

A new subspecies of *Candalides geminus* Edwards & Kerr, 1978 (Lepidoptera: Lycaenidae) from the Northern Territory, Australia

Michael F. Braby

Australian National Insect Collection, National Research Collections Australia, GPO Box 1700, Canberra, ACT 2601, Australia; and Division of Ecology and Evolution, Research School of Biology, The Australian National University, Acton, ACT 2601, Australia

Email: michael.braby@anu.edu.au

ABSTRACT – *Candalides geminus gagadju* ssp. nov. from the ‘Top End’ of the Northern Territory is described, illustrated and compared with the nominate subspecies *C. geminus geminus* Edwards & Kerr, 1978 and *C. erinus* (Fabricius, 1775). It differs from *C. geminus geminus* by four fixed phenotypic character states, but not in genitalic morphology nor in morphology of the immature stages. The taxon is restricted to sandstone blocks in the higher rainfall areas where it is sympatric with *C. erinus*, narrowly sympatric with *C. delospila* (Waterhouse, 1903), but allopatric with *C. geminus geminus* from eastern Australia. *Candalides geminus gagadju* breeds in heathy woodland where the larval food plants (*Cassytha filiformis* and *C. capillaris*) grow as hemi-parasitic vines. Although material of the subspecies has been known in museum collections for at least 45 years (earliest collections date to October 1972), its taxonomic identity, comparative morphology, distribution and biology have remained poorly known. During 2007–2014, I conducted detailed field investigations in north-western and northern Australia to address these substantial knowledge gaps.

KEYWORDS: Candalidini, Kakadu National Park, *Nesolycaena*, taxonomy, Top End

urn:lsid:zoobank.org:pub:A8240497-5EEC-45C2-B6FF-513120BA2220

INTRODUCTION

The lycaenid tribe Candalidini, as circumscribed by Eliot (1973), is endemic to the Australian zoogeographic region where it is restricted to Australia and mainland New Guinea and its adjacent islands (Parsons 1998; Braby 2000). It currently contains 37 species and 23 subspecies (60 taxa) referred to two genera (*Candalides* Hübner, 1819 and *Nesolycaena* Waterhouse & Turner, 1905), and thus represents a significant evolutionary radiation and characteristic component of the Australo-Papuan butterfly fauna. Since the revisionary work of Tite (1963), a remarkable number of new taxa have been described during the past 30 years (Parsons 1986; d’Apice and Miller 1992; Braby 1996, 2008; Williams and Bollam 2001; Tennent 2004; Braby and Douglas 2004; Müller 2013, 2014; Müller and Tennent 2016), suggesting that the taxonomic inventory of the tribe is incomplete and that additional taxa may await discovery.

As part of a broader study investigating the phylogenetic relationships and generic classification of the Candalidini, the purpose of this paper is to determine the species boundary of an isolated population of *Candalides* from the ‘Top End’ of the Northern Territory. The population was first recorded by Kikkawa and Monteith (1980) based on a small series of specimens collected from Radon Creek on the Arnhem Land plateau, and it had been assigned to the monotypic species *C. geminus* Edwards & Kerr, 1978. Elsewhere, *Candalides geminus* is known only from eastern Australia, mainly on or west of the Great Dividing Range from Cape York Peninsula, Queensland to Barryrennie [Conimbla National Park] near Cowra, New South Wales (Edwards and Kerr 1978), where it has a patchy distribution with populations restricted to heathy woodland on sandstone outcrops (south of Laura, Queensland) or coastal sands (north of Cooktown, Queensland). Prior to this study, very little material of *C. geminus* had been collected from the

Northern Territory (a total of 11 specimens (6 ♂, 5 ♀) from 1972–2007 are held in ANIC and QM), and it was previously known only from Kakadu National Park (Common and Waterhouse 1981). More recently, Braby (2011) reported the larval food plants from two locations in Kakadu and Nitmiluk National Parks, and discovered a new location at Wongalara Station based on material collected during a Bush Blitz expedition in 2012 (Braby 2012). Critical examination and comparison of this material has revealed that it is indeed conspecific with *C. geminus*, but that the population is taxonomically distinct according to the criteria proposed by Braby et al. (2012) for subspecies delimitation.

MATERIALS AND METHODS

Between 2007 and 2014, I conducted extensive field studies in the ‘Top End’ of the Northern Territory. Most of the major blocks of sandstone in this region (i.e., areas of potentially suitable habitat) were searched for presence of the butterfly (adults and/or immature stages), including Keep River-Spirit Hills National Park, Judbarra/Gregory National Park, Litchfield National Park, Limmen National Park and the Arnhem Land Plateau (Kakadu National Park, Nitmiluk National Park and Wongalara Wildlife Sanctuary). Searches were also conducted in the Kimberley region of Western Australia (Mitchell Plateau, Kalumburu, King Leopold Ranges, El Questro Wilderness Park, Purnululu National Park) and in western Queensland (Boodjamulla (Lawn Hill) National Park). Vines of the larval food plants (*Cassytha* spp.) were searched for the immature stages (eggs and larvae), which were reared on fresh cuttings of the food plant in captivity to adulthood in plastic containers.

The male genitalia of three specimens (from Kakadu and Nitmiluk National Parks, Northern Territory) were dissected, examined and compared with two specimens of *C. geminus* from eastern Australia (16 km SE of Hopevale, Queensland and Pilliga National Park, New South Wales). The genitalia were examined and compared by dissecting the terminal segments of the abdomen according to the method outlined in Braby (2000).

Adult size (both sexes) was compared with the nominate subspecies based on wingspan measurements. Wingspan was measured as the straight-line distance between the apices of each forewing of correctly spread specimens (i.e., in which the dorsum was set at right angles to the body) deposited in the ANIC using a digital calliper (K11100, Kinchrome©) to an accuracy of one decimal place (0.1 mm). Approximately 60 specimens of each sex were sampled from the Northern Territory and across the species’ geographical range

in New South Wales/Queensland. For each specimen two measurements were made and an average of the two readings was taken. Franklin and Bisa (2008) have demonstrated that wingspan is positively and significantly correlated with forewing length, and thus it is a useful proxy of adult size. The wingspan data was analysed using 2-way ANOVA (with LOCATION (NT or QLD/NSW) and SEX (Male or Female) as the independent variables) to assess any differences in size between the putative taxa.

The immature stages were compared with the published descriptions of *C. geminus* given by Edwards (1980) and material reared from Davies Creek National Park, the Burra Range, Queensland and Pilliga Scrub, New South Wales by the author.

Material was examined in the following repositories:

- ANIC: Australian National Insect Collection, Canberra
 QM: Queensland Museum, Brisbane
 NTM: Museum and Art Gallery of the Northern Territory, Darwin

TAXONOMY

Family Lycaenidae Leach, 1815

Subfamily Theclinae Swainson, 1831

Tribe Candalidini Eliot, 1973

Genus *Candalides* Hübner, 1819

Candalides Hübner, 1819: 73.

Rusticus xanthospilos Hübner, 1817 by subsequent designation of Scudder (1875).

Candalides geminus Edwards & Kerr, 1978

Candalides geminus gagadju ssp. nov.

Figures 5–8, 13, 14

urn:lsid:zoobank.org:act:50735CD9-1BE9-4AC7-A570-510B0A14AA66

MATERIAL EXAMINED

Holotype

Australia: Northern Territory: ♂ ‘12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, 4 MAY 2008, MF Braby & LJ Aitchison’ (ANIC).

Paratypes

Australia: Northern Territory: 67 ♂, 62 ♀. 1 ♂ '12.31S 132.58E, 9 km N by E of Mudginbarry H.S., N.T. 30 Oct. 1972, IFB. Common, E.D. Edwards, MS. Upton' (ANIC); 1 ♀ '12.25S 132.58E, 1 km N of Cahills Crossing, East Alligator River, N.T. 31 Oct. 1972, IFB. Common, E.D. Edwards, MS. Upton' (ANIC); 1 ♀ '12.52S 132.50E, Koongarra, 15km E of Mt. Cahill, N.T., 8 Mar 1973, M.S. Upton' (ANIC); 2 ♀ '12.50S 132.51E, 15km NE of Mt. Cahill, N.T., 23 May 1973, E.D. Edwards & M.S. Upton' (ANIC); 1 ♂, 1 ♀ '12.31S 132.58E, 9km NE of Mudginbarry H.S., NT. 26 May 1973, E.D. Edwards & M.S. Upton' (ANIC); 1 ♂ 'N.T. 12.45S, 132.53E, Radon Ck. (openforest), 14-16 July 1979, G. Monteith & D. Cook' (ANIC); 1 ♂ '12.85701°S, 132.79053°E, Nawurldnja, Kakadu NP, NT, 160m, 28 JAN. 2007, M.F. Braby', 'genitalia 024' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 20 JUL. 2007, MF Braby & LJ Aitchison' (ANIC); 2 ♂, 1 ♀ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 21 JUL. 2007, MF Braby & LJ Aitchison' (ANIC); 1 ♀ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, emg. 20 AUG. 2007, MF Braby & LJ Aitchison', 'Reared from early instar larva on *Cassythya filiformis*, coll. 21 JUL. 2007, pupated 8 AUG. 2007' (ANIC); 6 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 16 AUG. 2007, M.F. Braby & I. Morris' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, emg. 2 SEP. 2007, M.F. Braby & I. Morris', 'Reared from larva on *Cassythya filiformis*, coll. 16 AUG. 2007' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, emg. 8 SEP. 2007, M.F. Braby & I. Morris', 'Reared from larva on *Cassythya filiformis*, coll. 16 AUG. 2007' (ANIC); 1 ♀ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, emg. 10 SEP. 2007, M.F. Braby & I. Morris', 'Reared from egg on *Cassythya filiformis*, coll. 16 AUG. 2007' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, emg. SEP. 2007, M.F. Braby & I. Morris' (ANIC); 5 ♂, 2 ♀ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, 5 MAY 2008, MF Braby & LJ Aitchison' (ANIC); 1 ♂ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, emg. 20 MAY 2008, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 5 MAY 2008' (ANIC); 1 ♀ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, emg. 24 MAY 2008, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 5 MAY 2008' (ANIC); 3 ♂, 7 ♀ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, 30 JAN. 2009, MF Braby & LJ Aitchison' (ANIC); 1 ♂, 5 ♀ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, 4 DEC. 2009, MF Braby & J Armstrong' (ANIC); 1 ♂ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, emg. 22 DEC. 2009, MF Braby & J Armstrong', 'Reared from larva on *Cassythya filiformis*, coll. 4 DEC. 2009, pupated 13 DEC. 2009' (ANIC); 2 ♂, 1 ♀ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, 26 JUN. 2011, M.F. Braby' (ANIC); 1 ♂ '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, emg. 14 JUL. 2011, M.F. Braby', 'Reared from larva on *Cassythya filiformis*, coll. 26 JUN. 2011' (ANIC); 4 ♂, 7 ♀ '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, 4 MAY 2008, MF Braby & LJ Aitchison' (ANIC); 1 ♀ '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, emg. 18 MAY 2008, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 4 MAY 2008' (ANIC); 1 ♀ '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, emg. 19 MAY 2008, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 4 MAY 2008' (ANIC); 1 ♂ '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, emg. 3 JUN. 2008, MF Braby & LJ Aitchison', 'Reared from egg on *Cassythya filiformis*, pupated 23 MAY 2008, coll. 4 MAY 2008' (ANIC); 2 ♂ '13.43089°S, 132.41837°E, Waterfall Ck, Gunlom, Kakadu NP, NT, 28 AUG. 2008, MF Braby & LJ Aitchison' (ANIC); 6 ♂, 10 ♀ '13.42880°S, 132.41779°E, Waterfall Ck, Gunlom, Kakadu NP, NT, 29 AUG. 2008, MF Braby & LJ Aitchison' (ANIC); 1 ♂ '13.42880°S, 132.41779°E, Waterfall Ck, Gunlom, Kakadu NP, NT, emg. 22 SEP. 2008, MF Braby & LJ Aitchison', 'Reared from instar I on *Cassythya filiformis*, coll. 29 AUG. 2008' (ANIC); 3 ♂, 1 ♀ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Kakadu NP, NT, 50 m, 31 JAN. 2009, MF Braby & LJ Aitchison' (ANIC); 1 ♂ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Kakadu NP, NT, 50 m, emg. 13 FEB. 2009, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 31 JAN. 2009' (ANIC); 1 ♀ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Kakadu NP, NT, 50 m, emg. 14 FEB. 2009, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 31 JAN. 2009' (ANIC); 1 ♀ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Kakadu NP, NT, 50 m, emg. 15 FEB. 2009, MF Braby & LJ Aitchison', 'Reared from larva on *Cassythya filiformis*, coll. 31 JAN. 2009' (ANIC); 1 ♂, 1 ♀ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Nourlangie

Rock, NT, 8 NOV. 2009, M.F. Braby' (ANIC); 1 ♂ '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Nourlangie Rock, NT, emg. 22 NOV. 2009, M.F. Braby', 'Reared from larva on *Cassytha filiformis*, coll. 8 NOV. 2009' (ANIC); 1 ♀ '12.84650°S, 132.82295°E, Nourlangie Rock, Kakadu NP, NT, 120 m, 1 FEB. 2009, M.F. Braby & LJ Aitchison' (ANIC); 1 ♂ '12.84650°S, 132.82295°E, Nourlangie Rock, Kakadu NP, NT, 120 m, 8 NOV. 2009, M.F. Braby' (ANIC); 1 ♀ '12.84650°S, 132.82295°E, Nourlangie Rock, Kakadu NP, NT, emg. 9 FEB. 2014, MF Braby & LJ Aitchison', 'Reared from larva on *Cassytha filiformis*, coll. 26 JAN. 2014' (ANIC); 1 ♂, 1 ♀ '12.84650°S, 132.82295°E, 0.6 km E Nanguluwur, Kakadu NP, NT, 120m, 5 DEC. 2009, MF Braby & J Armstrong' (ANIC); 1 ♂ '12.84650°S, 132.82295°E, 0.6 km E Nanguluwur, Kakadu NP, NT, 120m, 5 DEC. 2009, MF Braby & J Armstrong', 'genitalia 051' (ANIC); 2 ♀ '12.84650°S, 132.82295°E, 0.6 km E Nanguluwur, Kakadu NP, NT, 120m, 7 DEC. 2009, MF Braby & J Armstrong' (ANIC); 1 ♀ '12.84650°S, 132.82295°E, 0.6 km E Nanguluwur, Kakadu NP, NT, 15 FEB. 2013, MF Braby' (ANIC); 1 ♀ '12.83721°S, 132.84970°E, 0.6 km W Gubara Tk carprk, Kakadu NP, NT, 16 OCT. 2010, M.F. Braby & S. Keates' (ANIC); 1 ♀ '12.83721°S, 132.84970°E, 0.6 km W Gubara Tk carprk, Kakadu NP, NT, emg. 26 NOV. 2010, M.F. Braby', 'Reared from larva on *Cassytha filiformis*, coll. 12 NOV. 2010' (ANIC); 1 ♀ '13.20353°S, 130.71574°E, Tolmer Falls, Litchfield NP, NT, 28 APR. 2011, MF Braby & JJ Armstrong' (ANIC); 4 ♂, 2 ♀ '13.19495°S, 130.70848°E, 1 km NW of Tolmer Falls, Litchfield NP, NT, 9 JUL. 2011, M.F. Braby & S. Keates' (ANIC); 1 ♂ '13.19495°S, 130.70848°E, 1 km NW of Tolmer Falls, Litchfield NP, NT, emg. 11 AUG. 2011, M.F. Braby & S. Keates', 'Reared from egg on *Cassytha capillaris*, coll. 9 JUL. 2011' (ANIC); 1 ♀

'13.19495°S, 130.70848°E, 1 km NW of Tolmer Falls, Litchfield NP, NT, emg. 12 AUG. 2011, M.F. Braby & S. Keates', 'Reared from egg on *Cassytha capillaris*, coll. 9 JUL. 2011' (ANIC); 3 ♂ '14.25149°S, 134.46429°E, 12 km S of H/S Wongalara WS, NT, 29 MAY 2012, M.F. Braby & R. Leijs' (ANIC); 1 ♀ '14.25149°S, 134.46429°E, 12 km S of H/S Wongalara WS, NT, 29 MAY 2012, M.F. Braby & R. Leijs' (NTM); 1 ♂ '14.25149°S, 134.46429°E, 12 km S of H/S Wongalara WS, NT, 5 JUN. 2012, M.F. Braby' (NTM); 4 ♂, 1 ♀ '14.25149°S, 134.46429°E, 12 km S of H/S Wongalara WS, NT, 5 JUN. 2012, M.F. Braby' (ANIC); 1 ♂ '14.16221°S, 134.12724°E, Mt Throsby, Wongalara WS, NT, emg. 26 JUN. 2012, M.F. Braby', 'Reared from larva on *Cassytha filiformis*, coll. 30 MAY 2012' (ANIC); 1 ♀ '14.16221°S, 134.12724°E, Mt Throsby, Wongalara WS, NT, emg. 14 JUL. 2012, M.F. Braby', 'Reared from egg on *Cassytha filiformis*, coll. 30 MAY 2012' (ANIC).

Other material

Australia: Northern Territory: 3 ♂ 'N.T. 12.45S, 132.53E, Radon Ck. (openforest), 14-16 July 1979, G. Monteith & D. Cook' (QM); 1 ♀ '13°25'43"S, 132°25'06"E, Gunlom, Kakadu NP, NT, 6 MAY 2007, L. Reid' (ANIC); 2 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 16 AUG. 2007, M.F. Braby & I. Morris' (ANIC); 3 ♀ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 20 JUL. 2007, MF Braby & LJ Aitchison' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 20 JUL. 2007, MF Braby & LJ Aitchison', 'genitalia 039' (ANIC); 1 ♂ '14.32032°S, 132.43723°E, Windolf Trail, Katherine Gorge, Nitmiluk NP, NT, 21 JUL. 2007, MF Braby & LJ Aitchison' (ANIC); 1 ♂ '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, 4 MAY 2008, MF Braby & LJ Aitchison' (ANIC); 1 ♀ '13.20353°S, 130.71574°E, Tolmer Falls,

TABLE 1 Wingspan measurements for *Candalides geminus* subspecies. Two-way ANOVA (with LOCATION and SEX as the independent variables) revealed significant differences in wing size between the two taxa ($F=454.3$, $df = 235$, $P<0.0001$), but no differences between the sexes within each subspecies ($P>0.01$).

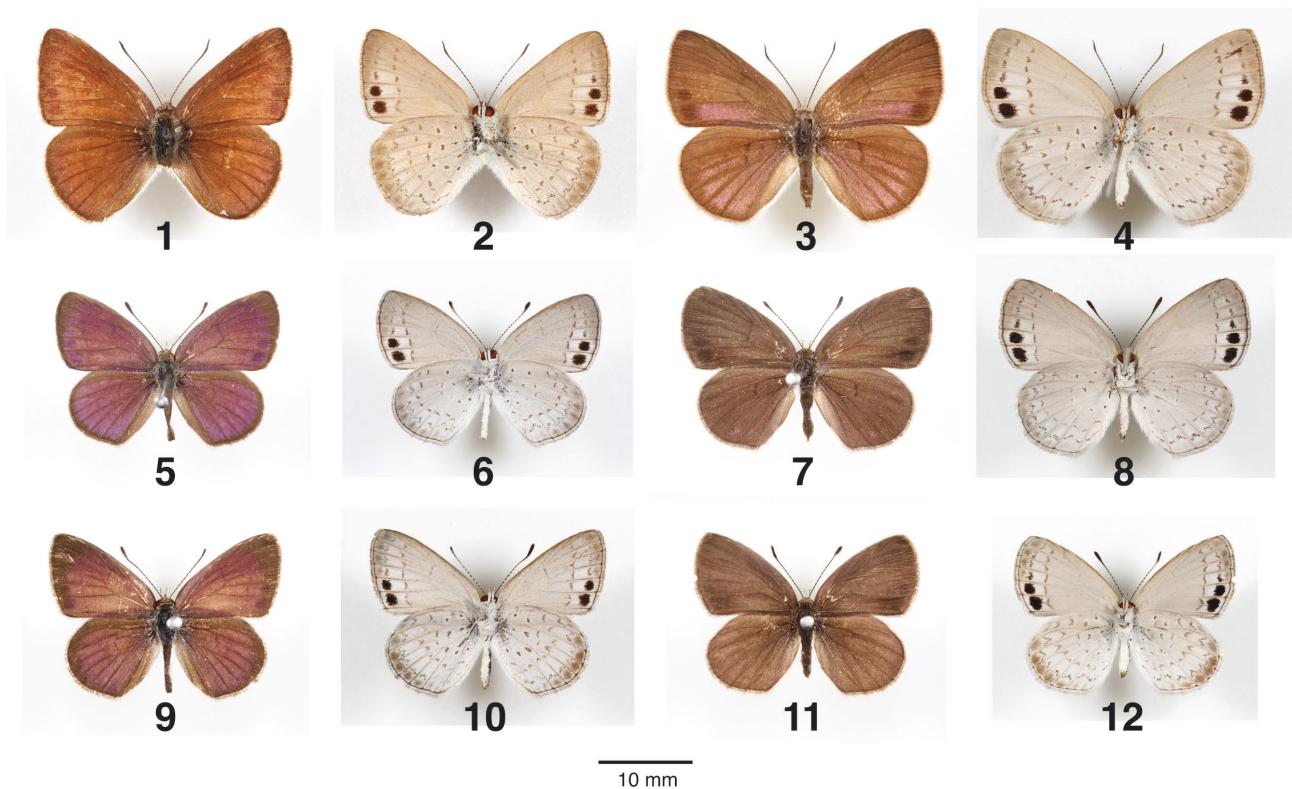
Subspecies	Location	Sex	Range	Mean ± SD	n
<i>C. g. gagadju</i>	NT	male	17.6–24.8	21.19 ± 1.455	60
<i>C. g. gagadju</i>	NT	female	18.2–24.6	21.72 ± 1.459	57
<i>C. g. geminus</i>	QLD/NSW	male	22.2–28.9	25.27 ± 1.488	60
<i>C. g. geminus</i>	QLD/NSW	female	22.1–31.2	25.92 ± 1.487	60

Litchfield NP, NT, 28 APR. 2011, MF Braby & JJ Armstrong' (ANIC); 1 ♂ '13.19495°S, 130.70848°E, 1 km NW of Tolmer Falls, Litchfield NP, NT, 9 JUL. 2011, M.F. Braby & S. Keates' (ANIC).

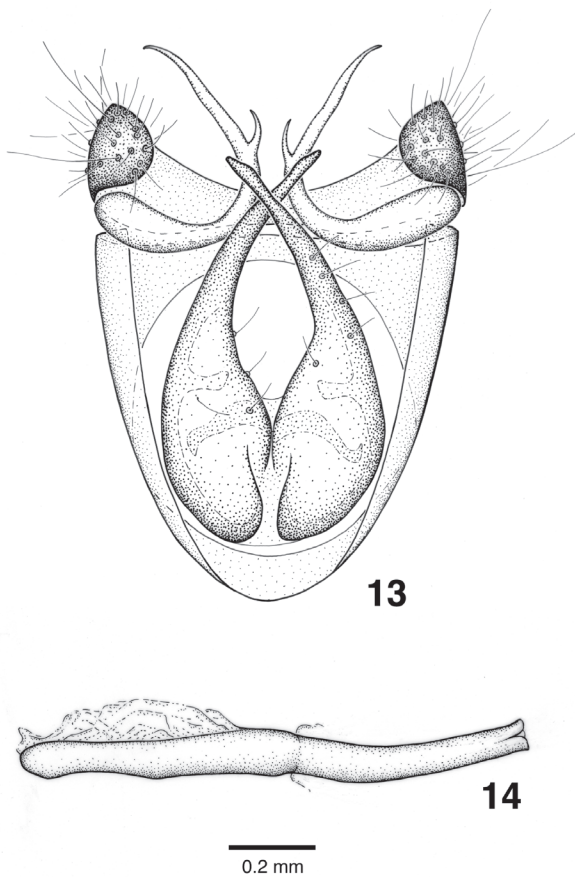
DIAGNOSIS

Candalides geminus gagadju (Figures 5–8) differs from the nominate subspecies *C. geminus geminus* (Figures 1–4) by the following four phenotypic characters: (1) adults are significantly smaller in size (Table 1); (2) the termen of the wings, particularly the forewing, is more rounded with the apex less sharply pointed, especially males; (3) the upperside colour of females is uniformly dark grey-brown with the basal and central iridescent purple areas either absent

(50% of specimens examined, $n = 60$) or substantially reduced to two small subterminal 'patches' of purple scales on the hindwing (between veins CuA_1 and $1A+2A$), whereas in *C. geminus geminus* the purple area, although variable in extent, is always present and far more extensive; and (4) the shape described by the postmedian line of spots on the underside of the hindwing is both generally more concave and displaced distally towards the subterminal line of spots so that the postmedian band (the intervening area between these two lines) is narrower and often a paler grey compared to the rest of the underside ground colour. The underside ground colour of *C. geminus gagadju*, like that of *C. geminus geminus*, is grey, although populations of *C. geminus geminus* from the southern



FIGURES 1–12 Adult specimens of *Candalides* spp. 1, 2, *C. geminus geminus* holotype male showing dorsal and ventral views [labelled 'Captain Billy Creek, Cape York Pen, N. Qld, 142°50'E, 11°45'S, 12–14.vii.1975, J.F.R. Kerr', 'Genitalia Slide M347' (ANIC)]; 3, 4, *C. geminus geminus* paratype female showing dorsal and ventral views [labelled same as holotype (ANIC)]; 5, 6, *C. geminus gagadju* ssp. nov. male holotype showing dorsal and ventral views [labelled '12.85463°S, 132.81677°E, Barrk Track, Nourlangie Rock, Kakadu NP, NT, 4 MAY 2008, MF Braby & LJ Aitchison' (ANIC)]; 7, *C. geminus gagadju* paratype female dorsal view [labeled '12.83696°S, 132.85626°E, Gubara Track carpark, Kakadu NP, NT, emg. 24 MAY 2008, MF Braby & LJ Aitchison, Reared from larva on *Cassytha filiformis*, coll. 5 MAY 2008' (ANIC)]; 8, *C. geminus gagadju* paratype female ventral view [labelled '12.84375°S, 132.82558°E, 1 km ENE Nanguluwur, Nourlangie Rock, NT, 8 NOV. 2009, M.F. Braby' (ANIC)]; 9, 10, *C. erinus erinus* male showing dorsal and ventral views [labelled '12.85930°S, 132.81754°E, Nourlangie Rock, Kakadu NP, NT, 4 MAY 2008, MF Braby & LJ Aitchison, MFB Collection 00369' (ANIC)]; 11, 12, *C. erinus erinus* female showing dorsal and ventral views [labelled '12.29586°S, 136.90302°E, Rocky Bay, Gove Peninsula, NT, 1 SEP. 2007, M.F. Braby, MFB Collection 00369' (ANIC)].



FIGURES 13–14 Male genitalia of *Candalides geminus gagadju* ssp. nov. 13, posterior view showing valvae and brachia, with phallus removed; 14, phallus, lateral view.

end of the range (Pilliga Scrub, Warrumbungle Ranges, and near Dubbo, New South Wales) differ in having the colour dark brownish-grey with the underside markings less distinct and the terminal blotches on the hindwing absent.

In many respects, *C. geminus gagadju* more closely resembles *C. erinus* (Fabricius, 1775) (Figures 9–12) from northern Australia in size, shape and colour pattern than *C. geminus geminus*. However, in *C. erinus* the postmedian band and dark grey terminal blotches on the underside of the hindwing are more distinct. In *C. erinus*, the postmedian band is both broader, with a straighter inner edge, and paler so that it contrasts against the grey ground colour, whereas in *C. geminus gagadju* the postmedian band is narrower, with the inner edge distinctly curved, and less contrasted. In males, the black terminal band or margin on the upperside of the forewing is broader towards the apex in *C. erinus*, whereas in *C. geminus gagadju* the band is narrower and even in width parallel to the termen. Also, the male

genitalia of *C. geminus gagadju* (Figures 13–14) differ considerably from *C. erinus*, but are typical of *C. geminus* in which the valvae gradually taper towards the apex (see comparative illustrations in Edwards and Kerr 1978, p. 85). In *C. erinus*, the valvae are very and long slender and do not taper from the swollen base.

DESCRIPTION

Male. Forewing length 12.4 mm (holotype, Figures 5–6), range 10.5–14.4 mm. Upperside colour purplish-bronze, with narrow black margins. Underside ground colour pale grey, with a series of small darker grey spots and markings; forewing with a postmedian line of spots extending from costa to dorsum, a line of three subterminal spots from costa to vein M_3 , an obscure black subterminal spot between veins M_3 and CuA_1 , and two larger prominent black subterminal spots near tornus between veins CuA_1 and $1A+2A$, each surrounded by a pale grey-white area that extends proximally to postmedian line; hindwing with a narrow paler postmedian band edged proximally by a series of darker spots and distally by a subterminal series of spots, followed by a series of larger obscure dark grey terminal blotches.

Female. Forewing length 12.6–14.1 mm (paratypes, Figures 7–8), range 10.8–14.6 mm. Upperside brown-black; forewing with two black subterminal spots near tornus; hindwing often with two small purple subterminal patches between veins CuA_1 and $1A+2A$. Underside colour and pattern similar to male.

VARIATION

In males, the upperside colour varies from dull bronze-purple to shining purple, with examples of the latter form collected or reared mainly during the cooler dry season months (May–August) suggesting that there may be a seasonal component to the variation.

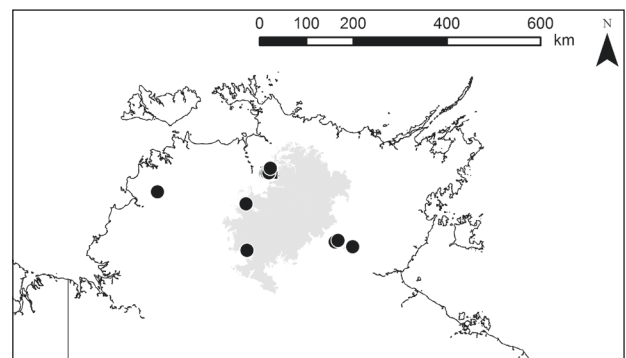


FIGURE 15 Distribution of *Candalides geminus gagadju* in the Top End of the Northern Territory. Grey shaded polygon shows extent of the Arnhem Land plateau.



FIGURES 16–32 Life history of *Candalides geminus gagadju*. 16, eucalypt heathy open-woodland habitat on broken sandstone at Nourlangie Rock, Kakadu National Park; 17, larval food plant *Cassytha filiformis* at Windolf Trail, Nitmiluk (Katherine Gorge) National Park; 18, egg; 19, first instar larva; 20, second instar larva; 21–29, final instar larva, showing phenotypic variation, 21–26, dorsal view, 27–29, lateral view; 30–32, pupa, showing dorsal, dorsolateral and lateral views.

The width of the black margin also varies. In females, the extent of the purple iridescent areas varies: when present, it is usually restricted to the subterminal region of the hindwing (comprising two small patches), but in cell 1A+2A it may extend towards the base, and occasionally a third subterminal patch occurs between veins M_3 and CuA_1 ; very occasionally there may be a dusting of purple scales at the base of the forewing, usually just above the dorsum. In both sexes, there is considerable variation in the extent and clarity of the underside markings, particularly the postmedian and subterminal series of spots, which may be very obscure in some specimens.

REMARKS

Edwards and Kerr (1978) described and illustrated *C. geminus*, which had previously been confused with the closely-related *C. hyacinthinus* (Semper), as a monotypic species from eastern Australia, with type locality Captain Billy Creek, Cape York Peninsula, Queensland. However, material from the Top End of the Northern Territory was not included in their description and diagnosis. Although specimens of *C. geminus gagadju* (2 ♂, 5 ♀ in ANIC) were first collected from western Arnhem Land in 1972–73 by I.F.B. Common, E.D. Edwards and M.S. Upton, this material was not considered in the description and distribution of *C. geminus* because it had been misidentified and confused with *C. erinus* (E.D. Edwards, pers. comm., 2017). The first published record of *C. geminus* from the Top End was the report by Kikkawa and Monteith (1980), who recorded the species based on a small series (4 ♂ in QM and ANIC) from Radon Creek on the Arnhem Land plateau in 1979.

The systematic relationships of the *C. erinus* species group have not been established, but a preliminary molecular phylogenetic analysis of the Candalidini indicates that *C. geminus* and *C. erinus* are sister taxa and are genetically divergent by 2.7% for mitochondrial COI (24 bp differences out of 880 bp for the barcode region) under the HKY substitution model, whereas the distance between the two subspecies of *C. geminus* for this region is 1.7% or 15 bp (M. Espeland and M.F. Braby, unpublished data).

ETYMOLOGY

The name Gagadju is the language name for the Australian Aboriginal tribe from western Arnhem Land in the Northern Territory where this butterfly is predominantly distributed. The name has several variations in spelling (e.g. Gagadu, Kakadju, Kakadu and Kakatu), but Gagadju is the name adopted here. It is intended as a noun in apposition.

DISTRIBUTION

Candalides geminus gagadju is endemic to the Top End of the Northern Territory where it has been recorded from Litchfield National Park (Tolmer Falls area), Kakadu National Park (including Nourlangie Rock and Gunlom), Nitmiluk (Katherine Gorge) National Park and Wongalara Wildlife Sanctuary. The distribution is centred mainly on the Arnhem Land plateau (Figure 15), although there is a disjunct population 200 km further west in Litchfield National Park. Searches for the taxon in the sandstone areas of the Kimberley region of Western Australia, Keep River-Spirit Hills, Judbarra/Gregory and Limmen national parks in the Northern Territory, and Boodjamulla (Lawn Hill) National Park in western Queensland by the author, did not detect the subspecies. *Candalides geminus gagadju* frequently occurs in sympatry with *C. erinus*, and at Wongalara Wildlife Sanctuary (12 km S of the homestead) it was recorded in sympatry with both *C. erinus* and *C. delospila* (Waterhouse, 1903).

BIOLOGY

Candalides geminus gagadju is restricted to blocks of sandstone in the higher rainfall areas (>900 mm mean annual rainfall) of the Northern Territory where it breeds in eucalypt heathy woodland and open-woodland with a spinifex understorey on rocky sandstone outcrops, escarpments and plateaus where the larval food plants grow as scrambling parasitic vines in the understorey (Figures 16–17) (Braby 2011). The usual larval food plant is *Cassytha filiformis* L. (Lauraceae), but *C. capillaris* Meisn. is also used where it is present (Braby 2011). Adults have been recorded during most months of the year, but they appear to be more abundant during the wet season (November–January) and in the mid dry season (July).

The immature stages (egg, larva and pupa) (Figures 18–32) are identical to those of *C. geminus geminus*, which were described by Edwards (1980). A feature distinguishing *C. geminus* from other *Candalides* spp. is the colour pattern of the final instar larva, which is characterised by a prominent white subdorsal line on abdominal segments 1 to 6 that is bordered laterally by a deep purple line, and the presence of two raised, red dorsal projections, on abdominal segments 1 and 6. The white subdorsal line extends to the mesothorax and metathorax, where it usually becomes pale yellow, and on the abdomen it may become yellow towards the rear of each segment. Larvae of *C. geminus gagadju* (Figures 21–29) possess these two characters, but they are highly variable in colour pattern, particularly with respect to the overall ground colour (which comprises various shades of green); the presence of the raised, red dorsal projections on abdominal segments 1 and 6

(the projections are usually present, but occasionally both may be absent, Figures 21, 24, 27); and the extent and clarity of the purple subdorsal line, which may comprise a continuous narrow band (Figures 22, 24, 27), a broken band of discrete spots (Figures 21, 23, 25, 28), or a continuous broad band edged posteriorly with bright red (Figures 26, 29). The immature stages have been recorded in most months of the year. The life cycle is completed relatively quickly (approximately one month, with the larval duration varying from 14–18 days and pupal duration 11–12 days), indicating that breeding occurs continuously and that several generations are completed annually.

ACKNOWLEDGEMENTS

I am grateful to L.J. Aitchison, J.J. Armstrong, S. Keates and I. Morris for assistance with field work, E.D. Edwards and M. Espeland for unpublished information, S. Wright for loan of material in the QM, M. Osterkamp for preparing the scientific line drawing of the male genitalia, Y.N. Su for preparing digital illustrations of type material of *Candalides geminus* in the ANIC, and M.R. Williams for comments on the manuscript. Specimens from Kakadu National Park were collected under scientific research permit numbers RK 704 and RK 729. This work was supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) Bush Blitz Strategic Taxonomy Grants Scheme for a project entitled 'Taxonomic revision of *Candalides* and allied genera in the tribe Candalidini (Lepidoptera: Lycaenidae)'. The ABRS Bush Blitz program is also gratefully acknowledged for provision of funds for field expeditions to Wongalara Wildlife Sanctuary in 2012.

REFERENCES

- Braby, M.F. (1996). A new species of *Nesolycaena* Waterhouse and Turner (Lepidoptera: Lycaenidae) from northeastern Australia. *Australian Journal of Entomology* **35**: 9–17.
- Braby, M.F. (2000). *Butterflies of Australia. Their Identification, Biology and Distribution*. CSIRO Publishing: Collingwood, Melbourne.
- Braby, M.F. (2008). Taxonomic review of *Candalides absimilis* (C. Felder, 1862) and *C. margarita* (Semper, 1879) (Lepidoptera: Lycaenidae), with descriptions of two new subspecies. *The Beagle, Records of the Museums and Art Galleries of the Northern Territory* **24**: 33–54.
- Braby, M.F. (2011). New larval food plant associations for some butterflies and diurnal moths (Lepidoptera) from the Northern Territory and eastern Kimberley, Australia. *The Beagle, Records of the Museums and Art Galleries of the Northern Territory* **27**: 85–105.
- Braby, M.F. (2012). *Butterflies and diurnal moths of Wongalara Station. Final Report to Department of Sustainability, Environment, Water and Communities*. Department of Land Resource Management: Darwin.
- Braby, M.F. and Douglas, F. (2004). The taxonomy, ecology and conservation status of the Golden-rayed Blue, a threatened butterfly endemic to western Victoria, Australia. *Biological Journal of the Linnean Society* **81**: 275–299.
- Braby, M.F., Eastwood, R.G. and Murray, N. (2012). The subspecies concept in butterflies: has its application in taxonomy and conservation biology outlived its usefulness? *Biological Journal of the Linnean Society* **106**: 699–716.
- Common, I.F.B. and Waterhouse, D.F. (1981). *Butterflies of Australia*. Angus and Robertson: Sydney.
- d'Apice, J.W.C. and Miller, C.G. (1992). The genus *Nesolycaena* Waterhouse and Turner (Lepidoptera: Lycaenidae) with a description of a new species. *Australian Entomological Magazine* **19**: 75–80.
- Edwards, E.D. (1980). The early stages of *Adaluma urumelia* Tindale and *Candalides geminus* Edwards and Kerr (Lepidoptera: Lycaenidae). *Australian Entomological Magazine* **7**: 17–20.
- Edwards, E.D. and Kerr, J.F.R. (1978). A new species of *Candalides* from eastern Australia and notes on *Candalides hyacinthinus* (Semper) (Lepidoptera: Lycaenidae). *Australian Entomological Magazine* **4**: 81–90.
- Eliot, J.N. (1973). The higher classification of the Lycaenidae (Lepidoptera): a tentative arrangement. *Bulletin of the British Museum (Natural History) Entomology* **28**: 371–505.
- Franklin, D.C. and Bisa, D. (2008). Field key to the lycaenid butterflies of the Top End and Kimberley. *Northern Territory Naturalist* **20**: 1–18.
- Kikkawa, J. and Monteith, G.B. (1980). *Animal ecology of monsoon forests of the Kakadu region, Northern Territory*. Queensland Museum consultancy report to Director, Australian National Parks and Wildlife Service: Canberra.
- Müller, C.J. (2013). A remarkable new species of *Candalides* Hübner, 1819 (Lepidoptera, Lycaenidae) from the Bismarck Archipelago, Papua New Guinea. *Nachrichten des Entomologischen Vereins Apollo* **34**: 69–72.
- Müller, C.J. (2014). A new species of *Candalides* Hübner, 1819 from Mainland Papua New Guinea (Lepidoptera: Lycaenidae). *Nachrichten des Entomologischen Vereins Apollo* **35**: 214–216.
- Müller, C.J. and Tennent, W.J. (2016). Two new species of *Candalides* Hübner, 1819 (Lepidoptera: Lycaenidae) from Papua New Guinea and Indonesia. *Tropical Lepidoptera* **26**: 25–31.
- Parsons, M.J. (1986). A new genus and twenty-six new species of butterflies (Lepidoptera: Hesperidae, Lycaenidae, Nymphalidae) from Papua New Guinea and Irian Jaya. *Tyô to Ga* **37**: 103–177.

- Parsons, M.J. (1998). *The Butterflies of Papua New Guinea. Their Systematics and Biology*. Academic Press: London.
- Tennent, W.J. (2004). A new *Candalides* (Lepidoptera, Lycaenidae) from the D'Entrecasteux island group (Papua New Guinea). *Futao* **49**: 2–3.
- Tite, G.E. (1963). A revision of the genus *Candalides* and allied genera (Lepidoptera: Lycaenidae). *Bulletin of the British Museum (Natural History) Entomology* **14**: 197–259.
- Williams, M.R. and Bollam, H.H. (2001). A new subspecies of *Candalides hyacinthinus* (Semper) (Lepidoptera: Lycaenidae) from Western Australia. *The Australian Entomologist* **28**: 49–54.

MANUSCRIPT RECEIVED 4 SEPTEMBER 2017; ACCEPTED 23 OCTOBER 2017.