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Copulation mechanism and description of the East Australian *Helicopsyche copulata*, spec. nov.

(Insecta, Trichoptera, Helicopsychidae)

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One male and one female of an undescribed species from North Queensland, Australia were examined in copula. The species is described and named *Helicopsyche copulata*, spec. nov. The copulation mechanism of the species is described based on the two specimens.

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Introduction

The genus *Helicopsyche* is distributed through the tropics and subtropics (Johanson 1995a) and is currently represented by fifteen species in the Australian mainland and Tasmania. The distributional range of the genus in Australia is restricted to the northern and eastern part of the continent and mainly to forested high altitude areas.

Previously, little interest has been devoted to the copulatory mechanism in Trichoptera except for the Hydropsychidae (Denning 1943, Stätzner 1974, Tobias 1972, Unzicker 1968). Some of the male appendages are assumed to have certain functions, like the gonocoxites which grasp the female during copulation, and the phallus which is inserted into the female vagina.

The present work is intended to stimulate further research on this neglected but taxonomically important topic within caddisflies.

Methods

The two specimens of *H. copulata*, spec. nov. were initially examined *in copula* in glycerine with a Wild M5 binocular and Leitz Laborlux microscope for identification and preliminary examination. The wings were transferred to 100 % ethanol for dehydration, then to a solution of orange peel oil (*Aurantii dulcis aetheroleum*) for fixation, and permanently mounted in Canada balsam. The bodies were macerated in 8 % KOH and transferred to acetic acid, 100 % ethanol and orange peel oil for neutralization, dehydration and fixation. They were mounted in Canada balsam on a microscope slide together with their wings.

Helicopsyche copulata, spec. nov.

Figs 1-15

Types. Holotype: ♂, Australia, North Queensland, Mt. Lewis, nr. Julatten, 16°35'S, 145°15'E, 27 Oct. 1988, K. Walker leg. – Paratype: 1♀, as holotype (both deposited in Victoria Museum, Abbotsford, Victoria, Australia).

Diagnosis. Male scape very long and directed anteriorly; maxillary palp basal joint as long as scape and mesally with long, dark setae; genitalia with tergum X deeply divided and apically slightly upturned; gonocoxite divided into a two-lobed dorsal and simple ventral branch; ventral branch about twice the length of dorsal branch. Female posterior wing with long, dark, broad setae in anal region; abdominal sternite VIII divided into small rounded sclerites with long microtrichia; abdominal pleurite VIII posteriorly divided into scale-like microtrichia with one or two central microtrichia; tergum X, in lateral view, with dorsal branch pointed and ventral branch truncate.

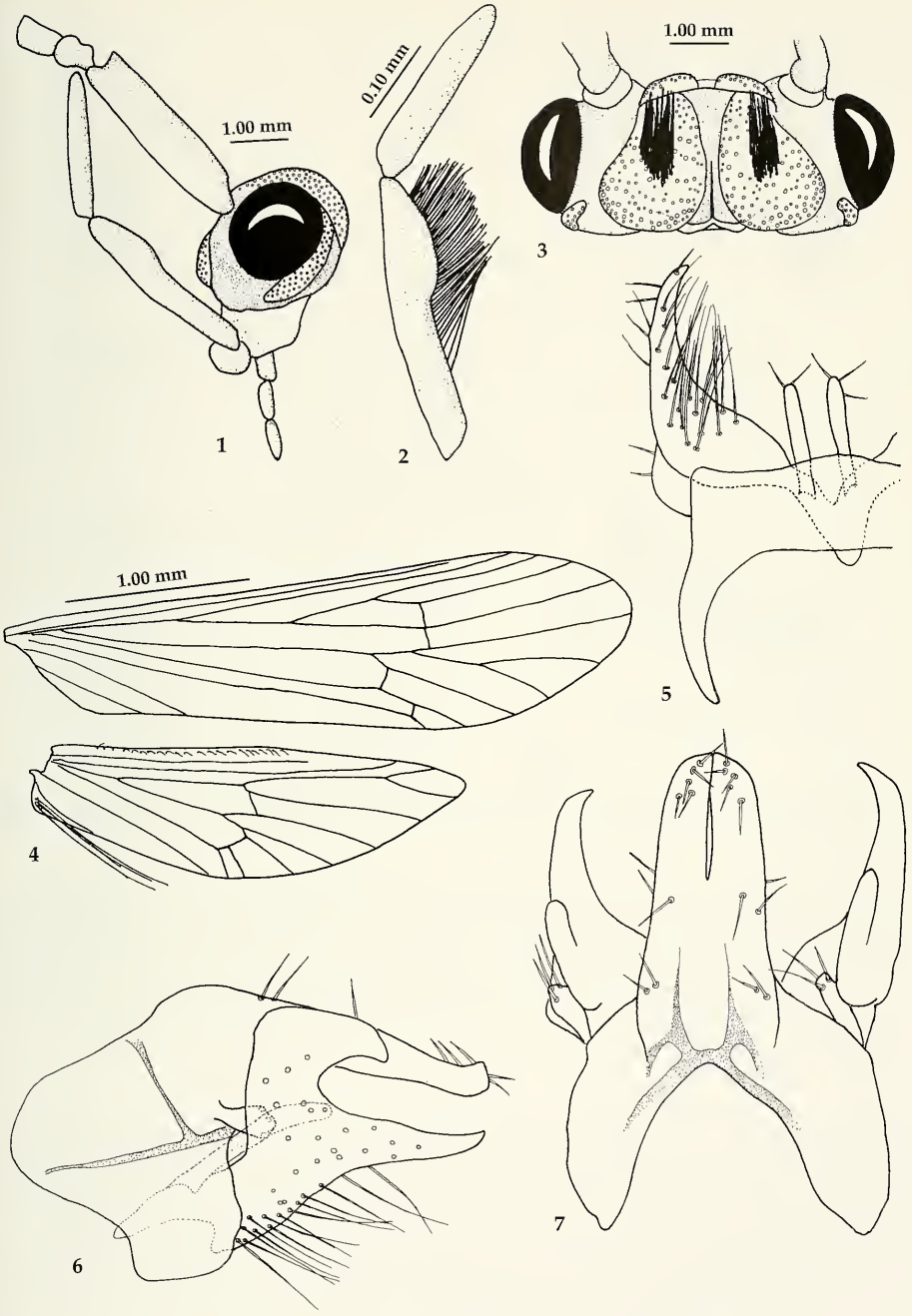
Description

Male (Figs 1-7, 12-15). Head cephalic warts large, pyriform; with central brush of black setae (Fig. 3). Eyes covering about 70 % of head in lateral view. Maxillary palp basal segment medially covered by long black setae (Figs 1, 2) and about 1.4 × longer than the distal joint. Antennae with long scape of equal length to proximal segment of the maxillary palps and 4.4 × longer than pedicel. Pronotum with two pairs of setal warts. Mesonotum, mesoscutellum and metascutellum with one pair of setal warts. Fore leg anterior spur about 2.0 × longer than posterior spur. Wings (Fig. 4): anterior wing length 3.3 mm. R_{2+3} bifurcate about midway on discoidal cell and opposite to bifurcation of M vein. Crossvein R_3-R_{4+5} opposite to bifurcation of R_{4+5}. Cu_1 and Cu_2 run parallel through their length. Hind wing length: 2.3 mm; with 22 hamuli. Fork 1 length about one third stalk length. Crossvein R-M closely opposite to bifurcation of R. Crossvein M-Cu_1 very short. Fork 5 present; Cu_{1a} joins crossvein M-Cu near M_{3+4}. Abdomen with truncate sternal process VI. Genitalia (Figs 5, 7, 12-15): segment IX with a horizontal and vertical apodeme. Superior appendage slightly club-shaped (Figs 12, 13), located laterally on the segment, above the horizontal IXth lateral apodeme. Gonocoxite primary branches divide into a posterioad curved upper branch and a tapering, slightly mesad curved lower branch (Figs 5, 12, 13). Lower branch with long setae on ventro-basal part, shorter setae on the lateral and distal parts (Fig. 5). Ventral branch of gonocoxites about as long as lower branch; slightly curved ventrad and with apical setae. Tergum X substraight, but distally slightly curved dorsad and with truncate apex (Fig. 13). Ten pairs of strong setae located in three groups on dorsal margin of segment: two basal pairs, three median pairs and five distal pairs (Figs, 7, 11). Phallus basally straight and distally slightly bent ventrad (Fig. 13).

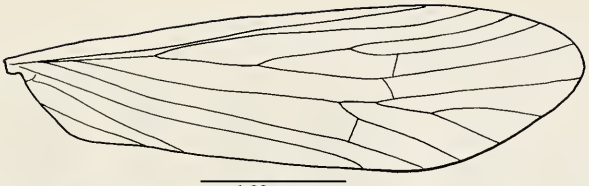
Female (Figs 8-9, 12-15). Wings (Figs 8-9): Anterior wing length 3.8 mm. Fork 1 as in male. Crossvein R_3-R_{4+5} located proximally to crossvein R-M. Forks 3 and 4 present. Fork 5 absent. Posterior wing length 2.8 mm. Fork 1 about one third length of R_{2+3}. R_{4+5} as long as M_1. Crossvein Cu1-M_{3+4} long and slightly sigmoid. Anal area with long, dark setae (Figs 8, 9). Abdominal sternite VI with truncate process present. Abdominal segment VIII laterally and ventrally with areas of small cells surrounding dark, circular oriented microtrichia (Fig. 12); sternite VIII with eight long stout setae oriented transversally on posterior half (Fig. 11). Genitalia (Figs 10, 12-15): Posterior margin of segment IX convex in lateral view (Fig. 13). Segment X, in lateral view, with dorsal branch tapering and slightly longer than ventral branch (Fig. 13); in dorsal view rounded and with several dorsolateral setae (Figs 10, 12); ventral branch smooth and rounded in lateral view (Fig. 13) and posteromedially notched in dorsal view (Fig. 10). Spermathecal sclerite subrectangular in dorsal view (Fig. 14). Ductus spermathecae posteriorly slender, with undulated margin, running anteriorly into slightly sclerotized and thicker part covered by microtrichia. Spermathecal gland slender, originating medially on posterior part of ductus spermathecae. Ductus bursae posterioally as long as spermathecal sclerite (Fig. 13).

Etymology. *Copulata*, from latin *copula*, referring to the copulatory state of the types of the species.

Remarks. The male genitalia closely resemble those of *Helicopsyche bellangrensis* Johanson, *H. tillyardi* Mosely and *H. neboissi* Johanson. The male *H. copulata* is easily distinguished from *bellangrensis* by the long scape and joints of the maxillary palp; the absence of long, dark setae on the anal region of the posterior wings; a shorter and thicker phallus; and the absence of lateral process on tergum X and the straight dorsal branches of the gonocoxite. It is distinguished from *tillyardi* by the absence of long, dark



Figs 1-7. *Helicopsyche copulata*, spec. nov. **1.** ♂ head, lateral view. **2.** ♂ maxillary palp, lateral view. **3.** ♂ head, dorsal view. **4.** ♂ right wings. **5.** ♂ genitalia, ventral view. **6.** ♂ genitalia, lateral view. **7.** ♂ genitalia, dorsal view.



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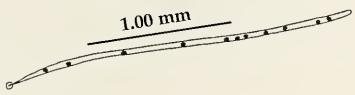

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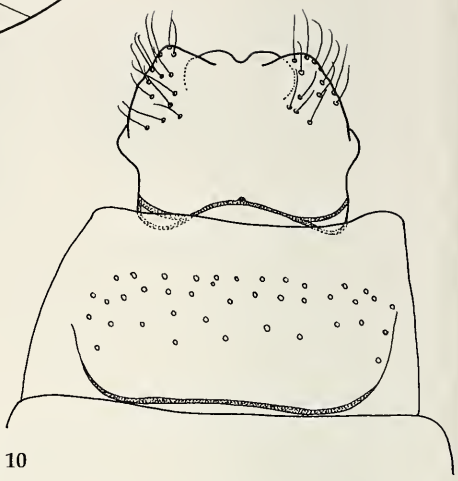

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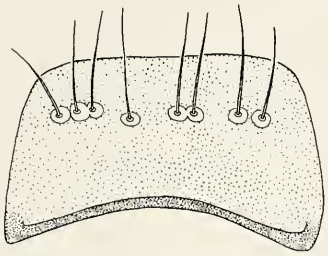

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Figs 8-11. *Helicopsyche copulata*, spec. nov. **8.** ♀ right wings. **9.** ♀ seta from anal area of hind wings, highly magnified. **10.** ♀ genitalia, dorsal view. **11.** ♀ sternite VIII, ventral view.

setae in the anal region of the posterior wing; narrower and ellipsoid division of the ventral branch of the gonocoxite; and the absence of a lateral process of tergum X. It is separated from *neboissi* by the IXth segment being anteriorly ellipsoid; tergum X, in dorsal view, apically more rounded and deeper divided; and the dorsal branch of the gonocoxite diverging.

The female is similar to those of *bellangrensis* and *tillyardi* but is easily distinguished by the long, dark modified setae in the anal region of the posterior wings; and, in dorsal view, the deeply incurved ventral branch of the Xth tergum.

Copulatory mechanism

The three parts of the male gonocoxites are all located on the external part the female genitalia (Fig. 12). The lower primary branches are pointed and bent mesad like large hooks; the upper primary branches are covered with strong setae on the inside. The ventral branches meet the posterior margin of the female segment IX and are not inserted (Fig. 13). Tergum X is inserted into the vagina together with the phallus immediately below (Fig. 13). The Xth tergite dorsal setae are directed slightly anterodorsad, forming spiniform hooks (Fig. 13). About half of the sclerotized part of the phallus is inserted into the female so that the apex of the posterior sclerotized part is located approximately opposite the apex of the Xth tergum (Fig. 13). The membranous part of the phallus is strongly erect, forming a dorsal and a posterior part (Fig. 13). The posterior erected part covers the posterior part of the spermathecal

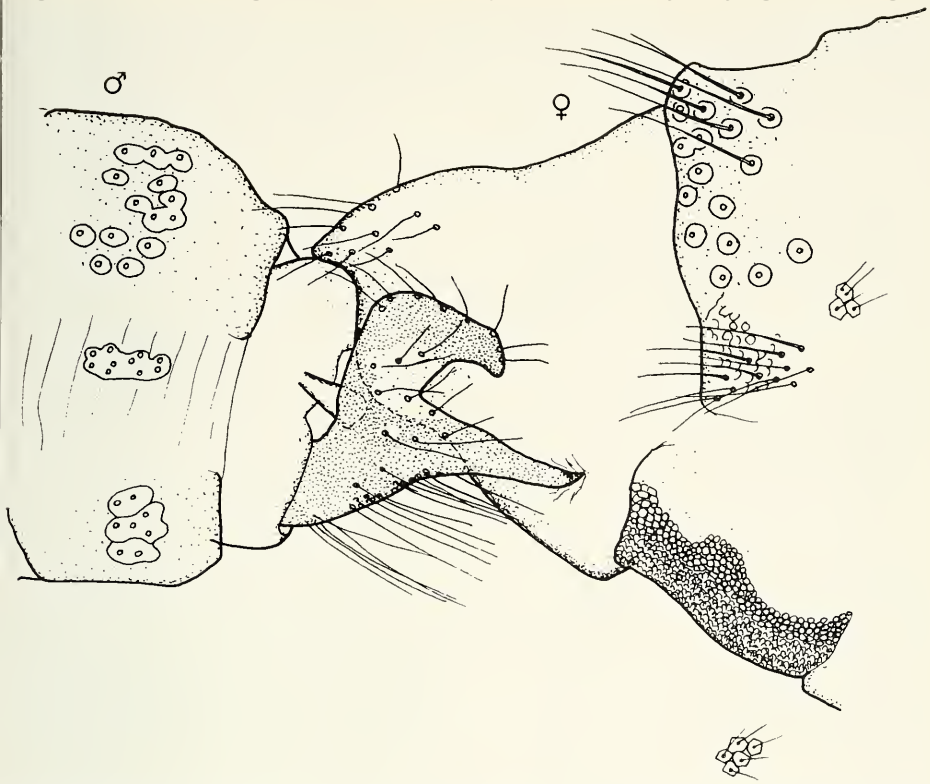

Fig. 12. *Helicopsyche copulata*, spec. nov., ♂ and ♀ in copula, lateral view from outside. Small cells of segment VIII highly magnified.

sclerite. The dorsal part is bifurcated into two lateral branches and runs dorsad into the spermathecal gland forming an S-shaped structure in lateral view (Fig. 13). The posterior margin of the dorsal part is covered by small microtrichia (Figs 13-15), and the microtrichia seem to touch both the dorsal part of the spermathecal sclerite and the anterior part of the colleteral duct (Fig. 13). The vas deferens of the phallus ends in the phallic sclerite (Figs 13-15).

Discussion

In Trichoptera the gonocoxites are generally considered inserted into female during the copulation. Studies on *Hydropsyche* (Tobias 1972, Unzicker 1968) and *Cheumatopsyche* (Denning 1943, Stätzner 1974) strengthened this hypothesis. In these examples from hydropsychids, the male gonocoxite is used to hold the female tight during copulation by insertion of the harpago into lateral pockets (= clasper receptacles (Denning 1943)) of the segment IX of the female. In most Helicopsychidae species, the gonocoxites are apically curved mesad, or have strong mesad directed setae on the inner part. They thus grip the female during copulation. Some species, like the East African *Helicopsyche* (Johanson 1993) all have strongly mesad curved ventral gonocoxite branches, and these are obviously very effective grabs. In male *Helicopsyche barbata* Johanson, 1993 a pair of lateral, pointed processes on tergite X of the male, previously termed phallus grip (Johanson 1993), probably have the same function of holding the female tight during copulation. The processes are probably inserted into ventrolateral pockets of the

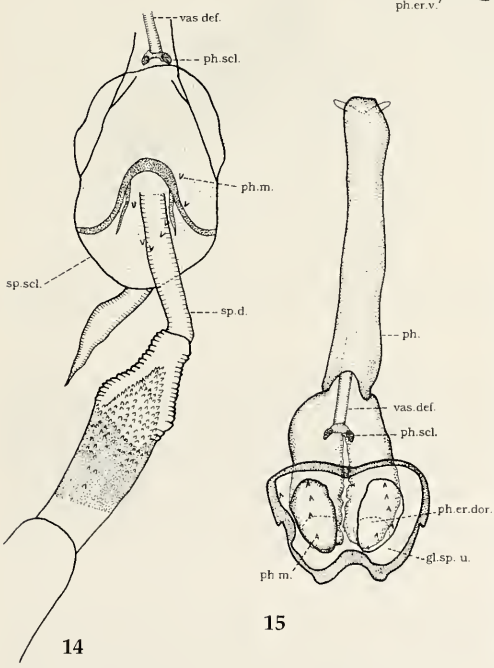

Fig. 13. *Helicopsyche copulata*, spec. nov., ♂ and ♀ in copula, lateral view. The primary branches of the gonocoxite are excluded. Abbreviations: **gl.sp.u.**: upper part of the spermathecal gland. **ph.**: phallus, sclerotized part. **ph.er.dor.**: dorsal erected membranous part of phallus. **ph.er.v.**: ventral erected part of phallus. **ph.scl.**: phallotremal sclerite. **s.app.**: superior appendage. **sp.d.**: ductus spermathecae. **sp.scl.**: spermathecal sclerite. **v.br.**: ventral branch of gonocoxite. **vas.def.**: vas deferens. VII-X refer to the number of abdominal tergites.

Figs 14, 15. *Helicopsyche copulata*, spec. nov. **14.** ♂ and ♀ in copula, relative position of male phallic sclerite and the female spermathecal sclerite, dorsal view. **15.** ♂ and ♀ in copula, phallus, with orientation of erected membranous part near the roof of what is believed to be the spermathecal gland. Dorsal view. Abbreviations: **gl.sp.u.**: upper part of the spermathecal gland. **ph.**: phallus, sclerotized part. **ph.er.dor.**: dorsal erected membranous part of phallus. **ph.m.**: phallic microtrichia. **ph.scl.**: phallotremal sclerite. **sp.d.**: ductus spermathecae. **sp.scl.**: spermathecal sclerite. **vas.def.**: vas deferens.

female segment IX. In species like *Cochliopsyche vazquezae* strongly sclerotized, toothed structures are present distally on the mesal part of the gonocoxites. These structures possibly have the function of holding the female tight. In most of the New World and Oriental species of *Helicopsyche* the gonocoxites are ventro-basally covered by strong setae or megasetae. These setae might be effective in holding the ventral part of the female sternite IX. Most of the New World *Helicopsyche* have strong megasetae on the apical part of the ventral gonocoxite branches. The function of these branches is unclear because

they are usually very short, and in many species the megasetae are oriented posterioad. They do, probably, touch upon the posteroventral part of the female segment IX, and possibly force the male genitalia into a fixed dorsoventral position. It is unclear whether the basal branches of the Australian *Helicopsyche* have the same function. Their length and form differ strongly between species, and probably havea more species-dependent function. Similar structures are found in European and Oriental *Helicopsyche* species.

The superior appendages seem not to be directly involved with copulation and their sexual function is unknown.

The significance of tergum X has been discussed earlier for Hydropsychidae. During copulation the Xth tergite of the male *Hydropsyche ornatula* [McLachlan] is oriented below the female tergite X and into the female segment IX (Tobias 1972). The male tergite X is not observed inside the female in this family. In *Helicopsyche copulata*, spec. nov. a large part of the tergum and megasetae is injected into the female vagina. The megasetae apparently function as hooks and probably work together with the gonocoxites to keep the male locked in a certain position during copulation.

The length, thickness and number of setae on tergum X vary consistently between species, and some extreme forms appear in the Australian *Helicopsyche curva* Johanson, 1995b and *Helicopsyche cochleaetesta* Korboot, 1964. In these species the setae are very long and thick and are assumed to be harmful to the female when tergum X is pulled out. Whether tergite X is inserted into the female vagina of these species, as in *H. copulata*, spec. nov. is not known, but it is reasonable to assume they are. Similar, but shorter setae are found in species of the New Caledonian *Helicopsyche vallonia* Ross, 1956 and *H. starmuehlneri* Ross, 1956. In some species, e.g. *Helicopsyche petersorum* Ross, 1956, *H. caledonia* Ross, 1956, *H. lapidaria* Ross, 1956, *H. boularia* Ross, 1956, and *H. hollowayi* Ross, 1956 the megasetae are even elevated on a dorsal process.

The phallic sclerite seems to be pulled by the erected membranous phallic mass. The vas deferens, which is attached to the phallic sclerite, thus gets in close contact with the spermathecal sclerite. During copulation, the sclerite and vas deferens come in contact with the spermathecal sclerite for sperm delivery into the ductus spermathecae. Different phallic sclerous processes are present in other Helicopsychidae species. The primary function of all these processes is uncertain, and not necessarily identical for all species. In the Oriental *H. maculata* the processes are directed posterioad and are long, straight and strongly pointed. In the African *Helicopsyche* species they are shorter, often covered with microtrichia. In Australian species, the processes are lacking, or if present short and nail-like or trianguloid. In *H. ptychopteryx* they are thin, pointed and strongly sickle-shaped.

The present study of copulation mechanism within Helicopsychidae is based on only one species. However, the genitalic appendages of other species in the group might possibly have the same function as in *H. copulata*. Some species within other families have strongly modified gonocoxites and tergites X, and the specific function of these structures certainly cannot be determined without critically examining each case. As shown by Stätzner (1974) the shape and length of the gonocoxite and the shape of tergite X of *Cheumatopsyche* are important taxonomic characters. He also demonstrated that hybridization between species can be prevented by these differences in shape and lengths. Due to the insertion of tergite X into the female vagina of *H. copulata*, spec. nov., and possibly other Helicopsychidae as well, the chaetotaxy of this segment is probably a very important taxonomic features of the Helicopsychidae. Not only the size, but also the number and position of setae on the segment should be focused on in the future systematics of the group.

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