

Development of male pedipalps prior to the final moulting in *Pholcus phalangioides* (Fuesslin) (Araneae, Pholcidae)

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ABSTRACT

In most spiders (except for Mygalomorphae), copulatory organs are known to develop in the last phase of growth - before final moulting. However there is little data concerning developmental changes in males' pedipalp and differentiation of their copulatory organs. Here, morphological changes in the development of male pedipalp in *Pholcus phalangioides* are described and the duration time of stages during this process is estimated. In the laboratory, spiders showed significant differences in duration time of every stage, especially in the last phase consisting of this 3 stages in itself.

INTRODUCTION

Male pedipalps in *Pholcus phalangioides*, like in any spiders, are more complex than female ones. These differences, however, appear only in adult individuals and in late stages of juvenile phases, prior to the final moulting. This is connected with the development of male copulatory organs in the last phase of growth - before moulting to the mature stage. In *P. phalangioides* differences in size and complexity between a male and a female pedipalp are significant (Uhl *et al.* 1995) and it is remarkable that such complex male palps emerge in just one step from simple juvenile ones. Another interesting question is how much time is required for a male *P. phalangioides* to develop its copulatory organ, in other words, how long the 5th phase of growth lasts (Tyshchenko 1971) in comparison to the previous phases (Fig. 1) (Bartos unpubl.).

MATERIAL AND METHODS

Young individuals of *P. phalangioides* were collected from several town houses in Łódź and cottages in Kampinoski National Park during winter 1995/96.

The spiders were kept separately in glass chambers (15 x 6 x 6 cm). The rearing room was maintained at 18-25 °C. The spiders were fed with 4

Drosophila melanogaster twice a week. The rearing chamber was moisturized with about 1 ml of water twice a week.

Morphology and position of the pedipalps were observed on the living spiders without any device. The males sacrificed to investigate palpal anatomy were previously chilled to death. The pedipalps were isolated and investigated with a Jenamed 2 (Zeiss Jena) light microscope. Microphotographs were taken using the same microscope and photographing device.

Observations of morphological changes were noted about every 5.5 days.

RESULTS

Characteristic differences in appearance of the male pedipalps during the last phase of growth allowed me to distinguish 3 stages in pedipalp development. Pholcids in these stages were named according to their state of maturity as: postjuvenilis, immaturus and subadultus.

I. Male pedipalp morphology and duration time of the stages

Stage I: *postjuvenilis*

This stage begins with termination of the 4th moulting and ends with changes in the pedipalp size and shape. The male pedipalps were very similar to females or juveniles. They had no swelling and their tips were pointed downwards (Fig. 5). Mean duration time of stage I was 64 days ($n = 9$, $sd = 42.7$), min. 27 days, max. 148 days.

Of the last growth phase, stage I took about 80 % of the time. Variability of stage I duration time is shown on Fig. 2.

Stage II: *immaturus*

Lasts from appearance of swelling on the distal end of the pedipalps, to a substantial increase in their volume and the bending of their distal ends to the horizontal position. The male pedipalps in stage II were swollen on its distal end, which made them spindle-shaped. They were the same length as the female ones but their distal parts were several times wider. Tips of the male pedipalps were pointed downwards, and in the end of this stage, the distal part of the male pedipalp bent slightly forwards (Fig. 5). Mean duration time of stage II was 7 days ($n = 9$, $sd = 4.1$), min. 1 day, max. 14 days.

Of the last growth phase, stage II took about 9 % of the time. Variability of stage II duration time is shown on Fig. 3.

Stage III: *subadultus*

This stage begins with a change in the shape of the pedipalp from a spindle to an elongated club. The end of the stage is the final moulting. In this stage the pedipalps were elongated and their distal parts were considerably swollen. They resembled a club bent in two points. In the end of stage III, dark structures were noticeable inside the distal end of the pedipalp. During this stage the distal end of the pedipalp is in the horizontal position

and is pointed forwards (Fig. 5). Mean duration time of the stage III was 10 days ($n = 31$, $sd = 4.7$), min. 3 days, max. 25 days.

The final stage takes the remaining 11 % of the last growth phase duration time. Variability of the stage III duration time is shown on Fig. 4.

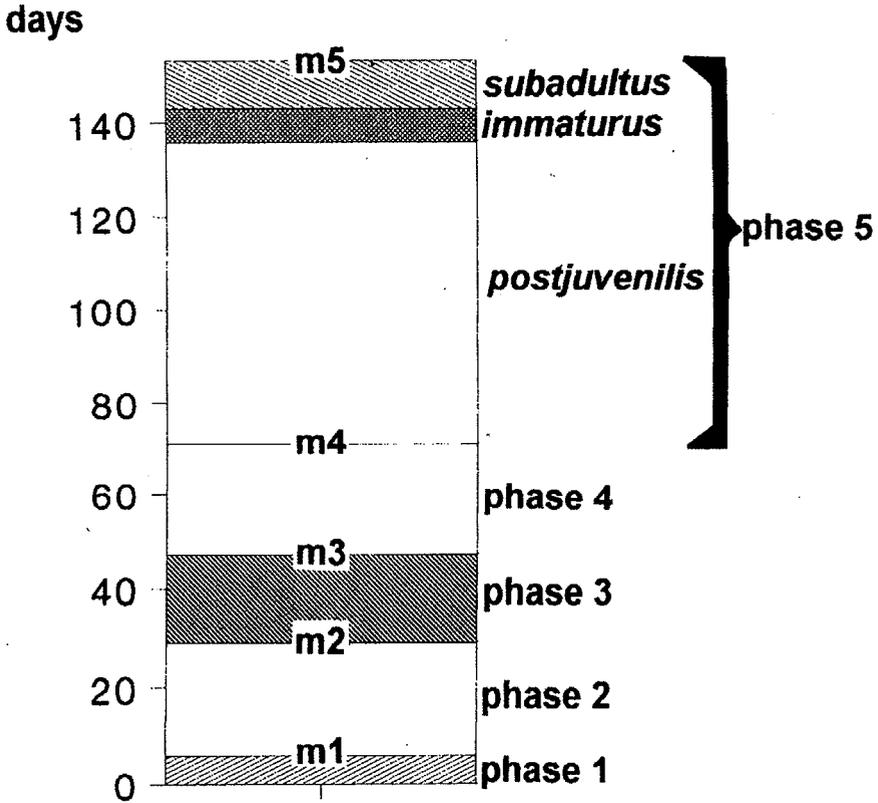


Fig. 1. Duration time of the phases in the development of *Pholcus phalangioides*; m - moults.

II. Mature male pedipalp morphology

External appearance of the mature male prosoma and pedipalpus are shown on Fig. 5.

III. Male pedipalp anatomy in the stage III

Several days before moulting to maturity, structures inside the male pedipalps were visible through their walls (Fig. 6A-B). Some of them were

twisted (embolus, uncus) but only the most sclerotized procurus was straight. The procurus had an apophysis on the top and a row of hair along one of its margins. Ductus ejaculatorius was noticeable through the walls of the embolus. The structure on the Fig. 6A between uncus and embolus is (comparing to mature male pedipalp, as on Figs. 7A, B) presumably an appendix.

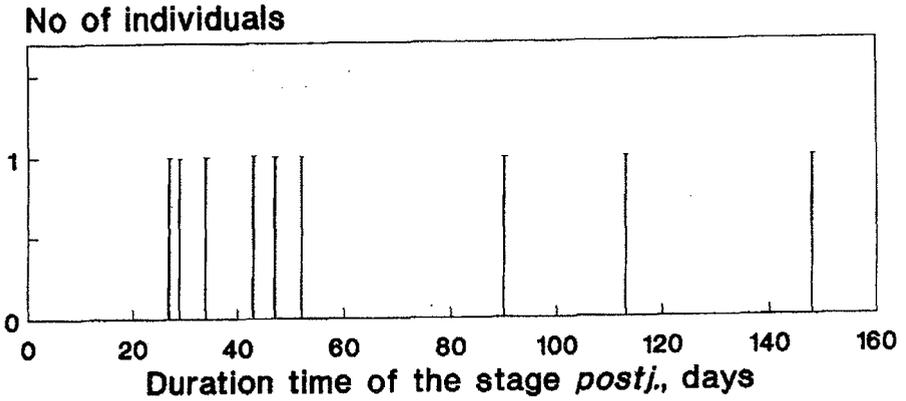


Fig. 2. Variability of the stage I duration time.

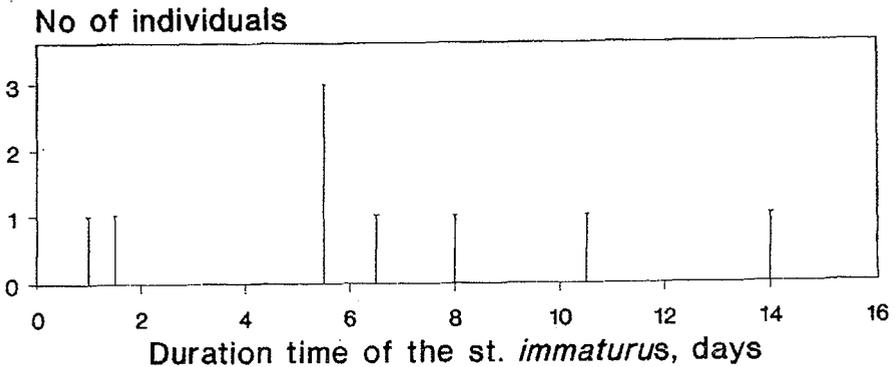


Fig. 3. Variability of the stage II duration time.

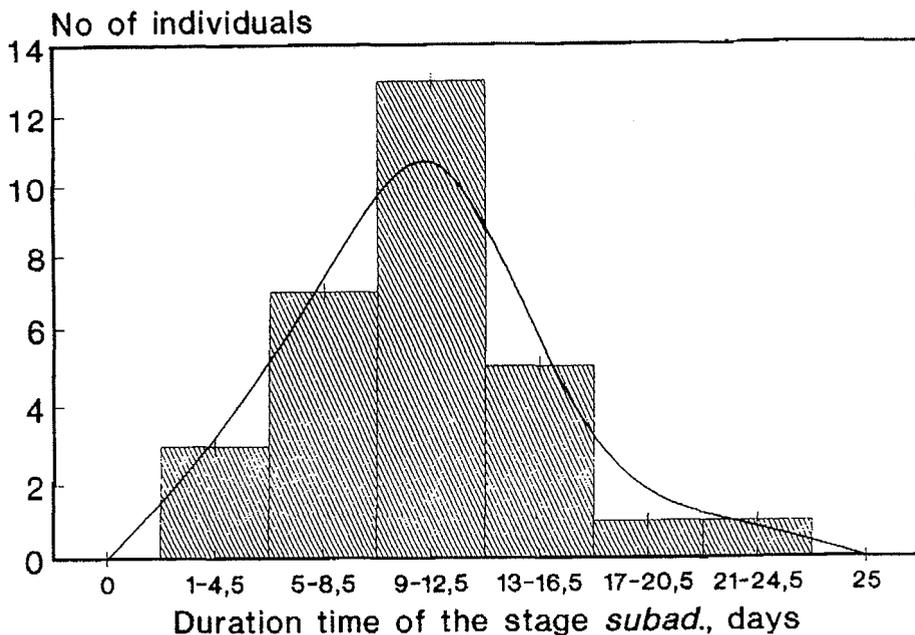


Fig. 4. Variability of the stage III duration time.

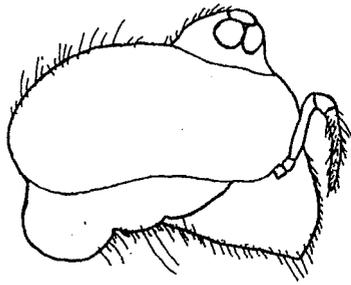
DISCUSSION

During the last phase of growth a male pedipalp in *P. phalangioides* increases his volume several times and changes his shape and position. These morphological changes are mainly connected with a differentiation of particular structures in the male copulatory organ.

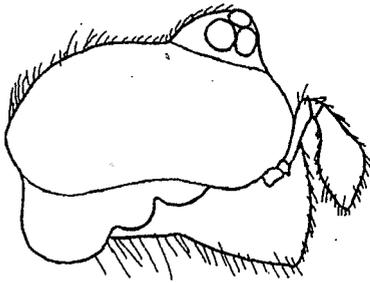
The extreme changes in pedipalp size during his development suggest that during the last phase of growth this structure is not so hard. Chitinous walls of pedipalp have to be soft and extendible enough to allow space for developing structures inside the pedipalp. Sclerotized structures of the male copulatory organ also have to be relatively elastic (e.g. uncus twisted on Fig. 6A) and harden only after final moulting.

Duration time of the last phase of growth is several times longer than any other phase. This has to be connected not only with the growth of different kinds of tissues prior to moulting but also with development of male copulatory organ and changes in male pedipalp.

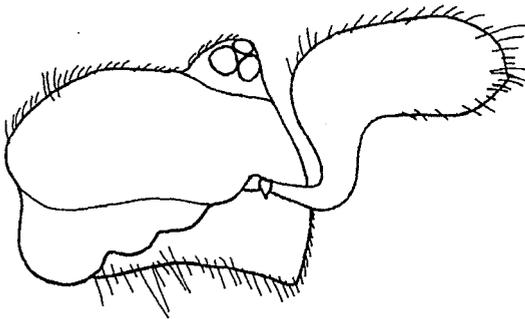
Another interesting aspect is also the great individual differences in duration time of the last phase of growth and of every stage this phase consists of. The differences cannot be ascribed to rearing conditions, which were the same for every spider. However juvenile spiders were caught at different ages, and their life history in the early phases of growth might influence latter phase of growth duration time.



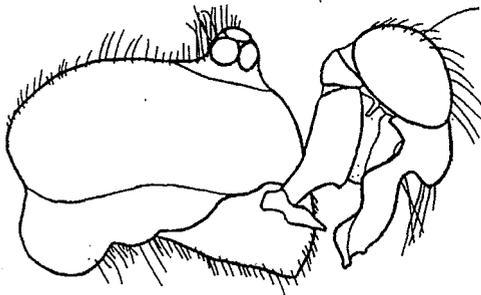
postjuvenilis



immaturus



subadultus



adultus

Fig. 5. Appearance of prosoma and pedipalpus of *P. phalangioides* in stage I (*postjuvenilis*), stage II (*immaturus*), stage III (*subadultus*) and in mature male (*adultus*)

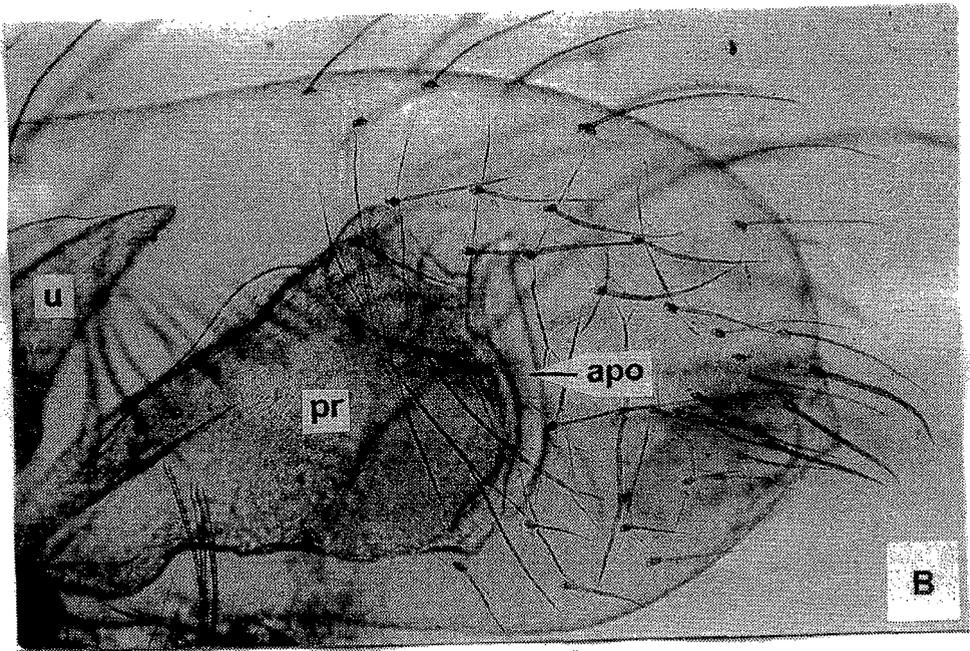
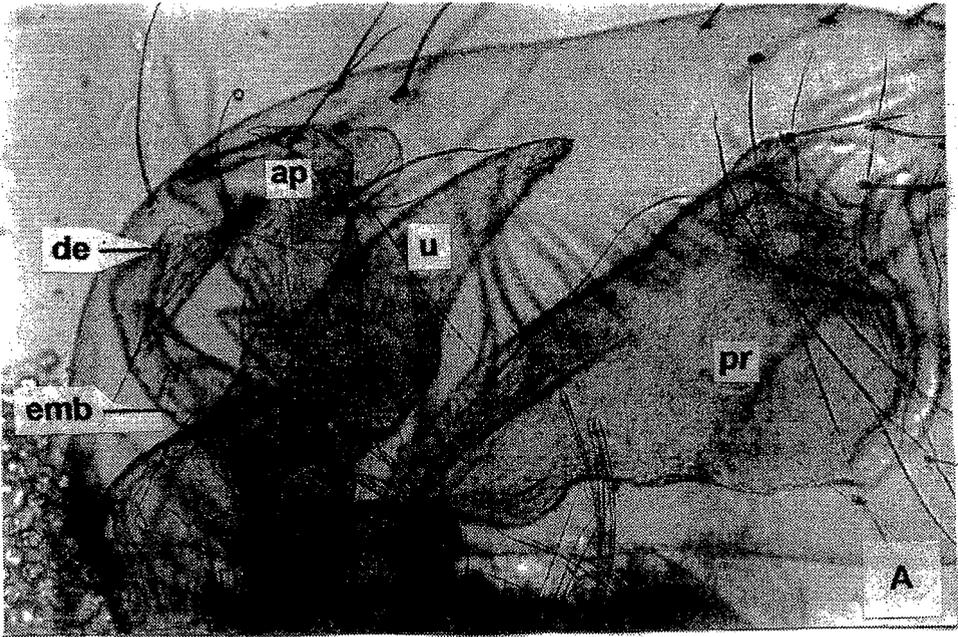
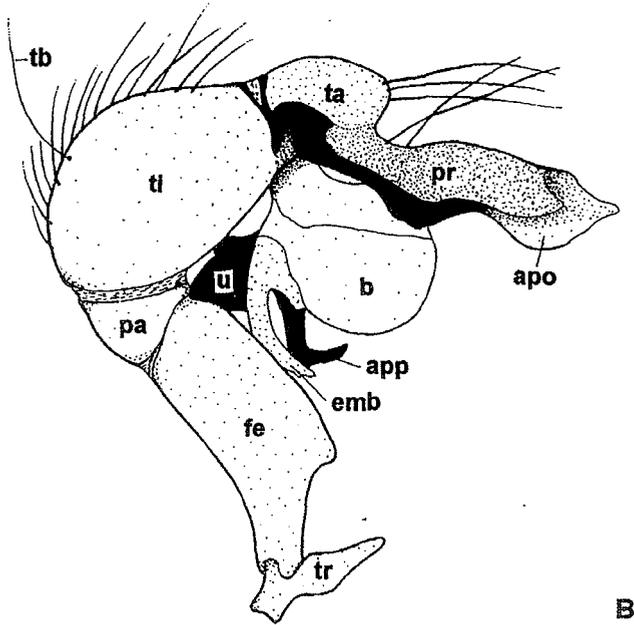


Fig. 6. The swollen (apical) part of male pedipalp in few days before last moulting, A - proximal fragment, B - distal fragment, ap - appendix, apo - apophysis, de - ductus ejaculatorius, emb - embolus, pr - procurus, u - uncus.



Figs. 7A, B. Mature male pedipalp; ap - appendix, apo - apophysis, b - bulbus, emb - embolus, fe - femur, pa - patella, pr - procursus, s - unidentified structure localized close to the male embolus, ta - tarsus, tb - trichobothrium, ti - tibia, tr - trochanter, u - uncus.

CONCLUSIONS

1. The male copulatory organ, which develops in the last phase of growth is formed definitely only a few days before the final moulting.
2. Development and differentiation of the male copulatory organs, because of their complexity, are gradual and may last up to about 180 days.
3. Males of *Pholcus phalangioides* exhibit great individual variability in duration time of the final phase of growth, ranging from about 50 to 180 days.
4. Particular elements of the male copulatory organs are tightly situated inside the immature pedipalps and only after final moulting achieve their proper position.

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