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Taxonomic Status of *Delias aestiva smithersi* Daniels, 2012 (Lepidoptera: Pieridae) comb. nov. from the Gulf Country of Northern Australia, with Description of the Female

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Abstract. The female of *Delias aestiva smithersi* Daniels, 2012 comb. nov. from northern Australia is illustrated and described for the first time. The subspecies is diagnosed and its taxonomic status clarified. Several unique character states concerning wing colour pattern elements of *D. aestiva smithersi*, together with evidence of the male genitalia, support the hypothesis that the subspecies belongs to *D. aestiva* Butler, 1897 and not to *D. mysis* (Fabricius, 1775). The taxon appears to have a restricted geographical range, being limited to the eastern Gulf of Carpentaria on the western side of Cape York Peninsula, Queensland (from Weipa to Karumba), where it occurs in mangrove habitats in coastal lowland areas. *Delias aestiva smithersi* and the nominate subspecies, *D. aestiva aestiva* Butler, 1897 from the "Top End", Northern Territory, are allopatric and geographically separated by the Gulf of Carpentaria, suggesting that this biogeographical barrier (the Carpentarian Gap) has facilitated differentiation within the species, either though vicariance or dispersal.

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The *Delias mysis* (Fabricius, 1775) complex is restricted to mainland New Guinea and its adjacent islands, through the Aru Islands to northern and north-eastern Australia (Talbot, 1928–1937; Yagishita *et al.,* 1993). The complex currently includes five largely allopatric species (Davenport & van Mastrigt, 2009; Braby, 2012), namely: (1) *D. mysis*, with three subspecies (from Aru Islands, through south-eastern West Papua of mainland New Guinea to northeastern Australia); (2) *D. lara* (Boisduval, 1836), with five subspecies (throughout mainland New Guinea and its adjacent islands); (3) *D. doylei* Sanford & Bennett, 1955 (montane areas of the central cordillera of Papua New Guinea); (4) *D. euphemia* Grose-Smith, 1894 (Biak and Supiori); and (5) *D. aestiva* Butler, 1897 (coastal areas of the 'Top End' of northern Australia). The last mentioned species, *D. aestiva*, is perhaps the most remarkable member of the complex, and indeed the genus, because of its unusual, and apparently unique, occurrence in tropical mangrove habitats where the larvae specialise on foliage of the tree *Excoecaria* (Euphorbiaceae) (Braby, 2012) rather than the typical aerial/root hemiparasites in the Loranthaceae, Santalaceae and Viscaceae (Braby, 2006).

More recently, specimens belonging to the *D. mysis* complex have been discovered from western Cape York Peninsula in the Gulf of Carpentaria of northern Australia, including Weipa (Braby, 2000; Hancock & Monteith, 2004), Kowanyama and Karumba, Queensland (Daniels, 2012). Specimens (3♂♂) from the last two mentioned locations

were subsequently described by Daniels (2012) as a subspecies of *D. mysis*, under the name *D. mysis smithersi* Daniels, 2012, whereas material from Weipa (1♂, 1♀ in the private collection of T. A. Lambkin, Brisbane, 6♂♂ in the Australian National Insect Collection and 1♀ in the Queensland Museum) was placed under the nominate subspecies *D. mysis mysis* (Braby, 2000; Hancock & Monteith, 2004). The record from Weipa referred to by Hancock & Monteith (2004) was based on a female specimen collected in February 1976 by K. DeWitte.

The female of *D. mysis smithersi* has hitherto remained unknown. However, comparative study of two female specimens from Weipa, and critical re-examination of the type material of *D. mysis smithersi*, has revealed that the taxon *smithersi* has been erroneously placed in the species *D. mysis*, it most likely belongs to the species *D. aestiva*, and that the nine specimens (7♂♂, 2♀♀) from Weipa are in fact *D. aestiva smithersi* Daniels, 2012 comb. nov. rather than *D. mysis mysis* in which they are currently placed. The purpose of this paper therefore is to describe the female of *D. aestiva smithersi* and to diagnose and clarify the taxonomy of this subspecies from the nominate subspecies *D. aestiva aestiva* Butler, 1897 and the closely related *D. mysis mysis* (Fabricius, 1775) from Australia.

The following abbreviations refer to repositories where material has been examined:

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection, Canberra
MFBC	private collection of Michael F. Braby, Darwin
QM	Queensland Museum, Brisbane
TALC	private collection of Trevor A. Lambkin, Brisbane

Delias aestiva smithersi comb. nov.

Delias mysis smithersi Daniels, 2012

Figs 1, 2

Material examined. Holotype ♂ "Karumba, Qld, 17°29'S, 140°50'E, 9 Oct. 2003, G.&A. Daniels" (AM); paratype ♂ "Karumba, Qld, 17°29'S, 140°50'E, 12 Dec. 2002, G. Daniels" (AM); paratype ♂ "Mitchell River [Kowanyama], Q., 26.x.[19]71", "I.S.R. Munro", "I.S.R. Munro Collection", "genitalia 082, *Delias aestiva smithersi* ♂. Det. M.F. Braby" (AM); 1♀ labelled "Weipa, N. Qld., 3–5 Feb., 1976, [K. DeWitte]", "QM Reg. No. T100951", "AN31 000858" (QM); 1♂ labelled "Weipa Qld, 29 Aug 1994, [R.A. Eggleton]" (ANIC); 1♂, 1♀ labelled "Uningan Nature Reserve, Weipa, Q., 13.ix.1997, T.A. Lambkin" (TALC); 3♂♂ labelled similarly in ANIC; 2♂♂ labelled similarly but with date "18. ix.1997" (ANIC).

Description

Female (Figs 1, 2). Forewing length 34.6 mm. Upperside pearly-white, with yellow markings on underside faintly visible; forewing with a black terminal band enclosing a series of three conspicuous cream subapical spots and three cream subterminal spots, the last between veins CuA_1 and CuA_2 very obscure, terminal band extends narrowly along costa to base and may extend proximally along veins M_3, CuA_1, CuA_2 and 1A+2A; hindwing with a black terminal band, the inner edge of which may extend proximally along all main veins (M_1–CuA_2), red markings on underside faintly visible. Underside forewing similar to upperside except basal area broadly suffused with yellow, and the series of six subapical and subterminal spots larger, more conspicuous and of a different colour, the three spots between veins R_1 and M_2 yellow, while the three spots between veins M_2 and CuA_2 white; hindwing ground colour white, with base and dorsum broadly suffused with yellow, and a black terminal band enclosing a bright red narrower subterminal band, which extends from costa (above vein Rs) to dorsum (below vein 1A+2A).

Diagnosis. Braby (2012) listed 10 unique character states of the adult wing colour pattern elements and an additional eight morphological characters of the male genitalia by which *D. aestiva aestiva* is distinguished from *D. mysis mysis*. Daniels (2012) provided a number of characters (6 wing colour pattern elements) in which *D. aestiva smithersi* (originally placed in synonymy with *D. mysis*) is distinguished from *D. mysis mysis* and *D. aestiva aestiva*. However, taxonomic reappraisal of the status of the species-group name *smithersi* and the discovery of the female sex of this taxon, has necessitated a review of the features that distinguish *D. aestiva* and *D. mysis*, and the two subspecies of *D. aestiva*, because some of the characters were found to be non-applicable while others were overlooked.

A revised list of characters, and their states, that separate *D. aestiva* from *D. mysis* are tabulated in Table 1. A total of 10 diagnostic characters were found that distinguish the two species. *Delias aestiva smithersi* possesses all of these characters, the states of which are listed under *D. aestiva* in Table 1.

The males of *D. aestiva smithersi* may be distinguished from those of *D. aestiva aestiva* by the following four characters: *(a)* the apex of the forewing is more pointed; *(b)* the subapical spots on the upper- and underside of the forewing are proportionally larger; *(c)* the black terminal band on the upperside of the hindwing is narrower; in *D. aestiva aestiva* the band is particularly broad, being approximately twice the width of *D. aestiva smithersi*; and *(d)* the black terminal band on the underside of the hindwing is narrower, with the inner margin almost confluent with the red subterminal band; in *D. aestiva aestiva* the band is broader, with the inner edge extending proximally well beyond the red subterminal band.

Examination and comparison of two females of *D. aestiva smithersi* with a large sample of *D. aestiva aestiva* females (n = 35, MFBC) revealed similar character differences to the males. For example, the black terminal band on the upperside of the hindwing in *D. aestiva smithersi* females is narrower (in one specimen the inner margin of this band extends proximally along the major veins, but not in the other specimen); in *D. aestiva aestiva* females the band is broader, with the inner extensions along the veins less pronounced. In the specimen illustrated (Fig. 2) the fourth and fifth spots in the series of six submarginal spots on the underside of the forewing (i.e. those in cells M_3 and CuA_1) are white suffused yellow in *D. aestiva smithersi*, but in the other specimen they are white; in *D. aestiva aestiva* these spots are always white without the yellow suffusion. In *D. aestiva smithersi* females, the inner margin of the black

Figures 1–4. Female *Delias aestiva* from northern Australia: (1, 2) *D. aestiva smithersi* from western Cape York Peninsula, Queensland (Weipa) (QM), showing upper- and underside; and (3, 4) *D. aestiva aestiva* from the Top End, NT (Darwin) (MFBC) showing extent of variation in underside pattern, particularly the width of the red subterminal band on the hindwing. Scale bar = 20 mm.

terminal band on the underside of the hindwing, like the males, extends only narrowly beyond the red subterminal band. The red subterminal band on the underside of the hindwing appears to be slightly broader compared with *D. aestiva aestiva*; however, additional material is needed to assess this character. The width of the red subterminal band is variable in *D. aestiva aestiva*, and the accompanying plate shows the extremes of variation (Figs 3, 4). For example, the width of the red spot in cell M_3 in this subspecies ranges from 1.0 mm to 2.3 mm (mean = 1.5 mm $\pm$ 0.26 s.d., $n = 35$) (Fig. 5). The width of this spot in both females of *D. aestiva smithersi* is 2.0 mm, which falls within the observed range of *D. aestiva aestiva* (Fig. 5). Further specimens are required to ascertain if they are significant differences in the sample means of this character between the two taxa.

Male genitalia. The genitalia of one of the paratype males are illustrated in Fig. 6. The specimen possesses features that place the taxon with *D. aestiva* rather than *D. mysis* (see Braby, 2012 for comparative illustrations). These features include the shape of the saccus, and the shape of the valva, which, in lateral view, is rounded and convex at its posterior end (in *D. mysis*, the posterior end of the valva is distinctly pointed or protruded). The valva, in dorsal view, in *D. aestiva smithersi* and *D. aestiva aestiva* is broader in width and less tapered apically with shorter setae on its inner surface compared with *D. mysis mysis*. The uncus of the two species is similar in profile, with the apex divided into three lobes; however, in *D. aestiva smithersi* and *D. aestiva aestiva*, the uncus is slightly broader and shorter in length, and there are substantial differences at its point of attachment with the tegumen, which is also broader than that of *D. mysis mysis*. The phallus was missing in the specimen dissected and therefore not available for comparison. Dissection of several specimens of *D. aestiva aestiva* (in MFBC) revealed minor variation in the male genitalia, particularly the form of the valva, but there was insufficient material to assess the extent of intrasubspecific variation within *D. aestiva smithersi*.

Distribution. Delias aestiva smithersi occurs in the eastern Gulf of Carpentaria where it is known from three locations on the western side of Cape York Peninsula, from Weipa to Karumba, QLD (Fig. 7). All locations are situated in coastal lowland areas that support extensive stands of mangroves,

Table 1. Phenotypic character state differences in wing colour pattern elements between *Delias aestiva* and *D. mysis*. *FW* = forewing; *HW* = hindwing.

character	*Delias aestiva*	*Delias mysis*
(1) ♂, ♀ FW upperside black apical band	narrower in width; longer in extent in ♂, extending beyond vein CuA_2, and with its inner edge more evenly rounded anteriorly	broader in width; shorter in extent in ♂, stopping at vein CuA_2, and with its inner edge relatively straight
(2) ♂, ♀ FW underside black apical band	narrower in width; in ♀ the inner edge usually extends proximally along veins M_3, CuA_1 and CuA_2	broader in width; in ♀ the inner edge is approximately straight
(3) ♂, ♀ FW upperside subapical and subterminal spots	larger and more pronounced, with up to 5 or 6 spots	smaller and less pronounced (especially ♀), with up to 5 spots
(4) ♂, ♀ HW underside black terminal band	inner edge less strongly curved and pronounced between veins CuA_1 and 1A+2A	inner edge strongly curved and pronounced between veins CuA_1 and 1A+2A
(5) ♂, ♀ HW underside red subterminal band	narrower in width, especially between veins CuA_1 and 1A+2A; shorter in ♂, terminating at vein Rs	broader in width, especially between veins CuA_1 and 1A+2A; longer in ♂, terminating at vein $Sc+R_1$
(6) ♂ HW underside yellow basal area	less extensive, rarely extending beyond vein CuA_2 and occupying less than half of discal cell	extensive, often extending beyond vein CuA_2 and occupying more than half of discal cell
(7) ♀ FW upperside basal area	white, without grey suffusion	white, with conspicuous grey suffusion
(8) ♀ FW underside subapical spots (3 spots between veins R_1 and M_2)	yellow	white, only anterior spot near costa is sometimes yellow
(9) ♀ FW underside yellow basal area	extensive, occupying more than three-quarters of discal cell, as well as extending into areas well below cell	restricted to very base of discal cell
(10) ♀ HW underside yellow basal area	extensive, especially along costa where it may extend to end of vein $Sc+R_1$	less extensive, especially along costa where it is restricted to basal area

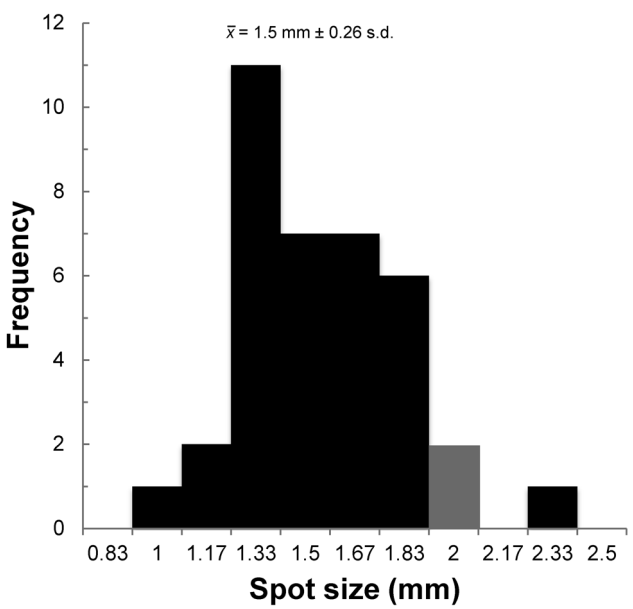

Figure 5. Frequency distribution of the size of the red subterminal band (width of red spot in cell M_3) on the underside of the right hindwing of female *Delias aestiva aestiva* based on a sample (n = 35, MFBC) of specimens from Darwin, Northern Territory. Sample mean and standard deviation are indicated above graph. The grey bar indicates the size of the corresponding band in the two female specimens of *D. aestiva smithersi* examined.

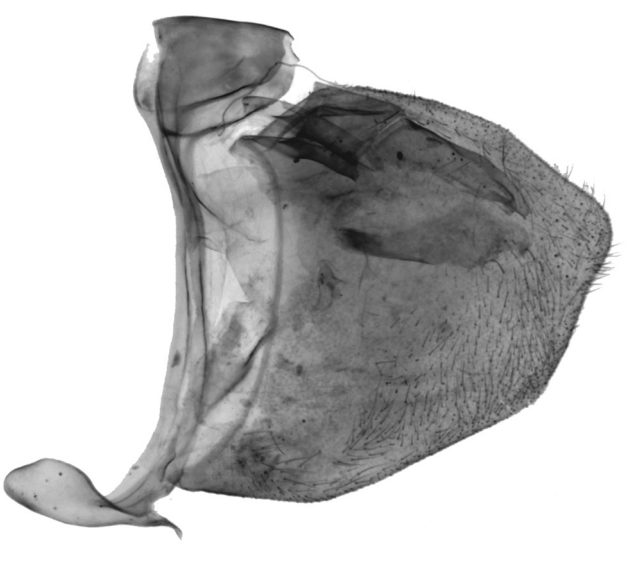

Figure 6. Male genitalia of *Delias aestiva smithersi* from Mitchell River, Queensland (AM); lateral view with left valva and phallus removed. Scale bar = 1.0 mm.

particularly in estuarine areas along banks of rivers and creeks. The geographical range is allopatric with *D. aestiva aestiva*, which is restricted to the northern coastal areas of the Top End of the Northern Territory on the western side of the Gulf of Carpentaria.

Discussion

The ten unique character states of *Delias aestiva smithersi* listed in Table 1, together with evidence of the male genitalia, support the hypothesis that the taxon belongs to *D. aestiva* and not to *D. mysis*. There are at least four phenotypic characters (wing colour pattern and shape) that distinguish *D. aestiva smithersi* from *D. aestiva aestiva*, indicating that subspecific classification is the most plausible hypothesis for this butterfly (see criteria proposed by Braby *et al.*, 2012).

Adults of *D. aestiva smithersi* have been collected in the months of February, September, October and December; they have also been collected in August at Weipa (along the Hay River) by I. R. Johnson and S. J. Johnson (pers. comm.). Collectively, these temporal records suggest a relatively long flight period, possibly throughout much of the year. The males fly low to the ground, usually within or in close proximity to mangroves (G. Daniels & T. A. Lambkin, pers. comm.), behaviour that is typical of the nominate subspecies in the Top End (Braby, 2012). This flight behaviour contrasts markedly with that of *D. mysis* and other members of the *D. mysis* species group, which fly higher in the canopy and mid-canopy of tropical forest.

The larval food plant and biology are presently unknown, but on account of its distribution and known habitat, *D. aestiva smithersi* is likely to specialize on the mangrove *Excoecaria agallocha-ovalis* complex, which is the larval food plant of *D. aestiva aestiva* in the Northern Territory (Braby, 2012). This plant is common locally in the Gulf of Carpentaria, and on western Cape York Peninsula it extends as far north as Weipa (CHAH 2009), which coincides with the distribution of the butterfly.

Further work is needed to clarify the spatial and temporal distribution and ecology of the subspecies. The known geographical ranges of *D. aestiva smithersi* and *D. aestiva aestiva* indicate that the two subspecies are allopatric, being geographically separated by the Gulf of Carpentaria. This large body of seawater and the adjacent mainland consisting of dry clay plains to the south, often referred to as the Carpentarian Gap, has been hypothesized to comprise a biogeographical filter, functioning as a barrier for taxa with disjunct distributions in Cape York Peninsula and the Top End of the Australian monsoon tropics and a corridor for others (Bowman *et al.,* 2010). During the last interglacial maximum (c. 9 ka BP), the coastline of the Gulf was connected at its northern end via Lake Carpentaria (Williams, 2001); however, since the demise of Lake Carpentaria during the Quaternary with sea-level rise (Lake Carpentaria is now submerged by the Gulf of Carpentaria), populations of some species distributed to the east (Cape York Peninsula) and west (Top End-Kimberley) of the lake became geographically isolated. Thus, the Carpentarian Gap may be barrier that has facilitated subspecific differentiation within *D. aestiva.* Further work on the timing of this event using DNA-based dating methods in relation to the geological history of the region may help elucidate the historical mechanism (i.e. vicariance or dispersal) of divergence.

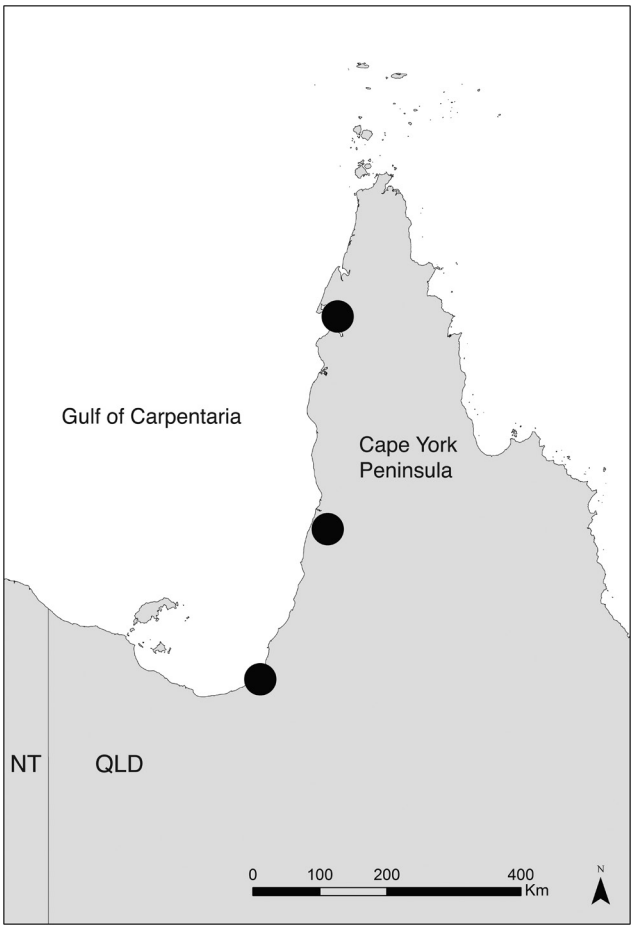

Figure 7. Spatial distribution of *Delias aestiva smithersi*, showing known locations on western Cape York Peninsula in the eastern Gulf of Carpentaria, Queensland, Australia.

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