Proceedings of the 15th European Colloquium of Arachnology. Edited by V. Růžička
Institute of Entomology, České Budějovice, pp. 84–88 (1995)

Notes on spinning activity and the way of life of the spiders *Cyrtophora citricola, Argyrodes gibbosus* and *Holocnemus pluchei*

JAROMÍR HAJER

Department of Biology, J. E. Purkyně University, České mládeže 8,
400 12 Ústí nad Labem, Czech Republic

Spinnerets, spinning activity, orb-webs, kleptobiosis

Abstract. Spinning activity of the spiders *Cyrtophora citricola, Argyrodes gibbosus* and *Holocnemus pluchei* was studied. The subadult and adult males of *Cyrtophora* do not build horizontal orb and can be designated as kleptobionts. The male spinning apparatus differs from the female's, namely by the appearance of the two functional glandulae ampullaceae on each of the anterior spinnerets. The kleptobiont *Argyrodes gibbosus* attacks the cocoons of *Cyrtophora citricola* only after the death of the host female. The spider *Holocnemus pluchei* living in the webs of *Cyrtophora* changes foraging strategy depending on the presence or absence of the original host.

INTRODUCTION

Cyrtophora citricola (Forskal, 1757) belongs to the family Araneidae. Spiders of this family are often considered as the apex of the spider's evolution. Araneid orbweavers usually construct two-dimensional, vertically situated sticky webs. In this respect the spiders of the genus *Cyrtophora* (Simon, 1864) are exceptional since the base of their spatial web is always the three-dimensional tangle of fibrils. The circular, completely dry web is built-in and situated horizontally. The web complex of *Cyrtophora* resembles the webs of the widely occurring spiders of the Linyphiidae family. This fact has recalled the longtime discussion about the actual phylogenetic position of the genus *Cyrtophora.* In both cases a knock-down trap is used for "hunting" (Lubin, 1980). For example Kullmann (1964) derived the *Cyrtophora* spiders from the family Linyphiidae, but later he also admitted theridial ancestors (Kullmann, 1971). Kullmann also believed that the type of *Cyrtophora* web is a precursor of proper orb-webs. Among many controversial views there exists a remarkable idea of Wiehle (1928). He suggested that the threads of the horizontal sheet of *Cyrtophora* correspond to a dry, temporary spiral that other orb-weavers build before they make a final spiral covered by a viscid secretion. Later the temporary spiral is digested and recycled. Wiehle further showed that in such a case *Cyrtophora* have to miss a special subsystem of glands which produce a thread covered by a viscid secretion. It is used by typical orb-weavers with two-dimensional webs to catch insects. The idea of Wiehle was later confirmed by Kovoor and Lopez (1982), who definitely confirmed that *Cyrtophora* lacks the so-called triad complex of the aggregate and flageliform glands and their corresponding spigots on the posterior spinnerets. The authors described two types of the piriform glands of adult females. The triad complex has become a key question to solve the phylogenetic position of the *Cyrtophora* genus. An answer could be provided by the

study of the complete ontogenetic cycle, especially the youngest developmental stages. The most competent study of the spinning apparatus of the adult *Cyrtophora* females was probably done by Peters (1993). He confirmed the existence of two types of the piriform glands and their spigots. This is the only case among spiders. Prof. Peters suggested the idea that some piriform glands secrete material for transverse connecting threads of the horizontal sheet. At present the team led by Prof. E. Tillinghast from the Department of Zoology, University of New Hampshire, USA is also involved in the research of the spinning apparatus of the orb-weavers *Cyrtophora citricola*. The team carries out analyses of chemical composition of threads, namely differences between female and male threads. As concerned spinning activity of females, web construction and the spinning apparatus, it is without any discussion that the *Cyrtophora* genus represents one of the best known genera.

On the other hand the spinning apparatus of adult males has not been sufficiently described yet and till now, nobody has studied the spinning apparatus of subadult males. The structure of the male spinning apparatus in the subadult stage as well as the adult stage of the life cycle is the main subject of this paper. I considered it necessary to verify the hypothesis of Prof. Peters concerning the existence of special piriform glands assigned for weaving of material for the horizontal sheet. I started from the point that males not constructing such a type of web, cannot possess these glands.

In the study of kleptoparasitism I focused on the conditions under which *Argyrodes gibbosus* (Lucas, 1846) attacked cocoons of *Cyrtophora*. A part of this work also describes a competition for prey between the host, i.e. female stages of the life cycle of *Cyrtophora citricola* and kleptobionts. The latter include not only *Argyrodes gibbosus* (family Theridiidae) and *Holocnemus pluchei* (Scopoli, 1763) (family Pholcidae) but all male stages of the *Cyrtophora* genus as well.

MATERIAL AND METHODS

Natural material was collected in the region of Catania, Sicily in August 1993. Only adult females were taken (eleven individuals of *C. citricola* and seven individuals of *A. gibbosus*). The living spiders were kept in plastic boxes or free in the laboratory and greenhouses. The number of the young *Cyrtophora* individuals which hatched in the greenhouses reached several hundreds. The young of *Argyrodes* were alive till the nymph stage of the second instar and then they died.

The scanning electron microscope TESLA BS 340 and the light microscope JENAMED 3 were used to study the spinning apparatus. Bouin mixture was used to fix specimen, and the combination of dyes haematoxylineosin was used to distinguish acidophilic and basophilic parts of glands. Special histochemical tests were not carried out.

RESULTS AND DISCUSSION

Spinning activity of the males of *Cyrtophora citricola*

Considerable sexual heterogeneity was found among the individuals of *Cyrtophora*. The body length of female can be 15–17 mm while the male body reaches 2–3 mm only.

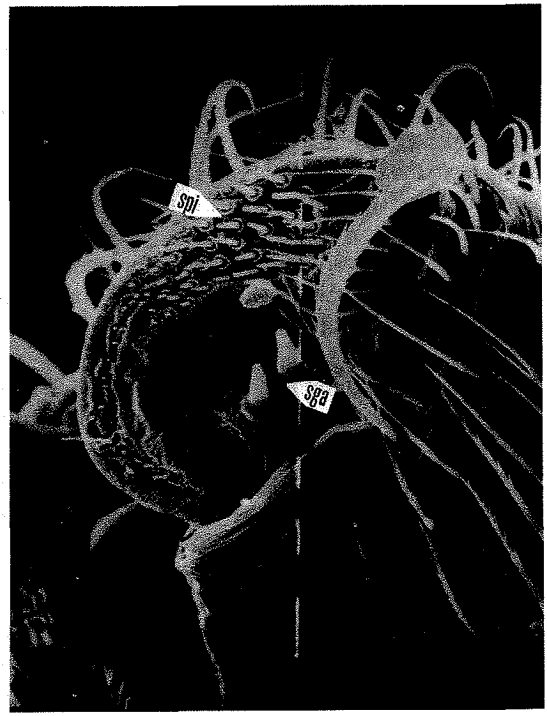

Fig. 1. Detail of the spinning area of the anterior spinneret of the subadult male *Cyrtophora citricola*. Sga—spigots of the two, fully functional glandulae ampullaceae, spi—spigots of glandulae piriformes. Scale line = 10 μm.

Males raised in the laboratory never built a web to hunt for food in any stage of their life cycle. Already in the nymphal stage of the second instar they were at the periphery of the maternal web, resp. in the periphery of webs of the nymphs that later developed to females. Several males could inhabit in a single female web. After both sexes reached sexual maturity only are male stayed in the centre of the web close to the female's "retreat". He was not attacked by the female. This male copulated with the female and also shared her prey. Other males, including the subadult individuals, occupied the periphery of the web where they lived on small insects omitted by the female. They competed with the kleptoparasitic spiders *Argyrodes gibbosus* and *Holocnemus pluchei* (in nature probably with other pholchids too).

The spinning apparatus of males is formed by three pairs of spinnerets, the spinning glands and their spigots:

□Anterior spinnerets (AS). On each of them there are two glandulae ampullaceae major, which are provided with two large spigots. The spigots differ in the ultrastructure of distal parts. Another type of gland represents a great number of the glandulae piriformes. The size of their spigots is different. The smallest spigots (of 80–90) are located at the margin of the vacant place which extends in the caudoventral direction and reaches the median spinnerets;

□Median spinnerets (MS). Each of them is equipped with one glandula ampullacea minor and several glandulae aciniformes. The glandulae aciniformes were developed into two types and their spigots differ in size and shape;

□Posterior spinnerets (PS). Each of them is provided with glandulae aciniformes which spigots are concentrated in two groups of 20–25. I consider the possibility that each of these groups has different function.

There exist the following main differences in the structure of the spinning apparatus of males and females: The females have only one glandula ampullacea functional on each anterior spinneret; the other is reduced starting from the nymphs of the second instar. I consider the fact that this gland persists in male population during the whole life as the most significant feature of their spinning apparatus. In other genera, studied up to now this gland disappears in both sexes and its spigot is rudimentary. On MS and PS no glandulae tubuliformes are developed; this is understandable since during the evolution of spiders this type of gland was developed for secretion of the material used for construction of cocoons.

The spinning apparatus of males is very similar to the apparatus of the young individuals leaving the cocoon. The only difference is that the young have the remains of the triad complex clearly visible.

The viscid threads produced by this triad in other Araneidae, are missing in the webs of *Cyrtophora*, but their presence in early developmental stages clearly proves that their ancestors wove webs containing an adhesive spiral.

As mentioned above, Prof. Peters supports the idea that the part of the piriformic glands and their spigots on the anterior spinnerets is used for transverse conjunctions between the radial threads of the horizontal orb. Since the same spinnerets and the same arrangement of spigots males was found on males that did not build orbs, the hypothesis seems improbable. There are no substantial differences in the architecture of the spinning apparatus of subadult and adult males. The adult males lived between 26 and 182 days in laboratory conditions. They always died hanging on drag lines. The size of the sample of examined males was 42 individuals.

Kleptobionts

Argyrodes gibbosus belongs to the family Theridiidae. The three-dimensional web is characteristic for spiders from this family. Therefore the three-dimensional, 'theriidal' parts of the *Cyrtophora* webs create suitable pre-adaptation conditions for potential theriidal guests that do not build webs but just settle in webs of the spiders . This strategy enables them to reduce lower metabolic costs (Volrath, 1987).

The spider *Argyrodes* steals insects caught on the peripheral tangle above and under the horizontal sheet. These are always very small insects, not attacked by the *Cyrtophora* spiders. *Argyrodes* is protected by the web as well as its cocoons hanging on a threads produced by *Cyrtophora*. The young of *Cyrtophora* may become the source of food for *Argyrodes* under certain conditions; this could be a key for the mutual relationship. Under laboratory conditions (and undoubtedly also in nature) *Argyrodes* attacks cocoons of *Cyrtophora* only after the death of female. The cocoons appear always in series (5–6) connected one to another and are laid vertically. The female herself can tear through two or three only.

After the death of the female, *Argyrodes* moves on to her cocoons, touching it with its long, slender legs. As soon as *Argyrodes* registers vibrations caused by the hatching young, it opens a hole in the wall in 2–3 minutes and the young leave the cocoon. One or two are usually hunted by *Argyrodes* allowing the others (about 150 in one cocoon) to escape.

The females of *Argyrodes* build its cocoons near by cyrtophora's egg-sacs. The first food of the spiderlings of *Argyrodes* is a fine silk which is woven by the specimens of cyrtophora's first nymphal stages. I consider a possibility that these silken threads originated by the spinning activity of the second pairs of glandulae ampullaceae of anterior spinnerets. The last named glands, as well as their spigots, are functional only with first nymphal stages of both sexes and later on males (including their subadult stages).

The second kleptobiotic species occurring in webs of *Cyrtophora* is *Holocnemus pluchei* that belongs to the family Pholcidae. The spiders of this family are, due to the extremely long and delicate legs, well pre-adapted for kleptobiosis. Their slow, sneaky movements cause only imperceptible vibrations of a web. The behaviour of the spider *Holocnemus pluchei* and its spinning activity principally depends on the fact whether the web is or is not occupied by the original builder and host. In the situation when the web is controlled by *Cyrtophora*, *Holocnemus* does not build its own web. It stays in the peripheral part of the host's web and fed on small arthropods which get stuck there. If there is a lack of this food, the spiders approach the centre of the web and steal the prey that was hunted, digested and guarded by their host. Here they might touch the host with their forelegs without being attacked. When the original host dies or leaves the web *Holocnemus* uses the threads of the host's web as a base for construction of its own, approximately ball-shaped web. It serves as a retreat and snare; in many points it is reinforced by a secretion that does not have fibrilar structure.

REFERENCES

KOVOOR J. & LOPEZ A. 1982: Anatomie et histologie des glandes séricigénes des Cyrtophora (Araneae, Araneidae) : affinités et corélations avec la structure et la composition de la toile. *Rev. Arachnol.* **4**: 1-21.

KULLMANN E. 1964: Neue Ergebnisse über den Netzbau und Sexualverhalten einiger Spinnenarten (Cresmatoneta mutinensis, Drapetisca socialis, Lithiphantes paykullianus, Cyrtophora citricola). *Z. Zool. Syst. Evolutionsforsch.* **2**: 41-122.

KULLMANN E. 1971: Bemerkenswerte Konvergenzen in Verhalten cribellater and ecribellater Spinnen. *Freunde Kölner Zoo* **13**: 123-150.

LUBIN Y. D. 1980: The predatory behavior of Cyrtophora (Aranea, Araneidae). *J. Arachnol.* **8**: 159-185.

PETERS H. M. 1993: Functional organization of the spinning apparatus of Cyrtophora citricola with regard to the evolution of the web (Araneae, Araneidae). *Zoomorphology* **113**: 156-163.

VOLLRATH F. 1987: Kleptobiosis in spiders. In Nentvig W. (ed.): *Ecophysiology of Spiders*. Springer, Berlin, 274 pp.

WIEHLE H. 1928: Beiträge zur Biologie der Araneen, insbesondere zur Kenntnis des Radnetzbaues. *Z. Morphol. Ökol. Tiere* **11**: 115-151.