

## Structure of head and thorax of *Livia juncorum* (Latreille, 1978) /Hemiptera, Psylloidea/

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### Abstract

The paper was concerned with providing the characteristics of morphological structure of the head and thorax of a palearctic species: *Livia juncorum* Latreille, 1789. Special attention was paid to specific morphological features of the head which were also previously discussed by other authors, including the horizontal position of the head and a flat, prolonged vertex, clearly incised in the middle, prolonged, flattened compound eyes placed on both sides of the head, not sticking out beyond the contours of the head as well as sensory tubercles on the head or a specific distention of the 2nd segment of antenna. Unique features in the structure of the thorax were also described, including: wide pronotum, decreased mesopraescutum, decreased pleurites of the pronotum towards the ventral side, and a shift of stigma plate of mesothorax. Lack of significant differences in the structure of these body parts between females and males of this species was stated.

### Introduction

*Livia juncorum* was described in 1798 by Latreille, who called it *Psylla juncorum*. Then in 1802 he established a new genus *Livia*, for which *Livia juncorum* was decided to be a typical species. Morphological structure of this

species was different than the structure of the then known remaining other psyllid species and, so in 1878 within the Psyllidae family Löw distinguished the Liviinae subfamily to place within it the *Livia* genus Latreille, 1802. A year later the same author upgraded the subfamily of Liviinae up to the Liviidae family. Such classification despite many changes within the superfamily Psylloidea kept the Liviidae family in this class for over 100 years. This is an untypical phenomenon because of the constant development of research methods and permanent flow of information on the species. Only did an analysis of morphological structure of larvae with the use of the cladistic analysis prompt WHITE & HODKINSON (1985) to include this family within the Aphalaridae family in the class of the Liviinae subfamily. Such classification which distinguished within the superfamily of Psylloidea eight families (Psyllidae Burmeister, Triozidae Löw, Aphalaridae Löw, Homotomidae Heslop-Harrison, Calyophyidae Vondraček, Carsidaridae Crawford, Phacopteronidae Becker-Migdisova and Spondyliaspidae Schwarz) is still considered by many researchers to be the most correct. Without a doubt, however, species of the *Livia* genus along with *Livia juncorum*, which is a typical species have a characteristic structure with many features which are considered to be primitive by many authors. The analysed morphological features of this species have so far included the head, forewings and hindwings and genitalia. The descriptions of these body parts may be found in several authors' publications (VONDRAČEK, 1957; KLIMASZEWSKI, 1975; OSSIANNILSSON, 1992). LOGINOVA (1974) in a paper concerning the classification of the Liviidae family provided an assessment of the most important morphological features of 21 species of this family but none of these features referred to the thorax. Therefore, the fact that despite many descriptions the thorax of this species was not studied or described is surprising. This is connected with the fact that most well known morphological data is concerned with features of diagnostic importance of which there are few in the construction of the thorax. Technological difficulties in the dissection of the thorax part was spotted by KLIMASZEWSKI (1975) and is also important in this respect. So far there has been research on the thorax part in only few selected at random species (STOUGH, 1910; CRAWFORD, 1914; WEBER, 1929; VONDRAČEK, 1957; TREMBLAY, 1965; JOURNET & VICKERY, 1978; OUVARD *et al.*, 2002; OUVARD *et al.*, 2008) and one research by KLIMASZEWSKI (1964) in which the author discusses the relation of alliance among psyllids using also the shape of thorax sclerites for the purpose apart from many other features. Therefore, the description of the thorax part of *Livia juncorum*, a species which is typical for the *Livia* genus classified within the subfamily of Liviinae, family of Aphalaridae seems to be justified. Since species classified in this subfamily have a specifically transformed head, which basing itself with its entire width on the pronotum forces changes in body structure, it is essential to describe its characteristic structure.

## Material and methods

The material (2 males and 3 females) was collected on 28<sup>th</sup> of August 2005 on rush (*Juncus* sp.) in a village of Baligówka in the Orawsko-Nowotarska Valley using an entomological sweep net. These specimens were dried stored and then the material was prepared for an analysis in the Electron Scanning Microscope S-3400N by using the low vacuum. This preparation involved cleansing with alcohol and washing in ultrasonic washer. After the separation of wings and legs the specimens were attached to a double sided cello tape and placed in a scanning microscope. They were not covered with powder.

Morphological terminology and abbreviation list used to describe photographs is after JOURNET & VICKERY (1978) and OUVARD *et al.* (2002, 2008): aas – anterior accessory sclerite, acl – anapleural cleft, an – antenna, apwp – anterior pleural wing processes, axc2 – axillary cord, ce – compound eye, cl – clypeus, cx1 – procoxa, cx2 – mesocoxa, cx3 – metacoxa, epm1 – proepimeron, epm2 – mesoepimeron, epm3 – metaepimeron, eps1 – proepisternum, eps2 – mesoepisternum, eps3 – metaepisternum, fr – frons, ftna2 – fossa of the trochantinal apodeme, ftna3 – fossa of the trochantinal apodeme, ge – genae, hepm – heel of the epimeron, kes2 – katepisternum, li – labium, loc – lateral ocellus, mcs – meracanthus, moc – median ocellus, ms – median suture, nt1 – pronotum, pas – posterior accessory sclerite, pls1 – propleural sulcus, pls2 – mesopleural sulcus, pls3 – metapleural sulcus, pnt2 – mesopostnotum, pnt3 – metapostnotum, ppt – parapterum, psc2 – mesoprescutum, ptm2 – mesothorax peritreme, ptm3 – metathorax peritreme, stn2 – mesosternum, sc2 – mesoscutum, sc3 – metascutum, scl2 – mesoscutellum, scl3 – metascutellum, tems – transepimeral sulcus, tg – tegula, tr – toruli, trn2 – mesothorax trochantin, trn3 – metathorax trochanti, tsp – tuberculum sensillum praeoculare, ve – vertex, vel – vertex lobe.

## Construction of head and thorax of *Livia juncorum*

### The head

Its colour is brown-reddish with tiny red and well visible spots. Both, the head and the thorax are massive. A horizontal placement of the head is a characteristic and rarely observed feature. It links with the thorax almost horizontally and moreover across its entire width. Between the head and pronotum no narrowing or incision is observed. The head is characterized by a flat, lengthened vertex (ve) clearly cut in the middle (Figs. 1, 2). In the front part the vertex forms two large vertex lobes (vel) reaching beyond of the antennae base, in a shape reminiscent of triangles. Looking from the dorsal side, the width of the head together with the eyes is smaller than its length. Vertex is much pleated and grooved, which makes it difficult to find median suture (ms). In the back

and on the sides of vertex there are two lateral ocelli (loc) (Figs. 1, 2). Compound eyes (ce) which are situated at the sides of the head are strongly lengthened and flattened, and at the sides they do not stick out beyond the head's contour. Toruli (tr) of *Livia juncorum* are well developed, wide and clearly separated from the vertex. In front of the eyes and beyond the antennae base, one can find tuberculum sensilium praeoculare (tsp) (Figs. 1, 2). A ten-segmented antennae are characterized by always clearly visible enlargement of basic segments, leading to an apparent division of an antenna into a massive base and processus terminalis. The second segment of antennae (an2) has a bulgy shape and is larger than the first segment of antennae (an1). Looking from the lateral side the head has a cave shape narrowing towards the front (Figs. 3, 4). Vertex is depressed, strongly pleated, vertex lobes are flat, narrowing to the front. Tuberculum sensilium praeoculare (tsp) and basis of antennae are well visible.

Looking from the bottom (Figs. 5, 6) a missing of genal cones (which are often seen in psyllids' cave cones formed out of prolonging of genae having the sensory function), genae are strongly pleated (ge). Vertex lobes (vel) which are pushed forward have a triangular shape. The frons (fr) is reduced to a narrow stripe around a well visible median ocellus (moc). This stripe lies in the middle, between genae, in the front it borders dorsally with vertex and in the back – ventral with clypeus. Clypeus (cl) is well visible, though labium (li) can be seen between coxae of the first pair of legs (Figs. 5, 6). One cannot point out to sexual dimorphism in the structure of the head of male and female (Figs. 1-6).

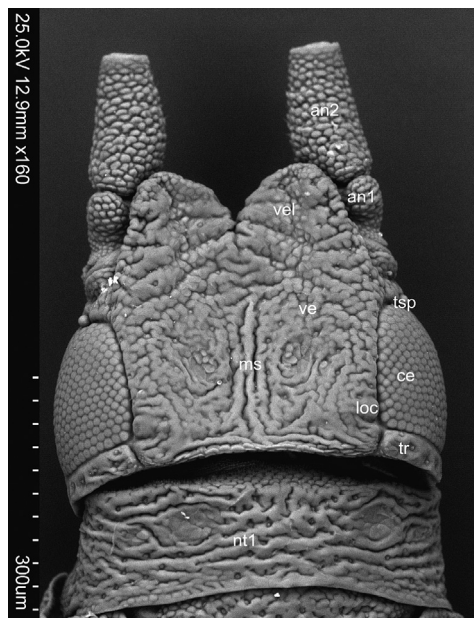


Figure 1. Head, dorsal view, male

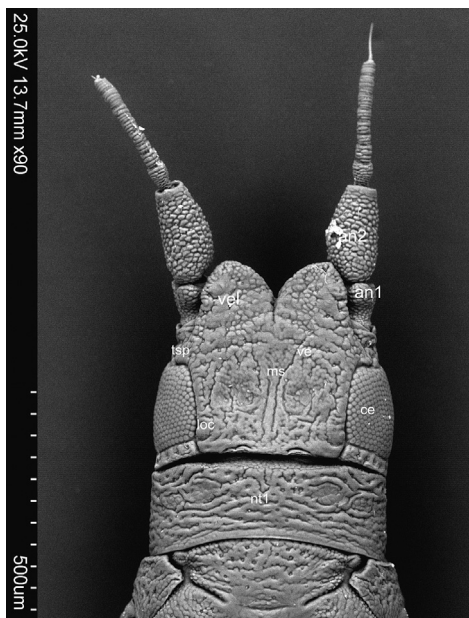


Figure 2. Head, dorsal view, female

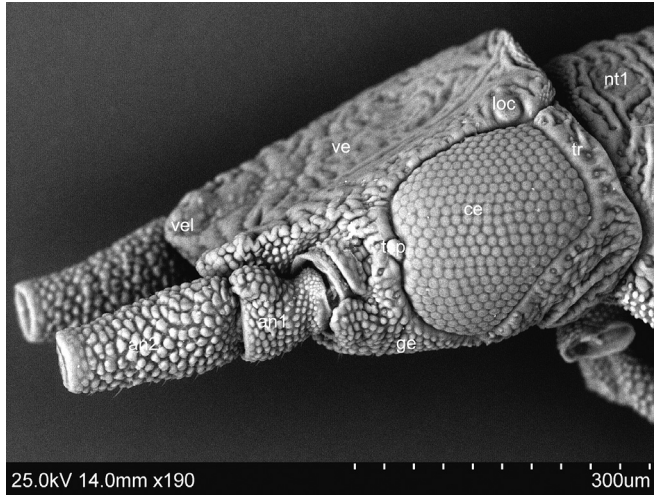


Figure 3. Head, lateral view, male

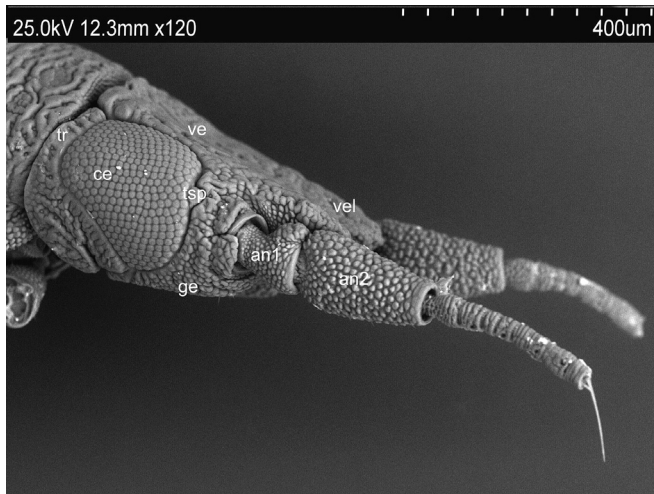


Figure 4. Head, lateral view, female

## Thorax

The colour of the thorax ranges from brown to dark brown with a red shade. This is the biggest and fullest of sclerites part of psyllids' body.

### Prothorax

Prothorax is the smallest segment of the thorax and undergoes strong modifications because mouth apparatus is moved to the back which makes the bottom labium grow with the ventral side of the prothorax. It is like that in all psyllids including *Livia juncorum*.



Figure 5. Head, ventral view, male



Figure 6. Head, ventral view, female

From the dorsal side the prothorax forms one sclerite – pronotum (nt 1, Figs. 7, 8). This sclerite, just like the others constituting the thorax of this species is massive. The width of pronotum corresponds with the width of head and it is not narrowed or incisioned in none of its parts, as it can be observed in other psyllid species. Both borders of pronotum, the front one with the head and the hind one with the mesopraescutum are clear and the sulcus separating the pronotum from mesopraescutum is slightly bended in its middle part to form a slight arch. The size, shape and bending of the hind border of pronotum is the same both in males and females (Figs. 7, 8). The side part of prothorax is constituted by 2 pleurites, proepisternum (eps1) and proepimerum (epm1). Usually, they are easily spotted and clearly separated from each other by means of propleural sulcus, and their border with prothorax is not always visible. In *Livia juncorum* the side part of prothorax is much pleated and grooved (Figs. 9, 10) which makes it difficult to find the propleural sulcus. Propleural sulcus (pls1) runs from joint appendix of coxa up to pronotum. Looking from the side one can point out to the deepest cleft and consider it to be propleural sulcus, while parts which it separates can be claimed to be proepisternum and proepimeron, respectively. However, looking at this side of the thorax from the ventral side, one can clearly see that proepisternum is separated from proepimeron and it is hidden under the hind part of the head and it is only this part of this plate that sticks out beyond the head. Both plates,

proepimeron and proepisternum are small, while propleural sulcus which separates them reaches up the front part of the pronotum. The sulcus has a obliquely almost horizontal line. The sternal part of prothorax in psyllids is much reduced and almost invisible because it is covered by rostrum which is partly grown onto it (Figs. 11, 12). One cannot point out to sexual dimorphism in the structure of the prothorax of male and female (Figs. 7-12). Between pleurites of pro- and mesothorax, there are 3 tiny sclerites of an arguable origin, which OUVARD *et al.* (2002) called anterior accessory sclerite and posterior accessory sclerite (aas and pas), and peritrema (ptm2) which surrounds spiracles of thorax. These sclerites are not always visible because sometimes they are overshadowed by mesoepisternum processes which is pointed forward. In *Livia juncorum* one cannot see the anterior and posterior additional sclerite. One may also find spiracle plate with a spiracle on it (stg2, Figs. 9, 10). It has an unusual position as for psyllids though it is much moved towards sternites.

### **Mesothorax**

The dorsal part of the mesothorax is divided into a large mesonotum and battened mesopostnotum (Figs. 7, 8). Mesonotum is divided into 3 sclerites (mesopraescutum (psc2) mesoscutum (sc2) and mesoscutellum (scl2)), which are separated from one another by a not completed sulcus. Mesopraescutum (psc2) is a plate of a medium size, its front margin is slightly arched, touching the pronotum, but this plate does not reach the pronotum in none of its parts. The hind stern of mesopraescutum is strongly bended in its middle part. The mesopraescutum and mesoscutum are linked together because the sulcus which separates them is not complete. In the middle part there are two symmetrical links. Mesoscutum (sc2) is the biggest part of mesonotum (Figs. 7, 8). It has a V shape, its arms reach parapteron which from the top has an unusual, angular shape of a pentagon. Mesoscutellum (scl2) is small and has a trapeze shape. Mesopostnotum, which is situated behind mesonotum from the dorsal side is not visible as it is completely covered by mesoscutellum (scl2), which is situated in the front. From the side mesopostnotum has a form of a narrow batten running diagonally towards mesoepimeral sclerite with which is partially is joined.

Looking from the side, the parapteron has a shape of pentagon. This is untypical because this structure in psyllids usually has a shape close to round. It never has such a large size. Such untypical shape and size can be found for tegula placed behind parapteron. Usually it has a shape of peas, though here it has a form of a lengthened bean.

Side walls of the mesothorax (Figs. 9, 10) are constituted of two large sclerites: mesoepisternum (eps2) and mesoepimerum (epm2). Mesoepisternum (eps2) has various shapes, depending on positions and line of pleural sulcus (pls2) and anapleural cleft (acl2). Pleural sulcus on mesothorax runs from joint

condyle of coxa and approaches the point in the middle of pleuron, but does not meet the base of wing. Pleural cleft of this species is almost horizontal and separates mesopleurites into a large plate mesoepimeron and a smaller mesoepisternum. Mesoepimeron is more complex than mesoepisternum because of a vertical cleft which after OUVARD *et al.* (2002) was termed transepimeral sulcus (tems, Figs. 9, 10). The widest part of mesoepimeron lies in the front towards transepimeral sulcus. Dorsal, hind margin of this sclerite (in the front to third peritreme and in the back of transepimeral sulcus) supports the base of anterior pleural wing processes (apwp, Figs. 9, 10). It is thin and flexible and distal depressed to the dorsal margin of mesopleuron. It is separated from this margin by a narrow, membranous area.

Katepisternal complex is formed by katepisternum (kes2) and trochantin (trn2) and is separated from anaepisternum by anapleural cleft (Figs. 9, 10). Katepisternal complex is rounded and striped with each row sharply isolating the elements of katepisternal complex (OUVRARD *et al.*, 2002).

Ventral side of mesothorax is constituted by a well developed sclerite – mesosternum grown with forecoxa of the second pair of legs (Figs. 11, 12). One cannot point out to sexual dimorphism in the structure of the mesothorax of male and female (Figs. 7-12).

### **Metathorax**

Dorsal side of the metathorax consists of metanotum and metapostnotum (Figs. 7, 8). In metanotum one can distinguish two plates, metascutum (sc3) and metascutellum (scl3). Metascutum (sc3) is a small plate, while metascutellum (scl3) is bigger and clearly raised in relation to metascutum. Metapostnotum (pnt3) is relatively large and has a trapeze shape. Apart from proper metapostnotum it also has a tergite of the first segment of thorax which is completely fused with it (Figs. 7, 8).

Marginal plates of the metathorax (metapleurites) are quite well developed. Metapleural cleft is hardly visible and does not separate them entirely (Figs. 9, 10). Metapleuron is much modified by a vertical lengthening of thigh's meron which forces on epimeron and episternum a development into a long, thickened arch which extends above metacoxa. On metaepisternum there is a metathorax stigma (stg3) the plate of which was completely included within this pleurite (ptm3, Figs. 9, 10). Trochantin (trn3) is well developed and prolonged along the hind margin of metapleuron in the front to thigh (Figs. 9, 10).

Sternal part of metathorax is narrow, in the front it takes the form of a thickened plate, surrounding coxae of legs of the third pair with prolonged processes (Figs. 11, 12). One cannot point out to sexual dimorphism in the structure of the metathorax of male and female (Figs. 7-12).





Figure 7. Thorax, dorsal view, male

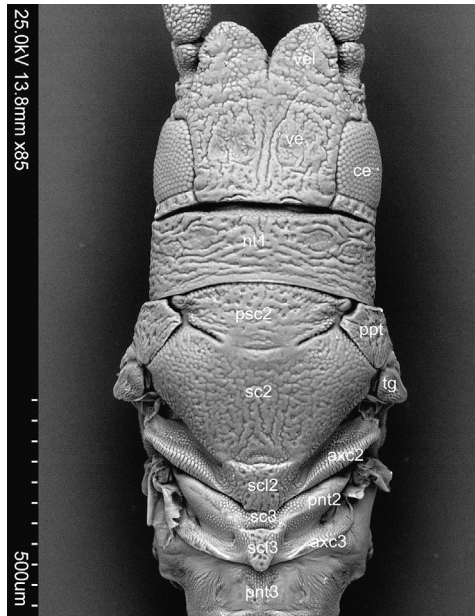


Figure 8. Thorax, dorsal view, female

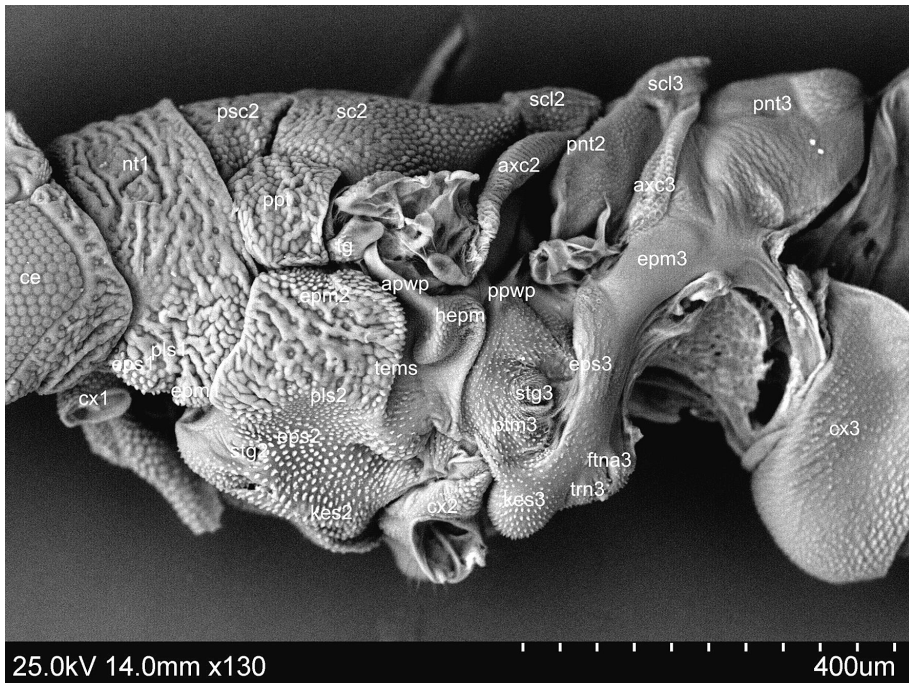


Figure 9. Thorax, lateral view, male



Figure 10. Thorax, lateral view, female

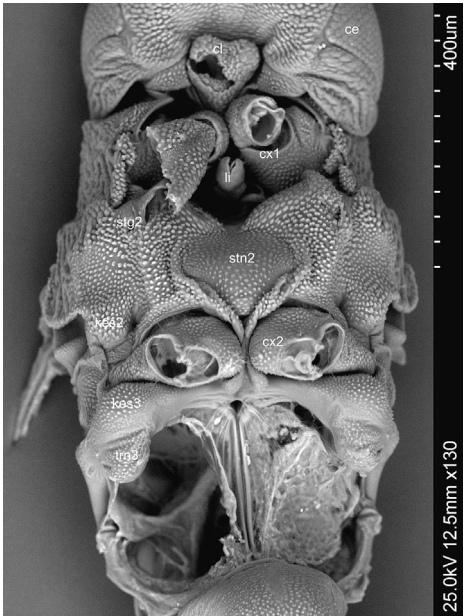


Figure 11. Thorax ventral view, male



Figure 12. Thorax ventral view, female

## Discussion

Specific morphological features of the head of *Livia juncorum* made it necessary to form separate taxonomic units of a various range: genus, subfamily and family.

In psyllids, the head is slanted to a different extent, often almost perpendicular towards a vertical body surface, whereas a horizontal position of the head is an untypical feature for this group of insects. In *Livia juncorum* the head is placed horizontally and only its frontal part falls gently down. The differences in the structure of the head that have been so far described are chiefly concerned with the formation of malar part (genal cones) and the shape of vertex (KLIMASZEWSKI, 1964). In *Livia juncorum* no genal cones were formed, though vertex underwent further transformation. It is flat and much prolonged and clearly cut in the middle. The central cutting in the frontal edge of vertex is considered to be a feature that distinguishes *Livia juncorum* from the next closest species *Livia crefeldensis* (OSSIANILSSON, 1992). The shape of eyes of this species is untypical for psyllids in the case of which they are usually spherical, semicircular and strongly stick out beyond the head's contour. Complex eyes of *Livia juncorum* are placed lateral to the head and are strongly prolonged and flattened and, more importantly they do not stick out beyond the head's contour. Sensual tubercles are a specific feature in the structure of the head of *Livia juncorum*. They are placed in front of the eyes and behind the base of the antennae and, as KLIMASZEWSKI observed (1975) they are characteristic only for species classified to belong to the Liviinae subfamily. The antennae of psyllids (usually consisting of 10 segments) are divided into base and processus terminalis. In *Livia juncorum* the 2<sup>nd</sup> segment was enlarged and bloated so along with the 1<sup>st</sup> large segment they reach the size of almost half length of the entire antenna. Such a significant enlargement of these two segments of the antennae is a characteristic feature of the *Livia* genus (KLIMASZEWSKI, 1975). All the mentioned features of the head's structure make this species easy to identify out of almost three thousand psyllids that have so far been described. When analyzing the head's morphology of this species one's attention is caught by the lack of sexual dimorphism. Females of psyllids are usually bigger than males which applies also to *Livia juncorum*. The shape of particular elements constituting the head and proportions among them have been preserved.

Because within this family a specific transformation of the head which rests with its entire width on pronotum, accompanying changes in the structure of thorax are understandable. These untypical features include e.g. wide pronotum and decreased mesopraescutum, which in this group is clearly narrower than pronotum. Mesoscutum is only slightly narrow in the front. An additional feature involves a shift of pleurites of prothorax towards the ventral side. HESLOP-HARRISON (1951) considered this fact by publishing drawings in which proepimeron and proepisternum are shifted towards ventral side of the body. Also the

course of propleural sulcus is not typical. It runs almost horizontally as WĘGIEREK notices (2002). Such a position of the sulcus is characteristic of species from the Liviidae family. Such an untypical shift of prothorax pleurites toward the bottom side of the body and a diagonal – nearly horizontal course of the propleural sulcus may be caused by a horizontal position of the head which thus forces a stronger resting of the head on pronotum and results in its stronger construction. As a result, it becomes wider and deprived of any cuts or bends which undoubtedly makes it more massive and, therefore, is a better base for the head.

Another unique feature of this species is the impossibility to find two out of three additional sclerites between prothorax and mesothorax. Neither the front nor the hind additional sclerite is visible. One can, however, find a stigma which is situated on stigma plate which is shifted to the ventral side. Often in psyllids additional sclerites are invisible, covered by a pleurite of the mesothorax which is strongly grown with it, but in *Livia juncorum*, the mesoepimeron is not that much enlarged. Stigma plate of mesothorax can be found to be strongly shifted towards sternites if this truly is stigma plate of thorax.

Analyzing this area from the external side, it seems that it indeed is the stigma but to make sure one would have to carry out an analysis of this region from the internal side. According to HESLOP-HARRISON (1952) this plate belongs not to mesothorax but to prothorax, while stigma of the mesothorax is reduced, and its plate was included in the side wall of the segment. The conclusion seems to be false because in other hemipterous insects and not only hemipterous insects, it is always prothorax stigma that is reduced and so there is no reason to consider it differently in psyllids. However, one cannot find in the meantime a reduction of prothorax stigma and mesothorax stigma so the observed slit on the bottom side of the frontal part of thorax was interpreted to be a mesothorax stigma. It is possible that the head which rests with its entire width on the thorax pushed (because of pressure) additional sclerites and stigma plate downwards.

Mesothorax is the largest part of the thorax which is connected with a functional domination of forewings which contributes to a development of muscles moving them. In this segment one can easily find all elements though shapes that they take are different than those in other species. A large parapteron of a pentagon shape, tegula of a bean shape and patch mesoepimeron are unique features of this species. Mesopleural sulcus in *Livia juncorum* is clear and almost horizontal, but the course of the pleural sulcus from almost vertical through diagonal to almost horizontal is observed in many other species of psyllids. This sulcus runs from condyle joint of the thigh and approached the point in the middle of pleuron but never meets the base of the wing. CLARK (1962) explained psyllids' weakness in flying with an incomplete pleural sulcus. Such a 'helpless' way of flying was also reflected in adjectives in Polish used to refer to this group of insects such as 'twirled up' or 'leaf-letted'. (SZWANOWICZ, 1956). Such an incomplete formation of pleural sulcus was the reason of a false interpretation of

components of mesothorax. Some authors (JOURNET & VICKERY, 1978) considered the transepimeral sulcus in the mesoepimeron to be a pleural sulcus. According to OUVARD *et al.* (2002) the transepimeral sulcus on the mesoepimeron does not have a pleural apophysis on the internal side and thus should be considered as a second sulcus and not a pleural one. A ventral side of mesothorax is constituted by a well visible mesosternum which according to JOURNET & VICKERY (1978) should be treated separately as precoxosternite and postcoxosternite but in the case of *Livia juncorum* these elements are difficult to point out.

Metathorax is unevenly developed on its dorsal and ventral side. The dorsal side is relatively small because muscles on it which move the hind wings are definitely less developed than the muscles of mesothorax. The ventral part, however, in which huge jumping muscles of the third pair of legs are located grows over significantly and, in addition it joins the fore-coxa of the third pair of the legs.

After an analysis of the head and the thorax of *Livia juncorum*, it was stated that the only difference between the male and the female is in the size of the latter. Shapes and proportions between particular elements of the structure of these body parts are the same in the representatives of both sexes. This made the author of this paper analyse the morphology of males and females in other psyllid species: *Cerna sonchi* (Förster, 1848), *Psylla fusca* Zetterstedt, 1828, *Psylla foersteri* Flor, 1861, *Bactericera femoralis* (Förster, 1848), *Paratrioza bielawskii* Klimaszewski, 1963, *Egeirotrioza ceardi* Bergevin, 1926, *Trioza galii* Förster, 1848. Such research allows one to state that in the head and thorax there are no differences in the morphological structure which would result from sexual determination. Thus, it seems justifiable to conclude that in order to carry out such analyses one can interchangeably use either males or females. It seems that the analysis of the head and thorax in the specimens of both sexes is not necessary.

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### **Budowa głowy i tułowia *Livia juncorum* (Latreille, 1798) /Hemiptera, Psylloidea/**

#### **Streszczenie**

W pracy podano charakterystykę budowy morfologicznej głowy oraz tułowia palearktycznego gatunku *Livia juncorum* Latreille, 1798. Zwrócono uwagę na specyficzne cechy morfologiczne głowy wykazywane wcześniej przez innych autorów, takie jak horyzontalne położenie głowy oraz płaskie, wydłużone ciemie, wyraźnie wcięte pośrodku, położone po bokach głowy, wydłużone i spłaszczone oczy złożone, nie wystające poza obrys głowy, guzki czuciowe na głowie czy specyficzne rozdzielenie 2 członów czułka. Wskazano także na wyjątkowe cechy w budowie tułowia: szerokie pronotum, zmniejszenie mesoprescutum, przemieszczenie pleurytów pronotum w kierunku brzuszynym, oraz przemieszczenie płytki przedlinkowej mesothoraxu. Wskazano na brak istotnych różnic w budowie tych części ciała samic i samców tego gatunku.