc.	$\dfrac{\text{sperm. proc.}}{\text{mov. digit}}$	mov. digit	sperm. proc.	$\dfrac{\text{sperm. proc.}}{\text{mov. digit}}$
44	307	6.98	50	382	7.65
44	348	7.91	50	385	7.70
50	400	8.00	50	389	7.78
48	385	8.02	50	415	8.30
48	393	8.19			
46	382	8.31			
48	400	8.34			

Although the range of the ratio (6.98-8.34) does not include the ratio given for the type of *P. hispani* Berlese as measured by HIRSCHMANN & KRAUSS (*op. cit.*), I cannot consider this as enough reason to change my determination. In conclusion, I shall retain *Pachylaelaps hispani* Berlese, 1908 for the specimens of *Pachylaelaps* found on *Copris hispanus* (L.) in Israel and I relegate *Pachylaelaps costai* Hirschmann & Krauss, 1965 into synonymy of that species.

SUMMARY.

A rearing cell and method for free-living mites are described. The juvenile stages of *Pachylaelaps hispani* Berlese are described and figured. The development of the dorsal chaetotactic pattern is discussed. *Pachylaelaps costai* Hirschmann & Krauss, 1965 is relegated into synonymy of *Pachylaelaps hispani* Berlese.

REFERENCES

COSTA (M.), 1963. — The mesostigmatic mites associated with *Copris hispanus* (L.) (Coleoptera, Scarabaeidae) in Israel. *J. Linn. Soc.* (Zool), **45** (303) : 25-45.

COSTA (M.), 1965. — *Neopodainum caputmedusae* comb. nov., a polymorphic mesostigmatic mite associated with *Copris hispanus* (L.). (Coleoptera, Scarabaeidae). *Israel J. Zool.*, in press.

EVANS (G. O.), 1963. — Observations on the chaetotaxy of the legs in the free-living Gamasina (Acari : Mesostigmata). *Bull. Brit. Mus.* (*Nat. Hist.*), *Zool.*, **10** : 277-303.

HIRSCHMANN (W.), 1957. — Acarologie — Gangsystematik der Parasitiformes. Teil I. Rumpfbehaarung und Rückenflächen. *Schriftenreihe für vergleichende Milbenkunde.* Fürth Bay., v-20 pp., pls 26.

HIRSCHMANN, (W.) & KRAUSS (W.), 1965. — Gangsystematik der Parasitiformes. Teil 8. Bestimmungstafeln von 55 Pachylaelaps-Arten. *Ibid.*, 5 pp., pls 28.

MAYR (E.), LINSLEY (E. G.) & USINGER (R. L.), 1953. — Methods and principles of systematic zoology. McGraw-Hill, 328 pp.