Revision of the Australian *Oenochroma vinaria* Guenée, 1858 species-complex (Lepidoptera: Geometridae, Oenochrominae): DNA barcoding reveals cryptic diversity and assesses status of type specimen without dissection

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Abstract

The assembly of a DNA barcode library for Australian Lepidoptera revealed that *Oenochroma vinaria* Guenée, 1858, as currently understood, is actually a mix of two different species. By analyzing DNA barcodes from recently collected specimens and the 150 year-old female lectotype of *O. vinaria*, we propose a reliable assignment of the name *vinaria* to one of these two species. A lectotype is designated for *Monoctenia decora*, a confirmed synonym of *O. vinaria*, and a new species, *Oenochroma barcodificata* sp. nov., is described. This species is only known from Tasmania and New South Wales; its biology and immature stages are described in detail.

Key words: *Oenochroma barcodificata*, Tasmania, new species, type sequencing, lectotype, redescription

Introduction

Identification of specimens of closely related or externally indistinguishable species of Lepidoptera usually requires scrupulous comparison with the corresponding type specimens. Quite frequently, however, an unambiguous identification cannot be obtained, either because the type specimen is missing the body parts which contain the important diagnostic features (e.g., antennae, legs, abdomen, etc.) or because it is of the "wrong" sex, precluding comparative study. In fact, the type specimen needed is often not accessible at all. Taxonomists have frequently encountered such shortcomings and as a result there often remains a degree of uncertainty in their taxonomic decisions.

Analysis of DNA barcodes offers an effective additional tool for the identification and distinction of lepidopteran species e.g., in situations where a type specimen is available, but damaged or of the wrong sex. The Biodiversity Institute of Ontario and collaborators are currently carrying out a comprehensive DNA barcoding project named ‘All Leps’ (http://www.lepbarcoding.org/). This targets, as a long-term objective, the analysis of all Lepidoptera through a combination of regional and continental campaigns, and more focused global campaigns on certain taxa. As a result of both an Australian regional campaign and a recently initiated global campaign on Geometridae, specimens of the Australian species *Oenochroma vinaria* Guenée, 1858 were sampled and barcoded. Surprisingly, DNA barcode analysis revealed an unusually deep divergence (maximum pairwise K2P distance of 3.6%; minimum distance between the two inferred clusters of 3.1%)
within the Tasmanian specimens of that species. Because these genetic differences were correlated with morphological features, we conclude that specimens of *Oenochroma vinaria* from Tasmania are actually a mix of two different species. This left unresolved questions, including which one of the two species is the true *Oenochroma vinaria*, and can the other one be attributed to an already known (perhaps synonymised) or new taxon. In this paper we solve this taxonomic uncertainty by combining DNA barcodes and traditional taxonomy in an integrative approach (Dayrat 2005).

**Material and methods**

**Institutional acronyms**

ANIC  Australian National Insect Collection (CSIRO), Canberra, Australia  
BIO  Biodiversity Institute of Ontario, Guelph, Canada  
CCDB  Canadian Centre for DNA Barcoding, Guelph, Canada  
MNHN  Muséum National d'Histoire Naturelle, Paris  
MVMA  Museum Victoria, Melbourne, Australia  
TASAG  Department of Primary Industries and Water, State Government of Tasmania  
TMAG  Tasmanian Museum and Art Gallery  
ZSM  Zoologische Staatssammlung München, Munich, Germany

**DNA Barcoding**

A total of 34 specimens of the “*Oenochroma vinaria* species-group” (see below under genus *Oenochroma*) was processed at the Canadian Centre for DNA Barcoding to obtain DNA barcodes. This sample contains specimens collected in Tasmania by the authors during the Forum Herbulot 2006 (http://www.herbolut.de/Herbolut_Reg/for_herb.htm) and specimens collected in the context of the Australian Lepidoptera DNA barcoding campaign (see also Hausmann *et al.* 2008). In spite of its age (approx. 150 years old: description published in 1858), DNA was extracted from a leg fragment of the lectotype of *Oenochroma vinaria* (MNHN) in an attempt to recover at least a partial DNA barcode sequence and include it in the genetic analysis of the species-complex.

DNA barcodes for recently collected specimens were obtained at the CCDB using the standard high-throughput protocol as described in Ivanova *et al.* (2006) and Vaglia *et al.* (2008); regularly updated protocols used at CCDB can also be found at: http://www.dnabarcoding.ca/pa/ge/research/protocols. Details of the 29 records for *O. vinaria* and the newly described species, as well as for 2 specimens of *O. decolorata* Warren, 1896, and 3 specimens of *O. pallida* Warren, 1898, used as references, are given in Table 1, along with GenBank accession numbers. Images, GPS coordinates and sequence trace files for each specimen as well as details on host institution can be obtained from the Barcode of Life Data Systems (BOLD; Ratnasingham & Hebert 2007; public access projects GZPPT and GZPAO; see also Results for access details). For the type specimen of *O. vinaria*, we used a commercial extraction kit (NucleoSpin® tissue kit, Macherey-Nagel, Düren, Germany) following the kit protocol. The DNA extract obtained was first analyzed by targeting a mini-barcode of 130bp at the 5’ end of the barcode region (Meusnier *et al.* 2008). Subsequently, a set of 6 primer pairs were used (detailed protocol to be published; Rougerie pers. obs.) to reconstruct a full-length barcode by assembling six “mini-barcodes” (see Meusnier *et al.* 2008, Hajibabaei *et al.* 2006). Sequences were analyzed using MEGA4 (Tamura *et al.* 2007).

**Morphological Analysis and Description**

Specimens of most taxa of *Oenochroma* have been examined in ZSM (especially collection Herbulot), ANIC, TASAG, MVMA, and in the collections E. Friedrich, Jena, and M. Sommerer, Munich. The only unexamined taxon is *Oenochroma unifasciata* Holloway, 1979 from New Caledonia, which was, however, well characterised in its original description and does not have any bearing on the results presented here.
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continued next page.
Five females and seven males of the *vinaria* species-complex *sensu stricto* were dissected, and further genitalia preparations were prepared for 17 specimens of other putatively related species from the Australian

### TABLE 1. (continued)

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mainland. Adult specimens were dissected for genitalic examination using standard techniques. Body parts were digested by boiling in a saturated solution of sodium hydroxide for approximately five minutes or until the body parts were softened. Softened specimens were stored in 80% ethanol. Body scales were removed with a brush and fine forceps with the exception of diagnostic tufts. Genitalia were usually examined and described before being mounted onto microscope slides in Euparal. The genitalia were stained with 1% Chlorazol Black (CY) or 2% Mercurochrom (AH) in 70% ethanol. Genitalia mounts were photographed using a Nikon Digital Sight system with a DS-L2 camera controller and DS-Fi1 camera head mounted on a Leica MZ16 stereomicroscope with motorized stage. Final images were produced by stacking approximately ten images using Combine Z (Hadley 2008). Most images were enhanced to maximise contrast and clarity using Adobe Photoshop 7.0.

Eggs were obtained from two adult female moths. For a detailed description of adult moth and egg collection and description methods used here, see Young (2006a). Eggs were measured in three dimensions: length (L), width (W) and thickness (T) (after Salkeld 1983), using a binocular microscope and an ocular micrometer. Eggs were photographed using a Wild MPS52 photoautomat camera attached to a Wild M8 zoom stereo-microscope and at high magnification using an environmental scanning electron microscope (ESEM), Electroscan Corporation, Wilmington, Massachusetts, U.S.A., located at the Central Science Laboratory, University of Tasmania. The images and descriptions of eggs presented here are typical of the eggs examined but as only eggs of a single female were utilized in the description, they may not necessarily reflect infraspecific variation.

A relative size for the aeropyle was obtained from measuring the maximum length and width, measured in micrometers directly from the microscope screen. The average length of the aeropyle (in micrometers) was then divided by the length of the associated egg (in mm) to arrive at a measurement corrected for egg size, the relative aeropyle size (Young 2006a).

Larvae were reared under laboratory conditions from one adult female (code no. G87, see details below) on the foliage of Grevillea sp. The rearing and description procedures are given in Young (2008). Different instars of each species were described and scored from live material, specimens preserved in 80% ethanol, and colour prints using a Canon EOS 5D camera and Kodak Gold 100 ASA film with infill flash under natural lighting conditions. Specimens of first, second, and final instar and pupae of each species were stored in 80% ethanol and kept as voucher specimens at TMAG. Morphological terms follow Stehr et al. (1987), de la Torre-Bueno (1989), and Scoble (1995). Pupal terminology follows Patocka & Zach (1994) and Nakamura (1987, 1994).

Results

A total of 28 barcode sequences was obtained from recently collected specimens of the vinaria species-complex; all but one (see Table 1) were more than 600 bp in length. The two approaches used for the type specimen of Oenochroma vinaria successfully amplified the short targeted DNA fragments, and yielded a full length DNA barcode (658 bp) with 20 ambiguous base pair calls within the sequence where poor quality sequence was obtained at the ends of overlapping PCR fragments, preventing reliable assignment of bases.

The pattern of genetic distances inferred from the barcode analysis of examined Oenochroma species in the vinaria-complex clearly showed that (see Fig. 1 and Table 2): there are two different mitochondrial lineages in the Tasmanian Oenochroma vinaria sensu auctorum; the female lectotype of Oenochroma vinaria is unambiguously part of the most widespread lineage (Tasmania, South Australia, Western Australia, New South Wales, Queensland); the other lineage is genetically different from all other named and examined Australian taxa of Oenochroma. Subsequent dissections revealed that this lineage is not confined to Tasmania but also present in New South Wales; each of these lineages shows low within-lineage genetic divergence, 0.03% and 0.05% respectively.
Hence, with the combined evidence from comparative morphological studies (see diagnosis below) and the DNA barcode results presented above, *Oenochroma vinaria* can be redefined, and the cryptic Tasmanian/NSW species hitherto confounded within *Oenochroma vinaria* sensu auctorum is described below as a new species.

**FIGURE 1.** Neighbor joining tree for 34 Australian specimens in the genus *Oenochroma* (Kimura 2 Parameter, built with MEGA4; all codon positions unweighted) based on sequences of the mtDNA COI gene (barcoding fragment 5'). Values above branches are bootstrap support values superior to 95%. Terminals are identified by their process ID code on BOLD.
Genus *Oenochroma* Guenée, 1858

All 20 species of the genus *Oenochroma* Guenée, 1858 as listed in Scoble (1999) are distributed in mainland Australia except one species which is restricted to New Caledonia (*Oenochroma unifasciata* Holloway, 1979). From dissections, it is most likely that *Oenochroma hieroglyphica* (Warren, 1906), which was described from Papua New Guinea, Mt. Kaindi, is a junior synonym of *Oenochroma turneri* (Lucas, 1892), described from Toowoomba near Brisbane. Two species are known to occur both in mainland Australia and in Tasmania: *Oenochroma vinaria* and *Oenochroma vetustaria* (Walker, 1860) (McQuillan 2004). The type species of the genus, *Oenochroma vinaria*, boasts the violaceous red "wine" colour ("rose-lie de vin" in the original description) that may have suggested to Guenée the chosen denominations of the species and of the genus. Only *Oenochroma vinaria* and the new species described here are intended to fall in the "vinaria species-complex." It is possible that they may group together, phylogenetically, with *Oenochroma pallida* and *Oenochroma decolorata*. However, both the definitions of infrageneric species-groups such as of the whole genus *Oenochroma* await an urgently needed major revision. Collection material (ANIC, ZSM, TASAG) suggests that the genus includes several other undescribed species.

*Oenochroma barcodificata* Hausmann & Young, sp. nov.


Description. Wingspan ♂ ♀ 42–47 mm. Habitus and external characters (Figs. 2–3): Forewing apex tapered, termen convex. Hindwing termen straight, angled at apex and tornus. Ground colour variable, usually purplish with dark suffusion and with blackish dotting of forewing costa. Fringe crimson. Antemedial line of forewing vague, at costa usually well marked by a costal spot. Postmedial line of forewing almost straight but slightly undulating, ochre with dark grey dots basally, obliquely leading into forewing apex. Border of postmedial line on the hindwing more violet and forked towards costa. Forewing apex with blackish fringe. Cell spots slightly elongate, black, with small hyaline filling. Underside of forewing with a large, round dark violet spot close to the inner termen at 2/3, i.e. at the position of the dotted postmedial line. Underside of hindwing with large white and grey speckled spot close to the costa at 2/3, i.e. at the position of the dotted postmedial line. Palpi, frons, and vertex concolorous with ground colour. Frons flat. Palpi at upperside of tip with dark grey scales, last segment narrow, length of palpi ca 1.5 times diameter of eye in both sexes. Proboscis well developed. Antennal flagellum thick in both sexes, male antennae unipectinate to 2/3 of length, female antennae filiform. Frenulum strong in ♂, absent from ♀. Wing venation, forewing: R separate from Rs, anastomosing with Sc for a short distance in the forewing, R2–5 stalked. Hindwing: M2 located at mid-point between M1 and M3. Hindleg with four very short spurs in both sexes. Ansa narrow at the base, widening mesally, tapering apically. Last abdominal segment with extremely large interior coremata. ♂ genitalia (Fig. 8): Uncus long, narrow. Gnathos slender; medial process broad, sub-acute posteriorly, posterior surface covered with rows of short, broad spicules. Juxta large, well-sclerotised, divided. Saccus broad rectangular, with central invagination. Costa of valva sclerotised, setose. Valva asymmetrically adorned with subapical processes on ventral margin: left valva with single, large, sclerotised subapical, flattened, acute process, right valva with two short, broad processes. Aedeagus comparatively broad; vesica well sclerotised posteriorly, with longitudinal ridges; long narrow sclerotised process attached anteriorly, no discrete cornuti; caecum long, slender, tapered. ♀ genitalia (Fig. 10): Apophyses anteriores, posteriores long, slender. Lamella postvaginalis membranous. Lamella antevaginalis poorly developed. Sternum A7 slightly sclerotised. Ductus bursae short, close to corpus bursae strongly sclerotised, towards antrum dilating. Corpus bursae with strong anterior and posterior dilatations, constricted between; posterior half sclerotised, strongly ridged; anterior half membranous, plicate. Signum absent.

Morphological diagnosis (most congeners illustrated in BOLD (2008)): Oenochroma vinaria in habitus and external characters (Figs. 4, 6) very close to Oenochroma barcodificata and externally only distinguished, usually, by the straighter postmedian fascia of the forewing, often with a continuous dark proximal border. Dark suffusion of ground colour and blackish dotting of forewing costa usually reduced. Oenochroma pallida Warren, 1898 differs from both Oenochroma barcodificata and Oenochroma vinaria at once by the fore tibiae having an anterior apical hook (cf. Prout 1910, Turner 1932), and by the ochreous brown fringe of wing termen, the larger forewing cell spot on a paler ground colour, inner termen of hindwing underside with a narrow, dark spot; Oenochroma orthodesma Lower, 1894 has pale ochreous grey ground colour and ochreous fringe, an ochreous postmedian line edged anteriorly with pale yellow, the (ochreous) discal dots mostly wanting, hindwing at apex with pink suffusion and no spot on underside; Oenochroma decolorata Warren, 1896, has grey forewings with fine brown iroration and purplish fringe, and a pale ferruginous postmedial
FIGURES 2, 3. *Oenochroma barcodificata* sp. nov., ♀ holotype, Tasmania. 2: dorsal view. 3: labels (photos AH). Scale bar 2 cm.
FIGURES 6, 7. Oenochroma vinaria, ♀ lectotype of Monoctenia decorata Wlk. 6: dorsal view. 7: labels (photos Peter Marriott and Peter Lilywhite, MVMA, Melbourne, Australia).
fascia on both wings; *Oenochroma phyllomorpha* Lower, 1899 is of light brown ground colour, the forewing postmedial line is sinuate, fringe fuscous, and the cell spot lacking; *Oenochroma cycnoptera* Lower, 1894 has anterior tibiae with a strong apical hook (cf. Turner 1932), a very faintly ochreous postmedian line not reaching apex of forewing, fringe pale brownish, hindwings pale, without pattern and with whitish fringe; the New Caledonian *Oenochroma unifasciata* Holloway, 1979, is broad-winged, without discal dots to the forewing.

**Molecular diagnosis** (see Fig. 1 and Table 2): DNA barcode analysis revealed a 3.34% K2P divergence between *Oenochroma vinaria* and *O. barcodificata*. Each species displays a very low mean intraspecific variation, with 0.05% (SE=0.03%, maximum distance of 0.33%) and 0.03% (SE=0.03%, maximum distance of 0.15%) for *O. vinaria* and *O. barcodificata* respectively and are thus unambiguously characterized by their DNA barcodes.

**Distribution.** Recorded in south-eastern and northern parts of Tasmania at altitudes from 0 to 870 m above sea-level, probably distributed all over the island. Further material from the central and southern tablelands of New South Wales dissected (T Edwards) but excluded from the type series to maintain geographical homogeneity in the type material.
FIGURES 10, 11. Female genitalia. 10: *Oenochroma barcodificata* sp. nov., Tasmania (paratype, DNA barcode LOTSA125-06/06-TASA-00125) (photo CY). 11: *Oenochroma vinaria*, South Australia (gen. prp. ZSM G 13864) (photo AH). Scale bars 2 mm.

TABLE 2. *Oenochroma vinaria* species-group. Genetic distance calculations. A: intraspecific mean K2P divergences; B: interspecific mean K2P divergences. Standard error estimate(s) were obtained by a bootstrap procedure (1000 replicates).

<table>
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<th>standard error</th>
<th>maximal distance</th>
<th>sample size</th>
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<tr>
<td><strong>A</strong></td>
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<tr>
<td><em>O. vinaria</em></td>
<td>0.05%</td>
<td>0.03%</td>
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<td>0.03%</td>
<td>0.15%</td>
<td>n=9</td>
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<td></td>
<td>n=3</td>
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<tr>
<td><em>O. decolorata</em></td>
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continued.

<table>
<thead>
<tr>
<th><strong>B</strong></th>
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<th>standard error</th>
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</tr>
</thead>
<tbody>
<tr>
<td><em>O. vinaria</em> vs <em>O. barcodificata</em></td>
<td>3.34%</td>
<td>0.65%</td>
<td>3.1%</td>
</tr>
<tr>
<td><em>O. barcodificata</em> vs <em>O. pallida</em></td>
<td>5.35%</td>
<td>1.17%</td>
<td>5.2%</td>
</tr>
<tr>
<td><em>O. barcodificata</em> vs <em>O. decolorata</em></td>
<td>6.31%</td>
<td>1.02%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>
**FIGURE 12.** Egg of *Oenochroma barcodificata*. sp. nov. freshly laid egg, scale bar 1 mm. (photo CY)

**Biology and morphology of immature stages.**

**Egg:** Marked on all surfaces by round to hexagonal, concave cells with broad walls (Figs 13, 15–18), micropylar cell walls narrow (Fig. 14). Aeropyles, slightly elevated, openings very small (Fig. 16), present on all surfaces apart from top of wider lateral side (Fig. 17). Micropylar cells slightly recessed. Micropyles offcentred (Fig. 13). Chorion undulating, irregularly pitted (Figs 16–18). Colour: Off-white (Fig. 12), becoming irregularly blotched rust-red, then transparent grey on maturity. Size (mm): (n= 4) L = 1.01 ± 0.01 (SE), W = 0.82 ± 0.01 (SE), T = 0.69 ± 0.01 (SE). Width/length: 0.81. Aeropylar opening size (micrometers) (n=10): L = 1.44 ± 0.07, W = 1.08 ± 0.04; relative aeropylar opening size [aeropyle length (micrometers)/egg length (mm)]: 1.4. Micropyles (Figs 13, 14): distinct; no. of openings: 6; no. of cells in rosette: 9; no. of rows of cells in micropylar area: 5. Shape: Broad, bluntly ovoid, dorso-ventrally flattened, anterior pole angled to horizontal axis (Figs 12, 13, 15).


**Larval description.** First instar (newly emerged): Head capsule width: 0.53 ± 0.03 mm (SE) (n=4). Head ground colour burnt yellow with chevroned dark-brown blotches, mouthparts lighter in colour, stemmata black, frons convex. Thorax and abdomen ground colour cream, except A6-A10 yellow, with numerous longitudinal wavy, dark brown stripes; posterior third of each segment, except A6-A10 and thoracic segments white; thoracic stripes less dense; venter dark chocolate brown. Thorax and abdomen becoming a uniform chocolate brown broken by numerous thin, wavy cream stripes after feeding. Setae very short, white, blunt on small dark brown pinacula on small raised black tubercles. Thoracic legs white with sparse dark brown spots. Prolegs on A5, A6, A10, rudimentary on A5. Spiracles very small, brown. Anal shield, no stripes, yellow with sparse orange streaks. Crochet arrangement, incompletely interrupted mesoseries. Resting position about 30° from substrate.
FIGURES 13–18. Egg of *Oenochroma barcodificata*. sp. nov. 13: anterior pole, scale bar 300 micrometers. 14: micropylar area, scale bar 200 micrometers. 15: whole egg, scale bar 1 mm. 16: aeropyles, scale bar 35 micrometers. 17: chorion on middle top of egg, scale bar 50 micrometers. 18: lateral chorion, scale bar 500 μm. (photos CY).
Second instar: Head capsule width: 0.91 ± 0.01 mm (SE) (n=7). Head ground colour light yellow with dark-brown blotches, dorso-lateral orange stripes, mouthparts pale brown, stemmata black, frons convex. Thorax and abdomen ground colour dark brown, broken by numerous longitudinal, narrow wavy, white stripes, venter smoky brown. A1 with dark brown spot on dorso-lateral line adjacent to anterior margin, directly adjacent and anterior to burnt orange blotch directly ventral to mid-dorsal line; A3 with two small orange blotches directly adjacent to mid-dorsal line, about one third segment length from posterior margin in some specimens, venter with black speckles. Setae very short, black, blunt on small dark brown pinacula on small raised black tubercles. Thoracic legs white with small brown blotches. Prolegs on A5, A6, A10, rudimentary on A5, same ground colour as body. Spiracles small, cream, peritremes black. Anal shield, same ground colour as body.

Third instar: Head capsule width: 1.48 ± 0.03 mm (SE) (n=5). Head ground colour cream with chevroned black blotches dorsally just lateral of mid-dorsal line, becoming two large circular, black blotches with orange centres, just posterior of frontoclypeus, dorso-lateral orange stripes, frontoclypeus pale brown streaked with black and brown, other mouthparts pale brown; stemmata black, frons convex. Thorax and abdomen ground colour cream, broad, dense-grey mid-dorsal band, centred by narrow white stripe connecting mid-segmental diamond shapes, thin wavy, grey stripes on rest of dorsum becoming yellowish-brown laterally. A1 with medial horn-like protuberances just lateral of mid-dorsal line, apex with black pinacula and setae, colour burnt orange with diagonal yellow stripe extending from mid-dorsal line to apex, black velvety blotch just anterior of protuberance at dorso-lateral position; similar small protuberances on A3. A8 D1 pinacula large, raised, bright burnt orange, venter paler from A3 to A10. Setae short, black, blunt, longer, transparent on venter A6-10. Thoracic legs cream with small black blotches. Prolegs on A5, A6, A10, rudimentary on A5, same ground colour as body. Spiracles pale brown, peritremes black. Anal shield, same ground colour as body.

Fourth instar: Head capsule width: 2.31 ± 0.04 mm (SE) (n=4). Head ground colour light orange-brown mottled heavily with dark orange-brown, lighter stripes extend from mid-dorsal line to frons, becoming lighter and wider anteriorly, mouthparts pale brown, stemmata black, antennae brown; frons convex. Thorax and abdomen ground colour light brown, scattered sparsely with small white spots; dorsal band white.
speckled with black, on thoracic segments band is defined loosely by lines of black spots, on abdominal segments band is constricted at segment margins and bulges at segment centres; large fleshy horn-like dorso-lateral protuberances on A1 just posterior of middle of segment, protuberances on A2 similar to A1 but smaller, apices of protuberances mottled orange-brown, large orange blotch mottled yellow, just anterior of protuberances, not extending laterally ventral of protuberances; venter pale brown speckled black; D1 pinacula on A8 on bright orange protuberances. Thoracic legs pale brown with sparse small black blotches. Prolegs on A5, A6, A10, rudimentary on A5, same ground colour as body. Spiracles orange, peritremes black, on white blotched with grey large spot.

Fifth instar (Fig. 19): Head capsule width: 3.78 ± 0.03 mm (SE) (n=4). Length: 45–50 mm (n=3). Similar to 4th instar, except for the following. Head ground colour pinkish brown with faint orange marbling, mouthparts pale brown, stemmata black, antennae reddish brown; frons convex. Thorax and abdomen ground colour light brown, scattered sparingly with small white spots; dorsal stripe light brown speckled with small black spots, two lines of small white spots circled in black define dorsal stripe on abdominal segments. Two large fleshy dorso-lateral protuberances on A1, apices black anteriorly, yellow posteriorly, horns preceded by large mid-dorsal yellow blotch narrowing anteriorly to A1 anterior margin; relatively smaller protuberance on A3 similar to protuberance on A1. Venter pale brown blotched dark brown, white between A6 – A10. D1 pinaculi on A8 on bright orange protuberances. Black spots surround pinaculi of sub-dorsal setae. Setae short, pale brown, blunt. Thoracic legs pale brown with sparse small black blotches. Prolegs on A5, A6, A10, rudimentary on A5, same ground colour as body. Spiracles orange, peritremes black. Chaetotaxy: trisetose SV setae on A1; SV1, SV3 and V1 setae on A1 unaligned; three lateral setae on A6 proleg.

Pupa. Length: ♂ 23, 24 mm; ♀ 24, 25 mm. Width: ♂ 7, 7 mm; ♀ 6, 8 mm. Colour: reddish-brown on maturity; wings duller than shiny abdomen. Silken cocoon constructed from soil, debris and body fluids. Pupa large, stout. Labrum sub-trapezoidal, slightly convex, well-defined. “Mandibles” flat, rugose, margin between labrum and “mandibles” broadly ridged. Labial palpus large, pentagonal, rugose. Border between genae, maxilla less steep than that between oculus and pro-leg; border between pro-tibia and antenna about same length as border between pro-tibia and oculus. Pro-tibia same length as mid-tibia. Pro-femora not visible. Pro-tibia meets maxilla at 2/3 length of maxilla, mid-tibia meets maxilla at 5/6 length of maxilla, antenna broad, almost reaches apex of maxilla, hind-leg barely visible. Hindwing becoming concealed at A4. Meta-notum short. Wing-bud callosity pronounced. Thoracic spiracles not visible, spiracles visible on A2-A8, poorly developed on A8; elliptical, elevated, pre-spiracular slit visible. Punctuation on A1-A8, punctures small, shallow, numerous on A2-a7, sparse on A1, A8; randomly arranged, uniformly sparse on venter. Setae very short. Anal area large, anal slit bordered by longitudinal furrows. Male genitalia area, simple longitudinal slit. Cremaster, long, slender, roughly trigonal, posterior third, very rugose; one pair of terminal, robust, hamate, long, parallel setae, directed ventrally; pronounced dorsal and lateral grooves, six pubescent teeth on anterior margin of A10.

Larval hostplants. Reared on Grevillea sp. (Proteaceae).

Etymology. The species name refers to the barcoding campaign for Australia, and especially the fact that the new species could be distinguished by DNA barcoding without the need for dissecting (and thus damaging) an antique type specimen.

Oenochroma vinaria Guenée, 1858, redefined

Oenochroma vinaria Guenée, 1858: in Boisduval & Guenée, Hist. nat. Insectes (Spec. gén. Lépid.) 9: 185, pl. 7, fig. 2. Syntypes 2♂ 1♀ (MNHN); lectotype ♀ designated by Viette (1950) using the term ‘type’ (cf. art. 74.5, Code ICZN 1999), Nouvelle Hollande [Australia], Barcode no. BC-MNHN 0007 (Figs 4, 5). One further paralecotype, mentioned in Viette (1950) as ‘paratype’, could not be traced in MNHN and may be lost or destroyed. Monoctenia decora Walker, 1869: Charact. Undescr. Lepid. Heterocera: 76 (Australia, not exactly specified, but very likely ‘Victoria’ (TE)). Syntype(s) ♀ (MVMA). At MVMA only one syntype could be traced, which is designated herewith as lectotype (cf. Figs 6, 7), in accordance with Article 74.7.3 of the Code (ICZN), in order to define the
herewith presented synonymy. Synonymization with true vinaria (cf. McQuillan & Edwards 1996, Scoble 1999) is supported by the straight postmedial line of the forewing, and structure of genitalia (examination by CY).

**Redescription.** Wingspan 40–50 mm. Habitus and external characters (Figs. 4, 6) very close to Oenochroma barcodificata. Ground colour variable, usually wine-red, sometimes brown or sand colour. Postmedial fascia of the forewing straight, often with a continuous dark proximal border. Dark suffusion of ground colour and blackish dotting of forewing costa usually reduced. Tasmanian populations of Oenochroma vinaria are characterised by a darker ground colour than in the nominotypical continental populations. It is worth noting that the figure in Boisduval & Guenée is too drab and not enough rosy as Guenée himself asserts in the original description. ♂ genitalia (Fig. 9): Uncus slightly longer and narrower than in Oenochroma barcodificata. Valvae broader. Process of left valva slightly larger. Right valva without the two spines arising from the edge subapically but with vestigial spines on the inner surface of valva. Tip of aedeagus narrower than in Oenochroma barcodificata. Sclerite of vesica much smaller. ♀ genitalia (Fig. 11): Differing from those of Oenochroma barcodificata in the strong sclerotisation of corpus bursae at the junction with the ductus bursae. Anterior and posterior dilatations of corpus bursae less pronounced.

**Distribution.** Tasmania and mainland Australia, widely distributed from Murchison River in West Australia through South Australia, Victoria and New South Wales to the Atherton Tableland in northern Queensland.

**Biology.** Larvae of ‘O. vinaria’ are recorded as feeding on various species of the Proteaceae genera Hakea, Grevillea and Banksia (McFarland 1988. Herbison-Evans & Crossley 2006; T. Edwards pers. obs.), for details see McFarland (1988). All these data refer to populations outside the known range of the sister species O. barcodificata, and for material from the host-plant genera Hakea, and Grevillea species identity as O. vinaria could be verified definitely (T. Edwards).

**Remarks.** Both McFarland (1988) and Herbison-Evans & Crossley (2006) highlight the large variability of larvae in colouration and even in shape e.g., length of fleshy dorsal appendages on segment A3. Further research is needed to examine if this variation refers to the presence of different taxa also in South Australia and Victoria.


Unispectinate antennae, although rare in the Geometridae, are characteristic of Proteaceae-feeding oenochromines (Scoble & Edwards 1990). Oenochroma vinaria, O. barcodificata and other Oenochrominae s. str. possess two wing venational characters usually present in Geometrinae: R separate from Rs and anastomosing with Sc for a short distance in the forewing and R2–5 stalked in the forewing (Young 2006b). Also, the ansa is similar to the geometrine type i.e., narrow at the base, widening mesally and again tapering apically, and is not the more typical tapering ansal morphology characteristic of Oenochrominae s. l. (Cook & Scoble 1992). As in the Geometrinae, the caecum of the aedeagus is long, slender and tapered and cornuti are reduced, tending not to be discrete rods and spines (Young 2006b). Similar aedeagus characteristics are found in the Australian oenochromine s. str. Monocentonia falernaria Guenée, 1858 (Young 2006b). This apparently close relationship between the Oenochrominae s. str. and the Geometrinae is also supported by molecular data (Young 2006b, Yamamoto & Sota 2007). The mature larva of O. barcodificata was exceptional among other geometrids examined in a study of Australian Geometridae by Young (2006b) by possessing trisetose SV setae on A1. The bifurcate cremastral spines, punctuation, dorsal and lateral grooves and mesothoracic spiracles described in O. barcodificata here were also noted in the oenochromines Arhodia lasiocamparia, Guenée, 1858, Monocentonia falernaria Guenée, 1858, M. smerintharia Felder & Rogenhofer, 1875, Dinophalus drakei (Prout, 1910), Hypographa Guenée, 1858, Parepisparis lutosaria (Felder & Rogenhofer, 1875) and Phallaria ophiusaria Guenée, 1858 (McFarland 1988).
Acknowledgements

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