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RESEARCH ARTICLE

Comparative morphology of pretarsus of the family Dolichopodidae (Diptera)

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Abstract: Forty six species belonging to 24 genera of family Dolichopodidae were investigated to study pretarsus morphology. Length measurements of the fifth tarsal segment, pulvilli, claws and empodium and width measurements of apical part of the fifth segment and claw at the base were performed, and 10 ratios were selected. Researching of morphometric characteristics of Dolichopodidae pretarsus allows the proposal of new taxonomic characteristics.

Key words: Diptera, Dolichopodidae, pretarsus, pulvilli, claws.

Introduction

On the apical end of the fifth segment of tarsi present the terminal segment, usually bearing a pair of claws – the pretarsus (also called the acropod). Its morphological characteristics provide valuable data for a classification system of Diptera in general, and are also useful to diagnose groups within the Order.

Acropod of Dolichopodidae represented by a pair of chitinous claws, under which there is a pair of processes – the pulvilli – arising laterally from a sclerite called basipulvillus (Cumming & Wood 2009). They are aimed to hold an insect on substrate.

The origin of claws is debatable. Hypotheses that the claws formed from a strong pair of apical setae (Sharov 1968), or originated from the lobe-shape overgrowth of pretarsal membrane (Puchkova 1970) have been proposed.

Between the claws there is an unpaired lobe named arolium. An unpaired setiform empodium arises from the ventral part of the arolium. The empodium is located between flap-

like processes named pulvilli. Both the pulvilli and the empodium are the bulging of pretarsal membrane by origin and act as adhesive organs. They have hollow hairs related to tactile perception (Cumming & Wood 2009).

The presence of pulvilli and empodium and the shape of the empodium are important diagnostic characteristics of Diptera and present in virtually all taxonomic groups. The functional significance of the empodium is not fully understood (Puchkova 1970).

The tarsi of Dolichopodidae usually possess setiform empodium and wide pulvilli. Some representatives of the subfamilies Hydrophorinae and Diaphorinae have pubescent empodium along the entire length, or at the base. Males of some genera have modified claws or these structures are lacking (one or both claws). Males of the genera *Mesorhaga* Schiner, 1868 and *Austrosciapus* Bickel, 1994, and several member of the subfamily Diaphorinae, have enlarged pulvilli.

However, morphology of the pretarsal structure was not described for many species of Dolichopodidae and aid to diagnose species only in a few genera: *Asyndetus* Loew, 1869, *Diaphorus* Meigen, 1824, *Neurigona* Rondani, 1856, *Chrysotus* Meigen, 1824 (Van Duzee 1916; Becker 1917-1918; Parent 1938; Negrobov & Stackelberg 1969; Grichanov 2010, 2013).

Material and methods

The aim of this research is to identify new taxonomic characteristics in morphology of pretarsal structure in Dolichopodidae flies. Forty six species belonging to 24 genera of family Dolichopodidae were investigated. Some speciose genera were more broadly sampled allowing examination of specific characters. Thus, we have studied the following genera (number of examined species in parenthesis): *Acymatopus* Takagi, 1965 (1), *Argyra* Macquart, 1834 (1), *Asyndetus* Loew, 1869 (1), *Campsicnemus* Haliday, 1851 (1), *Chrysotus* Meigen, 1824 (1), *Diaphorus* Meigen, 1824 (4), *Dolichopus* Latreille, 1796 (5), *Enlinia* Aldrich, 1933 (1), *Hercostomus* Loew, 1857 (1), *Hydrophorus* Fallen, 1823 (2), *Hypocharassus* Mik, 1878 (1), *Liancalus* Loew, 1857 (1), *Medetera* Fischer von Waldheim, 1819 (3), *Neurigona* Rondani, 1856 (4), *Orthoceratium* Schrank, 1803 (1), *Peodes* Loew, 1857 (1), *Poecilobothrus* Mik, 1878 (1), *Rhaphium* Meigen, 1803 (3), *Scellus* Loew, 1857 (1), *Sciapus* Zeller, 1842 (3), *Thinophilus* Wahlberg, 1844 (1), *Sympycnus* Loew, 1857 (1), *Syntormon* Loew, 1857 (1), *Tachytrechus* Haliday, 1851 (1). Information on morphology were taken from the literature and based on examination of specimens housed in the collection of Voronezh State University.

The study of morphology of the pretarsal structure was made using the drawing apparatus RA-4. The morphometric characteristics were taken according to the constructed figures; measurements were made in relative units. Measurements of the length of the fifth tarsal segment, pulvilli, claws and empodium and the diameter at the apical part of the fifth segment, the thickness of the claw at the base were performed and 10 ratios were selected. Further statistical analysis of the data was carried out by the median test.

Comparison of morphometric characteristics of the groups was based on of the significance of differences using Student's T-test at significance level of 0.95. The boundaries of the confidence intervals were calculated by the method of percentile. To improve the statistical inference was used bootstrap analysis with generation of 5000 samples. The calculations were made in the program SPSS Statistics 20.

Results

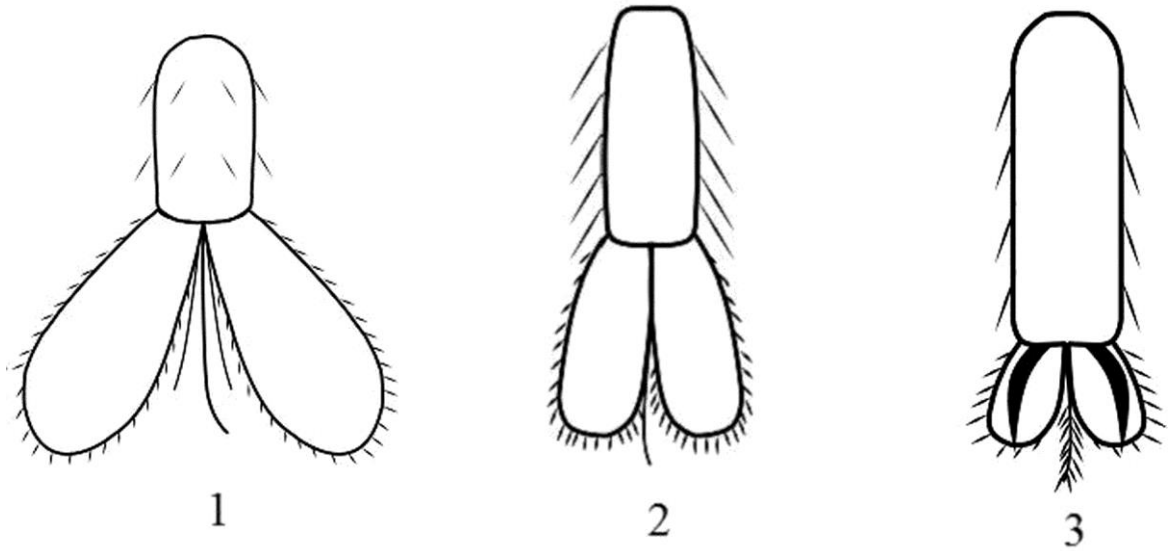
The species of the genera *Diaphorus* Meigen, *Dolichopus* Latreille, *Hercostomus* Loew, *Medetera* Fischer von Waldheim, and *Neurigona* Rondani were studied for comparative analysis of the pretarsal structures on the fore, middle and hind legs and signs of sexual dimorphism. The study of morphological and morphometric characteristics has not revealed significant intraspecific differences between pretarsal structures on fore, middle and hind legs of this genera and differences between male's and female's pretarsal structures, besides those characteristics, which were already mentioned in the literature data for *Diaphorus* Meigen (Parent, 1938). For further analysis, pretarsal structures of male fore legs were used.

The claws

The shape and degree of development of claws from representatives of Dolichopodidae family can vary in the subfamilies and even within genera. Diagnostic characteristics based on the morphology of the claws, have apparently species significance.

1) Presence of claws: claws present (1); claws absent (0).

So the absence of claws in some species of the genus *Asyndetus* Loew (*A. perpuvillatus* Parent, 1926, *A. latifrons* (Loew, 1857), *A. carcinophilus* Parent, 1937) is used as specific diagnostic characteristic (Negrobov & Stackelberg 1969; Grichanov 2013). Developed claws were not found at number of species of the genera *Diaphorus* Meigen and *Physopyga* Grootaert & Meuffels, 1990 on the front legs. Members of the subfamily Diaphorinae eventually show reduction/loss of claws (Figs. 1-3).



Figures 1–3. Pretarsal structure of the species of the subfamily Diaphorinae. **1,** *Asyndetus latifrons* Loew; **2,** *Diaphorus parenti* Stackelberg, 1928; **3,** *Chrysotus laesus* (Wiedemann, 1817).

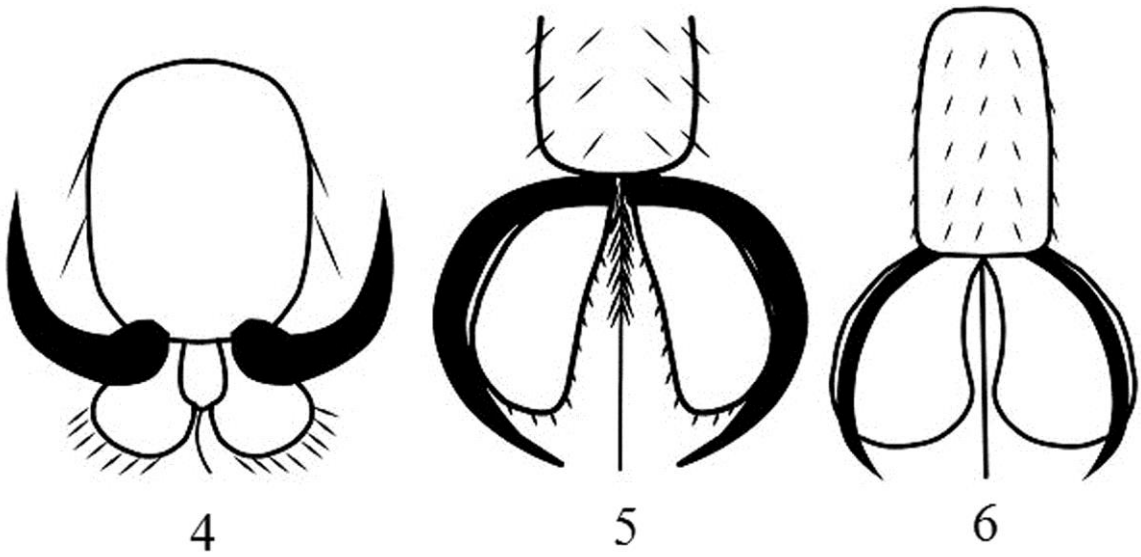
In most cases, the claws of Dolichopodidae are normally developed; claws are equivalent to each other and are the same on all legs. In exceptional cases, there is non-uniform development of claws.

2) Uniformity of development of the claws: both claws are equally developed (1); one of the claws is larger or modified (0).

Several species were described as having uneven claws. The fossil species *Palaeosystenus succinorum* (Meunier, 1907) was described with large external and reduced internal claws (Grichanov *et al.* 2014). More pronounced modifications were observed in some species of the subfamily Neurigoninae: *Macrodactylomyia magnicauda* Naglis, 2002 has an external claw extended and forms a thickened column, a posterior male claw of *Dactylomyia* Aldrich, 1894 species is broadened, *Paracoeloglutus chilensis* Naglis, 2001 and all remaining Coeloglutini have an elongated and curved external claw, while an internal claw is developed normally (Naglis 2001, 2002). In this latter case, it should be talk about tribal diagnostic level.

3) Ratio of the claws length to fifth tarsal segment length: claws are enlarged – ratio of the fifth tarsal segment length to claws length amount is 0.9 to 1.4 (1); claws are normally developed - ratio of the fifth tarsal segment length to claws length is from 1.5 to 1.9 (2); claws are reduced - ratio of the fifth tarsal segment length to claws length is more than 2.0 (3).

Enlarged claws, the length of which reaches half of length of the fifth tarsal segment or exceeds it, are characteristic for the species of Hydrophorinae: *Acymatopus* Takagi, *Orthoceratium* Schrank, *Peodes* Loew, *Hypocharassus* Mik, *Scellus* Loew (Figs. 4-6). Males of the group of species *Krakatauia trustorum* Bickel, 1994 also have enlarged claws (Bickel 1994).



Figures 4–6. Pretarsal structure of the species of the subfamily Hydrophorinae. **4,** *Acymatopus minor* Takagi, 1965; **5,** *Hypocharassus pruinosus* (Wheeler, 1898); **6,** *Orthoceratium lacustre* (Scopoli, 1763).

Another modification is the reduction of claws when they are shorter than half of length of the fifth tarsal segment, or claws are thin. Such claws are characterized by several species of the subfamilies Medeterinae, Neurigoninae, Sympycninae.

This ratio allows the selection of similarity between species of subfamilies Dolichopodinae, Sciapodinae and Enliniinae, as well as the between species of subfamilies Medeterinae and Neurigoninae, Diaphorinae and Hydrophorinae pairs (Fig. 7).

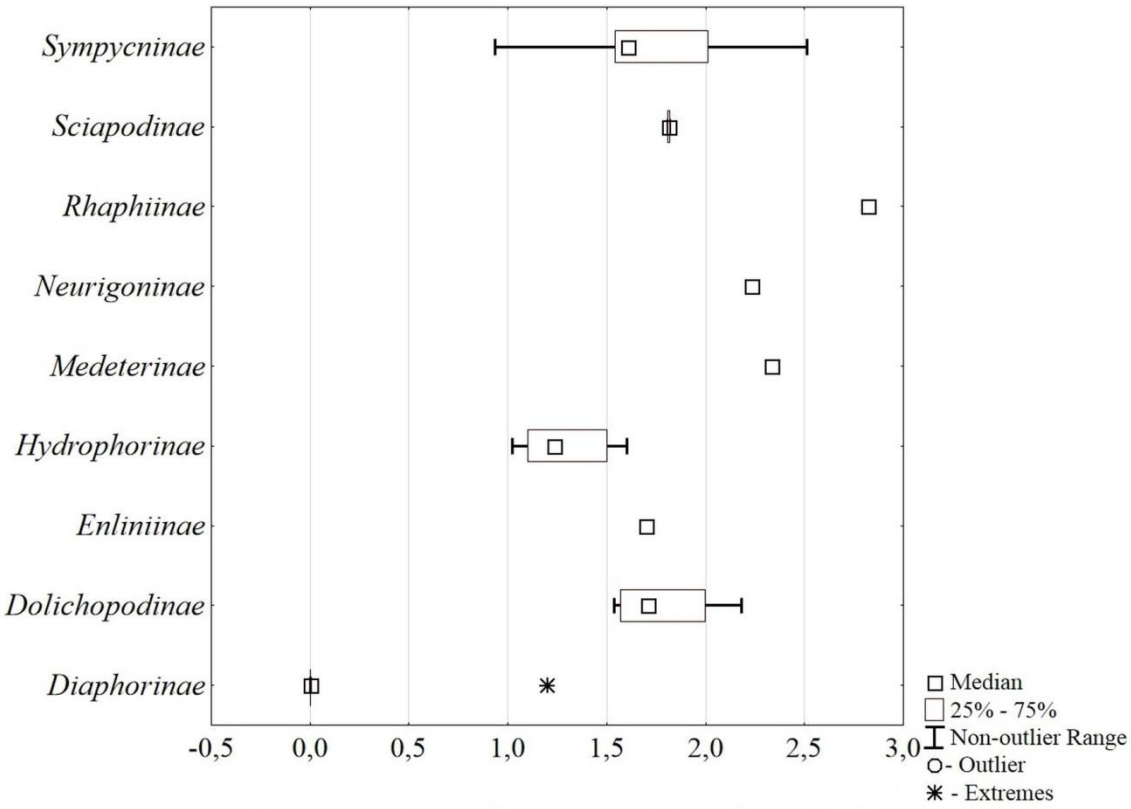


Figure 7. The diagram of median test results for ratio "length of claw / length of the fifth segment" for Dolichopodidae subfamilies (Statistica 10).

Empodium

Empodium of the majority of Dolichopodidae species is thin, setiform, naked, and similar in length to the claws. Setiform empodium, which is equal in length of claws, is characteristics to the genus *Dolichopus* Latreille – the typical genus in the family. Species with modified empodium also were allocated.

4) Shape of empodium: simple and setiform (1); modified (0).

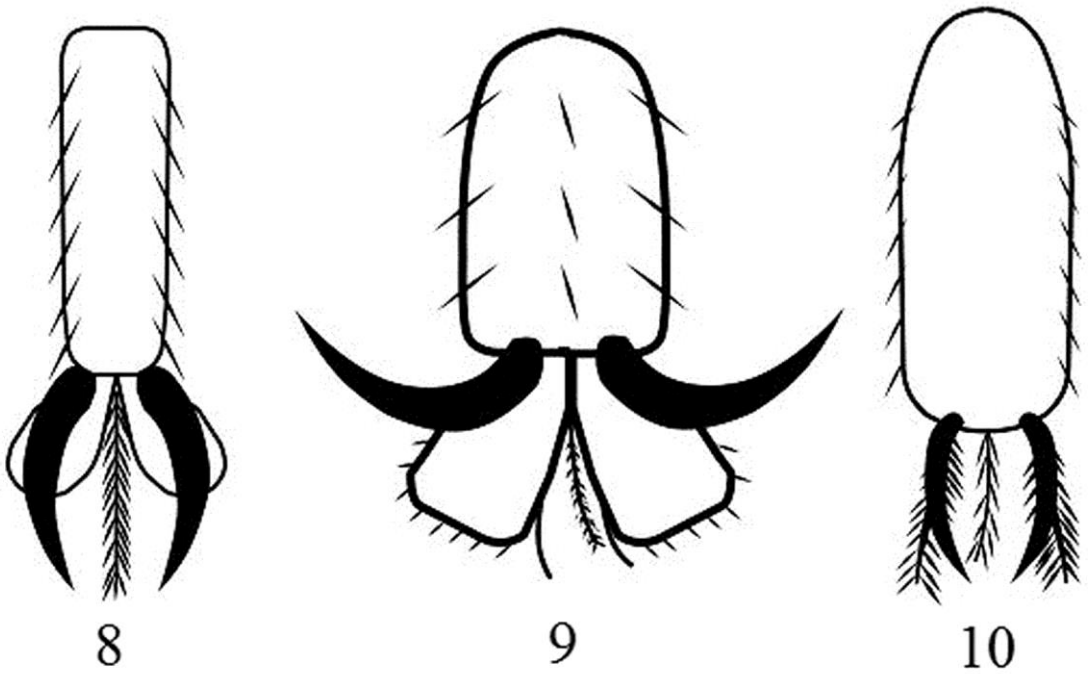
5) Pubescence of empodium: bare (1); densely pubescent (0).

Hypocharassus pruinosus (Wheeler, 1898) is characterized by elongated and densely pubescent at the base empodium (Fig. 5), while in *Acymatopus minor* Takagi, 1965 it is thickened at the base (Fig. 4). The empodium in *Hydrophorus praecox* (Lehmann, 1822), *Argyra diaphana* (Fabricius, 1775), *Campsicnemus lumbatus* Loew, 1857 are covered by hairs (Figs. 8-10).

Morphology of empodium including its length is stable within the family, and its modifications are specific diagnostic characteristics.

Pulvilli

Pulvilli of Dolichopodidae species usually round or oval (Figs. 11-12), but sometimes - trapezoid (Fig. 9), or at least thin and stripform (species *Thinophilus flavipalpis* (Zetterstedt,



Figures 8–10. Pretarsal structure of the species of the family Dolichopodidae. **8,** *Hydrophorus praecox* Lehmann; **9,** *Argyra diaphana* Fabricius; **10,** *Campsicnemus lumbatus* Loew.

1843) (Fig. 13), *Enlinia robinsoni* Steyskal, 1975). Pulvilli always possess short or long hairs.

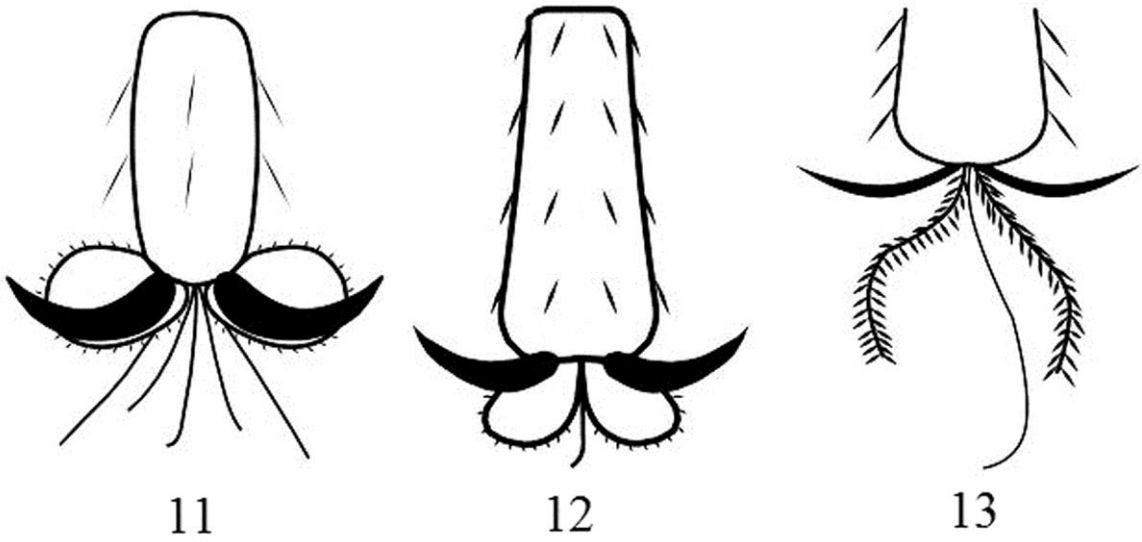
Size of pulvilli can be estimated in comparison with claws length or empodium length. However, in practice it turns out that the estimate of the empodium length is not always possible: because it can be badly visible. The estimation of the pulvilli length to claws length is more objective.

6) Size of pulvilli: two or more times shorter than claws or pulvilli are strongly reduced (1); approximately equal to claws, or a little shorter (ratio of pulvilli length to claws length: 0.6-0.9) (2); longer than claws (ratio of pulvilli length to claws length: 1.0-1.4) (3).

Pulvilli are strongly reduced in species of *Phrudoneura* Meuffels et Grootaert, 1987 with type species *Phrudoneura abbreviatus* Meuffels & Grootaert, 1987 (Sympycninae or *incertae sedis*).

Ratio of pulvilli length to empodium length has also been used as species diagnostic characteristics earlier for some species of the genus *Asyndetus* Loew (Van Duzee, 1916). The representatives of the subfamily Hydrophorinae often have large strong claws and pulvilli are shorter than claws.

Also the ratio of diameter of the fifth tarsal segment to pulvilli length is a representative index. This character split the studied species into two groups (Fig. 14). The representatives of the subfamilies Diaphorinae, Dolichopodinae, Enliniinae were referred to the first group. Their pulvilli are longer than the diameter of the fifth segment. Species of the subfamilies Neurigoninae and Medeterinae, included in the second group, have pulvilli shorter than the diameter of the fifth segment. For the *Sympycnus*, *Sciapus* and *Rhaphium* this characteristics on the scale of the studied specimens is close to unity and statistically may change with increasing of studied data.



Figures 11–13. Pretarsal structure of the species of the family Dolichopodidae. **11,** *Syntormon filiger* Verrall, 1912; **12,** *Medetera diadema* (Linnaeus, 1767); **13,** *Thinophilus flavipalpis* (Zetterstedt, 1843).

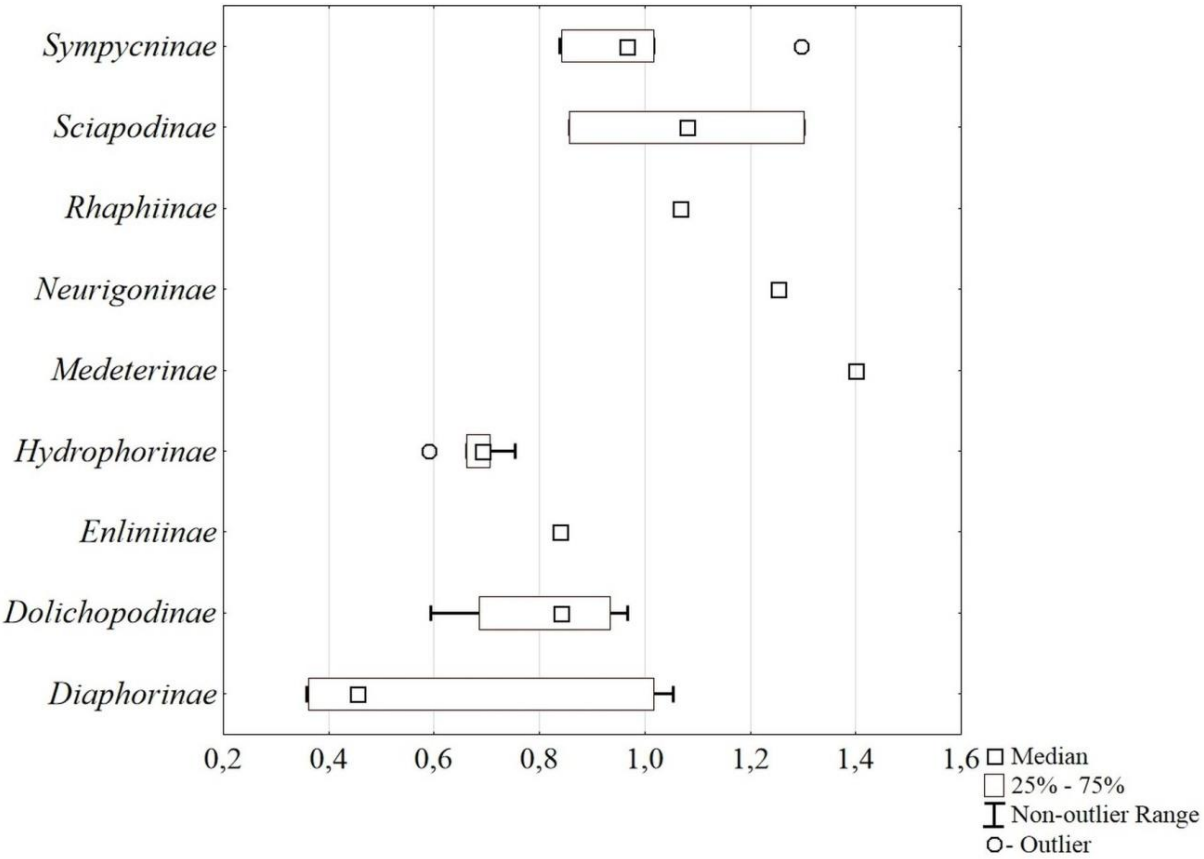


Figure 14. The diagram of median test results for ratio "diameter of the fifth tarsal segment at base / length of pulvilli" Dolichopodidae subfamilies (Statistica 10).

Discussion

The morphology of pretarsal structure can be used to build a system of the subfamily Diaphorinae. The absence of claws allow the including species of the genera *Asyndetus* Loew and *Diaphorus* Meigen in a separate group, this group also includes the genus *Chrysotus* Meigen on account of the relative length of the fifth tarsal segment. However, significant differences in the morphometric characteristics of pulvilli of species Diaphorinae with other members of the family have not been found.

The enlarged claws are characteristic for all examined species of Hydrophorinae. For this subfamily the ratio of fifth tarsal segment length to claws length significantly stands out from other species of the family. Thus, the medial value of the characteristic for the species Hydrophorinae is 1.20, its confidence interval is [1.06; 1.46], whereas for the other species investigated, respectively, 2.21 and [1.57; 2.58]. Also it is possible, for more precise definition of position of the subfamily Hydrophorinae in the system of Dolichopodidae subfamilies, to use the characteristics of pretarsal structures morphology.

Morphometric characteristics of pretarsus structure vary at a great extent in the other subfamilies of Dolichopodidae (useful for both generic and specific diagnostic), it is not possible to identify sustainable regularities of subfamilies level. A similar pretarsus morphometry of species *Medetera* Fischer, *Rhaphium* Meigen, *Neurigona* Rondani, *Sciapus* Zeller and *Dolichopus* Latreille shows up in the ratio of claws length and pulvilli length, which is usual for the family, and a relatively small ratio of claws length to the fifth tarsal segment length. Modifications of empodium (pubescence) and pulvilli (narrow, stripform) morphology are observed in different taxonomic groups of the family and are not correlated with other characteristics of morphology and morphometry.

The obtained data are preliminary; morphology of pretarsus structure requires additional investigation and a broader survey of species in future studies.

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