

# MORPHOLOGY AND FUNCTION OF THE GNATHOSOMA IN THE HISTIOSTOMATIDAE (ASTIGMATA)

BY S. WIRTH<sup>1</sup>

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ACARIDAE  
GNATHOSOMA  
COXAL-ENDITES  
HISTIOSTOMATIDAE  
PALPOMEMBRANE

**SUMMARY:** Studies on the characters of the gnathosoma, among other details, establish the Histiostomatidae to be a monophyletic group and the Guanolichidae to be its sister group. A synapomorphy of Guanolichidae and Histiostomatidae is the reduction of the digitus mobilis of the chelicerae to small remnants. For the first time a reconstruction of histological sections of internal structures of a histiostomatid gnathosoma, namely of *Histiostoma palustre* Wirth, 2003, is presented. The coxal endites are laterally connected with the pedipalps and close the ventral gnathosoma completely. An apomorphy of the Histiostomatidae and an important structure for comparative studies is the palpmembrane which is shaped distally by the coxal endites.

**ZUSAMMENFASSUNG:** Die Histiostomatidae sind eine monophyletische Gruppe mit den Guanolichidae als Schwestergruppe. Synapomorphie beider Taxa ist der zu schmalen Resten reduzierte digitus mobilis der Chelicere. Zum ersten Mal wurden innere Strukturen des Gnathosomas einer Histiostomatidae, nämlich *Histiostoma palustre* Wirth, 2003, als dreidimensionale Rekonstruktion nach histologischen Schnitten dargestellt. Als weitere Apomorphie beider Gruppen schließen die Coxal-Endite das ventrale Gnathosoma lateral vollständig ab, da sie fest mit den Pedipalpen verbunden sind. Wichtig bei der vergleichenden Analyse ist die Palpmembran, eine Struktur, die als Apomorphie der Histiostomatidae am distalen Gnathosoma gebildet wird.

## INTRODUCTION

The assumed functional morphology of the gnathosoma was discussed in WIRTH (2003). A reconstructed cladogram (WIRTH, 2004) demonstrates that characters of the gnathosoma, especially the palpmembrane, were transformed several times into more complex structures within the Histiostomatidae. His-

tological observations of the internal structures of the gnathosoma of histiostomatid mites were never performed before. WURST & KOVAC (2003) tried for the first time to understand the morphology of a histiostomatid gnathosoma with help of SEM observations. The morphology of the gnathosoma of astigmatid mites was explained in HAMMEN (1989) for *Rhizoglyphus echinopus*.

1. FU Berlin, Institut für Biologie/Zoologie, AG Evolutionsbiologie, Königin-Luise-Str. 1-3, 14195 Berlin, Germany. Email: [wirthstef@web.de](mailto:wirthstef@web.de)

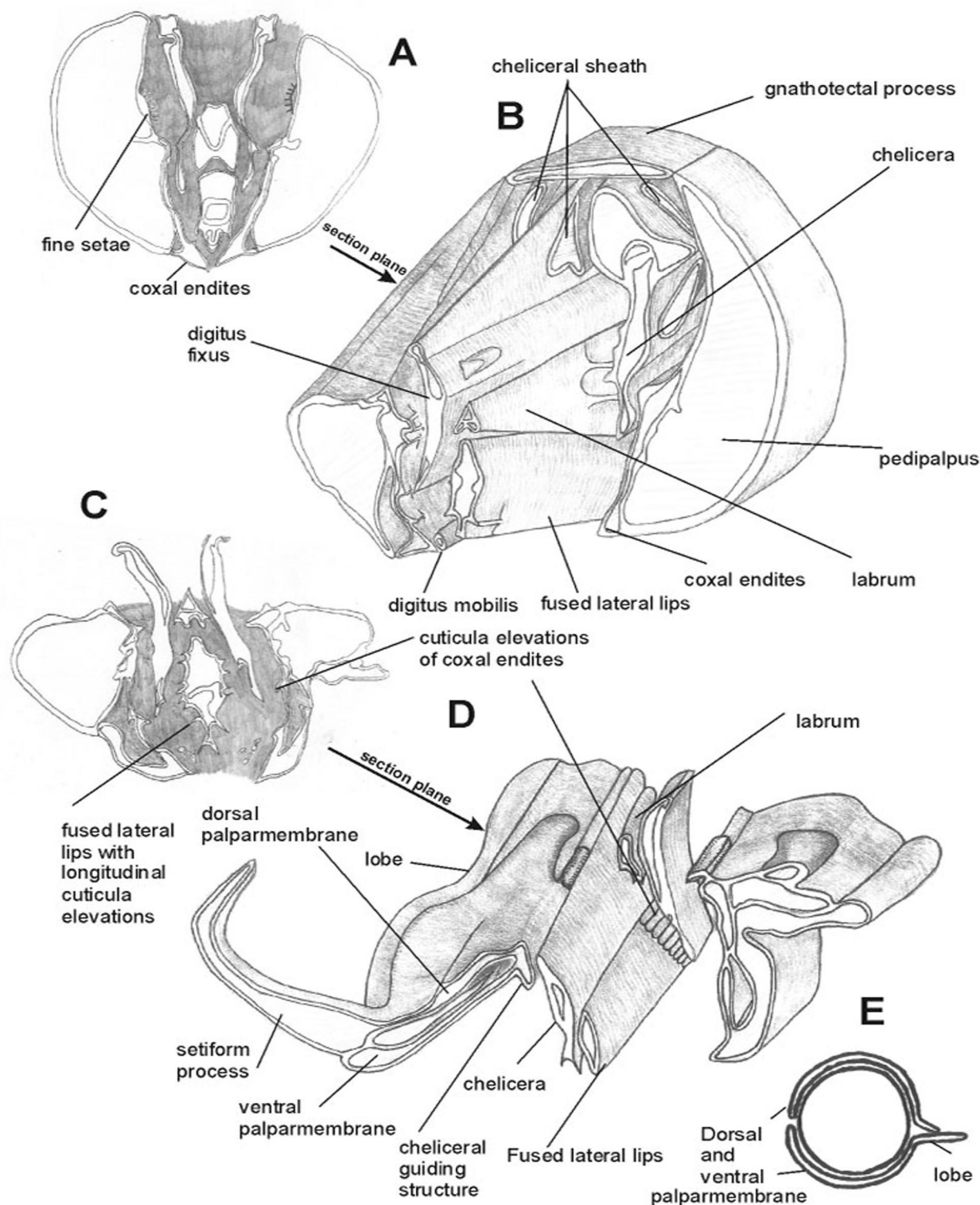


Fig. 1. A:— Proximal section showing a conspicuous small area with setae on the inside of each pedipalp of unknown function. B. — Proximal gnathosoma of *Histiotoma palustre* reconstructed with help of histological sections. It shows two different planes, more proximally and more distally. C. — Proximal section of the distal gnathosoma with longitudinal cuticula elevations at the fused lateral lips, star shaped in the transverse section. D. — Distal gnathosoma shows the arrangement of the conspicuous palpmembrane, which is part of the coxal endites. E: Schematic section from anterior to posterior of the distal pedipalp article to show the palpmembrane structures and the posterior lobe.

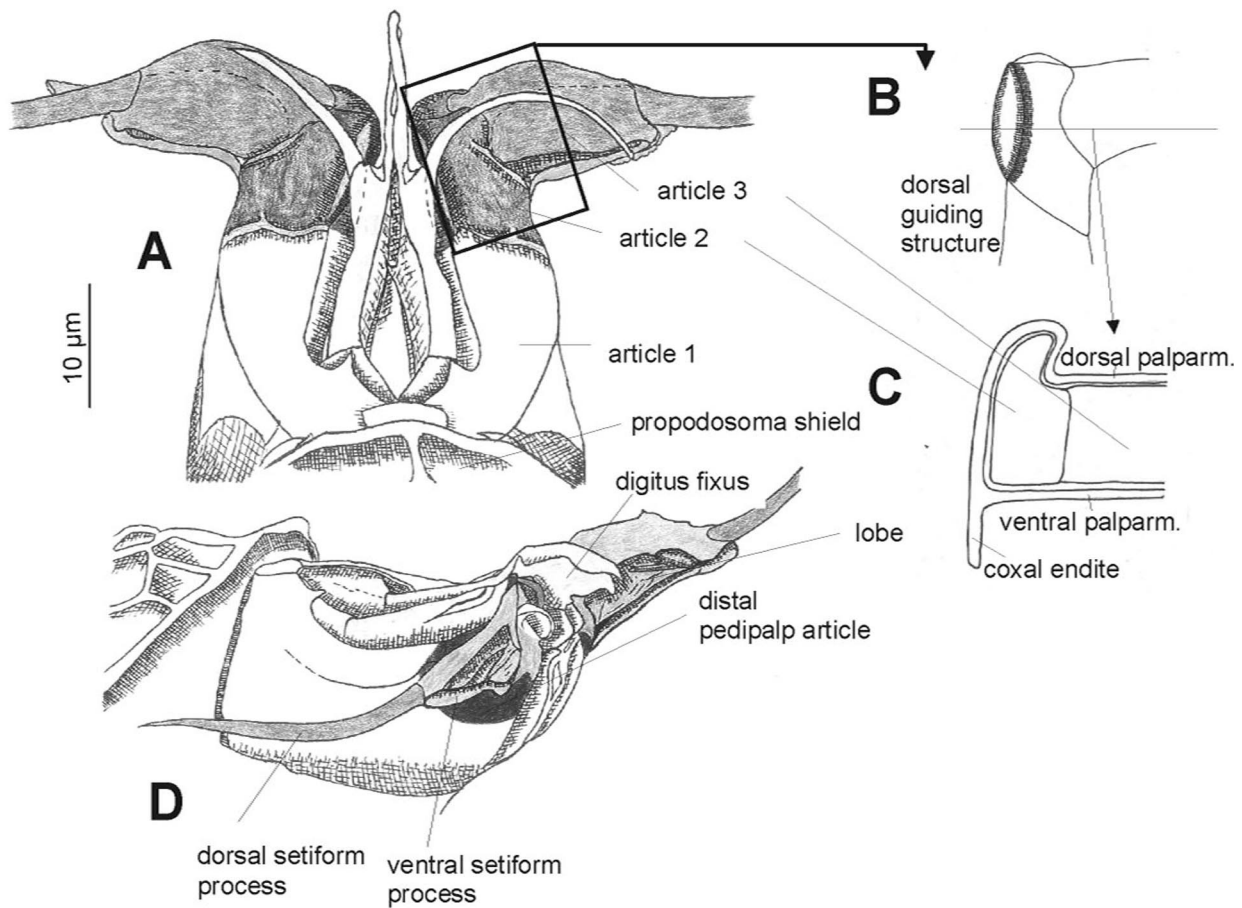


FIG. 2. A. — Gnathosoma of *Histiostoma* sp. in dorsal view. B. — The dorsal guiding structure enlarged in dorsal view. C. — Schematic section through the distal right gnathosoma from median to lateral. D. — Gnathosoma in lateral view.

#### MATERIALS AND METHODS

Objects for histological sections were embedded in Technovit 7100. Afterwards the objects were coloured with Eosin-red and Toluidin-blue.

The sections were observed under the light microscope to help understand the anatomy of the gnathosoma. Specimens for observation under the scanning electron microscope (SEM) were fixed in 100 % ethanol for at least 5 days. Those used to make palpar-membrane details visible were critical point dried, whereas those used for examining the “eyes” were air dried. Both were sputtered with gold prior to examination under the SEM.

#### MORPHOLOGY OF THE HISTIOSTOMATID’S GNATHOSOMA

The modified mouthparts which evolved in the stem species of the Histiostomatidae differ conspicuously from those of other astigmatid mites (SCHEUCHER, 1957, FIGS. 3B-D). The gnathosoma of *Histiostoma palustre* Wirth, 2003 (3A) as representative for all histiostomatids was examined in detail by the author with help of histological sections. Phylogenetic conclusion are based on the cladogram of the Histiostomatidae of WIRTH (2004). Some terms of mouthpart structures will be newly introduced and are important for comparative studies. To simplify the following explications, the gnathosoma is artificially divided into a proximal and a distal gnathosoma.

### *Proximal gnathosoma*

In both the Guanolichidae and Histiotomatidae, the digitus mobilis of the chelicera is reduced to a vestigial structure. Therefore both groups are argued to be sister taxa (O'CONNOR, 1981).

In both groups the proximal gnathosoma is similar. The pedipalps are enlarged in relation to the whole mite body with distinctly smaller chelicerae (FIG. 1B). The preoral cavity is enclosed laterally by the chelicerae, dorsally by the labrum and ventrally by a single lobe shaped by the walls of the preoral channel (FIG. 1B). This structure is termed the “lateral lips” (GRANDJEAN, 1938c). The coxal endites (AESCHLI-MANN, 1984) extend along the entire pedipalps and are laterally connected to them, thereby enclosing the ventral gnathosoma laterally and ventrally (FIG. 1A). In other Astigmata, only the proximal pedipalp article is connected to the coxal endites (HAMMEN, 1989).

A median dorsal fold is termed “gnathotecal process” (EVANS & TILL, 1979) and is in *H. palustre* and all Histiotomatidae laterally connected with the pedipalps (FIG. 1B). The “cheliceral sheath” (EVANS & TILL, 1979) which enable the in- and outwards movements of the mouthparts are clearly visible (FIG. 1B). In addition the following structures were discovered: some setiform structures in a small restricted cuticula area at the internal walls of the pedipalps (FIG. 1A) and more distally longitudinal cuticula elevations on insides of the coxal endites (FIG. 1B) and around the fused lateral lips.

The lateral lips are usually developed as a paired structure (FIG. 3D) in other astigmatid mite groups (for example in *Lepidoglyphus destructor* Schrank, 1781) or reduced to a single shaped ridge like structure as in *Rhizoglyphus* (EVANS, 1992). In *Histiostoma palustre* it is a distinct single structure, that is termed the “fused lateral lips” by the author (FIGS. 1B, D). caused by non histological comparative studies, it is assumed, that this character is an apomorphy of the Histiotomatidae. The coxal endites are termed “malapophyses” by some authors (EVANS, 1992). In the Histiotomatidae this term is not used by the author because the origin of important distal structures remains easier to follow when the term coxal endites is retained.

The function of the setiform structures on the internal walls of the pedipalps is unknown but they could function as mechanoreceptors (FIG. 1A). The conspicuous longitudinal cuticula elevations on the coxal endites could interdigitate with hair like structures on the lateral lips (FIG. 1B, C) to prevent unusable big particles to pass the preoral cavity (“filtering structures”). The comparative studies were not suitable to prove the existence of these structures in other histiotomatid species.

### *Distal gnathosoma*

As an apomorphy of the Histiotomatidae, the coxal endites distally form conspicuous structures, a cheliceral guiding structure and the palpar-membrane (FIG. 1D). Proximally of the distal gnathosoma the coxal endites shape a distinct structure with short, parallel running and downward directed components (FIG. 1D), which is termed “cheliceral guiding structure” by the author (WIRTH, 2005 a).

The distal pedipalp articles are directed laterally (FIG. 2A). Out from the coxal endites cuticula lobes surround the distal pedipalpal articles ventrally (= ventral palparmembrane) and dorsally (= dorsal palparmembrane) (FIG. 1F, 2C). There exist as usually for astigmatid mites three pedipalp articles, which are termed trochanterofemur, genotibia and tarsus (FIG. 4) by HAMMEN (1989). The genotibia is medianly elongated and reaching the anterior margin of the gnathosoma (FIG. 2B). In this distal area, both the distal part of article two and the whole of segment three are surrounded by the palparmembrane structures (FIG. 2C). Dorsal and ventral palparmembrane touch each other anteriorly and posteriorly (FIG. 1E). One pair of setiform processes origin on each end of the distal pedipalp articles (FIG. 1D). In addition parts of the ventral palparmembrane are posteriorly elongated. This structure is termed the “posterior lobe” (FIG. 1F) by the author. Contrary to the labrum, the fused lateral lips run to the anterior margin of the gnathosoma (FIG. 1D). Further proximal they shape longitudinal cuticula elevations (FIG. 1C, D) similar to those of the coxal endites of the proximal gnathosoma.

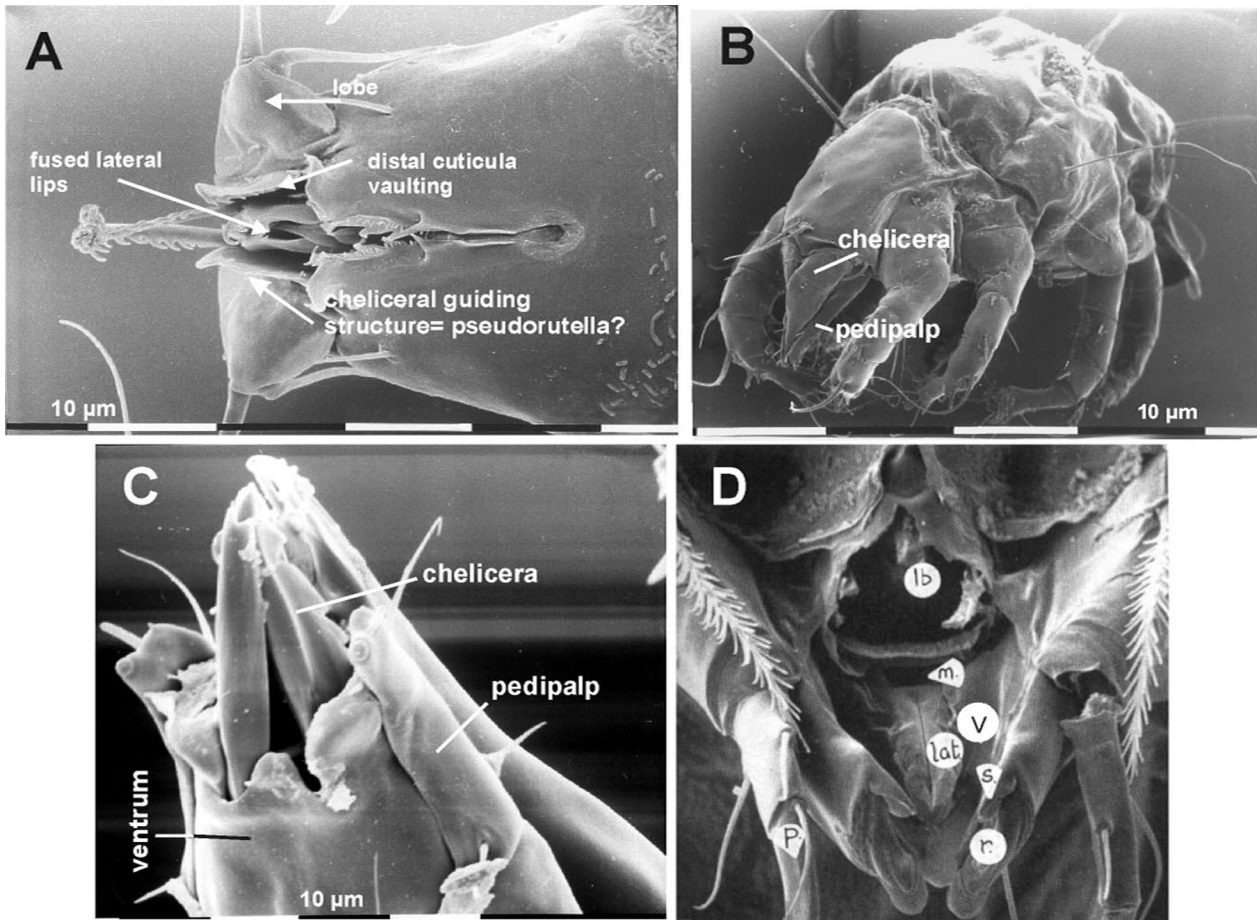


FIG. 3. A. — Gnathosoma of *Histiostoma palustre* in ventral view. B. — Female of *Acarus* sp. In anterior-latero view. C. — Gnathosoma of *Acarus* sp. in ventro-latero view. D. — Gnathosoma of an astigmatid mite in frontal view (EVANS, 1992), lat = lateral lips, lb = labrum, m = mouth, p = pedipalp, r = pseudorutella, s = setiform process, v = ventrum.

The strongly shortened coxal endite elements (FIGS. 1E,2C) are interpreted as ventral cheliceral guiding structures. The dorsal cuticula areas of the median parts of the second free pedipalpal articles are folded upwards and function as a dorsal guide for the chelicerae (FIGS. 2B,C). Distally of the coxal endites of “Oribatida” the rutella are positioned and interpreted to be of setal origin by GRANDJEAN, 1957 c). In the same position in the Astigmata a structure with the lack of a basal root and of birefringence is termed pseudorutella (JOHNSTON, 1965; AKIMOV, 1979). Characters of a real rutellum (GRIFFITHS, 1977) were not found. Obviously the morphologically distinctly separated “ventral cheliceral guiding structures” (FIGS. 1E,7H) could be homologous to that

structure. It is not of setal origin and is shaped by the coxal endites as in the pseudorutella of non histiostomatid Astigmata. To emphasize its function in the Histiostomatidae it is termed “ventral guiding structure”.

WURST & KOVAC (2003) observed the morphology of the gnathosoma of *Tensiostoma veliaphilum* Wurst & Kovac, 2003 with help of a SEM preparation using dorsal and ventral view and a longitudinal section. A terminology for the structures is introduced. But because some structures are distinctly modified, that derived gnathosoma does not represent a typical histiostomatid gnathosoma, and therefore cannot be used as a model for all Histiostomatidae. The introduced terminology can partly not be adopted,

because terms for important structures, missing in that species, are not introduced, and some given terms are not suitable for use in comparative studies. The distal pedipalp articles of *T. veliaphilum* are unusual elongated and tube shaped. The posterior lobes are reduced to hardly visible rests. The cheliceral guiding structures obviously are completely missing. The distal cuticula vaultings shaped by the coxal endites (FIG. 7H) are unusually enlarged. That's why the "rostral funnel" between these vaultings ("distal part of hypostome") and the distal pedipalp articles "normally" does not exist. I termed the "hypostomal ridge" "fused lateral lips", because the homology of these structures to those of non histiostomatid mites is obvious. It is unclear whether the longitudinal cuticula elevations proximally of the fused lateral lips of *Histiostoma palustre* are divided into equally sized denticles as in *T. veliaphilum*, where a longitudinal row of such denticles is found in the "hypostomal ridge".

Plesiomorphic character	Apomorphies of the Histiostomatidae
Usual chelicera	Digitus mobilis reduced to a vestigial structure
Small pedipalps consisting of 3 visible articles	Pedipalps distinctly enlarged in proportion to the whole body, distal article directed laterally
Pedipalps separated from coxal endites (malapophyse) in ventral view	Laterally connected to the pedipalps and therefore not separated in ventral view
Paired lateral lips	Fused lateral lips
Pseudorutella.	"Ventral cheliceral guiding structure" is possible homologous. It is elongated and forms the palpal membrane as apomorphy of the Histiostomatidae

### Feeding behavior

The observations of the author showed that the gnathosoma shoves microorganisms together into mounds in front of the mite's mouth. The posterior lobe that is directed downward (FIG. 1F) as a result of the gnathosome being distally bent upward aides in mounding the microorganisms in front of the mouthparts, working like an automobile windshield wiper. Probably the distal cuticula vaultings (FIG. 7H) sha-

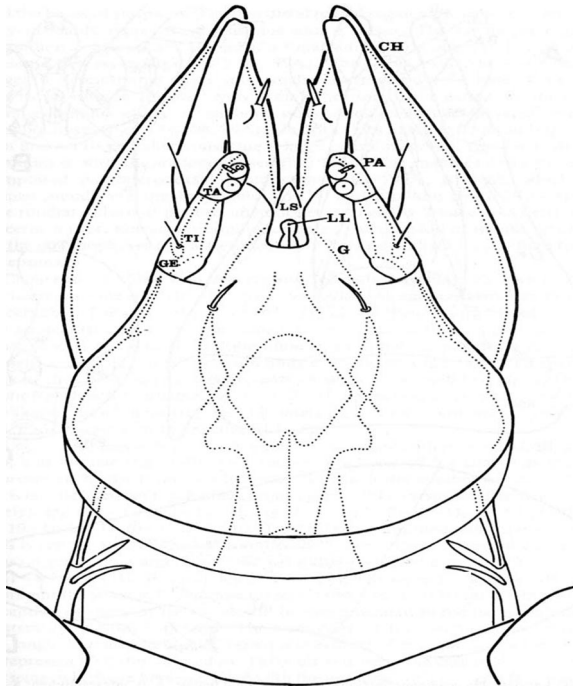


FIG. 4. Gnathosoma of *Rhizoglyphus echinopus* in ventral view (HAMMEN, 1989), CH = chelicera, G = gena, GE = Genu, LL = lateral lips, LS = labrum, PA = pedipalp, TA = tarsus, TI = tibia.

ped by the coxal endites support the function of the posterior lobes. A mobility of the pedipalps or the setiform processes during the feeding was not observed by the author as also confirmed by WURST & KOVAC (2003).

The setiform processes laterally of the distal pedipalp articles are interpreted to be solenidia by some authors (e.g. WURST & KOVAC, 2003) caused by the lack of birefringence. Nevertheless this function as chemosensitive structures probably remains doubtful, because it is unproved, and the lack of actinopilin is at most an indirect indication. They probably support the piling of microorganisms by enlarging the surface of the lobes and other palpal-membrane structures to lateral. The setiform processes of *Histiostoma ruehmi* Scheucher, 1957 for example have conspicuous cuticula fringes on their bases as the other ventral palpal-membrane structures too. The surface of the whole gnathosoma is additionally enlarged in that way (WIRTH, 2004). The setiform processes of that species are as well modified as the other mouthparts which are important for the piling of microorganisms.

*Important structures for comparative studies*

The following structures provided important support for the reconstruction of the phylogeny of the Histiostomatidae: dorsal and ventral palpal membrane, posterior lobe, cheliceral guiding structure, second and distal free pedipalp article. Concerning these structures *H. palustre* represents character states of the stem species of the Histiostomatidae (TABLE 1). The morphological understanding of these structures and the introduction of terms facilitate the description of mouthparts of other species.

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