

## Copulation and emasculation in *Echinotheridion gibberosum* (Kulczynski, 1899) (Araneae, Theridiidae)

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### Abstract

In *Echinotheridion gibberosum* (Kulczynski, 1899) from the Canary Islands and Madeira copulation regularly ends in emasculation and sexual cannibalism, which is unusual among spiders. The male dies already at the beginning of insertion. After ca. 4 min of insertion, the female amputates the single male palp by circling. The disconnected gonopod remains fastened to the epigynum for about 5 hours, probably acting as a non-permanent mating plug. During this period, the palpless male is consumed by the female. In a new species of the closely related genus *Tidarren* similar behaviour has already been observed.

**Key words:** Copulatory behaviour, emasculation, sexual cannibalism, *Echinotheridion*, *Tidarren*, Theridiidae, Canary Islands.

### INTRODUCTION

The genus *Echinotheridion* Levi, 1963 is considered to be closely related to *Tidarren* Chamberlin & Ivie, 1934 (Wunderlich 1992). In both genera males are dwarf and possess only one palp (Fig. 1), which is unique among spiders. Generic separation is mainly based on a female character, spurs on the fourth coxae, which are typical of *Echinotheridion*. In *Tidarren* outstanding behavioural traits were found. Males amputate one of their palps after the penultimate moult. The single-palp copulation routinely ends in sexual cannibalism (Branch 1942; Knoflach & van Harten 2000). *Tidarren argo* Knoflach & van Harten, 2001 (from Yemen) even synchronises copulation and sexual cannibalism by amputation of the male palp, which then remains attached to the epigynum as an ephemeral mating plug, while the female feeds on the emasculated male (Knoflach & van Harten 2001). Does similar behaviour occur also in *Echinotheridion*? To answer this question, it was of interest to investigate more closely the

only Old World representative of this genus, *E. gibberosum* (Kulczynski 1899) from the Canary Islands and Madeira, and to re-evaluate a first casual copulatory observation on this species by Schmidt (1980). Self-removal of a palp was already suggested for *Echinotheridion* by Levi (1980)



**Fig. 1.** *Echinotheridion gibberosum*. Copulation, late phase, right palp inserted; female already has started to turn around.

and Ramirez & Gonzalez (1999), but has not been observed hitherto. Even emasculation might be expected, as once a female was found with the male palp fixed to the epigynum (Ramirez & Gonzalez 1999).

#### MATERIAL AND METHODS

Specimens of *Echinotheridion gibberosum* were collected in pine and laurel forest on Tenerife, Canary Islands, above Orotava/Aguamansa and in mts. Anaga, near Las Mercedes, February 2000. They were maintained in plastic boxes at room temperature. Behaviour was observed with a stereo microscope with horizontal objective body (Nikon SMZ-2B), magnification up to x50. Five copulations were videotaped with a SONY DXC-325P. Altogether 25 successful copulations were observed, all referring to virgin pairs. There are differences in the numbers given for each copulatory element, as it was not possible to record all

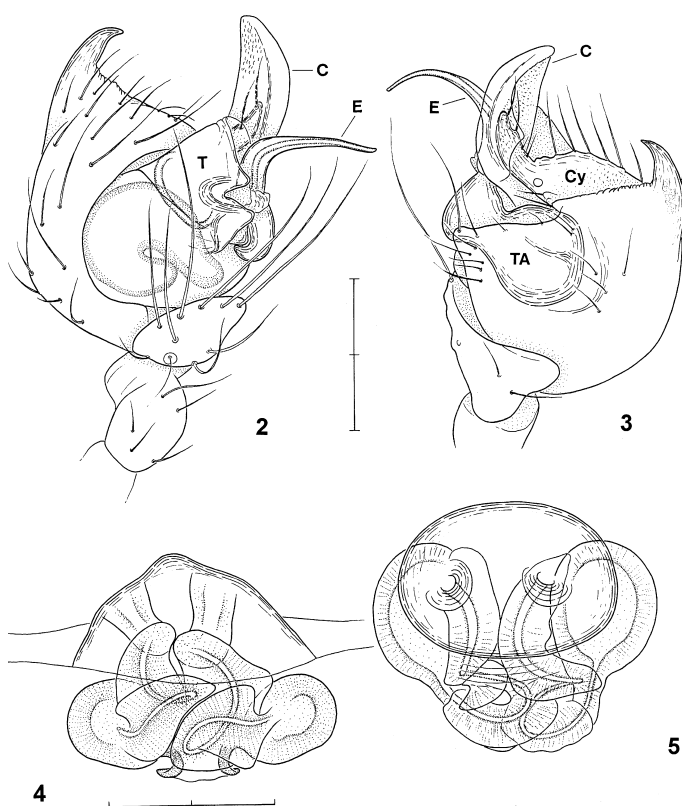
traits with the same accuracy in each observation. Functional contact of genitalia was analysed in 8 females freezed after emasculation, with the aid of a stereo- and compound microscope.

#### RESULTS

##### Morphology

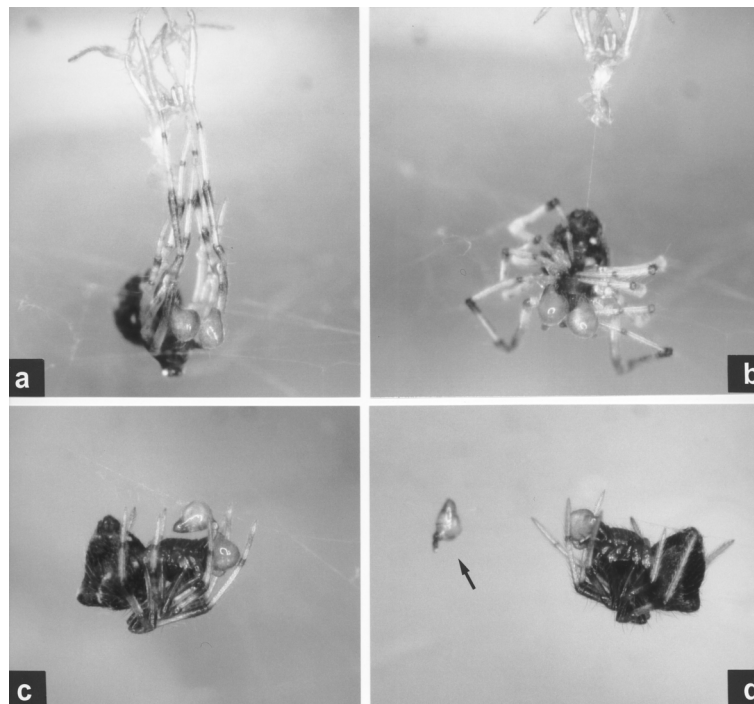
Dimensions of male / female [mean (min-max), n = 10]: body length 1.7 (1.4 - 1.9) / 3.5 (3.3 - 3.7), prosoma length 0.7 (0.6 - 0.7) / 1.4 (1.3 - 1.6), prosoma width 0.6 (0.5 - 0.6) / 1.1 (1.0 - 1.2), length femur I 1.3 (1.2 - 1.4) / 3.0 (2.7 - 3.4), tibia I 0.8 (0.8 - 1.0) / 1.9 (1.8 - 2.2) mm; femur of male palp ca. 0.3 mm long.

All adult males possess only one palp. Out of 45 males investigated, 20 had the left and 25 the right palp. The male palp is pincershaped, owing to the strongly protruding cymbium and conductor (Figs. 2, 3, 9, 10), see also Schmidt (1981; sub *Tidarren pseudogibberosum* Schmidt, 1973). The cymbium ends in a hook-like, apical process and



**Figs 2 - 5.** *Echinotheridion gibberosum*: (2) Right male palp, prolateral. (3) retrolateral-apical. (4) epigynum/vulva, aboral. (5) ventral. Scale lines: 0.2 mm. Abbreviations: C: conductor, Cy: cymbium, E: embolus, T: tegulum, TA: tegular apophysis.

**Fig. 6.** *Echinotheridion gibberosum*. (a) Ecdysis into subadult stage of male. (b) Moulting completed, legs bent, both palps present. (c) Early phase of amputation, circling with left palp raised. (d) Another specimen, right palp just amputated.



in a hairy, slender lobe, which bears the tarsal organ and which adjoins the broad furrow of the conductor. Base of embolus is slender.

Females have a spur on the posterior base of coxae IV. The claw of the female palp is fan-like. The epigynum is a broadly rounded, sclerotised protuberance (Figs. 4, 5, 9, 10). On its anterior declivity open the separate introductory orifices. The copulatory ducts are heavily sclerotised, coiled and folded, with narrow lumen.

Genitalia coupling (Figs. 9, 10): Holdfast structures of the palp are sclerites, not modified haematodochae. The basal haematodocha is large, the distal one rudimentary. The hook-like apex of the cymbium locks behind the epigynal protuberance in a fold of the integument, whereas the conductor adjoins the anterior side of the epigynum. The coxal spurs on legs IV of the female are not necessarily used for genitalia coupling. During insertion, contact between the male palp and the coxal spurs sometimes was present and sometimes not.

#### Palp-amputation

Loss of one palp is achieved by self-amputation

also in *E. gibberosum* males. For the first time in this genus two amputations were observed. Two (three) hours after the penultimate moult (Figs 6a, b) the subadult male raised one palp (Fig. 6c) and started to rotate until the palp became fixed to the threads of the web (see Knoflach & van Harten 2000). Then the male circled around its own appendage, thereby twisting off the palp (Fig. 6d). The process lasted 6 (11) minutes and involved 16 (17) rotations. The detached palp was sucked out. Another two freshly moulted males did not perform the amputation during 7 hours of observation.

#### Copulatory behaviour

Sperm induction obviously takes place in the period before copulation, but was not observed. For courtship the male walks around the female, attaching draglines and moving his abdomen in jerks from time to time. He regularly approaches the female and palpates her forelegs. The female vibrates her body throughout the whole courtship, regularly moves her first legs up and down and also cleans them with the chelicerae. She faces towards the male, adjusting her position



**Fig. 7.** *Echinotheridion gibberosum*. Sequence of copulation: **(a)** male approach along mating thread; **(b)** insertion of left palp; **(c)** emasculation by female circling; **(d)** emasculation completed, female starts to feed on male. Arrow points to dismembered palp, breaking point between trochanter and femur.

relative to him. The male then spins the mating thread, which may be reinforced several times and is 2 - 5 cm long. This thread is intensively pulled by the male 1 - 19 times. With each pulling sequence the female becomes strongly shaken and approaches along the thread. Finally, the male also approaches her for insertion with his palp extended forwards (Fig. 7a). Courtship lasts about 12 minutes ( $\bar{x} = 12.2 \pm 4.2$  s.e.; range 1.4 - 56.0;  $n = 14$ ). It should be mentioned, that not every pairing ended in successful copulation. An additional 12 virgin pairings were negative.

Copulation takes place on the mating thread. Insertion was successful at once in 12 out of 18 copulations; further two copulations with 1, two with 2, one with 3, and one with 5 unsuccessful insertion attempts. During insertion both partners are completely motionless (Figs. 1, 7b). The male dies from fatigue as soon as genitalia contact is achieved. He remains passively coupled to the

female, his legs being contracted as in dead spiders. The female is cataleptic. After about 4 minutes ( $\bar{x} = 3.9 \pm 0.9$  s.e.; range 0.3 - 15.4;  $n = 21$ ) the female awakes from her catalepsy, entangles the male and starts to turn around in circles (Fig. 7c) by using her legs. After 3-20 rotations the palp becomes amputated (Figs. 7d, 8). Some females started several times until they succeeded in breaking off the palp. Emasculation is completed after ca. 3 minutes ( $\bar{x} = 3.4 \pm 0.8$  s.e.; range 0.5 - 12.0;  $n = 17$ ). The palp broke off between tibia and tarsus (Fig. 8) in 23 cases, between femur and trochanter in two cases (Fig. 7d). The detached palp then remains on the epigynum for the next five hours on average ( $\bar{x} = 5.4 \pm 1.0$  s.e.; range 1.0 - 11.4;  $n = 9$ ), until it is removed by the female. Synchronously the female feeds on the palpless male (for 2-5 h; Figs. 7d, 8). One female was observed to suck out the removed male palp, after she had pushed it away from the epigynum with her

**Fig. 8.** *Echinotheridion gibberosum*. Sexual cannibalism after emasculation; palpless male is sucked out, detached palp (arrow) fastened to epigynum. Arrow points to dismembered palp, breaking point between tibia and tarsus.



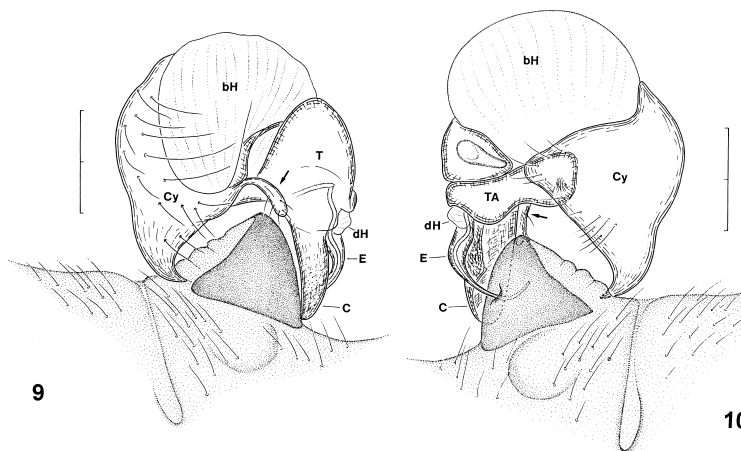
hindlegs. Three females were allowed to remate on the next day. However, instead of vibrating their body they pulled threads and no copulation followed (observation time from 7 hours up to 3 days).

Anomalous observations: One female performed 55 rotations for successful emasculation, changing five times direction of rotation. Another female started to feed on the male already during insertion when she still was circling. 90 minutes later she completed emasculation. A third female did not amputate the male palp nor did she feed on him during observation. For about 3 hours the

dead male was observed to be just connected to the epigynum. On the following day I found him emasculated and sucked out.

#### DISCUSSION

*Echinotheridion gibberosum* exhibits similar behavioural traits as the two *Tidarren* species hitherto studied. Palp-amputation of the subadult male follows the same pattern (Branch 1942; Knoflach & van Harten 2000). Also courtship and copulation correspond to *T. cuneolatum* (Tullgren, 1910) and in particular to *T. argo* from Yemen: Courtship proceeds via a mating thread; copulation



**Figs 9 - 10.** *Echinotheridion gibberosum*. Functional contact of genitalia after emasculation, epigynum with left palp, (9) from the left side and (10) from the right side, female punctured. Abbreviations: bh: basal haematodocha, dh: distal haematodocha; C: conductor, Cy: cymbium, E: embolus, T: tegulum, TA: tegular apophysis; arrow points to lobe of cymbium. Scale lines: 0.2 mm.

takes place on the mating thread, involves single usage of the male palp and ends in exhaustion of the male, in emasculation and subsequent sexual cannibalism (Knoflach & van Harten, 2001). The courtship repertoire of *E. gibberosum* females lacks twanging with second legs, which is a typical element of *Tidarren* spp. Instead, the first legs are used. Remarkably, copulatory behaviour of *E. gibberosum* was already basically observed by Schmidt (1980), with reference to palp-disconnection and fatigue of the male. However, this observation was mistaken as a heterospecific copulation between two genera (Schmidt 1980, 1981).

In *Tidarren argo* from Yemen the male is emasculated immediately after application of the male palp. The separated palp remains fixed to the epigynum for several hours, supported by special haematodochal holdfast structures. Unlike this new *Tidarren* species, in *E. gibberosum* emasculation does not take place at the beginning of genitalia contact. At first there is a 'normal' insertion for about four minutes, during which both partners are completely motionless and the male apparently dies. Emasculation is not that efficient as in *T. argo*. It lasts more than three minutes. Breaking point of the palp usually is identical to *T. argo*. Holdfast structures of the palp are provided only by sclerites, not by haematodochal horns. The result is the same: the male palp is fastened to the epigynum for hours, while the female is occupied with mate consumption. The function of the coxal spurs on legs IV of the female remains uncertain, as they are not necessary for genitalia coupling.

Emasculation obviously allows long contact of genitalia and concurrent nutritional benefits to the female. The palp blocks the epigynum and therefore may serve as an ephemeral mating plug, reducing female receptivity for a while. Probably, the dismembered palp goes on with sperm transfer independently.

Could palp-amputation of the subadult male and emasculation behaviour have evolved convergently in both genera? It appears that such peculiar traits are unlikely to have evolved twice. However, some morphological structures differ considerably, in particular the copulatory ducts

and coxal spurs of the female as well as holdfast structures of the male palp. For conclusions on relationships and the evolutionary constraints of such behaviour it will be necessary to analyse further representatives of these genera.

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