Koleopterologische Rundschau	76	15–21	Wien, Juli 2006

Notes on Australian *Hyphydrus* ILLIGER, including taxonomy, key to the species and sexual dimorphism
(Coleoptera: Dytiscidae)

C.H.S. WATTS & R. LEYS

Abstract

The Australian *Hyphydrus* (Coleoptera: Dytiscidae) species, *H. decemmaculatus* WEHNCKE and *H. effeminatus* WATTS, are synonymised based on mtDNA sequence data and larval morphology despite the considerable differences in adult sexual dimorphism. Comments are made on the concept of a sexual arms race in this species and the three other Australian *Hyphydrus* species and it is concluded that this is not obviously the case in these species. A key is given to the adults of the four Australian species and one form. Colour illustrations of all species and forms are included.

Key words: Coleoptera, Dytiscidae, *Hyphydrus*, Australia, sexual dimorphism, mtDNA sequence.

Introduction

Australian predatory diving beetles (Dytiscidae) of the genus *Hyphydrus* are common, widespread and well studied (WATTS 1978, BISTRÖM 1982). Thus it was a puzzle when Yves Alarie and the senior author found no difference between larvae soundly associated with *H. decemmaculatus* WEHNCKE and *H. effeminatus* WATTS (ALARIE & WATTS 2005), which are quite distinctive in the adult stage. This led to a study of the relationship of these two species using molecular methods. These clearly showed that *H. decemmaculatus* and *H. effeminatus*, despite their large morphological differences, were members of the same species. This paper presents our results, formally synonymises *H. effeminatus* and *H. decemmaculatus*, provides a key to the Australian species and briefly comments on a possible sexual arms race (BERGSTEN et al. 2001, MILLER 2003) within *H. decemmaculatus*.

Methods

Specimens of all Australian *Hyphydrus* species from the collections of the South Australian Museum Adelaide were examined with the aid of a Leica M8 binocular microscope. Initial identifications were made using the key in WATTS (1978). Electronic images were manipulated and enhanced using the program Photoshop 8. Specimens used in the molecular studies were either snap-frozen (from the Australian Frozen Tissue Collection, South Australian Museum) or preserved in 100% ethanol.

DNA extraction, polymerase chain reaction (PCR) amplification, sequencing and phylogenetic analyses were performed as described in COOPER et al. (2002) and LEYS et al. (2003). An 822 bp region of the 3' end of the cytochrome oxidase subunit 1 (CO1) gene was used to assess genetic variation within specimens identified as either *H. decemmaculatus* or *H. effeminatus*. *Hyphydrus lyratus* SWARTZ was used as the outgroup. DNA sequences have been submitted to GenBank accession numbers DQ374640 - DQ374645. DNA-vouchers are lodged in the Australian Biological Tissue Collection (ABTC) at the South Australian Museum under numbers 78790–793, 78800, 78838.

Results

The results of the mtDNA analysis are given in Fig. 1. The pairwise sequence divergence of the *H. decemmaculatus*-*H. effeminatus* cluster is small (0.25–1.08%), which is in the normal range of within-species divergence. The fact that the *H. decemmaculatus* specimens from Queensland do not form a separate group but are intermingled within the *H. effeminatus* specimens from Northern Territory localities strongly supports the idea that *H. decemmaculatus* and *H. effeminatus* are conspecific. In addition, there are two other lines of thought to support the idea that *H. decemmaculatus* and *H. effeminatus* belong to the same species. Firstly, ALARIE & WATTS (2005) did not find any differences in larval morphology between *H. decemmaculatus* and *H. effeminatus*, while differences in larval morphology between other *Hyphydrus* species are apparent. Secondly, the adult morphology that originally separated Australian *H. decemmaculatus* from *H. effeminatus*, which is reticulate vs. smooth dorsal surface of the female elytra and the degree of modification of the pro- and mesotarsi in the males, appear to be unreliable characters for separation of species, because these characters are polymorphic in several Dytiscid species (BISTRÖM 1982, BERGSTEN et al. 2001, MILLER 2003). BISTRÖM (1982) specifically mentioned that some females of *H. decemmaculatus* have shiny elytra but did not give the location of these specimens. WATTS (1978) also separated the two taxa on differences in the medial lobe of the aedeagus but, with the much larger number of specimens now available, we consider that the aedeagus of the two taxa are identical. (The correct illustration is that given by WATTS (1978) for *H. effeminatus*: the additional piece on the illustration of the medial lobe of *H. decemmaculatus* is erroneous).

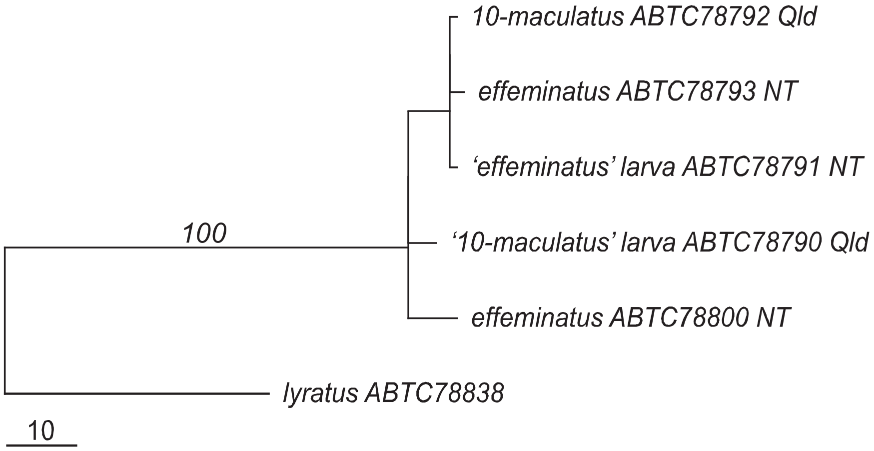


Fig. 1: Neighbour joining tree of *Hyphydrus decemmaculatus* and *H. effeminatus* specimens with *H. lyratus* used as the outgroup. The bar indicates the number of nucleotide changes in the branches; the number in italics above the branch shows the bootstrap proportion.

Taxonomic decision

Hyphydrus effeminatus WATTS, 1978 is synonymised with *H. decemmaculatus* WEHNCKE, 1877. It is proposed that specimens with the morphology of *H. effeminatus* can be considered a form of *H. decemmaculatus*.

Key to Australian species of *Hyphydrus*

1	Protrochanter greatly elongate: pro- and mesotarsi greatly expanded (either character or both) (males)	2
	Protrochanter simple: pro- and mesotarsi narrow or only moderately expanded (females)	5
2(1)	Protrochanter greatly elongate	3
	Protrochanter simple	4
3(2)	Length 4.0–4.7 mm; protrochanters asymmetrical	*decemmaculatus* WEHNCKE
	Length 3.2–3.8 mm; protrochanters symmetrical	*contiguus* WEHNCKE
4(2)	Pro- and mesotarsi similarly expanded; ventrite 2 with large spine in midline	*lyratus* SWARTZ
	Protarsi more enlarged than mesotarsi; ventrite 2 without a spine	*elegans* (MONTROUZIER)
5(1)	Elytra shiny, non-reticulate	7
	Elytra matt, strongly micro reticulate	6
6(5)	Length 3.2–3.8 mm; dorsal colour pattern usually as in Fig. 6	*contiguus* WEHNCKE
	Length 3.8–4.7 mm; dorsal colour patterns usually as in Figs. 4, 5	8
7(5)	A small reddish macula just behind middle of each elytron (Figs. 2, 3)	*decemmaculatus* form *effeminatus* WATTS
	Elytron lacking such a macula (Fig. 5)	*elegans* (MONTROUZIER)
8(6)	A small reddish macula just behind middle of each elytron (Fig. 3)	*decemmaculatus* form *decemmaculatus* WEHNCKE
	Elytron lacking such a macula (Fig. 4)	*lyratus* SWARTZ

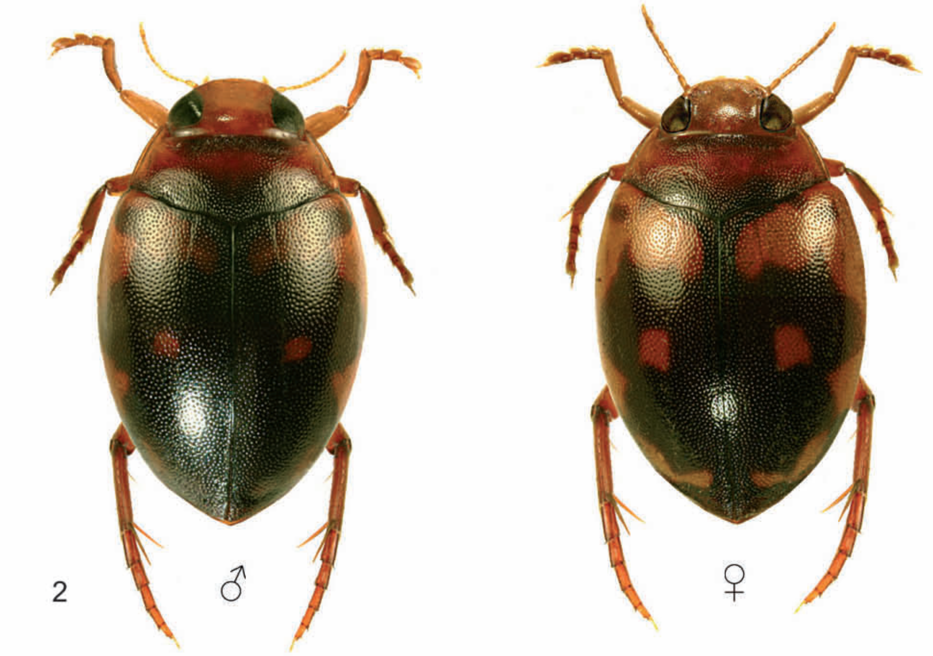
Distribution

The localities listed below are based on specimens deposited in the South Australian Museum.

Hyphydrus decemmaculatus form *decemmaculatus*: **Western Australia:** Bigge Island, 14.4833S 1254.1667E; Lower Camp Creek, 14.8833S 125.75E; Mitchell Plateau, 14.667 S 125.733E; **Queensland:** Brisbane, 27.467S 153.003E; Cairns, 16.917S 145.767E; Caloundra, 26.8S 153.133E; Eubenangee Swamp, 17.433S 125.75E (DNA extractions ABTC78790, ABTC78792); Mt Molloy, 16.667E 145.333E.

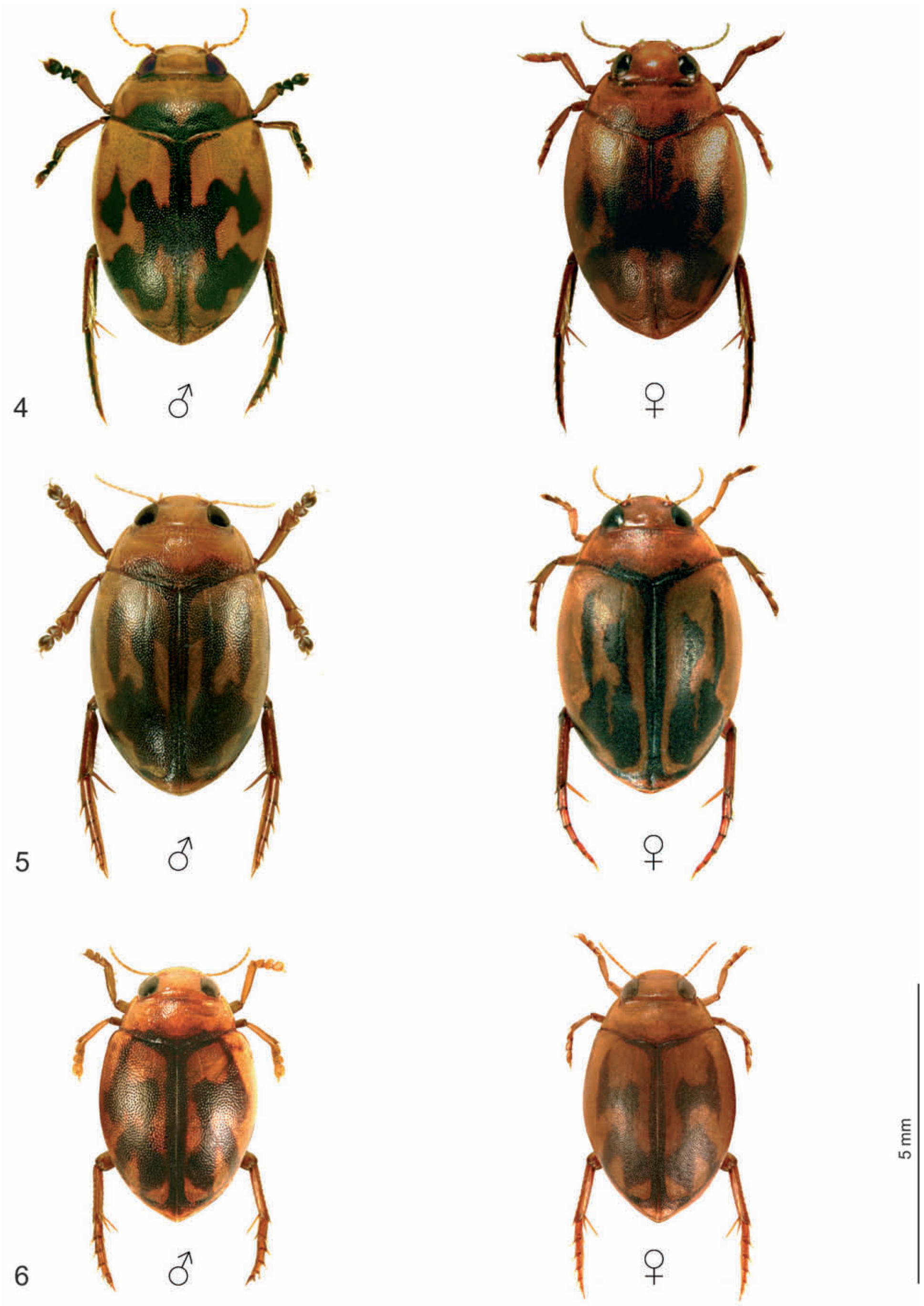
Hyphydrus decemmaculatus form *effeminatus*: **Northern Territory:** South Alligator River, 12.433S 132.416E; Darwin, 12.45S 130.833E; Jabiru, 12.667S 132.9E (DNA extractions ABTC78800); Manton Reservoir, 12.85S 131.116E (DNA extractions ABTC78791, ABTC78793); Mount Borradaile, 12.05S 132.9E; Mt Borradaile Station, 12,08S 132.933E; **Queensland:** Archer Bend, 13.466S 142.2E; Coen, 13.75S 143.2E; Lakeland Downs, 15.85S 144.85E; Townsville, 19.6S 146.81E.

At no locality have the two forms been collected together. In the Northern Territory and Cape York only the *effeminatus* form has been collected: in the Kimberly only the nominate form. Apart from the Townsville record the nominate form is the only form collected in Queensland between Cairns and Brisbane. Thus there appear to be areas where one form is dominant. Outside of Australia the nominate form occurs in New Guinea and some adjacent islands (BISTRÖM 1982) but the *effeminatus* form has yet to be collected outside of Australia.


2


3

Figs. 2–3: 2) Male (left) and female (right) habitus of *Hyphydrus decemmaculatus* form *effeminatus*; 3) same, *H. decemmaculatus*, typical form.



Figs. 4–6: 4) Male (left) and female (right) habitus of *Hyphydrus lyratus*; 5) same, *H. elegans* ; 6) same, *H. contiguus*.

Discussion

Our decision to synonymise *H. effeminatus* with *H. decemmaculatus* was based on several lines of reasoning with equal importance. The use of mtDNA is a very useful tool to separate species, especially when specimens from two entities divide into two phylogenetic monophyletic reciprocal groups. However, we need to be aware that the use of mtDNA delivers a one-way test: in our case the specimens of *H. decemmaculatus* and *H. effeminatus* did not separate into reciprocal monophyletic groups, indicating that there is no support for two species, but, unfortunately, this does not confirm without doubt that there is only one species involved. Theoretically, there is still the possibility that there are some very recently evolved species within this cluster, but only molecular markers that evolve faster than mtDNA, such as allozymes and microsatellite DNA would be able to shed some light here.

As now constituted *H. decemmaculatus* within Australia is strongly sexually dimorphic: the females of the nominate form have strongly reticulate dorsal surfaces and thin pro- and mesotarsi (Fig. 3); the males have a highly polished dorsal surface and strongly expanded pro- and mesotarsi (Fig. 3); in the form *H. effeminatus* both males and females have a highly polished dorsal surface (Fig. 2) and thin pro- and mesotarsi (Fig. 2).

Recently a study by BERGSTEN et al. (2001) on sexual dimorphism in the European dytiscid *Graphoderus zonatus verrucifer* (SAHLBERG) showed that variation in the morphology of the male protarsi was correlated with variation in the granulation of the female dorsal surface. In this case the males in populations in which all the females had a granulated upper surface had fewer medium sized suckers and more large and small suckers on their tarsi. This was interpreted as evidence of a potential 'sexual arms race' since male suckers are vital in obtaining a grip on initially reluctant females during copulation, and increased surface granulation made gaining a grip by suction more difficult. MILLER (2003) expanded the investigation of the evolution of sexual conflict to include 52 taxa in the Dytiscidae and concluded that the evidence was "consistent with the hypothesis that intersexual conflict over mating decisions occurs within the Dytiscinae". His data did not include an investigation of the Hydroporinae to which *Hyphydrus* belongs.

In the case of *H. decemmaculatus* the ancestral morphology, based on character distribution within the genus, would appear to be a shiny dorsal surface in the female and enlarged pro- and mesotarsi with numerous small adhesive setae in the male. The mat dorsum in females and small male tarsi are therefore the derived states.

In this case a smooth female dorsal surface is correlated with a reduction in the area of adhesive setae on the tarsi of the male. It is not obvious what advantage this reduction gives the male.

There is also variation in the dorsal sculpture and male tarsi within the other three Australian species of *Hyphydrus*. In two of these the dorsal surface of the female is reticulate and in one it is smooth (Figs. 4–6). All the males have enlarged pro- and mesotarsi hence there is no clear correlation between tarsal size and roughness of the female dorsal surface.

Thus it would appear that the inter- and intraspecies variation in female surface sculpture in Australian *Hyphydrus* does not obviously fit the sort of evolutionary scenario proposed by BERGSTEN et al. (2001) for *Graphoderus.*

In *H. decemmaculatus* and *H. contiguus* the male protrochanters are enlarged. Again what role these play in mating is unknown. It is notable that both forms of *H. decemmaculatus* have identical enlarged male protrochanters.

Nothing is known of the mating behaviour of *Hyphydrus* species or any other hydroporine (BALKE 2005) which makes speculation on the evolutionary driving force(s) for the observed sexual dimorphisms in Australian *Hyphydrus* difficult. As pointed out by EBERHARD (1985) and MILLER (2003) physical modifications to males may be a part of courtship behaviour and may be more involved in stimulating her to allow mating than in coercing a resistant female to mate.

Acknowledgements

We would like to thank Andy Austin of the University of Adelaide for allowing access to the photomontageing equipment, Howard Hamon for his help in enhanceing the resulting images and Michael Balke for useful comments on the manuscript.

References

ALARIE, Y. & WATTS, C.H.S. 2005: Larval morphology of four species of the *Hyphydrus lyratus* species-group (Coleoptera: Dytiscidae: Hydroporinae). – Australian Journal of Entomology 44: 244–251.

BALKE, M. 2005: Dytiscidae.– In Beutel, R.G. & Leschen, R. (eds.). Handbook of Zoology, 4 (2), Coleoptera, Volume1: Morphology and Systematics (Archostemata, Adephaga, Myxophaga, Polyphaga partim). – Berlin, New York: DeGruyter, 567 pp.

BERGSTEN, J., TOYRA, A. & NILSSON, A.N. 2001: Interspecific variation and intersexual correlation in secondary sexual characters of three diving beetles (Coleoptera: Dytiscidae). – Biological Journal of the Linnean Society 73: 221–232.

BISTRÖM, O. 1982: A revision of the genus *Hyphydrus* Illiger (Coleoptera: Dytiscidae). – Acta Zoologica Fennica 165: 1–121.

COOPER, S.J.B., HINZE, S., LEYS, R., WATTS, C.H.S. & HUMPHREYS, W.F. 2002: Islands under the desert: molecular systematics and evolutionary origins of stygobitic water beetles (Coleoptera: Dytiscidae) from central Western Australia. – Invertebrate Systematics 16: 589–598.

EBERHARD, W.G. 1985: Sexual selection and animal genitalia. – Cambridge, MA: Harvard University Press.

LEYS, R., WATTS, C.H.S. COOPER, S.J.B. & HUMPHREYS, W.F. 2003: Evolution of subterranean diving beetles (Coleoptera: Dytiscidae: Hydroporini, Bidessini) in the arid zone of Australia. – Evolution 57: 2819–2834.

MILLER, K.B. 2003: The phylogeny of diving beetles (Coleoptera: Dytiscidae) and the evolution of sexual conflict. – Biological Journal of the Linnean Society 79: 359–388.

WATTS, C.H.S. 1978: Revision of Australian Dytiscidae (Coleoptera). – Australian Journal of Zoology Supplementary Series No 57.

Dr. C.H.S. WATTS & Dr. R. LEYS
South Australian Museum, North Terrace, Adelaide, South Australia, Australia 5000
(Watts.chris@saugov.sa.gov.au; Leijs.remko@saugov.sa.gov.au)

Zeitschrift/Journal: Koleopterologische Rundschau

Jahr/Year: 2006

Band/Volume: 76_2006

Autor(en)/Author(s): Watts C.H.S., Leys Remko

Artikel/Article: Notes on Australian Hyphydrus ILLIGER, including taxonomy, key to the species and sexual dimorphism (Coleoptera: Dytiscidae) 15-21