A new species of trapezitine skipper (Lepidoptera: Hesperiidae) from the Kimberley in the Australian Monsoon Tropics

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Abstract

A new species of skipper butterfly, *Toxidia aurantia* Braby, sp. nov., is illustrated, diagnosed and described from the northern Kimberley of Western Australia. A molecular phylogeny based on one mitochondrial (COX1 barcode fragment) and four nuclear genes (EF1-a, RSB2, RSB5, Wingless) for nearly all members of *Toxidia* Mabille, 1891 and its sister genus *Timoconia* Strand, 1909 according to the Maximum Likelihood optimality criterion, indicated that the new species belongs in the *Toxidia xanthomera* species-group (formerly classified in the genus *Neohesperilla* Waterhouse & Lyell, 1914) and is most closely related to *T. crocea* (Miskin, 1889). These two taxa are sister to *T. xiphiphora* (Lower, 1911). *Toxidia aurantia* Braby, sp. nov. is currently known from only a limited area on the mainland in the Admiralty Gulf near the Osborn Islands and Borda Island, WA. The discovery of this new species contributes to the emerging picture that the northern Kimberley is likely an area of high species richness for butterflies and day-flying moths within the Australian Monsoon Tropics.

Key words: Biogeography, butterfly, Ord Arid Intrusion, Trapezitinae, Victoria River Drainage Basin barrier.

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Introduction

The trapezitine skipper genus *Toxidia* Mabille, 1891 includes 11 species restricted to Australia and mainland New Guinea and its neighbouring islands (Toussaint et al. 2022). The type species of the genus is *Toxidia thyrrhus* Mabille, 1891 by monotypy. Four species, previously classified in the genus *Neohesperilla* Waterhouse & Lyell, 1914, comprise a monophyletic group and are a characteristic component of the butterfly fauna of the Australian Monsoon Tropics (Braby 2008). This group of species is referred to here as the *T. xanthomera* (Meyrick
& Lower, 1902) species-group. Two of these species, _T. xiphiphora_ (Lower, 1911) and _T. crocea_ (Miskin, 1889), are very similar in appearance and are closely related sister taxa (Toussaint et al. 2022). _Toxidia xiphiphora_ (Figs 2–4, 8–11) has a disjunct distribution, occurring in the ‘Top End’ and western Gulf Country of the Northern Territory and in the Wet Tropics World Heritage Area and Cape York Peninsula of north-eastern Queensland (Braby 2000; Braby et al. 2018). In the Top End, _T. xiphiphora_ has been recorded breeding in savanna and eucalypt woodlands in the higher rainfall areas (> 1,000 mm mean annual rainfall), particularly along the edges or bases of rocky outcrops where the larval food plant, _Sorghum intrans_ F.Muell. ex Benth. (Poaceae), grows as an annual grass in the open shaded understorey beneath eucalypt trees (Braby 2015). _Toxidia crocea_ (Figs 5–7, 12–15) has a similar disjunct distribution, but it also extends to the northern Kimberley (Braby et al. 2018) and southern Papua New Guinea (Sands & Fenner 1978). Its geographical distribution broadly overlaps that of _N. xiphiphora_ but it occurs in moister habitats (Johnson et al. 1994), including edges of monsoon vine thicket, riparian forest and paperbark swampland in the Top End (Braby et al. 2018).

Recently, a specimen, tentatively identified as _T. xiphiphora_, was collected from the northern Kimberley in Western Australia (Braby 2019): on the 18th February 2019, a single male was collected in mixed coastal paperbark swampland and monsoon vine thicket on the mainland east of Middle Osborn Island, approximately 500 km west of the known range of _T. xiphiphora_. The specimen was in slightly worn condition and Braby (2019) noted that it differed from typical _T. xiphiphora_ from the Top End with regard to the upper and underside ground colour, which were deeper orange, and the central spots on the hind wing, which were enlarged. Since that report, additional material (1♀, 4♂) has become available and allowed better comparison with _T. xiphiphora_ and _T. crocea_ from the Northern Territory and northern Queensland. Closer examination, dissection and molecular analysis of the Western Australian material has revealed that the western Kimberley population comprises a distinct species closely allied to _T. crocea_. The purpose of this paper, therefore, is to illustrate, diagnose and describe this new species. We also analyse the phylogenetic relationships of these species within the genus _Toxidia_ and its closest relative _Timocoenia_ Strand, 1909 based on a molecular dataset.

Methods

Molecular data

Genomic DNA was extracted from legs of 12 ethanol-preserved specimens (voucher specimens in ANIC, Table 1) using a Qiagen DNeasy Blood and Tissue Kit (Qiagen), following the manufacturer’s protocol and eluting with 15 μl of water. DNA extracts were used to build miniaturised Illumina DNA sequencing libraries for low coverage. Whole Genome Shotgun sequencing (“genome skimming”) was based on the QIAseq FX DNA Library UDI-A Kit (Qiagen). Uniquely indexed libraries were pooled, and a total of 384 pooled samples, which included additional samples not part of this study, was sequenced on an Illumina NovaSeq 6000 S1 flow cell with 300 cycles (150 bp PE).

DNA sequence data were demultiplexed, quality- and adapter-trimmed with Trimmomatic v0.36 (Bolger et al. 2014), merged with BBMerge v38.37 (Bushnell et al. 2017) and de novo assembled with SPAdes v3.13.1 (Bankevich et al. 2012). Mitochondrial contigs were extracted from the assemblies using BLAST+ v2.10.1 (Camacho et al. 2009) and annotated with MITOS2 v2.0.8 (Donath et al. 2019), using 63 Metazoa RefSeq and default parameters. A subset of 657 bp of COX1, which corresponds to the COX1 DNA barcode fragment, was selected and combined with publicly available sequence data from 14 specimens of _Toxidia_ and _Timocoenia_ species. The publicly available sequence data from the study of Toussaint et al. (2022) include additional fragments of the genes EF1-a, RPS2, RPS5 and Wingless, and an effort was made to mine these genes from the WGS assemblies using the public data as query sequences in Tblastx searches. However, due to the low read coverage of the genome skimming data, success was very limited. All genes were individually aligned as amino acid sequences with MAFFT v7.310 (Katoh & Standley 2013) and concatenated into a datamatrix of 2,967 bp length. All new sequence data have been deposited in NCBI’s Genbank (Table 1).

The data matrix was analysed phylogenetically with IQ-TREE v2.2.08 (Nguyen et al. 2014; Chernomor et al. 2016) using the Maximum Likelihood (ML) optimality criterion. Partitioning by gene and codon position was applied (15 partitions), and the optimal combination of possibly merged partitions and models was determined by ModelFinder (Kalyaanamoorthy et al. 2017) in IQ-TREE (MF+MERGE) using the small-sample corrected Akaika Information Criterion (AICc) and an edge-linked partition model with same branch lengths but independent evolutionary rates across partitions (-spp). One-hundred independent ML tree searches were performed and the tree with the highest likelihood score was selected. Statistical node support was estimated for each tree using Shimodaira-Hasegawa approximate likelihood ratio test with 1,000 replicates (SH-aLRT, -alrt 1000 Shimodaira & Hasegawa 1999) and ultrafast bootstraps with 1,000 replicates (UFBoot, -b 1000 Hoang et al. 2018). Following the IQ-TREE manual, nodes with at least UFBoot >=95 and at least SH-aLRT >= 80 were subjectively considered to have strong support. The tree was visualised with FigTree v1.4.4 (https://github.com/rambaut/figtree) and prepared as an illustration in Inkscape v0.92 (https://inkscape.org/).
Table 1. GenBank accession numbers for the 12 additional samples sequenced in this study.

<table>
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<tr>
<th>Species</th>
<th>Voucher number</th>
<th>Location</th>
<th>COX1</th>
<th>Wingless</th>
<th>RSP2</th>
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<td>Kimberley mainland, E of Middle Osborne Island, WA</td>
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<td>OQ992200</td>
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</table>

Morphological data

The genitalia of two males of *T. xiphiphora* were dissected from Cape York Peninsula in northern Queensland and the ‘Top End’ of the Northern Territory for comparison with the putative new species, as follows: 1 ♂ labelled “Station Ck. Spray, Silver Plains, Cape York Pen., Q, Mar. 1959, J.L. Wassell”, “Genitalia No. MFB-133” (ANIC); and 1 ♂ labelled “Lee Point, Darwin, N.T., 7 Mar. 1967, M.S. Upton”, “Genitalia No. MFB-134” (ANIC). The genitalia of two males of *T. crocea* were also dissected from the Wet Tropics in northeastern Queensland and the Top End, as follows: 1 ♂ labelled “Cooktown, Q, 3 July 1964, J.C. Le Souef”, “Genitalia No. MFB-149” (ANIC); and 1 ♂ labelled “12.52S 132.47E, Nourlangie Creek, 8 km E of Mt. Cahill, N.T., 27 Oct. 1972, I.F.B. Common, E.D. Edwards, M.S. Upton”, “Genitalia No. MFB-148” (ANIC). Dissection of the genitalia was performed using standard techniques: the entire abdomen was removed and placed in 10% KOH and boiled for 20 minutes, and then transferred to 30% ethanol for cleaning, dissection and examination. Completed dissections were fixed in 95% ethanol and then 100% isopropanol. The genitalia were placed in an alcohol-based gel in an excavated glass block and photographed using a Leica M205A microscope and were stacked using Helicon Focus 5.3 according to the technique of Su (2016). Terminology for genitalia follows Klots (1970).

Adult size was estimated by measuring the length of the fore wing, that is, the straight-line distance between the apex and base (i.e., the point of attachment of the wing with the thorax), using a digital calliper to an accuracy of 0.1mm.

For species concept, we follow de Queiroz’ general lineage concept based on phenotypic, morphological, reproductive and phylogenetic criteria (de Queiroz, 1998).

The following acronyms refer to repositories where specimens have been examined or deposited:

- AMS: Australian Museum, Sydney;
- ANIC: Australian National Insect Collection, Canberra;
- NMV: Museums Victoria, Melbourne;
- QM: Queensland Museum, Brisbane;
- SAMA: South Australian Museum, Adelaide;
- WAM: Western Australian Museum, Perth.

Results

The 657 bp fragment of COX1 was successfully generated for all 13 specimens, while RSP2 and Wingless were only recovered for *Toxidia aurantia* sp. nov. (MFB-18-B147; holotype) and *Toxidia xiphiphora* (MFB-10-P070), respectively. ModelFinder favoured a partitioning scheme that separated the three codon positions of COX1, and merged the 2nd codon positions of EF1-a and RSP5, 3rd codon positions of EF1-a and RSP5, 3rd codon positions of RSP2 and Wingless, and all remaining gene and codon positions (Datafile S1). The resulting Maximum Likelihood tree (Fig. 1; lnL -7486.200) was rooted against *Timoconia*, with maximum statistical support (SH-aLRT 100%, UFBoot 100%) separating *Timoconia* and *Toxidia*. Within *Toxidia*, the monophyly of all species represented by multiple specimens was very strongly to maximally supported, and the distinctiveness of all species was evidenced by long branches separating these species. The monophyly of the *T. xanthomera* species-group (*T. xanthomera*, *T. senta*, *T. xiphiphora*, *T. aurantia* sp. nov. and *T. crocea*) was maximally supported, and relationships between its five species were near maximally supported. The new species *T. aurantia* sp. nov. was very strongly supported as sister to *T. crocea*, and together they were very
Recognition of *Toxidia aurantia* sp. nov. from the Kimberley brings to 12 the total number of species recognised in the genus *Toxidia* and the number in the *T. xanthomera* species-group to five. The *T. xanthomera* species-group is distinguished from other species of *Toxidia* by the paler brown colour to the dorsal surface of the wings and the yellowish ground colour to the ventral surface of the wings. This species-group is distinctive in that its members are largely restricted to savannah woodland in the monsoon tropical biome of northern Australia (Braby 2008; Bowman et al. 2010); most other species of *Toxidia* occur in rainforest or temperate/subtropical open-forest along the east coast of Australia, with three species also occurring in mainland New Guinea, one of which is endemic to the island (Toussaint et al. 2022).

*Toxidia aurantia* differs from *T. crocea* and *T. xiphiphora* by at least 17 character states (11 phenotypic based on wing colour pattern elements, 6 morphological based on male genital features), as well as phylogenetically according to molecular markers. The long branches leading to these species, and the very strong support values for the reciprocal monophyly of *T. aurantia* and *T. crocea*, indicate substantial differentiation between these sister taxa. The sex-brand on the fore wing of *T. aurantia* and *T. xiphiphora* males is similar, and these two species are distinguished from others in the *T. xanthomera* species-group by having the broadest patch of sex-scales. However, the underside ground colour of *T. aurantia* is bright orange, rather than dull yellow or yellow-brown, and this feature is unique to *T. aurantia*, distinguishing it from all others in the genus.

The discovery of *T. aurantia* adds to the growing richness of the butterfly and day-flying moth fauna recognised for the Kimberley. The northern Kimberley was identified as a putative centre of endemism based on analysis of weighted endemism of diurnal Lepidoptera, but not as a biodiversity hotspot when species richness, endemic richness and weighted endemism were considered together (Braby et al. 2020c). However, as Braby (2019) pointed out, the rate of newly discovered and recorded species from this region over the past 30 years, but especially during the past decade (since 2014), indicates that the inventory for the northern Kimberley is far from complete, and new species continue to be recorded. For example, further surveys and sampling of the northern Kimberley by J.E. & A. Koeyers in 2020–2022 have uncovered three additional species of diurnal Lepidoptera (*Idalima aethrias* Turner, 1908, *Idalima metasticta* Hampson, 1910, and *Cruria darwiniensis* (Butler, 1884)), species previously known only from the Top End (Braby et al. 2018).

Conversely, endemic richness in the Kimberley appears to be relatively low for butterflies and day-flying moths. The only diurnal Lepidoptera truly endemic to the Kimberley at the species level are the lycaenid *Candalides caesia* (d’Apice & Miller, 1992), the sun-moth *Syemon kimberleyensis* Braby, Edwards & A.A.E. Williams, 2020 and now the skipper *Toxidia aurantia*. Interestingly, two
of these species have their nearest relatives (i.e., sister species) in the Top End and western Gulf Country or Top End and north-eastern Queensland – for *C. caesia* the sister species is *Candalides urumelia* (Tindale, 1922) (NT-w. QLD) (Braby et al. 2020b); and for *S. kimberleyensis* the sister species is *Synemor phaeoptila* Turner, 1906 (NT-ne. QLD) (Braby et al. 2020a). In contrast, the sister species for *T. aurantia* is *T. crocea* which has been recorded in the Top End and north-eastern Queensland, as well as in the Kimberley at Drysdale River Station (Braby et al. 2018) and on the mainland east of Middle Osborn Island. The five known sites of *T. aurantia* are all located in the higher rainfall zone of the Kimberley near the coast (Fig. 35) indicating that it is narrowly sympatric with *T. crocea*.

Further work is needed to understand the historical processes underlying biogeographic patterns of these species pairs between the Kimberley and the Top End – are they the result of vicariance or long-distance dispersal across the Ord Arid Intrusion and Victoria River Drainage Basin barrier? In contrast, other species of diurnal Lepidoptera that have disjunct distributions between these two areas (e.g., *Cressida cressida*, *Taractrocera psammoreata*, *Eurema alitha*, *Appias paulina*, *Euploea darchia*, *Hypolycaena phorbas*, *Petrelaea tombusgensis*, *Cupido lacturnus*, *Birthana cleis*, *Dysphania numana*, *Idoloma leonora* and *Radinocera* sp. “Sandstone”) (Braby et al. 2018) do not show patterns of allopatric differentiation at the species or even subspecies level, suggesting that there are different layers of biogeographic history between the Kimberley and Top End for these Lepidoptera.

**Taxonomy**

Trapezitinae Waterhouse & Lyell, 1914

*Toxidia* Mabille, 1891

Type species: *Toxidia thyrrhus* Mabille, 1891 (by monotypy)

**Toxidia aurantia** Braby, sp. nov.

(Figs 16–19, 32–34)

http://zoobank.org/urn:lsid:zoobank.org:act:DAA60297-0A06-499A-BEB4-ACD5CC3DFF45

Type locality: Kimberley mainland east of Middle Osborne Island, Western Australia, Australia.


**Diagnosis**

*Toxidia aurantia* (Figs 16–19) differs from the four other species in the *T. xanthomera* species-group by the deep orange underside ground colour, contrasted with conspicuous black or dark brown edges to the pale yellow spots. Phenotypically, it is most similar to *T. xiphiphola* (Figs 2, 3, 8–11) and *T. crocea* (Figs 5, 6, 12–15), from which it differs by the following unique 11 phenotypic character states: (1) The upperside ground colour of *T. aurantia*, as in *T. xiphiphola* and *T. crocea*, is dark brown, but in *T. aurantia* it is overlaid or suffused with patches of orange scales, whereas in the two other species the patches of scales are dull yellow. (2) The ‘hyaline’ spots on both wings are pale yellow in *T. aurantia*, but white or cream in *T. xiphiphola* and *T. crocea*. (3) In *T. aurantia*, these pale yellow spots are substantially larger, particularly the three subapical spots on the fore wing, the central spot between veins CuA1 and CuA2 on the fore wing (in the female), and the two central spots between veins M3 and CuA2 on the hind wing. The postmedian spot between veins Rs and M1 on the hind wing is present and well-developed in *T. aurantia*, whereas in *T. xiphiphola* and *T. crocea* this spot is usually absent or, if present, minute or reduced to a brown dot. (4) In the female, the median spot near the dorsum on the upperside of the fore wing is orange in *T. aurantia*, but yellow in *T. xiphiphola* and *T. crocea*. (5) The upperside ground colour is bright orange in *T. aurantia*, whereas in *T. xiphiphola* and *T. crocea* it is dull yellow or yellowish-brown. (6) The ‘hyaline’ spots on the underside of both wings are distally edged with brown in *T. xiphiphola* and *T. crocea*, whereas in *T. aurantia* the distal edges to these spots are black or dark brown and more extensive and contrasting. (7) The broad area above the dorsum on the underside of the fore wing is dark brown extensively suffused with yellow in *T. aurantia*, whereas in *T. xiphiphola* and *T. crocea* it is uniformly pale brown or dark brown with the posterior half suffused with pale brown. (8) The brown submedian spot on the underside of the hind wing is substantially larger in *T. aurantia* than in *T. xiphiphola* and *T. crocea* in which it is often reduced to a dot. (9) The broad linear streak between the anal veins 1A+2A and 3A on the underside of the hind wing is orange in *T. aurantia*, whereas in *T. xiphiphola* and *T. crocea* it is brown. (11) The scale fringe of the hind wing is bright orange in *T. aurantia*, but yellow or pale yellow in *T. xiphiphola* and *T. crocea*.

In addition, in the male, the linear patch of black sex scales (sex-brand) from vein M3 to beyond vein 1A+2A near dorsum on the fore wing is exceptionally broad in both *T. aurantia* and *T. xiphiphola*, whereas in *T. crocea* the sex-brand is considerably narrower. The inclination of the subapical band of spots on the fore wing differ between the three species: in *T. aurantia* and *T. crocea*, a line drawn along the inner edge of the subapical band joins the termen between veins CuA2 and 1A+2A, whereas in *T. xiphiphola* the line joins the termen higher up, between veins CuA1 and CuA2.
Description

Male (Figs 16, 17)

**Head:** eyes black; frons black with a few pale yellow piliform scales; labial palp clothed with pale yellow and orange piliform scales, third segment very short and slender; antenna 7.5 mm long, flagellum black with 40 segments (shaft 20, club 20), shaft ringed with orange bands, club sharply bent before middle with apiculus long and pointed, ventral surface dark orange. **Thorax:** black, with orange piliform scales on dorsal surface, and pale yellow-orange piliform scales on ventral surface; legs dark orange, mid and hind tibia each with a single pair of spines. **Fore wing:** length 13.0 mm (from base to apex); upperside ground colour dark brown, suffused with orange; a sickle- or 'boomerang-shaped' elongate pale yellow spot near end of discal cell, a broad, linear patch of black sex-scales (androconia) from vein $M_3$ to beyond vein 1A+2A near dorsum, two pale yellow postmedian spots between veins $M_3$ and $CuA_2$, and a subapical band of three smaller pale yellow spots from veins $R_3$ to $M_1$, scale-fringe chequered brown and orange; underside ground colour orange, pale yellow spots similar to upperside but edged distally with dark brown or black; area below cubitus and vein $CuA_2$ to dorsum dark brown extensively suffused with yellow.
Hind wing: upperside ground colour dark brown, suffused with orange; a series of three pale yellow postmedian spots, the two largest between veins M3 and CuA2 and the smallest between R and M1, scale-fringe orange; underside ground colour orange, pale yellow spots similar to upperside but edged distally with dark brown or black; a brown submedian spot at end of discal cell, a broad yellow streak between anal veins 1A+2A and 3A, followed by a black tornal patch. Abdomen: dorsal surface black with scattered orange scales; ventral surface pale yellow with a few orange scales.

Genitalia (Figs 32–34): saccus straight and relatively short; vinculum wider basally; tegumen broad and curved dorsally (‘hood’-like); uncus with numerous dense fine setae on dorsal surface, lobes sclerotised, terminating in a pair of short blunt apical spines; gnathos absent; valva slightly inwardly curved and divided apically into two asymmetric processes; dorsal process longer than ventral process, broad and rectangular posteriorly, sclerotised along posterior margin with numerous setae and a few apical spines or ‘teeth’; lower process sclerotised, narrow and rectangular posteriorly with apex truncate bearing numerous setae and a few apical ‘teeth’; phallus long, narrow and upcurved (in lateral view).

Female (Figs 18, 19)

Head and thorax: similar to male. Fore wing: length 13.5–14.0 mm (from base to apex); upperside ground colour and markings similar to male except pale yellow spot in discal cell variable quadrate in shape, black androconial patch absent, pale yellow postmedian spot between veins CuA1 and CuA2 substantially larger, an additional obscure orange median spot near dorsum; underside ground colour orange, markings similar to upperside except pale yellow square-shaped spot in discal cell proximally edged with black. Hind wing: similar to male. Abdomen: similar to male.

Type Material

Holotype

Western Australia: ♂ “14°32’35”S, 126°07’32”E, mainland E of Middle Osborne Is., WA, 18 FEB. 2019, J.E. & A. Koeyers”, “ANIC Database No. 31 084581”, “MFB Collection 00420” [private registration number], “MFB-18-B147” [DNA voucher]; “Genitalia No. MFB-135” (ANIC).

Paratypes


Remarks

Lower (1911) described Hesperilla xiphiphora Lower, 1911 based on 15 syntypes, collected from ‘Port Darwin’, NT (14 specimens) and Cairns, QLD (1 specimen) by F.P. Dodd, but he did not designate a holotype. Waterhouse (1933) referred to syntypes in SAMA and AMS and mentioned a holotype male and an allotype female from Darwin. Edwards et al. (2001) interpreted Waterhouse’s reference to a holotype in SAMA as a lectotype designation. Of the other paratekotypes, seven (5♂, 2♀) are in SAMA (E.P. Beaver, pers. comm. 2021) and three (2♂, 1♀) are in AMS (Peters 1971); the remaining four paratekotypes have not been traced, possibly destroyed. Seven historic specimens (4♂, 3♀) from Darwin collected by F.P. Dodd between November 1908 and March 1909 in NMV (voucher numbers LEP 1736–1742) do not represent types.

Miskin (1889) described Hesperilla crocea Miskin, 1889 based on at least two syntypes, collected from Cooktown (1♀) and Brisbane (1♀), but he did not designate a holotype. However, Miskin had a mixed series of two species. Lower (1911) referred to the type male and type female, but noted that the female was not of this species “nec croceus”. Waterhouse (1937, p. 116) stated “Holotype male from Cooktown at Brisbane. Miskin described the female of xanthomera as the female of this species.” Telesto xanthomera Meyrick & Lower, 1902 was described by Meyrick and Lower (1902), 13 years after the name crocea was introduced by Miskin (1889), so at the time of Miskin’s publication Miskin had two undescribed species. Hancock (1995) located two of Miskin’s types in QM and provided type data. He interpreted Waterhouse’s (1937) incorrect reference to a ‘holotype’ male as a valid lectotype designation. This action is justified because Lower (1911) did not clearly state which species Miskin’s second syntype (i.e., the type female) represented.

The lectotype male of Toxidia xiphiphora (Lower, 1911) (Figs 2–4) and the lectotype male of Toxidia crocea (Miskin, 1889) (Figs 5–7) are illustrated so the nomenclature and fixation of these names is clear. This step is important because the correct identity of these species forms the basis of comparison with the new taxon described herein. Toxidia aurantia, T. xiphiphora and T. crocea belong to a set of five closely related tropical species formerly placed in the genus Neohesperilla Waterhouse & Lyell, 1914, here referred to as the T. xanthomera species-group. In a recent molecular phylogenetic analysis of
Figures 8–15. Toxidia spp. from the 'Top End' of northern Australia showing dorsal and ventral views: (8, 9) T. xiphiphora (Lower, 1911) male from 6.5 km N of Berry Springs, NT, 21 JAN. 2012, M.F. Braby (ANIC); (10, 11) T. xiphiphora female from Mount Burrell, NT, 21 FEB. 2009, M.F. Braby & D.A. Young (ANIC); (12, 13) T. crocea (Miskin, 1889) male from Dundee Beach, NT, 1 APR. 2012, M.F. Braby & G. Brown (ANIC); (14, 15) T. crocea female from Hayes Creek, NT, 29 MAR. 2013, M.F. Braby & L.J. Aitchison (ANIC) (ANIC). Scale bar = 10 mm.
the Trapezitinae, Toussaint \textit{et al.} (2022) demonstrated that \textit{Toxidia sensu stricto} was paraphyletic with regard to \textit{Neohesperilla}. Although \textit{Neohesperilla} comprised a monophyletic group, it was embedded within a larger clade that consisted of six other species of \textit{Toxidia}. Given this phylogenetic pattern, previous morphological studies, and the lack of clear synapomorphies by which to distinguish \textit{Neohesperilla} from \textit{Toxidia}, these authors synonymised \textit{Neohesperilla} as a junior synonym of \textit{Toxidia sensu lato}.

In addition to the phenotypic differences in wing pattern elements, there are also striking differences in the male genitalia between \textit{T. aurantia}, \textit{T. crocea} and \textit{T. xiphiphora}, particularly regarding the form of the uncus and valva. In \textit{T. xiphiphora} (Figs 21, 24) and \textit{T. crocea} (Figs 27, 30), the uncus is divided into two long sclerotised processes (lobes), each bearing two short inwardly pointed apical spines, whereas in \textit{T. aurantia} (Fig. 33) the uncus lobes are substantially shorter with the spines less pronounced. In both \textit{T. xiphiphora} and \textit{T. crocea}, the gnathos consists of a conspicuous pair of sclerotised ‘teeth-like’ patches on the ventral surface of the tegumen, but in \textit{T. aurantia} these sclerotised patches are absent. The relative length of the two processes of the valva differ between the three species: in \textit{T. xiphiphora} (Figs 20–25), the lower (ventral) process of the valva (in dorsal and lateral views) is very long and longer than the upper (dorsal) process; in \textit{T. crocea} (Figs 26–31), the two processes are similar in length or the upper process is slightly longer; whereas in \textit{T. aurantia} (Figs 32–34) the lower process is exceptionally short and truncate and much shorter relative to the length of the upper process. In \textit{T. aurantia} (Figs 33, 34), the upper process of the valva (in lateral view) is rectangular-shaped and parallel to the lower process, whereas in \textit{T. xiphiphora} (Figs 21, 22, 24, 25) it is rotated or inclined at an angle of approximately 45 degrees to the lower process. In \textit{T. crocea} (Figs 27, 28, 30, 31), the valva is more variable in shape at its distal end, but the upper process (ventral edge) is inclined at approximately 30 degrees to the lower process. The apices of both processes of the valva are more heavily sclerotised with spine-like ‘teeth’ in \textit{T. xiphiphora} and \textit{T. crocea} than in \textit{T. aurantia}. The saccus (in dorsal view) of \textit{T. aurantia} is narrower than in \textit{T. xiphiphora} and \textit{T. crocea}.

\textbf{Etymology}

The species group name \textit{aurantia} is derived from the Latin word \textit{aurantium}, which means orange and refers to the underside ground colour that is a unique and
Figures 20–34. Male genitalia of *Toxidia* spp. from northern Australia showing dorsal view, lateral view with left valva removed, and left valva lateral view: (20–22) *T. xiphiphora* from Cape York Peninsula (Silver Plains, QLD, MAR. 1959, J.L. Wassell); (23–25) *T. xiphiphora* from the Top End (Darwin, NT, 7 MAR. 1967, M.S. Upton); (26–28) *T. crocea* from the Wet Tropics (Cooktown, QLD, 3 JUL. 1964, J.C. Le Souef); (29–31) *T. crocea* from the Top End (Kakadu NP, NT, 27 OCT. 1972, I.F.B. Common et al.); (32–34) *T. aurantia* Braby, sp. nov. holotype. Scale bar = 1.0 mm.

distinctive feature of this species. It is intended as an adjective and is constructed to agree with the gender of *Toxidia*, which is feminine.

**Biology**

The general biology and life history of this species are unknown. All specimens have been collected in January and February, suggesting that adults are highly seasonal with the flight period limited to the wet season. Most specimens have been observed or collected in moist habitats comprising mixed coastal paperbark swampland and monsoon vine thicket or edges of vine thicket.

**Distribution**

This species is endemic to the Kimberley of northern Western Australia (Fig. 35). It is currently known from only a limited area in the Admiralty Gulf of the northwest Kimberley where the mean annual rainfall is 1000–1200 mm. All specimen records are from coastal areas of the mainland east of the Osborn Islands.
specimen was also observed, but not collected, on the mainland coast east of Borda Island (14º13'54"S, 126º07'53"E) during late February 2022 (J.E. Koeyers, pers. comm.). *Toxidia aurantia* is allopatric with *T. xiphiphora* but sympatric with *T. crocea* to which it is most closely related. *Toxidia crocea* is currently known from only two sites in the Kimberley: Drysdale River Station based on a single female (Braby et al. 2018), and on the mainland east of Middle Osborn Island (14º21.50'S, 126º04.80'E) where a single female was collected flying with *T. aurantia* in early February 2023 (J.E. Koeyers, pers. comm.).

**Disclosures**

There are no conflicts of interest

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Supplementary Data
Partition and model data file for the concatenated dataset available on request from the authors.

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