

INTERACTION BETWEEN ORNITOCHEYLETIA HALLAE SMILEY 1970  
(ACARINA, CHEYLETIELLIDAE)  
AND MICROMONOSPORA CHALCEA (FOULERTON 1905) ØRSKOV 1923  
(STREPTOMYCETACEAE, ACTINOMYCETALES) IN THE SKIN OF PIGEON

BY

NIELS HAARLØV AND JØRGEN MØRCH

*Zoological Institute and Institute for Poultry Diseases,  
Royal Veterinary and Agricultural University, Copenhagen (Denmark).*

In October 1971 a carrier-pigeon from the Netherlands arrived at a pigeon-house in Jutland, Denmark, in a very bad state, and was consequently killed by the owner of the pigeon-house and sent for autopsy to the institutes of the authors.

The internal organs showed no pathological changes, nor were the feathers attacked. Yet the skin seemed to be quite abnormal being covered — as it were — with a mouldy layer which, on closer examination, evidently swarmed with mites.

On inspection of the pigeon-house in 1972, no pathological symptoms like those found in the carrier-pigeon could be found on the premises or on the pigeons housed there.

The following is consequently based on the one vector only; however, the mite material consists of several hundreds of animals in all stages of development and are kept at The Zoological Institute, Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Through the courtesy of Dr. Robert SMILEY the species has been identified as *Ornitocheyletia hallae* Smiley 1970 (figs. 1, 2), originally described from a pigeon in Texas, U.S.A., and only on a female. So far the species has not been refound elsewhere.

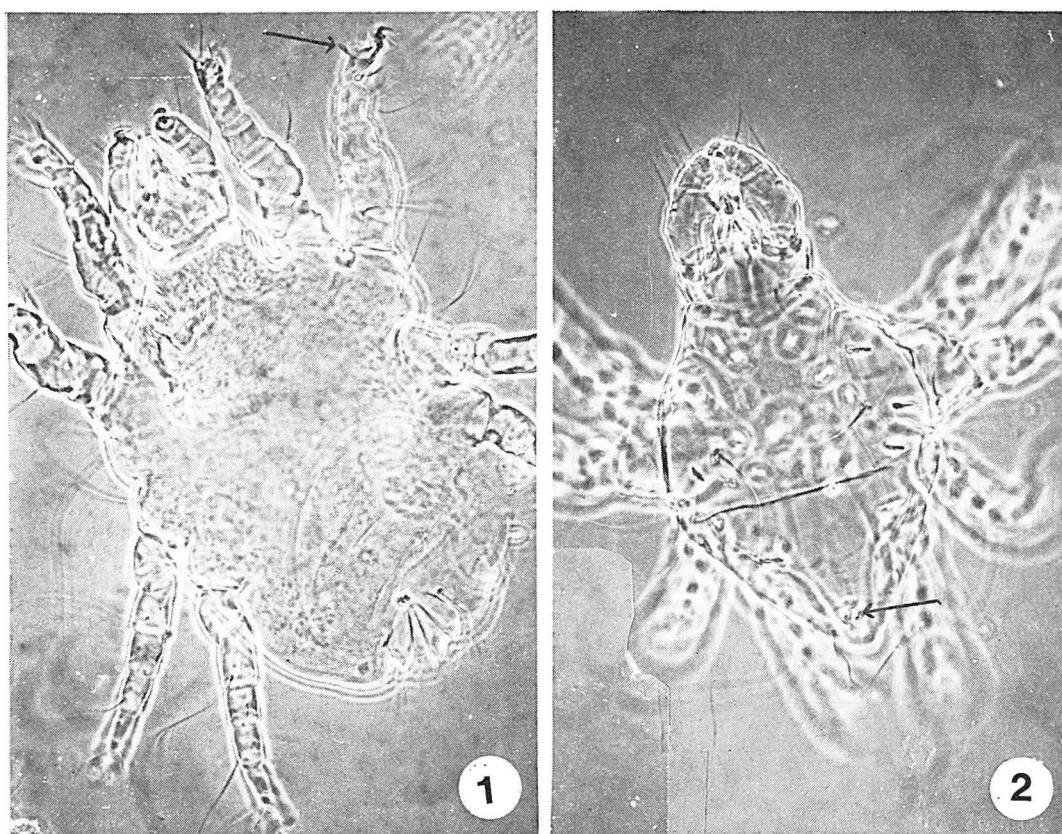
# METHODS.

After autopsy a certain area of the skin was dissected out, fixed in 4 % formol for some days and then kept in alcohol. For serial sections pieces of the skin were embedded in paraffin, cut into serial sections of 8-10  $\mu$  and stained with Haemalum/Eosin, PAS and Gram staining procedures. Mites were embedded in Faure's Liquid before identification.

## KEY TO MALES OF *Ornitocheyletia* VOLGIN 1964.

1. Idiosoma without a pair of long simple setae terminally..... 2  
Idiosoma with a pair of long simple setae terminally..... *canadensis* (Banks) Smiley 1970
2. Dorsal side of hysterosoma without serrate setae..... 3  
Dorsal side of hysterosoma with serrate setae..... 5

*Acarologia*, t. XVII, fasc. 2, 1975.



FIGS. 1-2 : *Ornitocheyletia hallae*. 1) the female is seen from the ventral side, with palpal claws distinctly visible and with the arrow pointing to one of the forked hairs of tarsus II (cf. fig. 9) ; 2) the dorsal side of a male with the arrow indicating the genital aperture. Scale : 150  $\mu$ .

- |  |                               |
|--|-------------------------------|
| 3. The four anterior and lateral propodosomal setae serrate.....   | <i>dubinini</i> Volgin 1964   |
| The four anterior and lateral propodosomal setae smooth.....   | 4                             |
| 4. The four anterior and lateral propodosomal setae subequal in length.....  | <i>gersoni</i> Smiley 1970    |
| The third of the four anterior and lateral propodosomal setae is more than three times longer than the other ones..... | <i>hallae</i> Smiley 1970     |
| 5. Hysterosoma with 1 pair of serrate setae.....   | 6                             |
| Hysterosoma with 3 pairs of serrate setae.....   | <i>lawrenceae</i> Smiley 1970 |
| 6. Aedeagus straight, genital setae thick at base and tapering.....  | <i>volgini</i> Smiley 1970    |
| Aedeagus curved, genital setae normal at base and not tapering.....  | <i>lukoschusi</i> Smiley 1970 |

#### MALE AND FEMALE.

Idiosoma of male is rhomboid with a length of about 275  $\mu$  and a width of about 150  $\mu$  (figs. 2, 3 and 4).

Striae, shields and setae on dorsal and ventral sides of male as in figs. 3 and 4. Aedeagus short, straight, and slender, originating between the level of coxae IV, with aperture between two rows of minute, setae-carrying papillae like those figured for *Cheyletus trouessarti* Oud. by HUGHES (1961) and *Ornitocheyletia dubinini* Volgin by VOLGIN (1964).

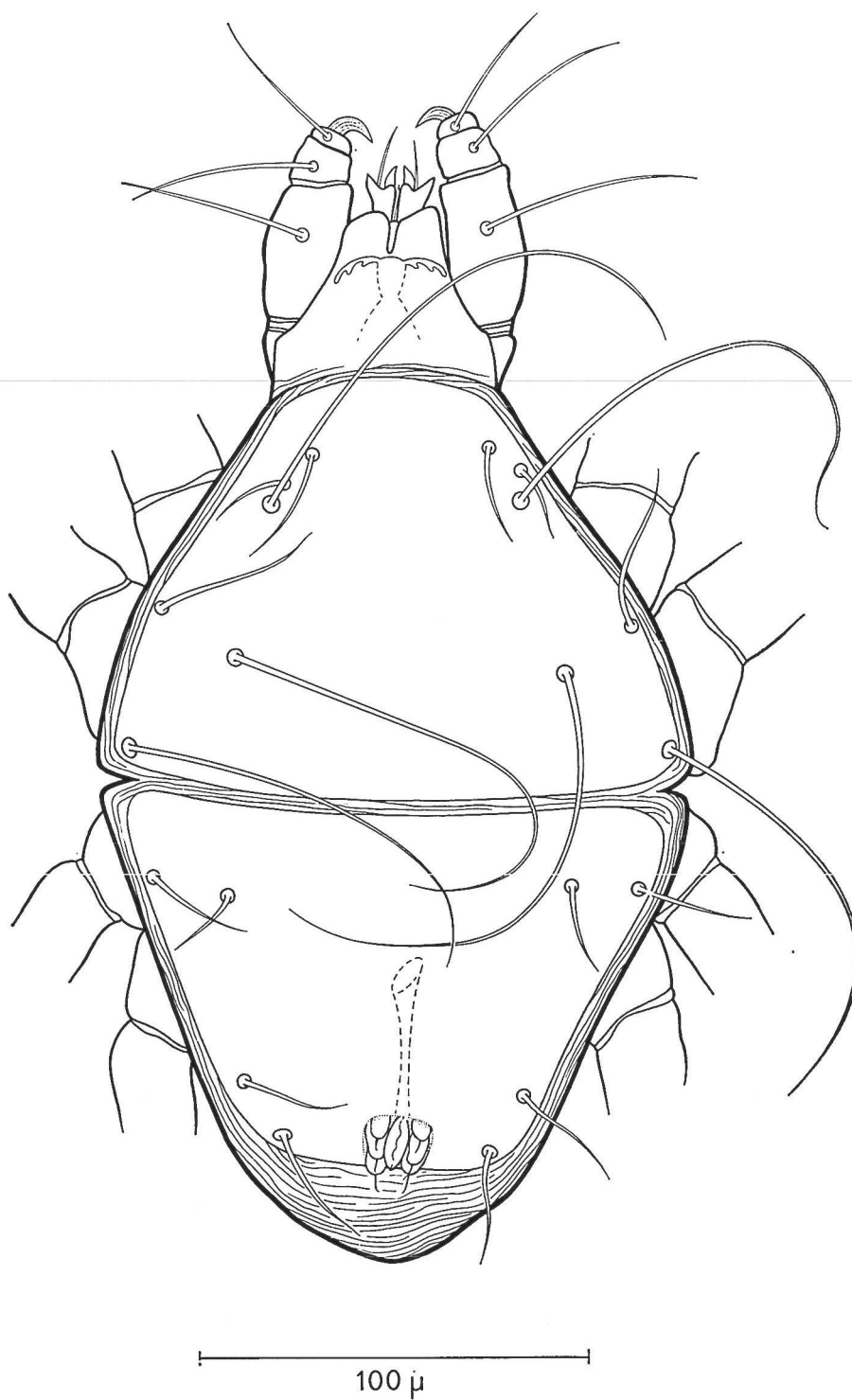


FIG. 3 : Dorsum of *Ornitocheyletia hallae* (male) showing the three characteristic anterior pairs of propodosomal setae, and posteriorly the genital aperture with aedeagus indicated underneath.

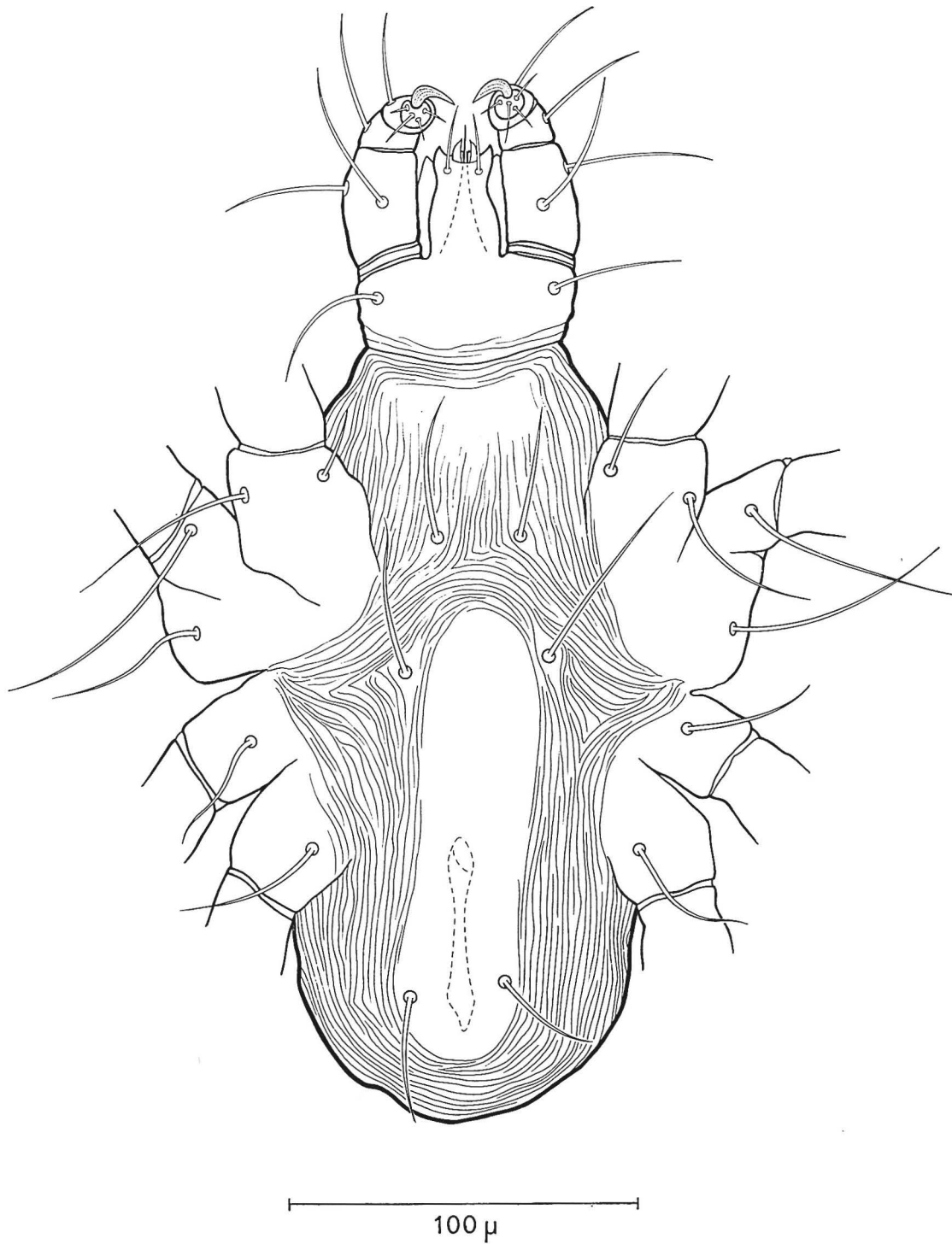


FIG. 4 : Ventral side of *Ornitocheyletia hallae* (male) with the outline of aedeagus shown by a dashed line.

Gnathosoma (sensu VAN DER HAMMEN 1968) is principally alike for both sexes. Dorsally, gnathosoma (fig. 5) has a biloped tegulum with superficially placed peritremes and interiorly with tracheal trunk (MILLS 1973). Besides apodema (BLAUVELT 1945) and the pointed cheliceral apoteles are visible between the apophyses of infracapitulum.

In some of the males palpi may be heteromorphic with protuberances of varying shapes on the inner sides of femur and genu (fig. 5). Palpal claws of both sexes have a smooth surface.

Ventrally, gnathosoma is dominated by infracapitulum (fig. 6) which, anteriorly, has one or two pairs of lateral lips (EVANS *et al.*, 1961); here named apophyses (a slight apophysis ventrally to the oral aperture ("underlip") may also be observed, cf. fig. 7).

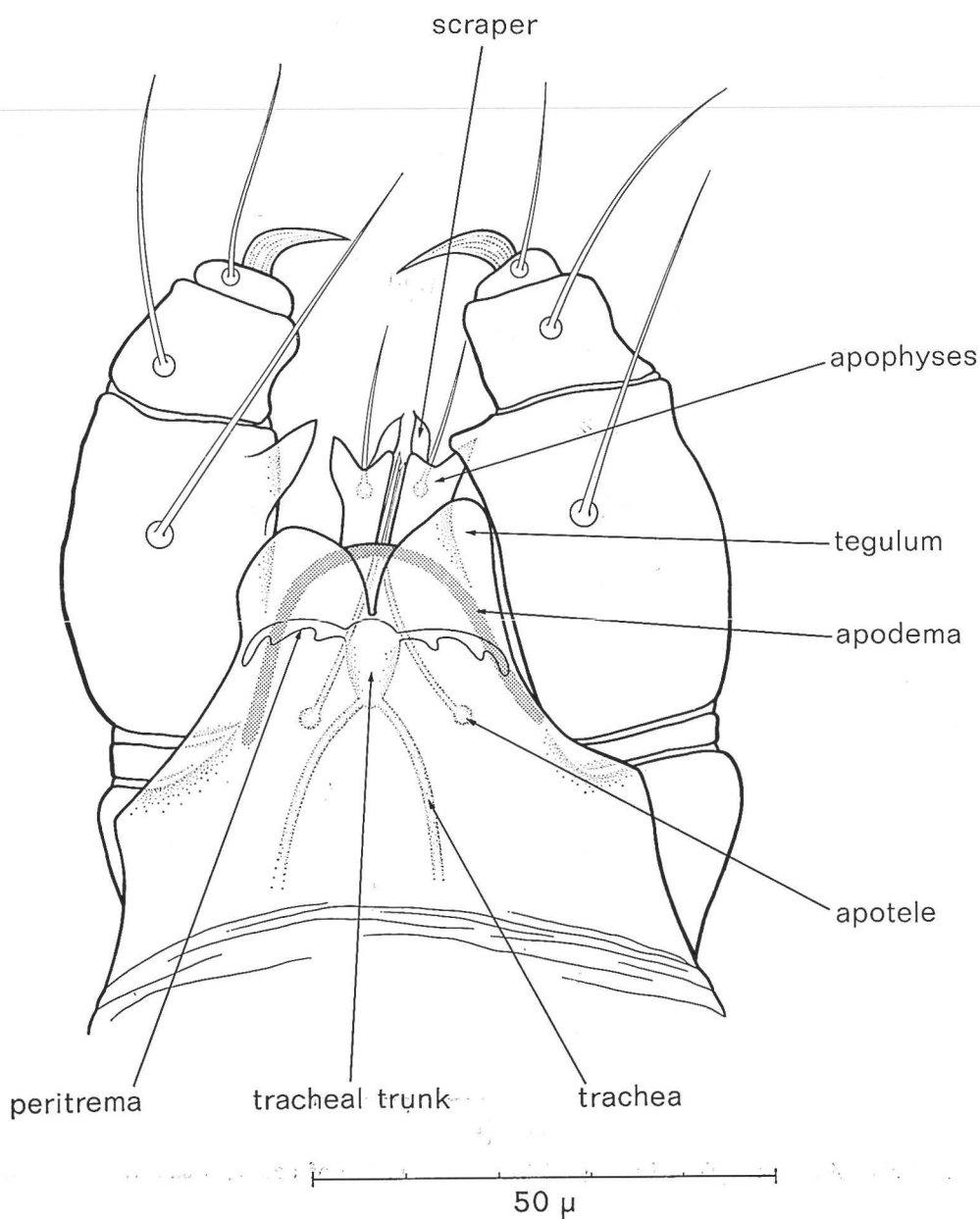


FIG. 5 : Gnathosoma of heteromorphic male of *Ornitocheyletia hallae* seen from above.

Within the two pairs of apophyses and flanking the oral opening, a pair of hairs is seen ; these may be of cheliceral origin and are named scrapers with reference to their presumed function ; they are curved longitudinally as well as transversely, have pointed tips, and a rather sharp and stiff inner edge. They may be mobile against each other as their angles to the base vary from one individual to another.

At the level of the palpal femur, the females (fig. 7) have a pair of infracapitular setae not found in the males. On the palpal tarsus, females have two pairs of setae — again not observed in males.

Fig. 8 is drawn from a longitudinal section (10  $\mu$ ) of the distal part of infracapitulum and demonstrates both pairs of apophyses and chelicerae ; these are extremely sharp-pointed and, furthermore have a groove running along their inner sides up to a little projection. Whether the section originates from a male or a female cannot be established.

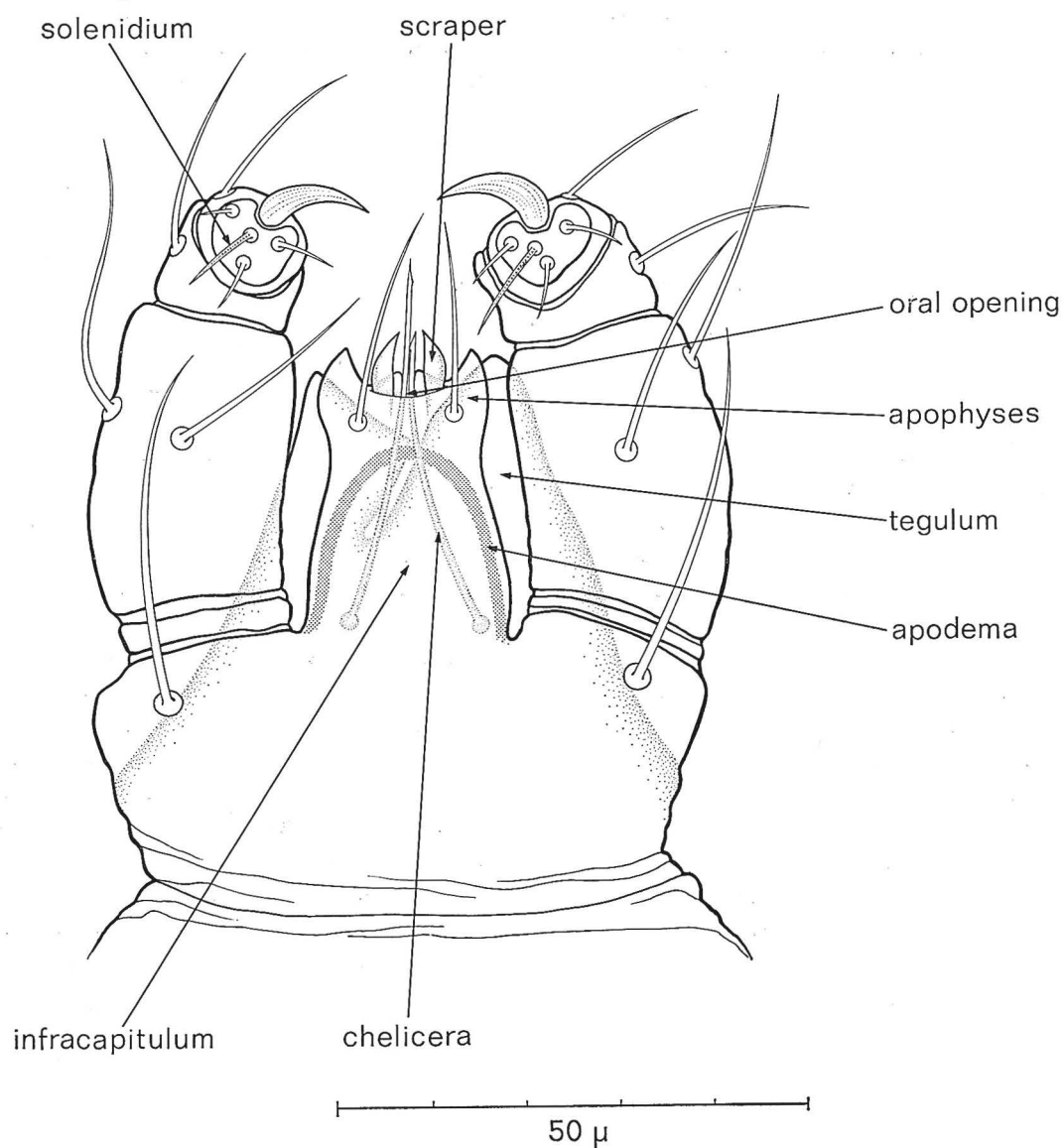


FIG. 6 : Ventral view of gnathosoma of a normal male of *Ornitocheyletia hallae*.

It will be observed that beyond the oral opening the one apotele is extended about 20  $\mu$  (about 2  $\mu$  in width). In a specimen of *Cheyletiella parasitivorax*, mounted in Faure's Liquid, it protruded about 40  $\mu$  (4-5  $\mu$  in width), and the same length is seen in an illustration by DODD (1970) of the same species.

A varying number of small refractive bodies are found internally not only in gnathosoma, but also scattered around in propodosoma, and even in the proximal segments of the forelegs. They are no doubt fat-bodies and comparable to those found in *Tetranychus telarius* (BLAUVELT 1945).

As regards all legs of both sexes, ambulacra, including praetarsus and tarsus (fig. 9), are in general constructed in the same way, and follow the basic morphological principles for mites (GRANDJEAN 1941, 1943).

In this connection special attention is paid to the bipectinate empodium which, on its concave side, has two rows of converging setae; at first glance they might be presumed to function as an elastic unity against a substratum. DODD (1970) has a photo of the ambulacrum of *Cheyletiella yasguri*; this shows clearly a similar empodium.

#### MICROHABITAT.

The habitat of *Ornitocheyletia hallae* is the skin of pigeon, while the microhabitat is its horny layer (*stratum corneum*) as modified by the mite.

Fig. 10 shows normally developed skin of a pigeon. At the top *stratum corneum* is seen as slightly elevated from the underlying living epidermal cells (4-5 cells high). Corium underneath is marked with undulating, fibrous strings, while at the bottom a subcutaneous layer with fat cells is visible.

At higher magnifications prickles cells, desmosomes, and intercellular spaces with serous fluid can be demonstrated (BELL & FREEMAN 1971).

In general it is noteworthy for all sections from skin inhabited by *Ornitocheyletia hallae* that neither subcutis nor corium show any histopathological symptoms; this is in strict contrast to epidermis where acanthosis, intra as well as intercellular oedemata, hyperkeratosis, and high mitotic activity are evident (figs. 11-13).

Fig. 11 shows mite-infested skin suffering from acanthosis and hyperkeratosis, and with the exfoliated cornified cells making a spongy, undulating horny layer of flakes of about 2 mm height, with an almost coherent surface to the exterior, corresponding to what was initially termed a "mouldy layer". In fig. 11 it is also evident how nuclei of epidermal cells are relatively big indicating a high degree of mitotic activity combined with tendencies towards oedemata.

Figs. 12 and 13 show pronounced cases of oedemata, which have presumably pushed the exfoliated horny flakes outward thereby causing real blisters on the skin surface.

Microclimatologically these histopathological phenomena must mean that the air-filled interspaces between the flakes in the horny layer must be rather humid, and that a gradient of decreasing temperatures will be actual from the skin surface to the uppermost layer of the exfoliated horny flakes.

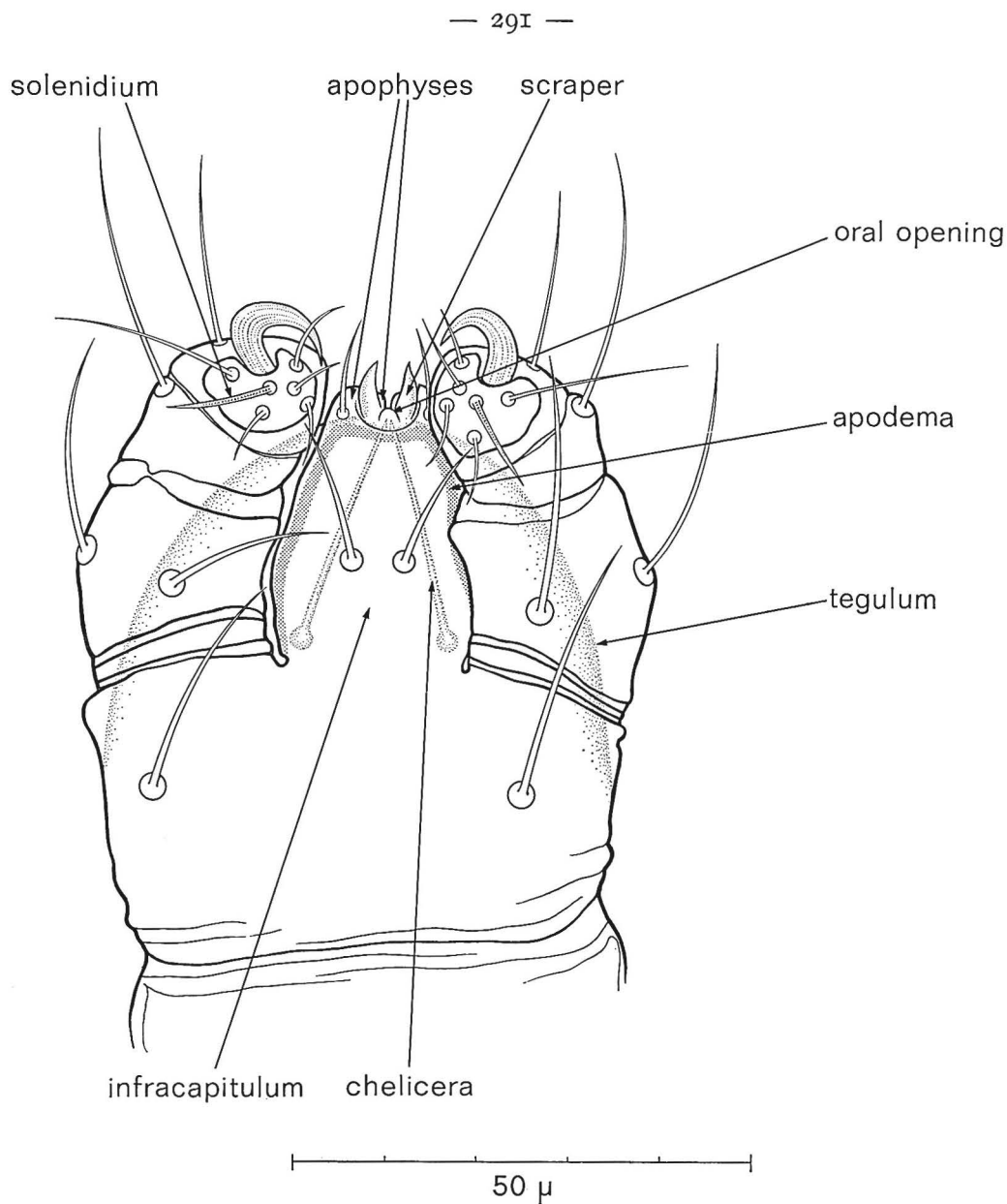


FIG. 7 : Gnathosoma seen from the ventral side of *Ornitocheyletia hallae* (female).

*Micromonospora chalcea.*

When the horny layer was inspected at rather a high magnification, a network was in many cases apparent, crossing the interstices, and made of extremely thin, branching filaments, often terminated by a little bud (fig. 14).

Now and then the filaments were so dominating that they even penetrated the outermost layer of the horny layer (fig. 15), which, in those cases, had almost lost its original structure, however. Inside the outer layer the interstices are comparatively big and merging with many



remnants of eggs and discarded skins of mites, (fig. 16) resembling, albeit on a smaller scale, the "nests" described on the skin of birds attacked by *Bakericheyla chanayi* (FURMAN and SOUSA 1968).

Considering the structure of these filaments it could be excluded that they were made by the mite. Having consulted a microbiologist it turned out that the filaments were probably part of a network made by *Micromonospora chalcea* (FOULERTON 1905) ØRSKOV 1923, which is a Streptomycetaceae under the Actinomycetales, that is aerobic, strongly proteolytic, and commonly found in nature (BREED *et al.*, 1957, WILSON and MILES 1957, ALEXANDER 1961, LUEDEMANN 1971) and according to PUGH (1966) and PUGH and EVANS (1970) not yet located to skin or feathers of birds.

In the present case, the horny layer should then constitute the culture medium for *Micromonospora chalcea*, decomposing the layer's organic compounds, and especially the keratin, followed up by a simultaneous but gradual disintegration of the structure of the horny components of the layer, which as mentioned above was actually visible in several cases.

Judging from the life requirements of *Micromonospora chalcea* (LUEDEMANN l.c.), the horny layer may be exposed to natural infection as soon as the first exfoliated horny flakes have been produced.

#### DISCUSSION.

Ectoparasitic mites from birds are recruited from several systematic groups, and, excluding those dealing with feathermites only, reviews have been given by, for example HUGHES (1959), EVANS *et al.* (1961), FAIN (1965), and SOULSBY (1969).

In case of pigeons, BROWN (1971) has from Boston, U.S.A., registered eight species with *Neochyletiella heteropalpus* (MEGNIN 1878) BAKER 1949 as the only representative, however, for Cheyletiellidae.

As no information seems to exist about the bionomics of *Ornitocheyletia hallae*, an attempt to elucidate this problem must be discussed partly based on the results of this study and partly on what is known from related species and with general principles as to adaptations to parasitism in mites (FAIN 1969) as a basic guide for these considerations.

Basically the Cheyletiellidae are free-living predators on different substrata including the skin of birds and mammals (BAKER 1949). This statement was originally also made about *Cheyletiella parasitivorax* in respect of skin and fur of different mammals, including man, as their habitat. Later, however, it was definitely proved that this species was a mange mite only (SMILEY 1970).

When feeding, a free-living, predatory Cheyletiellidae such as, for example, *Cheyletus eruditus* will inject a secretion that paralyses the victim almost instantly after chelicerae have been plunged into its body (VITZTHUM 1943). This character seems to have been preserved even for a mange mite like *Cheyletiella parasitivorax* with reference to OLSEN and ROTH (1947) who observed a distinctly visible, red swelling around the bite, which, even in man, can develop into a papular and highly itching dermatitis. In dogs, cats, and rabbits dry, scaly and crusted skin has been induced similarly by this or a closely related species (KRAL and USCAVAGE 1960/61, EWING *et al.* 1967, BOCH and SUPPERER 1971). Furthermore, it has been demonstrated on a rabbit (FOX and EWING 1969) that the *Cheyletiella* species might cause dermatitis with hyperkeratosis, infiltration of inflammatory cells of different types, and some congestion of dermal papillae, and that the guts contained structures resembling erythrocytes, a phenomenon which without doubt was identified in the gut of *Bakericheyla chanayi* (FURMAN and SOUSA 1968).

EVANS *et al.* (l.c.) mention an observation of an individual of *Cheyletiella parasitivorax* which had its cheliceral apoteles deeply embedded in the skin of its host.

When *Ornitocheyletia hallae* is compared with the above mentioned species, to which it is closely related as regards general morphology, the following more specific characteristics will first be mentioned.

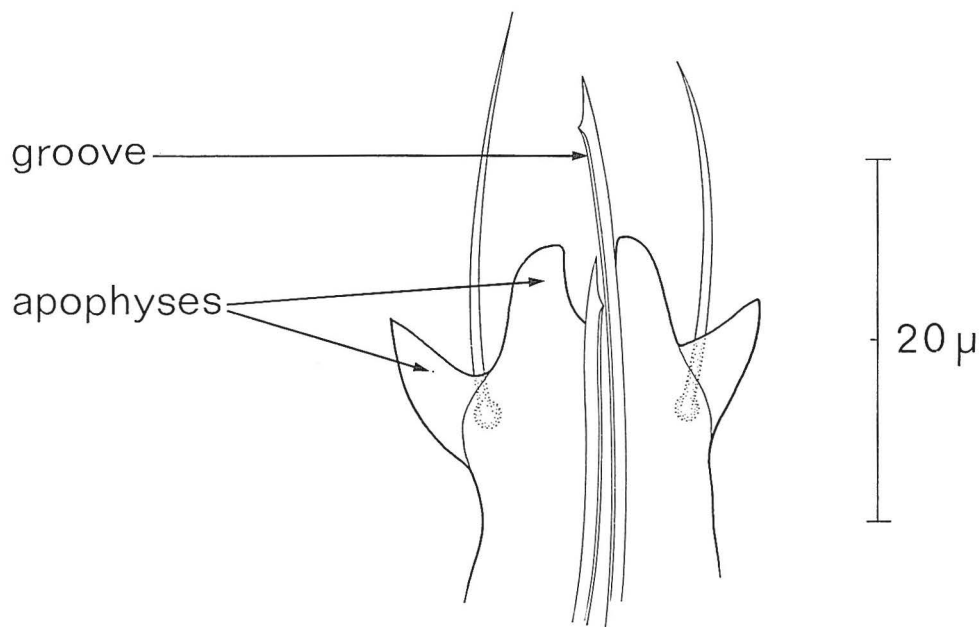


FIG. 8 : Longitudinal section of gnathosoma of *Ornitocheyletia hallae* to show the groove up to projection along the inner side of each cheliceral apotele.

The length of idiosoma in females and males measures about 350  $\mu$  and 230  $\mu$  respectively, while that of other species mentioned is about 500  $\mu$  and 300-350  $\mu$ . Similarly, the extruded apoteles of chelicerae are about half the length and width of those of these species. Furthermore the palpal claw of *Ornitocheyletia hallae* does not have a toothed inner side which is characteristic of the other larger species.

Compared with other species of Cheyletiellidae, *Ornitocheyletia hallae* thus seems to be a regressive modification sensu FAIN (1969), which, however, does not need to make its parasitological adaptations to parasitism less efficient.

Its smaller dimensions must make it even better adapted to move in and to be protected by the horny layer than for instance *Cheyletiella yasguri*, which FOXX *et al.* (l.c.) have observed running even rapidly in the interstices present there.

The absence of the toothed inner side of the claws must certainly be correlated with the fact that *Ornitocheyletia hallae* is not dependent on slippery surfaces of hairs or other structures outside the horny layer to the same degree as the other species, once a population has been founded.

As to ambulacra all Cheyletiellidae seem to have pectinate empodia, which, however, for a free-living species like *Cheyletus eruditus* consists of relatively few and coarse setae (HUGHES 1961), while the empodium is bipectinate in the ectoparasitic ones, with the reservation that in *Bakericheyla chanayi* the setae are tenent while in for instance *Ornitocheyletia hallae* they are pointed (fig. 9). Thus a mutual model can be noted for the parasitic species contrary to the

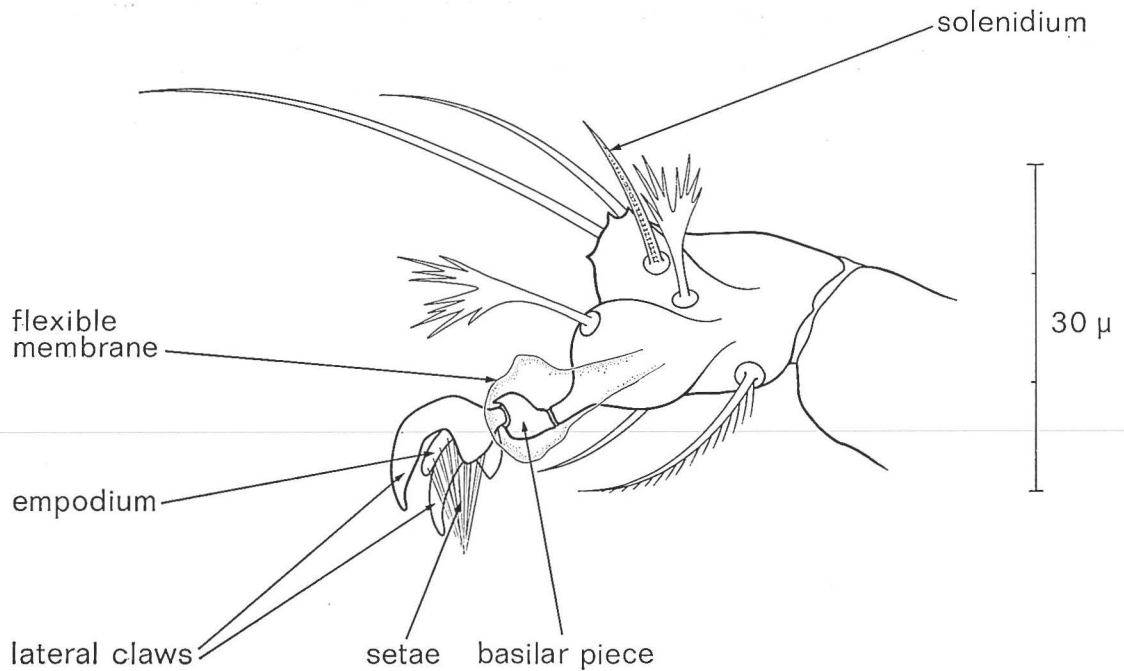


FIG. 9 : Ambulacrum of *Ornitocheyletia hallae* (leg No. 2 to the right).

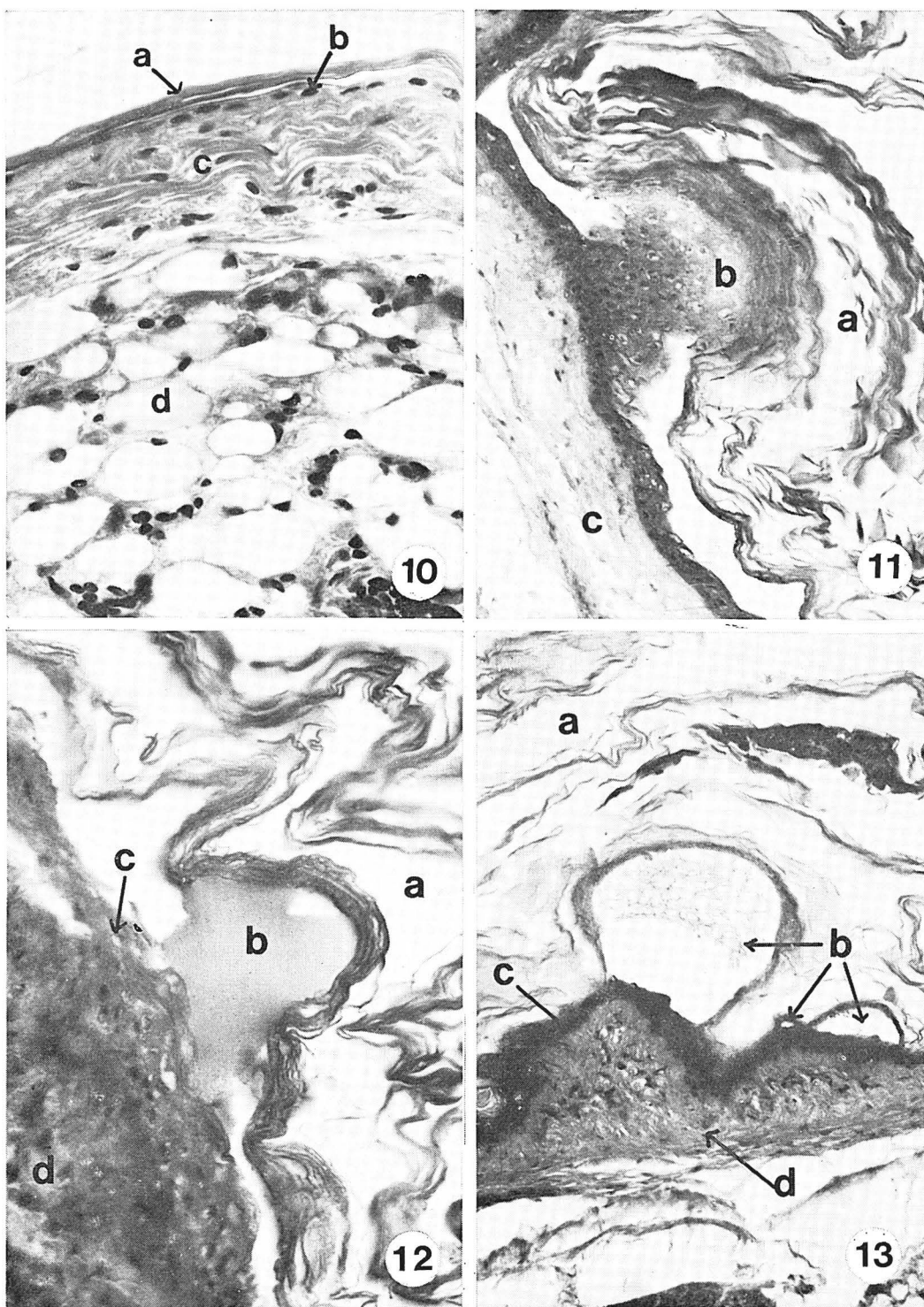
free-living ones, which certainly must have an adaptive background. So in the absence of experiments it is hypothetically pointed out, that the two rows of converging empodial setae may act together as an elastic unit to disentangle and push away the claws when they have loosened their grip on the substratum, when this is covered with a network of fine threads made for instance by *Micromonospora chalybeata*. From observations made on oribatid mites, whose ambulacra have no empodia, the animals almost seem to be trapped if they try to pass substrata covered with mycelia, and VITZTHUM (l.c.) mentions similar observations as to threads of spider mites with which other species of mites get into contact.

If so, these bipectinate empodia of the parasitic Cheyletiellidae might functionally be similar to experimental findings for some ambulacral setae of spiders when their claws have to be quickly disentangled from the threads of their webs (NIELSEN 1931).

That *Ornitocheyletia hallae* using its cheliceral apoteles will inject a secretion into the skin when it bites must definitely be true considering experiences from related species and the formation of the longitudinal groove on the apotele (fig. 8) ; and similarly that these injections are responsible for the pathological reactions of the skin with oedemata, hyperkeratosis etc.

Considering the length, however, of the apoteles in relation to the skin structure of the pigeon, the apoteles will, when the mite bites, only be able to reach the uppermost layers of the corium and certainly in most cases only the deeper lying cells of epidermis, contrary to the larger species mentioned earlier, which may be able to get 5  $\mu$  to 10  $\mu$  into the corium, based on a thickness of 30  $\mu$  to 35  $\mu$  of the epidermis in dogs. These factors make it natural for findings of structures of blood-cells in their guts.

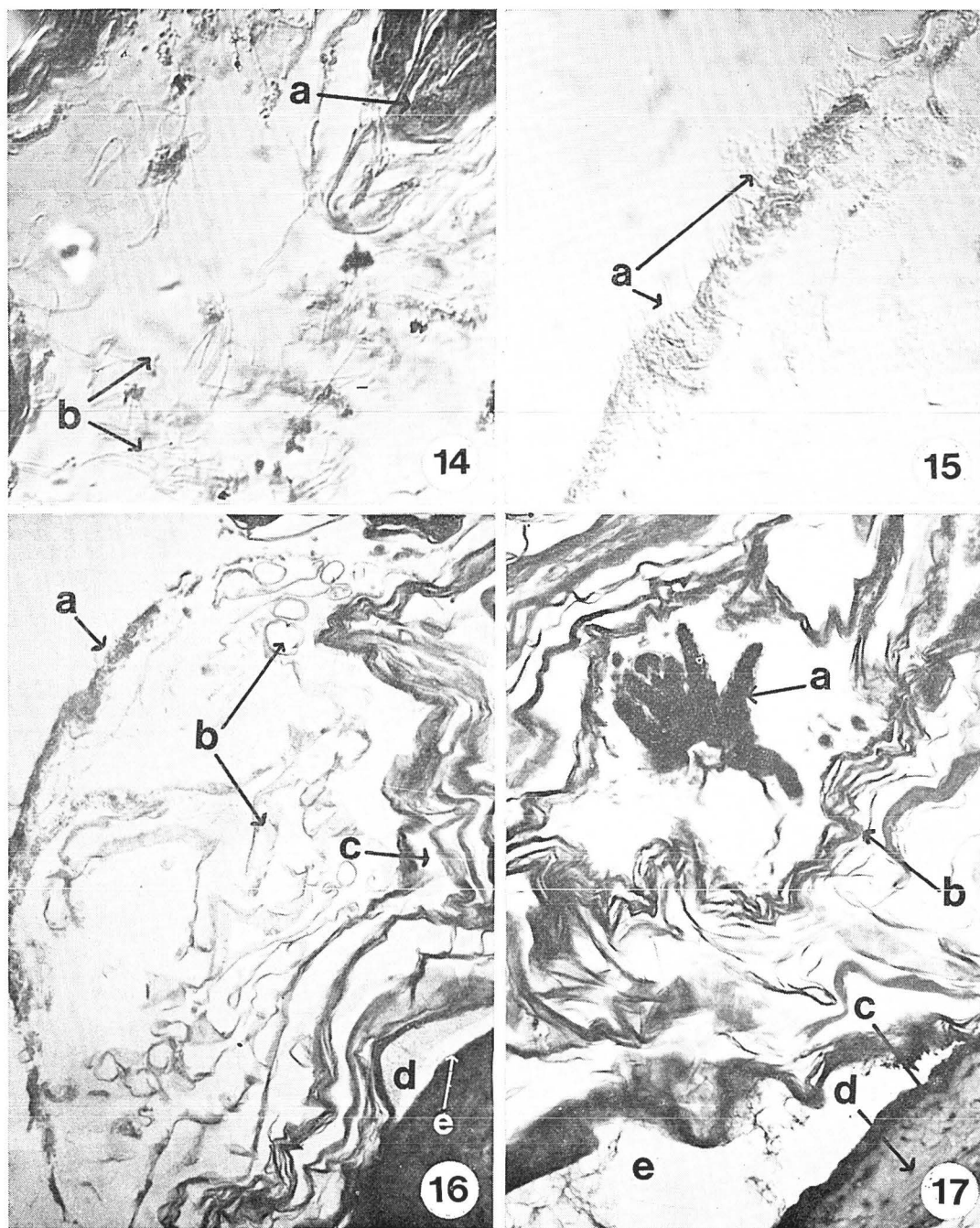
For a recessive species like *Ornitocheyletia hallae* this situation is still worse, as the reaction of the skin with hyperkeratosis, which, so to say, will push away the animal from the surface of the skin, will make its chances of getting into regular contact with even the epidermal cells less than is the case for the larger species.



FIGS. 10-13 : 10) section of normally developed skin of pigeon. a) stratum corneum ; b) living cells of epidermis ; c) corium ; d) fat cells of subcutis.

FIGS. 11-13 : sections of skin of pigeon attacked by *Ornitocheyletia hallae* ; 11) a : hyperkeratosis ; b : acanthosis ; c : corium ; 12) a : hyperkeratosis ; b : blister ; c : living epidermal cells with oedemata ; d : corium ; 13) a : hyperkeratosis ; b : different stages of development of blisters ; c : living epidermal cells ; d : corium.

Scale : 100  $\mu$ .



FIGS. 14-17 : Skin of pigeon attacked by *Ornitocheyletia hallae*; 14) a : longitudinal section of the gnathosoma of the mite situated in the exfoliated layer of horny flakes; b) filaments of *Micromonospora chalicea* with terminating buds; 15) a : outline of "nest" in the horny flakes (cf. fig. 16 : with protruding filaments; 16) a : surface of skin with filaments (cf. fig. 15) and "nest" below; b) remnants of exuviae; c : horny flakes; d : blisters; e : living epidermal cells; 17) a : mite cut longitudinally; b : horny flakes; c : living epidermal cells; d : corium; e : serous fluid.

Top : scale for figs 14 and 15 : 50  $\mu$ ; Bottom : scale for figs. 16 and 17 : 100  $\mu$ .



As a supplement to their diet and perhaps as the only nutritional basis for the juveniles — it is, therefore, presumed that *Ornitocheyletia hallae* is also adapted to utilize the horny layer as a source of food incl. its content of nutrients from the serous fluids (MARPLES 1965), even if it seems improbable that it can assimilate directly the keratin of the horny layer. According to personal information from a microbiologist, however, it seems very likely that *Micromonospora chalcea* with its well known high proteolytic abilities will be able to decompose keratin and thus indirectly make it possible for *Ornitocheyletia* to utilize it.

Thus a situation similar to that found for instance in soil litter will appear in the skin, namely that the organic compounds, which the animals cannot assimilate because of lack of relevant enzymes, can nevertheless be utilized, but not until a pretreatment by bacteriae, fungi, etc. has decomposed these compounds to products, which the animals now can digest by means of enzymes available to them (WALLWORK 1970).

These viewpoints also correspond well with the fact that the highest number of strains of *Micromonospora chalcea* observed is correlated partly with partial obliteration of structures in the original exfoliated flakes in the horny layer and partly with the greatest occurrence of remnants from the mites indicating former aggregations of individuals (fig. 16). Furthermore the non-structured remains of the horny layer are stained with haematoxylen similarly to the interior of the mites.

In relation to morphology of *Ornitocheyletia hallae* these considerations may also be relevant to the scrapers of infracapitulum (figs. 5-7); these are presumably well adapted for scraping together into the mouth the more or less decomposed and soft-bodied products of keratin.

Whether the exfoliated horny layers made by other parasitic Cheyletillidae are attacked by microorganisms with nutritional and supplementary consequences as shown above for these mites, which with their bites have provoked such a condition, cannot yet be said.

#### ACKNOWLEDGEMENTS

We are greatly indebted to Dr. Robert SMILEY for valuable discussions and especially for his checking the key to males of the genus *Ornitocheyletia*, to Dr. L. van der HAMMEN for correct interpretations of the different structures of gnathosoma, and to Professor VAGN JENSEN and Dr. Esther HOLM of The Institute of General Microbiology and Microbiological Ecology, Royal Veterinary and Agricultural University, for information on microbiological subjects.

#### SUMMARY

Males of *Ornitocheyletia hallae* from pigeon are described and an analysis made on a number of structures of gnathosoma of both sexes. The habitat of *Ornitocheyletia hallae* is skin of pigeons where only epidermis is affected by the mites transforming its *stratum corneum* to a spongy layer of exfoliated horny flakes combined with serous exudations. The cheliceral apoteles can only reach down to the uppermost layer of corium.

The transformed horny layer is attacked by an actinomycet, *Micromonospora chalcea*, and a mutualistic interrelationship is suggested to exist between this microorganism and the mite; with its proteolytic enzymes the microorganism may decompose the high organic components of the horny layer to products which the mite can assimilate directly.

Modified cheliceral setae ("scrapers") are looked upon as an adaptive mode to transport decomposed products into the mouth and the bipectinate empodia of the ambulacra may serve to disentangle the claws from the filaments of *Micromonospora chalcea*.

#### ZUSAMMENFASSUNG

Männchen von *Ornitocheyletia hallae* bei Tauben sind beschrieben, und eine Analyse von den Strukturen des Gnathosomas beider Geschlechter ist vorgenommen. Habitat von *Ornitocheyletia hallae* ist die Haut der Tauben, wo nur Epidermis durch die Milben berührt ist, indem *stratum corneum* in eine schwammige Schicht von abgestossenen hornartigen Flächen umbildet ist, mit serösen Aussonderungen kombiniert. Die chelicerale Apotelen können nur bis zu der obersten Schicht von corium eindringen.

Die umbildete, hornartige Schicht ist durch einen Actinomycet, *Micromonospora chalcea*, angegriffen, und es ist vorgeschlagen, dass ein gemeinsames Abhängigkeitsverhältnis zwischen diesem Mikroorganismus und der Milbe besteht; mit seinen proteolytischen Enzymen darf der Mikroorganismus die hochmolekulären organischen Substanzen der hornartigen Schicht in einfachere Komponenten auflösen, die die Milbe unmittelbar assimilieren kann.

Modifizierte chelicerale Setae ("scrapers") werden betrachtet als dazu angepasst, aufgelöste Komponenten in den Mund zu transportieren, und die bipectinaten Empodia der Ambulacra dürfen der Freimachung der Krallen von den Fäden der *Micromonospora chalcea* dienen.

#### LITERATURE

- ALEXANDER (M. A.), 1961. — Introduction to Soil Microbiology. John Wiley & Son.
- BAKER (E. W.), 1949. — A review of the mites of the family Cheyletidae in the United States National Museum. — Proc. U.S. Nat. Mus., **99**, no. 3238 : 267-320.
- BELL (D. J.) & (B. M.) FREEMAN, 1971. — Physiology and Biochemistry of the Domestic Fowl. vol. 2. Acad. Press.
- BLAUVELT (WILL. E.), 1945. — The Internal Morphology of the Common Red Spider Mite (*Tetranychus telarius* Linn.). — Cornell Univ. Agr. Exp. Stat., Memoir **270** : 1-35.
- BOCH (J.) & (R.) SUPPERER, 1971. — Veterinärmedizinische Parasitologie. — Paul Parey Verlag.
- BREED (Rob.), (E. E. D.) MURRAY, (N. R.) SMITH, 1957. — Berger's Manual of Determinative Bacteriology, 7th edition. Williams & Wilkins Co.
- BROWN (N. Sandra), 1971. — A survey of the arthropod parasites of pigeons (*Columba livia*) in Boston. J. Parasitology **57**, 6 : 1379-1380.
- DODD (K.), 1970. — *Cheyletiella yasguri* : Widespread infestation in a breeding kennel. — Vet. Rec. **86** : 346-347.
- EVANS (G. Owen), (J. G.) SHEALS, (D.) MACFARLANE, 1961. — The terrestrial Acari of the British Isles. — I. Trustees of the British Museum, London.
- EWING (S. A.), (J. E.) MOSIER, (Teralene S.) FOXX, 1967. — Occurrence of Cheyletiella on Dogs with Skin Lesions. — J. Amer. Vetr. Med. Ass. **151**, 1 : 64-68.
- FAIN (A.), 1965. — A review of the family Epidermoptidae Troussart parasitic on the skin of birds (Ac. : Sarcoptf.). — Konink. VI Acad. Wetensch. Let. schone Kunst Belgie, **84**, I-II : 1-176 ; 1-144.
- , 1969. — Adaptation to parasitism in Mites. 2nd Int. Congress Acarology in Sutton Bonington. — Acarologia, XI (3) : 429-449.
- FOXX (Teralene S.) & (S. A.) EWING, 1969. — Morphologic features, behavior and life history of *Cheyletiella yasguri*. — Am. J. Vet. Res., **302** : 269-284.
- FURMAN (Deane P.) & (Octavio E.) SOUSA, 1968. — Morphology and Biology of a Nest Producing Mite, *Bakericheyla chanayi* (Acarina : Cheyletidae). — Ann. Ent. Soc. Amer., **62**, 4 : 858-863.
- GRANDJEAN (F.), 1941. — L'ambulacre des Acariens (1<sup>re</sup> série). — Bull. Mus., 2<sup>e</sup> sér., XIII, 5 : 422-429.
- , 1943. — L'ambulacre des Acariens (2<sup>e</sup> série). — Bull. Mus., 2<sup>e</sup> sér., XV, 5 : 303-310.
- VAN DER HAMMEN (L.), 1968. — The Gnathosoma of *Hermannia convexa* (C. L. Koch) (Acarida : Oribatina) and comparative Remarks on its Morphology in other Mites. — Zool. Verhand., no. **94** : 1-45.

- HUGHES (A. M.), 1961. — The Mites of Stored Products. — Techn. Bull. no. 9. Her Majesty's Stationery Office, London.
- HUGHES (T. E.), 1959. — Mites or the Acari. — The Athlone Press, London.
- KRAL (F.) & (J. P.) USCAVAGE, 1960-61. — *Cheyletiella parasitivorax* Infestation in a Dog. — J. small anim. Pract., 1 : 277-278.
- LUEDEMANN (George M.), 1971. — Designation of Neotype Strains for *Micromonospora coerulea* Jensen 1932 and *Micromonospora chalcea* (Foulerton 1905) Ørskov 1923. — Int. Journ. Systematic Bacteriology, 21, 3 : 248-253.
- MARPLES (Mary J.), 1965. — The Ecology of the Human Skin. Charles C. Thomas Publ.
- MILLS (L. R.), 1973. — Morphology of glands and ducts in the two-spotted spidermite *Tetranychus urticae* Koch 1836. — Acarologia, XV, 2 : 218-236.
- NIELSEN (E.), 1931. — The Biology of Spiders. Levin & Munksgaard.
- OLSEN (S. J.) & (H.) ROTH, 1947. — On the mite *Cheyletiella parasitivorax* occurring on cats, as a facultative parasite of man. J. Parasitology, 33 : 444-445.
- PUGH (G. J. F.), 1966. — Associations between birds' nests, their pH and keratinophilic fungi. — Sabouroudia, 5, 1 : 49-53.
- PUGH (G. J.) & (Mary D.) EVANS, 1970. — Keratinophilic fungi associated with birds. — Trans. Br. mycol. Soc., 54 (2) : 233-240.
- SMILEY (Robert L.), 1970. — A Review of the Family Cheyletiellidae (Acarina). — Ann. Ent. Soc. Amer., 63 (4) : 1056-1078.
- SOULSBY (E. J. L.), 1969. — Helminths, Arthropods and Protozoa of Domesticated Animals. — Baillière, Tindall and Cassell, London.
- WALLWORK (John A.), 1970. — Ecology of Soil Animals. McGraw-Hill.
- WILSON (Graham S.) & (A. A.) MILES, 1957. — Principles of Bacteriology and Immunity. 4th edition, vol. 1. Edw. Arnold Publ.
- VITZTHUM (H. Graf), 1943. — Acarina. Bronn, Tierreich, Bd, 5, Abt. 4, Buch 5 : 1-1011. Akad. Verlagsgesellschaft, Leipzig.
- VOLGIN (V. I.), 1964. — On the taxonomy of predatory mites of the family Cheyletidae. VI. The genus *Ornitocheyletia* Volgin. — Gen. N. Zool. Jh., 43 (1) : 28-36.
- ØRSKOV (J.), 1923. — Investigations into the Morphology of the Ray Fungi. (Disp.) Levin og Munksgaard.