A specimen of *Tirumala hamata hamata* (Macleay, 1826) (Lepidoptera: Danainae) from Captain Cook's First Voyage

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ABSTRACT
On 29 May 1770 Joseph Banks described a spectacular swarming of "milions"[sic] "of one sort" of butterfly at Thirsty Sound, near what is now Rockhampton, Queensland, comparing it to a species from China that had been named by Linnaeus. Discovery of what appears to be an Endeavour Voyage specimen of this Australian butterfly in the Hunterian Zoology Museum, Glasgow, allows us to confirm its long-suspected identity as *Tirumala hamata hamata* (Macleay) – a species unnamed and unknown at the time of Cook's First Voyage. Investigations into several collections that include 18th century Australian Lepidoptera and associated literature have not positively identified any further specimens taken from the swarm, although a pair in Oxford University Museum of Natural History could be from the same source. Taxonomic confusion due to mimicry, convergence and/or non-divergence affecting blue tiger patterned butterflies is most likely the principal reason such a specimen has previously gone undetected.

ARTICLE HISTORY

KEYWORDS
(in addition to those in title)
Joseph Banks; David Burton; James Charles Dale; Dru Drury; Johann Christian Fabricius; John Francillon; Alexander Macleay; William Sharp Macleay; the Endeavour; Australia; *Papilio similis*; geographical variation

Introduction

> . . . the earliest observation of Australian butterflies known to science was the account in Joseph Banks' *Endeavour* journal . . . [of] masses of a Danainae butterfly at Thirsty Sound . . . it is unclear which species was involved but it is likely to have been *Tirumala hamata,* the Blue Tiger, or *Euploea core . . .*
> *Lucas et al. (1997: 121)*

> Some internet sites state that Captain Cook recorded seeing masses of this butterfly [Blue Tiger] in 1770 but a search of his journal entries whilst he was in Queensland waters did not locate any such mention, that I could find … it is easy for mistakes to be propagated by simply being repeated.
> *http://tomandannesgarden.blogspot.co.uk/2010/10/blue-tiger-butterfly.html*

Joseph Banks mentions just two encounters with Australian butterflies during the Endeavour voyage (1768–1771) (Moulds 1977). Bank's description of the

first is cursory: on 16 April 1770 “At noon our second lieutenant observed a small butterfly”, mid Tasman sea, en route to the East Coast of ‘New Holland’. The second mention is much more evocative. On 29 May 1770 Banks described a spectacular swarm at Thirsty Sound, close to what is now Stanage Bay, about 175 km north of Rockhampton, Queensland. Banks wrote in his diary [all spellings sic]: “Insects in general were plentifull, Butterflies especialy: of one sort of these much like *P. Similis* Linn. the air was for the space of 3 or 4 acres crowded with them to a wonderfull degree: the eye could not be turnd in any direction without seeing milions and yet every branch and twig was almost coverd with those that sat still: of these we took as many as we chose, knocking them down with our caps or any thing that came to hand.” (Banks *Endeavour* journal, in Beaglehole 1962: 71; also State Library New South Wales 2017.)

Banks’s provisional comparison with the Linnaean species would have been based on the closest match in the literature he had available to him. We know he had a copy of Carl Alexander Clerck’s (1759–1764) *Icones Insectorum Rariorum* on board (Carr 1983), which includes a beautiful coloured plate depicting *Papilio similis* (Library of Congress online 2017). Moulds (1977) maintained that Banks’s description was ‘strongly suggestive’ of the milkweed butterfly *Tirumala hamata* (Macleay) (Fig. 1) but noted that the Banks Collection contains no specimens of this species.

The presence of insects from Bank’s first voyage in William Hunter’s collection is well established, the process involving Fabricius as Hunter’s curator, as described by Hancock (2015: 157). Referring to Banks, Fabricius stated “He has not only given me permission to examine and describe all of his insects, but has also given me his duplicates, which have increased my insect collection by no small amount, particularly of the rarest insects of all, those from the South Seas” (Fabricius 1784a). Some of these ‘duplicates’ were almost certainly added to the Hunter collection. In a description of Hunter’s insect cabinet Fabricius wrote “I laid it out myself and contributed to its gradual increase in size” (Fabricius 1784b). Fabricius also enthused about the addition of the Thomas Pattison Yeats Collection, following its bequest to Hunter in 1782 (the year of Yeats’s death), as “It includes, in particular, some of Sir Joseph Banks’ duplicates” (Fabricius 1784b).

An enquiry received by JR from a historian relating to Banks’s butterfly sighting prompted an inspection of the Hunter collection for possible material. The only specimens matching Banks’s description were two under a label “*Papilio similis*”, the Linnaean species referred to by Banks in his diary. However, the two specimens appeared to belong to different species, and neither matched modern descriptions or the lectotype of *Papilio similis* (Fig. 2), prompting a more comprehensive investigation into the identity of the Hunterian specimens, the potential fate of other specimens presumably gathered from the 1770 swarm, and consideration of the taxonomic confusion affecting this group of butterflies in the 18th century.

A putative Cook voyage specimen of *Tirumala hamata* in the William Hunter collection

The two William Hunter specimens in question, both of which appear under the name *Papilio similis* (HMAGC 2017), belong to the danaine butterfly genus *Tirumala* Moore, 1880. As discussed above, the identification "*Papilio similis*" would have been made by Fabricius – at a time when all butterflies were included within *Papilio*. One of the two specimens is a male (now numbered 127068) of *Tirumala limniace* (Cramer, 1775) – an Asian species not found east of Timor (Fig. 3a).

On the evidence of the other specimen (127067; Fig. 3b; see Appendix 2, HMAGC 2017), the swarming butterfly from Thirsty Sound was the Australian race of the then undescribed Blue Tiger, a danaine first named from Java by Stoll in 1781 as *Papilio melissa*, but now correctly known as *Tirumala hamata* (Macleay, 1826). *Tirumala hamata* (a species formerly long included in the genus *Danaus* – e.g. Talbot 1943; D'Abrera 1971; Common & Waterhouse 1981) occurs from the Philippines, Java and southern Sulawesi to New Guinea, Australia and the Pacific, east as far as American Samoa, and is currently divided into more than 20 named subspecies (Morishita 1981; Appendix 1). Of all Australian butterflies, *T. hamata* is the only one that bears a strong resemblance in size, shape and coloration to *Papilio similis* Linnaeus, 1758, a butterfly first described from China (Corbet 1949; Honey & Scoble 2001; Fig. 2), and now included in the related but very distinct danaine genus *Ideopsis* (Morishita 1981; Ackery & Vane-Wright 1984; Brower et al. 2010).

Tirumala hamata, together with some other Australian danaines (notably *Euploea corinna* and *E. tulliolus*) is also well known "in certain areas [of Queensland] … to accumulate in vast numbers" (Common & Waterhouse 1981: 306; see also Braby 2000: 592). Barrett & Burns (1951) report similar behaviour in New Guinea. These 'areas' are dry-season or over-wintering sites, where along the Queensland coast the butterflies start to aggregate from the beginning of May, and then don't disperse again until spring, with few individual *T. hamata* persisting after October (Scheermeyer 1993). Banks's encounter with the swarming butterfly at Thirsty Sound took place at the end of May.

Thus Moulds (1977: 27; 1999: 3) was correct in his supposition regarding the identity of the Thirsty Sound butterfly – but he continued to entertain some doubts because, as he also correctly noted, *Tirumala hamata* is unrepresented in the Banks Collection at the Natural History Museum (NHMUK) in London (Watkins 1923; Moulds 1999); nor was it illustrated in William Jones's *"Icones"* (OUMNH 2017), which included extensive coverage of the Banks Collection as it was while still at Soho Square. *T. hamata* is also lacking in the Linnaean Collection (see Linnean Society 2016). Because of this uncertainty it has even been suggested that the species concerned might have been another milkweed butterfly, *Euploea corinna* (Macleay) (e.g. Lucas et al. 1997, quoted above, as *Euploea core*).

Initially this uncertainty all seems surprising: given that supposedly many specimens were 'knocked … down' at Thirsty Sound, at least some would surely have been brought back to London on return of the *Endeavour* in July 1771. However, Lepidoptera are not the most robust of creatures and ocean crossings can be perilous, rough weather and ship board pests would have taken some toll on specimens. We know through Banks's diaries that a month after the stop at Thirsty sound the Endeavour had to go ashore for major repairs. On the 26th June, Banks writes that the act of hauling the

vessel ashore had driven the flooding to the stern of the vessel and that, in consequence, “my plants, which for safety had been stowed in the bread room, were this day found under water.....many were saved but some entirely spoiled”. Perhaps this space was reserved exclusively for Banks’s treasured plants or perhaps some other specimens i.e. the insects also suffered. Many of the specimens could have been lost before the Endeavour made it home.

Collecting insects in the field is quick relative to the time required to process and study the catch. Thirteen years after the Endeavour returned, Fabricius described the fate of the zoological specimens from Cook’s First Voyage at Banks’s Soho Square home thus: “The remaining collections from the animal kingdom…contain the many new fish, birds, amphibians, insects and worms found on the voyage to the South Seas. They are certainly very important because of the many unknown specimens, but are not preserved with the care that they surely deserve. It grieves me to see a good many of them decay.” (Fabricius 1784a). Some of the Thirsty Sound butterfly swarm may well have perished in storage.

Identification of the Australian subspecies of *Tirumala hamata*

The Hunterian *Tirumala hamata* specimen has now been compared with the extensive holdings of this species at the NHMUK – with special reference to material from Java, Ambon, and various Pacific islands, the only likely sources for *T. hamata* other than Australia during the period up to the end of the first Cook voyage (Vane-Wright & Hughes 2005; see Appendix 2). The Hunterian specimen (Fig. 3b) is a close fit for both Australian *T. hamata hamata* (Figs 4a,b) and the very similar Javan *T. hamata neomelissa* (Bryk, 1937) (Fig. 4c). It is less like the Ambon *T. hamata nigra* (Martin, 1910) (Fig. 4d), which is slightly darker above and more strikingly so beneath (Talbot 1943). Nor is it like any of the more distinct and generally smaller-sized populations found in the Pacific (Figs 4f–h) other than the slightly darker south-eastern Papua New Guinea population (Fig. 4e), and the populations infrequently encountered on the islands of Milne Bay (not visited by Cook, which are similar to Fig. 4e). Nominate *T. hamata hamata* is a rare visitor to New Zealand, the first published record apparently being from Kapiti Island, March 1940 (Hudson 1950; see also Early et al. 1995).

Thus, based on size and wing pattern, the Hunterian specimen is consistent with either an Australian or Javanese origin, while the only other likely contemporary sources for this species can be more or less firmly ruled out. Application of new biometrical data for certain forewing pattern elements demonstrates that the Hunter specimen lies close to the mean values obtained for the three chosen parameters for Australian material, but outside the observed ranges of these values for Java (Appendix 2). On this basis we conclude that the Hunter specimen came from Australia.

Fabricius would have identified the Banks specimen as *Papilio similis* sometime between July 1771 and his last visit to London in 1782, before Hunter’s demise in March 1783. The specimen was listed in the Trustees Catalogue dated 1783–1785. Probably because Fabricius had identified the specimen as *P. similis* Linnaeus rather than something new to be described, there is no further useful descriptive information in Fabricius’s own texts.

Although Fabricius identified this specimen in Hunter's collection, the existing cabinet label was prepared between 1783 and 1785 by Hunter's nephew, Matthew H. Baillie (Hancock 2015). In the case of Hunter's specimen of "*Papilio similis*" (=*T. hamata*), the label reads "Fabr. Pag. 101, No. 446," which corresponds to the entry for *P. similis* in Fabricius (1781). Baillie name labels generally correspond to Fabricius (1781), even when the species have been referenced in earlier publications.

The Australian Blue Tiger could have reached Hunter's collection either directly from Fabricius's own redistribution of Banks Collection duplicates, or indirectly from the Banks duplicates in the collection of T.P. Yeats. Whatever the precise history of this specimen with respect to its inclusion in the Hunter Collection, there is a very strong probability that this is a survivor from those specimens 'knocked down' at Thirsty Sound on 29 May 1770. If so, then the butterfly swarming that day in "milions" can be confirmed as *Tirumala hamata hamata* (Fig. 3b).

Where else might Cook voyage *Tirumala hamata* specimens survive?

The most obvious collections, other than NHMUK (Banks's own collection) and the Linnean Society where Cook voyage material of *Tirumala hamata* might have survived, would be in Fabricius's own Lepidoptera collection in Copenhagen, and the Macleay Museum in Sydney, Australia.

In his biography Fabricius describes how during his time in London the collections and libraries of "Banks, the two Hunters, Fordyce, Lee, Drury etc…were soon open" to him. He writes "my collections of insects were greatly increased; I sent them to Copenhagen, where Zoega arranged and preserved them" (Hope 1845). The Natural History Museum of Denmark's Zoological Museum in Copenhagen still houses the Lepidoptera from Fabricius's personal collection. Ole Karsholt, curator in charge of the Lepidoptera has confirmed (pers. comm.) that there are no examples of *T. hamata* in this collection.

William Jones (1745–1818), in his seven (now six) volumes of watercolours that were long ago dubbed "*Jones' Icones*", illustrated butterflies from a variety of collections from all around the globe (OUMNH 2017). The figured butterflies from Australia (Nova Hollandia) were noted to come from Dru Drury's (1724–1803) and John Francillon's (1744–1816) collections in addition to that of Banks. Volumes one to five of the *"Icones"* all include butterflies from Australia. However, the only *Tirumala* represented in the entire *"Icones"* is a fine image of *T. limniace* (vol. 2(2), pl. 79), apparently based on a specimen in Jones's own collection (Vane-Wright unpublished).

A catalogue of the exotic insects in the collection of Dru Drury at the OUMNH (Drury 1784–*c*1790s) specifies that Banks supplied Drury with specimens from the antipodes from as early as 1775. Volumes 1–3 of the *"Icones"* were perhaps completed between 1783 and 1785, making the first Cook voyage the only likely source of the figured specimens. Volume five is the last volume that lists Australian butterflies. Dates for all the volumes, especially the later ones, remain uncertain, but conceivably they could have been completed at any time up to 1818, when Jones died. However,

according to John Calhoun (see Vane-Wright 2010), “it does not seem likely that much was added after the early 1790s”. Even so, if volume five was completed after 1792, it could include figures prepared from specimens collected by David Burton (d.1792) on behalf of Francillon.

Burton arrived in New South Wales on the H.M.S. Gorgon on 22 September 1791. Banks had recommended his appointment as superintendent of convicts. Shortly before his departure Banks had privately commissioned Burton to collect botanical specimens, with the stipulation that he was not to supply “any vegetable production” directly or indirectly to any other person. He didn’t mention anything about insects. Keen to secure more entomological specimens from Australia, Francillon conducted his own negotiations with Burton. He trained, equipped and sponsored him to collect on his behalf. Burton kept his side of the deal – but, after developing an infection from a self-inflicted gunshot wound, he died prematurely in April 1792. Some of Burton’s insects miraculously made their way back to Francillon in London, despite being auctioned off in Australia after his death (Gray 1966; Anemaat 2014). So Francillon’s collection contained specimens collected from later voyages as well as the Endeavour.

Alexander Macleay (1767–1848) (also spelled McLeay) was a man of many accomplishments, including an important role in establishing the Linnean Society of London and, from late 1824, he was Colonial Secretary to the Government of New South Wales. On transfer to Australia in 1825, Macleay took with him his vast and renowned world collection of insects. Alexander’s insect collection later became a core element of the Macleay Museum, established in Sydney in 1888 at the direction of William John Macleay (1820–1891), cousin of Alexander’s oldest son, William Sharp Macleay (Stanbury & Holland 1988). WS Macleay, also a naturalist and the author of both *T. hamata* and *Euploea corinna* (Macleay 1826), added considerably to the Macleay Museum collections.

Alexander Macleay received insects from friends in the Linnean Society, from correspondents abroad, and added greatly to his cabinet through purchases at auctions. He acquired parts of Drury and Francillon collections; the former in 1805, the latter in 1817 and 1818 (King 1817, 1818; Vane-Wright & Hughes 2005; Anemaat 2014; Stanbury & Holland 1988). According to Julian Holland (in Stanbury & Holland 1988), “If the annotations in Macleay's copy of the [1818] auction catalogue indicate his purchases, then he acquired some 1200 specimens representing only a small fraction of the insects sold.” Some of Francillon’s specimens were collected by Surgeon-General John White, who came to Australia in the First Fleet in 1788, and whose collections are also cared for at the Macleay Museum (Woody Horning, *in* Stanbury & Holland 1988).

Photographs of Macleay Museum butterflies kindly sent by Robert Blackburn show several specimens of *Tirumala hamata.* However, without direct examination it is not possible to have confidence that any could have come from the Cook voyages, and Thirsty Sound in particular. In cabinet 74 drawer 53 there is an undoubted specimen of *T. hamata neptunia*, the Fiji race; Cook visited Fiji briefly on his second voyage (Appendix 2) – but this seems an unlikely source. However, it is possible that amongst this collection some of the supposedly lost type material of *T. hamata* (Edwards et al 2001), collected during the King expedition to northern and western Australia, may

yet be found. According to Horning (in Stanbury & Holland 1988), “192 species of insects collected by Captain P.P. King during his survey of the intertropical and western coasts of Australia between 1818 and 1822” were acquired by Macleay. At the end of his short original description, Macleay (1826) noted: “Captain King found this insect in surprising numbers on various parts of the North-east Coast, particularly at Cape Cleveland.” King himself described his encounters with this insect thus:

“Here [near Cape Cleveland, on 16 June 1819], as well as at every other place that we had landed within the tropic, the air is “crowded” with a species of butterfly, a great many of which were taken. It is doubtless the same species as that which Captain Cook remarks as so plentiful in Thirsty Sound; he says, “we found also an incredible number of butterflies, so that for the space of three or four acres, the air was so crowded with them, that millions were to be seen in every direction, at the same time, that every branch and twig were covered with others that were not upon the wing.” The numbers seen by us were indeed “incredible;” the stem of every grass-tree (*xanthorrhœa*) which plant grows abundantly upon the hills, was covered with them, and on their taking wing the air appeared, as it were, in perfect motion. It is a new species, and is described by my friend Mr. W.S. Macleay, in the Appendix, under the name of *euplæa hamata.*” (King 1826: 195). King made a fine original sketch of the butterfly (Fig. 5). (The quotation from Cook, which clearly refers to the same encounter as that related by Joseph Banks, can be found in Cook 1821: 112.)

In addition to the possible inclusion of King material, according to Robert Blackburn (pers. comm.), “Whilst there is certainly potential for the Macleay cabinets to contain Cook voyage material, nothing from the first voyage has been found here yet”. The arrangement of the Macleay Museum’s older Lepidoptera is essentially taxonomic. The 18th century Lepidoptera are mixed with 19th and 20th century specimens from numerous collectors, but often the individual collectors cannot be identified. Most of the Lepidoptera maintain their original pins and labels, but individual specimen labels were rare in 18th century collections. The Museum includes many Danainae, some with 18th century pins; however most if not all certainly originate from sources other than the Endeavour voyage.

In summary, searches, and photographs of blue-tiger-patterned milkweed butterflies sent to us by Ole Karsholt from Copenhagen, and Robert Blackburn from Sydney, indicate that Cook first voyage specimens of *Tirumala hamata* either never were in those collections – or that none has survived in Copenhagen – while, if any do exist in Sydney, they cannot yet and may never be reliably identified.

Two 18th century Australian *Tirumala hamata* in the J.C. Dale collection

The collection of James Charles Dale (1792–1872) has been housed at OUMNH, Oxford, since 1906, where it is considered to be one of the “treasures of the Hope Collections” (Salmon 2000: 139). The Dale archive includes over 5000 letters, 50 notebooks, catalogues, journals, and his diary, which he maintained for 64 years. Although the collection is mainly focussed

on British insects, notably from his native Dorset, it includes a considerable quantity of exotic material, evidently obtained from numerous sources.

Among Dale's collection of exotic butterflies are two *Tirumala hamata*, placed over drawer labels "Java" and "Melissæ". *Papilio melissa* Stoll, 1781, an invalid homonym since replaced by *Danaus* (*Tirumala*) *neomelissa* (see Appendix 1), was the first name applied to the collective species now known as *T. hamata*. Java was the type locality – specifically, "environs de Batavia" and "Samarang". The Dale specimens (Figs 6a,b) bear no written indication of their provenance. Only the female has written labels: "37", "Melissa ? / Cr: 377 C D", "Euplea [sic] hamata M^{c}L.". We do not know what "37" refers to (possibly a Dale catalogue number), but one of a pair of *T. limniace* in the same drawer bears a similar label "31". The *melissa* label refers to the plate and figures of the original description, "Cr" being short for Pieter Cramer, whose great work was completed after his death in 1776 by his assistant Caspar Stoll (Chainey 2005). The third label is a slightly erroneous rendition of *Euplaea*[sic] *hamata*, W.S. Macleay's original binomen under which he described this species from Australia. In addition, both specimens have a very small, *ca* 3 x 3 mm square of blank, very pale pink paper or thin card pinned beneath, pressed right up against the thorax. An entry in Smith (1986: 99) suggests that such pink labels could code for Australia, but on what basis and by whom the labels were added in the case of these Dale specimens is not clear.

The male (Fig. 6a), which has no label other than its little pink square, has a forewing length of 39 mm; the female (Fig.6b) has a forewing length of 44 mm (both well within the normal range for Australian *hamata*: Appendix 2). If these two old specimens of *T. hamata* in the Dale collection are relevant to the Thirsty Sound story, it would need to be established with some certainty that one or both could only have come from Australia because, unlike the Hunter material, we do not have any direct evidence that Dale received or obtained Cook voyage material. As already outlined above, if the specimens were received in England in the latter half of the 18th century, then there are only two likely sources: Java (including material collected there by members of the Cook voyage: Vane-Wright & Gaonkar 2006), or Australia (where most of the butterflies collected on the first voyage would appear to have been obtained: Watkins 1923). As already discussed, the phenotypic differences between Javan and Australian *hamata* are slight and overlapping – such that some individual specimens without locality data cannot be placed with absolute certainty based on external phenotype alone. However, our quantification of certain differences between the Javan and Australian phenotypes strongly suggests that, like the Hunter female, the Dale specimens are examples of the nominate subspecies – and therefore almost certainly from Australia, not Java (Appendix 2).

Why was *Tirumala hamata* initially misidentified?

To be fair to Banks, in his diary he stated only that the Thirsty Sound butterfly was "much like" Linnaeus's *Papilio similis.* This however was evidently accepted by Fabricius as a correct identification. How did this confusion with a butterfly from China, now considered so distinct as to be placed in a separate

genus, come about? The most obvious answer is mimicry, as with *Danaus plexippus* and *Limenitis archippus*, *Danaus chrysippus* and *Hypolimnas misippus*, and various other butterflies which, up to the mid-19th Century, caused similar confusion (Vane-Wright 2007a). Linnaeus, Banks, Fabricius and many other outstanding 18th Century naturalists were working within a special creation framework (even though Fabricius and even Linnaeus himself started to have doubts: Vane-Wright 2007b). It wasn't until the theory of evolution by natural selection was announced to the world by Charles Darwin and Alfred Wallace in 1858, and then Henry Bates introduced his mimicry hypothesis in 1862, that there was any reason to think about, let alone expect that well-defended organisms in the same environment would come to look deceptively similar due to signal-pattern convergence.

Indeed, the idea of 'convergence' itself makes no sense until you have a general theory of divergent evolution. Although the publications of Lamarck and others introduced such a general theory in the early 19th C, evolution was not widely embraced until after the publication of Darwin's *Origin*, in 1859. In the case of the milkweed butterflies discussed here, by the time that Fabricius was organising Hunter's collection, up to eight 'blue tiger' patterned species had been named (Appendix 3: Table 3), but all were widely confused in both collections and the literature; even today, misidentifications are common on the Internet.

Although *Ideopsis similis* and *Tirumala hamata* collectively cover almost all of the Indo-Pacific tropics and subtropics, their geographical ranges do not overlap. However, subsets of the Indo-Australian blue-tiger-patterned milkweed butterflies overlap in many areas (Morishita 1981; Ackery & Vane-Wright 1984). For example, *T. liminace*, so often confused with both *Ideopsis similis* and *T. hamata*, occurs with the former in continental SE Asia, and with the latter in the Philippines, Java and western Lesser Sunda Islands. Thus mimicry in a broad sense can offer an explanation for the 18th C confusion of *Ideopsis similis* and *Tirumala hamata.* However, these observations suggest further possibilities, such as ancestral patterns, non-divergence and symplesiomorphy, in addition to convergence and mimicry – issues which one of us (RIVW) proposes to explore elsewhere.

Conclusions

If specimen 127067 in the Hunter Collection, Glasgow, is accepted as a genuine survivor of the butterflies similar to *Ideopsis similis* seen and collected by Joseph Banks and others at Thirsty Sound on 29 May 1770, then the identity of the these butterflies can finally be settled as *Tirumala hamata hamata* (Macleay, 1826). There are no examples in the personal collections of Banks, Fabricius or Linnaeus. Two further specimens of *T. hamata*, now in the Dale Collection in OUMNH, could be from the same source but, like those in the Macleay Museum, they do not have adequate provenance to link them to the *Endeavour* voyage. Mimicry is the most obvious but not necessarily the complete or even correct explanation for the frequent misidentification of *Tirumala hamata*, *Ideopsis similis* and other similar, blue-tiger-patterned butterflies in 18th and early 19th century literature and collections.

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[**Legends to Figures**]

Figure 1. *Tirumala hamata hamata*, Magnetic Island, Queensland, Australia. 1st June 2011. In life the Blue Tiger has a wonderful pattern of bright blue spots and stripes against an inky-black ground colour. The blue is not in the scales, but is due to a bile pigment located between the wing membranes. After death the blue fades, often totally, to leave a dull straw coloured pattern (Figs 3–5). Photograph by "Daniela", courtesy Wikimedia Commons. https://en.wikipedia.org/wiki/File:Blue_Tiger_(Tirumala_hamata)_(5795261179).jpg#file

Figure 2. *Papilio similis* Linnaeus, 1758 (now *Ideopsis similis*), male lectotype, Linnean Society of London collection. Specimen collected in China by Pehr Osbeck. Reproduced here with permission of the Society.

Figure 3. Specimens of the genus *Tirumala* in Hunterian Museum, Glasgow, identified by Fabricius as "Papilio similis": **a**, male *Tirumala limniace* (Cramer, 1775) specimen no. 127068 (this species, which belongs to a different species-group than *Tirumala hamata*, does not occur east of Timor, or in Australia); **b**, female *Tirumala hamata hamata* (Macleay, 1826) specimen no. 127067 (see text regarding critical identification, where this specimen is argued to be from Thirsty Sound, nr Rockhampton, Australia, collected on 29th May 1770 during the first Cook voyage).

Figure 4. Examples of 7 of the 20+ currently recognised subspecies of *Tirumala hamata* (all specimens in NHMUK; all females; not to scale): **a** *T. hamata hamata* Australia, Queensland, Westwood, nr Rockhampton, 8.iii.1924, *GH Wilkins* [NHMUK 010242199]; **b** *T. hamata hamata* Australia, Port Darwin, vi.1890, *JJ Walker* [NHMUK 010242198]; **c** *T. hamata neomelissa* Indonesia, Java, 1904, ex *J Waterstradt, ex Oberthür* [NHMUK 010242197]; **d** *T. hamata nigra* Indonesia, ex *J Waterstradt, ex Oberthür* [NHMUK 010242196]; **e** *T. hamata subnubila*, paratype, Papua New Guinea, Aroa River, *AS Meek* [NHMUK 010242200]; **f** *T. hamata neptunia* f. protoneptunia, Fiji, Mango, Tairuni, ix. 1882, *Woodford* [NHMUK 010242201]; **g** *T. hamata moderata*, Vanuatu, Espiritu Santo, *Woodford* [NHMUK 010242203]; **h** *T. hamata angustata* Tonga, Tongatabu [NHMUK 010242202].

Figure 5. Original sketch of "Euplaea hamata Macleay" made by Phillip Parker King, *ca* 1820 [presumed to be based on a specimen from coast of NE Australia, possibly Cape Cleveland]. This can be considered an iconotype representing one of the potentially numerous syntypes (King 1826: 195); it appears to be a male, but this is not certain. Remarkably, given this is presumably a free-hand drawing, the fwl/M1+M2 ratio of 3.25 (mean of left forewing at 3.56, and right forewing at 2.93), is only a little below the observed sample mean value for *Tirumala hamata hamata*, but outside the observed range for *T. h. neomelissa* (Table 1, Appendix 2). Image scanned from a transparency, and reproduced here with permission of the State Library of Western Australia, where it is curated as "Scenes of North West Australia", no. 23B/11. SLWA image no. 20252P. The original is in the Art Gallery of Western Australia.

Figure 6. Dale specimens of *Tirumala hamata hamata* in Oxford University Museum of Natural History: **a** male (no written labels); **b** female (labelled "Euplea hamata McL."). It is possible that one or both of these specimens could also be from Cook's First Voyage.

Figure 7. Forewing of *Tirumala hamata* indicating location of basal pale (blue) spots in cells M_1 and M_2. Double headed arrow indicates forewing length. (See text and Appendix 2, Table 1.)

Appendix 1

Alphabetical list of names currently attributed to* Tirumala hamata (*Macleay, 1826*), *with type localities and annotations on current status.

Following the segregation by Kawazoé & Wakabayashi (1976) of *Tirumala septentrionis* (Butler, 1874) from *T. hamata* sensu Talbot (1943) as separate species, *Tirumala hamata* as now restricted (Morishita 1981; D'Abrera 1982; Ackery & Vane-Wright 1984) occurs from Java and the Philippines eastwards through the Malay Archipelago to American Samoa in the mid Pacific.

Over 20 subspecies of *Tirumala hamata* are conventionally recognised. Some of these are distinct but a majority are only distinguishable from long series, and clinal variation may also be a factor; most of these divisions are not fully diagnosable and are arguably suspect (cf. Braby et al. 2012). In addition, at least two further fundamental taxonomic challenges are involved. First, according to Ackery & Vane-Wright (1984), *T. hamata* is a paraspecies, lacking a recognised synapomorphy that could give evidence and thus some confidence that it is a monophyletic, collective natural group (for a discussion of paraphyletic species, see Crisp & Chandler 1996). Second, given this state of affairs, it is possible that some *hamata* "subspecies" could be separate species in their own right (e.g. in the work of Brower et al. 2010, based on four specimens, *T. hamata coarctata* appeared as sister to *T. septentrionis* + *T. hamata hamata*) – or be misplaced, perhaps belonging instead to one of the other widespread paraspecies currently included in the genus *Tirumala*. That this is plausibly not the case, supportive of the current arrangement for *T. hamata* at least, is the fact that the collective ranges of its subspecies form a largely coterminous, geographical whole.

One exception is the San Cristobal island group in the Solomon Islands (including Santa Ana and possibly Ugi) where, despite some disputed claims, *T. hamata* does not appear to occur – although the very closely related but phenotypically very distinct endemic *T. euploeomorpha* does. The strong possibility remains that *T. euploeomorpha* is nothing more than a local, divergently mimetic subspecies of *hamata* (Ackery & Vane-Wright 1984: 152; Tennent 2002: 113; Hashimoto et al. 2012).

In addition to the status of *T. euploeomorpha*, it would be desirable to reconsider *T. ishmoides* Moore, 1883, which together with *T. hamata, T. septentrionis* and *T. euploeomorpha*, and based on the results of Hashimoto & Yata (2007, 2008a, 2008b), may well form a distinct subclade within *Tirumala*. All four taxa were considered by Ackery & Vane-Wright (1984) to be paraspecies. *T. septentrionis* is larger, and overlaps extensively with *T. hamata*, giving confidence that these are indeed separate (biological) species. In some contrast, *T. ishmoides* is only clearly distinct from *T. hamata* on Sulawesi, where *T. hamata* is rare and mostly absent. As discussed by Morishita (1981), where both nominal species more regularly occur together, notably Java and the Philippines, the two are often hard to separate (Morishita speculating that this might be due to hybridization). However, Treadaway & Schroeder (2012) still accept *hamata, septentrionis* and *ishmoides* as separate species in the Philippines, and indicate that all three occur on the island of Mindanao. Thus the current system still recognises *T. hamata* in the sense of Morishita (1981) and Ackery & Vane-Wright (1984), and that is the scheme accepted here.

Names listed in bold are currently in use for subspecies of *T. hamata*. Names not in bold are either available names currently considered to be synonyms, or invalid (unavailable) names. Brackets around author names indicate those specific, subspecific and infrasubspecific epithets not originally introduced in combination with the current generic name, *Tirumala*.

***angustata* Moore**
Tirumala angustata Moore, 1883.
Type loc: Tonga – Tongatabu.
Status: currently regarded as a subspecies endemic to the Tongan islands of Tongatabu, Pangaimotu and Eua (Morishita 1981; Ackery & Vane-Wright 1984; Miller & Miller 1993; Tennent 2006a).

***arikata* (Fruhstorfer)**
Danaida (*Tirumala*) *melissa arikata* Fruhstorfer, 1910.
Type loc: Indonesia – Sula Mangole, Sula Besi.

Status: currently regarded as a subspecies of *hamata* endemic to the Sula Islands (Morishita 1981; Vane-Wright & de Jong 2003), although Talbot (1943) considered it doubtfully separable from *T. hamata paryadres*.

australis (Blanchard)
Danais australis Blanchard, 1848.
Type loc: Australia – Raffles Bay (Edwards et al. 2001: 324).
Status: currently regarded as a subjective synonym of *T. hamata hamata* (Bryk 1937; Edwards et al. 2001; Braby 2010).

claribella (Butler)
Danais claribella Butler, 1882.
Type loc: Fiji – Viti Levu.
Status: often treated as a polymorphic form of *T. hamata neptunia* (e.g. D'Abrera 1971; Evenhuis 2007), but considered by Robinson (1975) to be an aberration.

***coarctata* (Joicey & Talbot)**
Danaida (*Tirumala*) *melissa coarctata* Joicey & Talbot, 1922.
Type loc: Indonesia – Papua Province, Biak.
Status: currently regarded as a subspecies endemic to Biak, in Cenderawasih Bay (Talbot 1943; D'Abrera 1971; Morishita 1981; Ackery & Vane-Wright 1984).

gariata (Fruhstorfer)
Danaida (*Tirumala*) *melissa gariata* Fruhstorfer, 1910.
Type loc: Papua New Guinea – New Ireland.
Status: currently regarded as a subjective synonym of *T. hamata obscurata* (Morishita 1981; Tennent 2006a).

***goana* (Martin)**
Danais (*Tirumala*) *melissa goana* Martin, 1910.
Type loc: Indonesia – South Sulawesi, Goa.
Status: currently regarded as a subspecies endemic to southern Sulawesi (Morishita 1981; Vane-Wright & de Jong 2003).

***hamata* (Macleay)**
Euplaea[sic] *hamata* Macleay, 1826.
Type loc: north-eastern coast of Australia (Edwards et al. 2001: 323). According to Macleay's (1826: 461) original description: "Captain King found this insect in surprising numbers on various parts of the North-east Coast, Particularly at Cape Cleveland. See vol. i. p. 195." King also made an excellent sketch of one of the numerous specimens collected (Fig. 5).
Status: currently regarded as the oldest valid name for the collective species; the nominate subspecies occurs in northern and eastern Australia with vagrant status on Lord Howe, Norfolk and New Zealand (Gibbs 1980; Morishita 1981; Ackery & Vane-Wright 1984; Smithers 1995; Braby 2000; Tennent 2006a).

***insignis* (Talbot)**
Danaus hamata insignis Talbot, 1943.
Type loc: Solomon Islands – Malaita.
Status: currently regarded as a subspecies endemic to Malaita, Solomon Islands (Ackery & Vane-Wright 1984; Morishita 1981; Tennent 2002, 2006a).

***leucoptera* (Butler)**
Danais leucoptera Butler, 1874.
Type loc: Indonesia – Papua Province, Dorey.
Status: currently regarded as a subspecies endemic to Gebe, Waigeo, Salawati, Numfoor and NW New Guinea (Talbot 1943; D'Abrera 1971; Morishita 1981; Ackery & Vane-Wright 1984).

melissa (Stoll)
Papilio melissa Stoll, 1781.

Type locality: Indonesia – Java, Semarang and near Jakarta.
Status: oldest formal name applied to the species now known as *T. hamata*, but invalid (junior primary homonym); see *neomelissa* Bryk, replacement name.

melissina (Rothschild)
Danaida melissa melissa f. *melissina* Rothschild, 1915
Type loc: Indonesia – Bali.
Status: currently regarded as a form of *T. hamata neomelissa* (Bryk 1937).

***melittula* (Herrich-Schäffer)**
Danais melittula Herrich-Schäffer, 1869.
Type loc: Samoa – Upolu.
Status: currently regarded as a subspecies endemic to Samoa, including the islands of Savaii and Upolu (Morishita 1981; Ackery & Vane-Wright 1984; Tennent 2006a).

mendica (Talbot)
Danaus hamata angustata f. *mendica* Talbot, 1943.
Type loc: Tonga?
Status: an unavailable, infrasubspecific name introduced as a form of *T. hamata angustata*. Based on a single female labelled "Fiji" with its abdomen missing and said to have come from the Banks Collection (Talbot 1943), its status must be considered very uncertain. This specimen is presumably the same as that noted by Butler (1874: 275) as belonging to *T. hamata neptunia* from Fiji: "I found one specimen of this well-marked species in the supplementary drawers of the Banksian cabinet". Not noted or discussed by Morishita (1981) and Miller & Miller (1993); the name is listed under *T. hamata* but not discussed by Ackery & Vane-Wright (1984).

***moderata* (Butler)**
Danais moderata Butler, 1876.
Type loc: Vanuatu – Efaté. For correct date of publication, see Tennent (2006b).
Status: currently regarded as a subspecies endemic to part of the Solomons (Nendo, Vanikoro) and Vanuatu (Espiritu Santo, Ambae, Maewo, Pentecost, Malakula, Ambrym, Paama, Epi, Efaté, Erromango, Tanna, Futuna, Aneityum) (Morishita 1981; Ackery & Vane-Wright 1984; Tennent 2004, 2006a, 2009).

***neomelissa* (Bryk, 1937)**
Danaus (*Tirumala*) *neomelissa* Bryk, 1937: 115, nom. nov. for *Papilio melissa* Stoll, 1781, nec *Papilio melissa* Fabricius, 1775.
Type locality (replacement name): Indonesia – Java, Semarang and near Jakarta.
Status: currently treated as a subspecies endemic to Java, Bali, Bawean and the western Lesser Sunda Islands, including Lombok, Sumba, Sumbawa, and Flores (Talbot 1943; Morishita 1981). Morishita (1981) also included Alor, but this was regarded as subsp. *parayadres* by Ackery & Vane-Wright (1984), following Talbot (1943).

***nephthys* (Fruhstorfer)**
Danaida (*Tirumala*) *melissa nephthys* Fruhstorfer, 1911.
Type locality: Philippines – Sulu Islands.
Status: currently regarded as a subspecies endemic to the Sulu Islands: Jolo, Sanga Sanga, Sibutu and Tawitawi (Morishita 1981; Treadaway & Schroeder 2012).

***neptunia* (Felder & Felder)**
Danais neptunia Felder & Felder, 1865
Type loc: Fiji.
Status: currently regarded as a subspecies endemic to Fiji, including the islands of Yasawa, Lailai, Naviti, Waya, Vanua Levu, Taveuni, Viti Levu, Ovalau, Moturiki, Mango, Lau (Talbot 1943; D'Abrera 1971; Robinson 1975; Morishita 1981; Ackery & Vane-Wright 1984; Tennent 2006a). Note: this name has sometimes been misspelled "neptunica", following Bryk (1937).

***nigra* (Martin)**

Danais (*Tirumala*) *melissa nigra* Martin, 1910.
Type loc: Indonesia – Seram.
Status: currently regarded as a subspecies endemic to Central Maluku (sensu Vane-Wright & Peggie 1994), including Geser as well as Buru, Ambon, Saparua as well as Seram (Talbot 1943; D'Abrera 1971; Morishita 1981; Ackery & Vane-Wright 1984). Note: the genus *Tirumala* has long been considered absent from Northern Maluku, including Obi (Ackery & Vane-Wright 1984; Vane-Wright & Peggie 1994) – but Rawlins (2008) records *T. hamata* from Bacan, based on a personal communication, without indicating a subspecies. This requires confirmation.

***obscurata* (Butler)**
Danais obscurata Butler, 1874.
Type loc: "Upolu" (Samoa), but considered erroneous (Bryk 1937; Tennent 2006a).
Status: currently regarded as a subspecies endemic to Papua New Guinea (New Britain, Duke of York, Mioko, New Ireland, Simberi, Bougainville) and Solomon Islands (Shortlands, Choiseul, Kolombangara, New Georgia, Rendova, Santa Isabel, Guadalcanal) (Talbot 1943; D'Abrera 1971; Morishita 1981; Ackery & Vane-Wright 1984; Tennent 2006a). Note: Butler (1874) described *obscurata* on the basis of two specimens said to have been collected on "Upolu" by "Brenchley". The next taxon that Butler (1874) lists is "*Danais melittula*", which does come from Upolu, but he does not mention any Brenchley material. Talbot (1943) gives the type locality as "Solomons" without qualification. Julius Lucius Brenchley (1816–1873) collected widely in the Pacific, including both the Solomons and Samoa (Brenchley 1873).

***orientalis* (Semper)**
Danais orientalis Semper, 1879.
Type loc: Philippines – Luzon.
Status: currently regarded as a subspecies endemic to the Philippine islands other than Cuyo, Camotes, Jolo, Sanga Sanga, Sibutu and Tawitawi (Morishita 1981; Treadaway & Schroeder 2012).

***pallidula* (Talbot)**
Danaus hamata pallidula Talbot, 1943.
Type loc: Indonesia – Papua Province, Cyclops Mts, Sabron.
Status: currently regarded as a subspecies endemic to south-eastern areas of Papua Province (Morishita 1981; Ackery & Vane-Wright 1984). However, both D'Abrera (1971) and Parsons (1998) suggested that it was distinguished on trivial grounds.

***paryadres* (Fruhstorfer)**
Danaida (*Tirumala*) *melissa paryadres* Fruhstorfer, 1910.
Type loc: Indonesia – Kai and Tanimbar islands.
Status: currently regarded as a subspecies endemic to the eastern Lesser Sunda Islands, including Alor, Timor, Wetar, Kisar, Roma, Leti, Moa, Lakor, Damar, Sermata, Babar, Tanimbar, Kur, Kai and Aru (Talbot 1943; D'Abrera 1971; Morishita 1981; Ackery & Vane-Wright 1984; Rawlins 2008).

***pelagia* (Fruhstorfer)**
Danaida (*Tirumala*) *melissa pelagia* Fruhstorfer, 1911.
Type loc: Philippines – Cuyo.
Status: currently regarded as a subspecies endemic to the Philippine island of Cuyo (Morishita 1981; Treadaway & Schroeder 2012).

protoneptunia (Poulton)
Danaida melissa neptunia form *protoneptunia* Poulton, 1924
Type loc: Fiji – Tavenui.
Status: currently regarded a unimodal polymorphic form of *T. hamata neptunia* (D'Abrera 1971), occurring together with the typical form on Viti Levu and Ovalau which, according to Robinson (1975), are the only two islands where the nominate form is found; further investigation is desirable.

***richardi* Tennent**
Tirumala hamata richardi Tennent, 2001.
Type loc: Solomon Islands – Ulawa.
Status: currently regarded as a subspecies endemic to Ulawa, and possibly Santa Ana, Solomon Islands (Tennent 2001, 2002, 2006a). Ackery & Vane-Wright 1984 noted *T. hamata* from Ulawa as an unnamed subspecies; this was based on a male from Ulawa collected 27.iv.1955 by ES Brown, and a female from Ulawa Island, Hada, v.1963, collected by WRM Low, of which the latter had been labelled by TG Howarth, *D. hamata* ? ssp. n. However, not only do these two specimens differ in appearance from each other, neither approaches the much darker upperside phenotype of the Ulawa material described as *richardi* by Tennent (2001). In his type series Tennent included a pair of older specimens from "Ulawa" (Ulaua on the labels) collected by Woodford. These do correspond to the darker phenotype, as does a female labelled "Ilets near Isabel I. teste Webster" in the Rothschild Collection (NHMUK). The significance of these observations is difficult to assess, but it seems unlikely that the Brown and Low specimens are mislabelled.

sassina (Fruhstorfer)
Danaida (*Tirumala*) *melissa sassina* Fruhstorfer, 1911.
Type loc: Philippines – Mindoro, Cebu and Camiguin de Mindanao.
Status: currently treated as a subjective synonym of *T. hamata orientalis* (implicit in Treadaway & Schroeder 2012).

singaria (Fruhstorfer)
Danaida (*Tirumala*) *melissa singaria* Fruhstorfer, 1910.
Type loc: Indnonesia – Damar.
Status: currently regarded as a subjective synonym of *T. hamata paryadres* (Talbot 1943; Morishita 1981; Ackery & Vane-Wright 1984).

***subnubila* (Talbot)**
Danaus hamata subnublia Talbot, 1943.
Type loc: Papua New Guinea – Aroa Rover.
Status: currently regarded as a subspecies endemic to SE Papua New Guinea (Morishita 1981; Ackery & Vane-Wright 1984), although its status as distinct from *T. hamata hamata* has been questioned by D'Abrera (1971) and Parsons (1998). In addition to the type locality and adjacent areas of the main island, if separate and correctly identified at subspecies level, it has also been reported singly or in small numbers on a few Milne Bay islands, including Goodenough (probably resident), Fergusson, Normanby (all D'Entrecasteaux group), Kiriwina, Kitava (both Trobriands), Woodlark, Tube Tube, Wialoai, Dawson (the last three belong to the Engineer group, western Louisiades) and Misima (eastern Louisiades) (records from John Tennent, in litt. 10 May 2017).

***talautensis* (Talbot)**
Danaus hamata talautensis Talbot, 1943.
Type loc: Indonesia – Talaut Islands, Salibabu.
Status: currently regarded as a subspecies endemic to Kep. Talaud (Morishita 1981; Vane-Wright & de Jong 2003).

***tibula* (Fruhstorfer)**
Danaida (*Tirumala*) *melissa* Fruhstorfer, 1911.
Type loc: Philippines – Camotes
Status: currently regarded as a subspecies endemic to the Philippine island of Camotes (Morishita 1981; Treadaway & Schroeder 2012).

***tutuilae* (Hopkins)**
Danaida (*Tirumala*) *melissa tutuilae* Hopkins, 1927.
Type loc: American Samoa – Tutuila.
Status: currently regarded as a subspecies endemic to the islands of Tutuila and Manua, America Samoa (Morishita 1981; Ackery & Vane-Wright 1984; Tennent 2006a).

Appendix 2

Populations of* Tirumala hamata *that could have been sampled during the three Cook voyages across the Pacific, with special reference to the separation of Javan and Australian specimens by means of biometrical data

The following list indicates Cook voyages landfalls where specimens of *T. hamata* could have been collected, together with Ambon – the only other likely source of *T. hamata* material during the mid-late 18th C (Vane-Wright & Hughes 2005).

Fiji. Cook made brief landfall in the Lau Group during his 2nd voyage. Watkins (1923) does not list any butterflies from Fiji in the Banks Collection. Talbot (1943) mentions a specimen of *T. hamata* from "Fiji" from Banks, but the provenance seem very doubtful (see *mendica*, Appendix 1). Fiji is populated by subsp. *neptunia*, a small race that is dimorphic in both sexes on Viti Levu and Ovalau (Robinson 1975). Fig. 4f illustrates f. protoneptunia, the form most similar to *T. hamata hamata.* Based on major differences in phenotype, the Dale and Hunter *T. hamata* cannot have come from Fiji.

Tonga. These islands were visited by during the 2nd and 3rd Cook voyages. Watkins (1923) lists some butterflies from Tonga in the Banks Collection. The relatively small Tongan race, subsp. *angustata* (Fig. 4h), to which Talbot (1943) referred the Banks "Fiji" specimen (see *mendica*, Appendix 1), is quite unlike the Dale and Hunter material.

New Zealand. All three Cook voyages visited New Zealand, and Watkins (1923) indicates the presence of several New Zealand butterflies in the Banks Collection. Although *T. hamata hamata* does occur on NZ, it is a rare visitor that does not establish, with the first known record given as 1940 (Hudson 1950; see main text). That the Dale and/or Hunter material could have come from NZ seems very unlikely.

Norfolk Island. *T. hamata hamata* was first recorded from Norfolk Island by Smithers (1995) where, as in New Zealand, it has vagrant status. The 2nd Cook Voyage made landfall on Norfolk, but Watkins (1923) does not list any butterflies from the Island in the Banks Collection, and it seems very unlikely that the Dale and/or Hunter material could have originated there.

Vanuatu. The 2nd Cook voyage visited the New Herbrides (now Vanuatu), where the resident population belongs to subsp. *moderata* (Fig. 4g). This phenotype does not match the Dale or Hunter material.

New Caledonia. Visited on the 2nd Cook voyage, New Caledonia is also populated by subsp. *moderata*, where it occurs in forest and woodland, but is "nowhere common" (Holloway & Peters 1976: 296).

New Guinea. Brief landfall is said to have been made on the southern New Guinea coast during the 1st voyage, after *Endeavour* left Australia. Most New Guinea *hamata* populations have the ground colour of the outer margin of the hind wing distinctly paler than the discal area (this reaches an extreme in the population found in the Jimi Valley). However, in parts of coastal Milne Bay and inland, including the Aroa River, the resident *T. hamata* are very similar to the Australian race. Talbot (1943) described this population as *T. hamata subnubila*, but D'Abrera (1971) followed by Parsons (1998) suggested the differences between *subnubila* and subsp. *hamata* were trivial. Fig. 4e suggests that, although the differences are indeed small, the two are not identical. This could be pursued, but for present purposes there is no evidence that any butterflies were collected from New Guinea during the Cook voyages. Material from southern New Guinea was very rare during the mid-late 18th C and, as already noted, other than in one restricted area, the New Guinea phenotypes are distinctive from both Australian and Javan material.

Savu. According to Vane-Wright & Gaonkar (2006), although *Endeavour* made brief landfall on the island of Savu (Sawu), south-west of Timor, there is no evidence that any butterflies

were collected. Ackery & Vane-Wright (1984) found no record of *T. hamata* for this island, although it seems likely that subsp. *paryadres* occurs there.

Ambon. None of the Cook voyages visited the Spice Islands (Maluku). Ambon (Amboina) was then a garrison and headquarters for the extensive Dutch trading in the Far East, and one of the main sources of SE Asian insect material during the 18th C. However, as discussed by Vane-Wright & Hughes (2005), at that time most of the material from Ambon ended up, understandably, in Dutch and other continental cabinets; little reached England. Central Maluku is inhabited by *T. hamata nigra* (Fig. 4d) – a slightly darker race that can be differentiated from *T. hamata hamata* and *T. h. neomelissa*.

Java. As recounted by Banks (in Beaglehole 1962) and O'Brian (1987), during the return of the 1st Cook voyage, *Endeavour* was forced to stop at Java for several weeks. Even though the crew were ill and found themselves in terrible circumstances, some insect material was obtained– although it was poorly documented then, or subsequently (Vane-Wright & Gaonkar 2006). The endemic *T. hamata* population belongs to subsp. *neomelissa* (Fig. 4c). Although Javanese *hamata* are very similar to *T. hamata hamata*, most individuals can be separated by 'jizz' – which we have made operational by biometric comparison of certain forewing spots (Table 1).

Australia. Only the 1st voyage spent time in Australia in those areas (e.g. Queensland coast) where *T. hamata* is common. We know from Banks's diary that near Rockhampton he and other members of the *Endeavour* crew encountered and apparently collected multiple specimens of a species which he likened to another 'blue tiger', *Ideopsis similis*(Linnaeus). Among the Australian fauna *T. hamata* is the only species that fits such a comparison. Two examples of *T. hamata hamata* are illustrated (Fig. 4a,b), to give some of idea of the range of variation. Of the *hamata* populations that Banks and the Cook voyages could have encountered, working from individual specimens without provenance the most difficult to separate are those from Java and Australia. However, the biometric data presented in Table 1 suggest that, having eliminated all possibilities except Java and Australia, the putative Cook voyage material discussed in this paper almost certainly came from Australia, not Java.

Table 1. Forewing length; length of basal pale spots in forewing cells M_1 and M_2; and ratio of fwl divided by sum of lengths of M_1 and M_2 spots for male and female samples of *Tirumala hamata melissa* from Java, and *T. hamata hamata* from Australia (Aus). M = male; F = female; number following M or F = sample size. Spots M_1 and M_2, see Fig. 7; all lengths in mm. Ratio = fwl divided by (length of spot M_1 + length of spot M_2). $\bar{x}$ = sample mean, s = standard deviation, max = maximum value observed, min = minimum value observed. All measurements taken by dial callipers from material in NHMUK. See text. Raw data available from RIVW.

	Fwl				spot M_1				spot M_2				ratio: fwl/M_1+M_2			
	$\bar{x}$	s	max	min	$\bar{x}$	s	max	min	$\bar{x}$	s	max	min	$\bar{x}$	S	max	min
Java (M20)	**42.25**	2.139	45.3	36.5	**5.21**	0.687	6.5	4.0	**4.06**	0.531	5.4	3.5	**4.59**	0.464	5.6	3.63
Java (F16)	**41.44**	1.815	44.0	38.4	**5.27**	0.869	7.3	4.1	**4.38**	0.652	5.4	3.1	**4.37**	0.572	5.25	3.64
Aus (M20)	**42.545**	2.890	46.2	35.6	**6.16**	0.704	7.2	4.4	**6.04**	1.083	8.0	3.7	**3.53**	0.349	4.4	2.95
Aus (F20)	**43.23**	2.259	47.6	39.7	**6.50**	0.837	8.1	5.0	**6.45**	0.829	7.7	5.0	**3.37**	0.344	3.95	2.80

Table 2. Comparison of the three putative Cook voyage specimens with Australian and Javan *T. hamata*, based on the biometrical data summarised in Table 1

Hunter Female		
Forewing l.	44 mm	≈ average for *h. hamata*, = max. observed for *h. neomelissa*
M_1	8.4 mm	> max. observed for *h. hamata*, > max. observed for *h. neomelissa*
M_2	6.5 mm	≈ mean for *h. hamata*, > max. observed for *h. neomelissa*
fwl / M_1+M_2	2.95	within range for *h. hamata*, outside range for *h. neomelissa*
Dale Male		
Forewing l.	39 mm	within observed range for both *h. hamata* and *h. neomelissa*

M_1	5.9 mm	within observed range for both *h. hamata* and *h. neomelissa*
M_2	5.9 mm	within observed range for *h. hamata*, > max for *h. neomelissa*
fwl / M_1+M_2	3.31	within range for *h. hamata*, outside range for *h. neomelissa*

Dale Female

Forewing l.	44 mm	≈ average for *h. hamata*, = max. observed for *h. neomelissa*
M_1	7.3 mm	< max. observed for *h. hamata*, = max observed for *h. neomelissa*
M_2	6.2 mm	> min. observed for *h. hamata*, > max. observed for *h. neomelissa*
fwl / M_1+M_2	3.30	within range for *h. hamata*, outside range for *h. neomelissa*

Conclusion

On the basis of these biometric comparisons (notably fwl/M_1+M_2, which appears diagnostic for these individuals), all three putative Cook voyage specimens are consistent with an Australian origin, not Javan – and if they are Cook material, then they must come from the 1st voyage, with the most likely location being, given the Banks diary entry, Thirsty Sound, near Rockhampton, Queensland.

Appendix 3

Table 3. Eight blue-tiger-patterned milkweed butterflies named by the end of the 18th Century (from Ackery & Vane-Wright 1984). Judging by the results of online image searches these species, frequently misidentified by 18th and early 19th century entomologists, are still quite often misidentified even today.

Ideopsis similis (Linnaeus, 1758)	type locality:	China
Tirumala limniace (Cramer, 1775)		China
Ideopsis juventa (Cramer, 1777)		Java
Euploea mulciber (Cramer, 1777) [female]		India
Danaus ismare (Stoll, 1780)		Ambon
Parantica aglea (Stoll, 1782)[1]		India
Parantica agleoides (Felder & Felder, 1860)[2]		Malay Peninsula
Tirumala hamata (Macleay, 1826)[3]		Australia

1. Stoll (1782) gave the Coromandel Coast (southern India) and Java as type localities for *Parantica aglea.* Although Ackery & Vane-Wright (1984) recorded a specimen from Java, which appeared to be genuine, this butterfly is generally not thought to extend south-east even as far as Singapore (Morishita 1981).

2. The first binomen applied to the danaine now known as *Parantica agleoides* was *Papilio eryx* Fabricius, 1798, an invalid homonym of *Papilio eryx* Linnaeus, 1771. It has been replaced by the subjective synonym first introduced as *Danais algeloides* Felder & Felder, 1860. *Parantica agleoides* has the type locality Malay Peninsula. This species does not occur in China, but there is a subspecies from Java (*P. agleoides furius* (Fruhstorfer, 1909)).

3. The first binomen applied to the danaine now known as *Tirumala hamata* was *Papilio melissa* Cramer, 1779, based on material from Java. However, this name is a junior primary homonym of *Papilio melissa* Fabricius, 1775, now *Oenis melissa* (F.), a North American satyrine. Cramer's invalid name was eventually given an explicit replacement, *Danaus neomelissa* Bryk, 1937 – now used to designate the Javanese race of *Tirumala hamata*. (See Appendix 1.)

[The images presented below (Figs 1–8) are for evaluation purposes only. The authors are in the process of sourcing better quality images for Figures 2, 3a (to be equivalent to 3b) and 5. If accepted these plates will need to be recreated based on the best individual images available.]

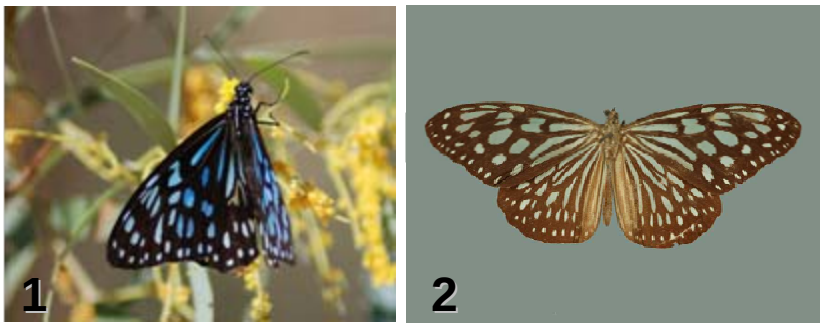

Figure 1. *Tirumala hamata hamata*, Magnetic Island, Queensland, Australia. 1st June 2011. In life the Blue Tiger has a wonderful pattern of bright blue spots and stripes against an inky-black ground colour. The blue is not in the scales, but is due to a bile pigment located between the wing membranes. After death the blue fades, often totally, to leave a dull straw coloured pattern (Figs 3–5). Photograph by "Daniela", courtesy Wikimedia Commons. https://en.wikipedia.org/wiki/File:Blue_Tiger_(Tirumala_hamata)_(5795261179).jpg#file

Figure 2. *Papilio similis* Linnaeus, 1758 (now *Ideopsis similis*), male Lectotype, collection of the Linnean Society of London.

Figure 3. Specimens of the genus *Tirumala* in Hunterian Museum, Glasgow, identified by Fabricius as “Papilio similis”: **a**, male *Tirumala limniace* (Cramer, 1775) specimen no. 127066 (this species, which belongs to a different species-group than *Tirumala hamata*, does not occur east of Timor, or in Australia); **b**, female *Tirumala hamata hamata* (Macleay, 1826) specimen no. 127067 (see text regarding critical identification, where this specimen is argued to be from Thirsty Sound, nr Rockhampton, Australia, collected on 29th May 1770 during the first Cook voyage).

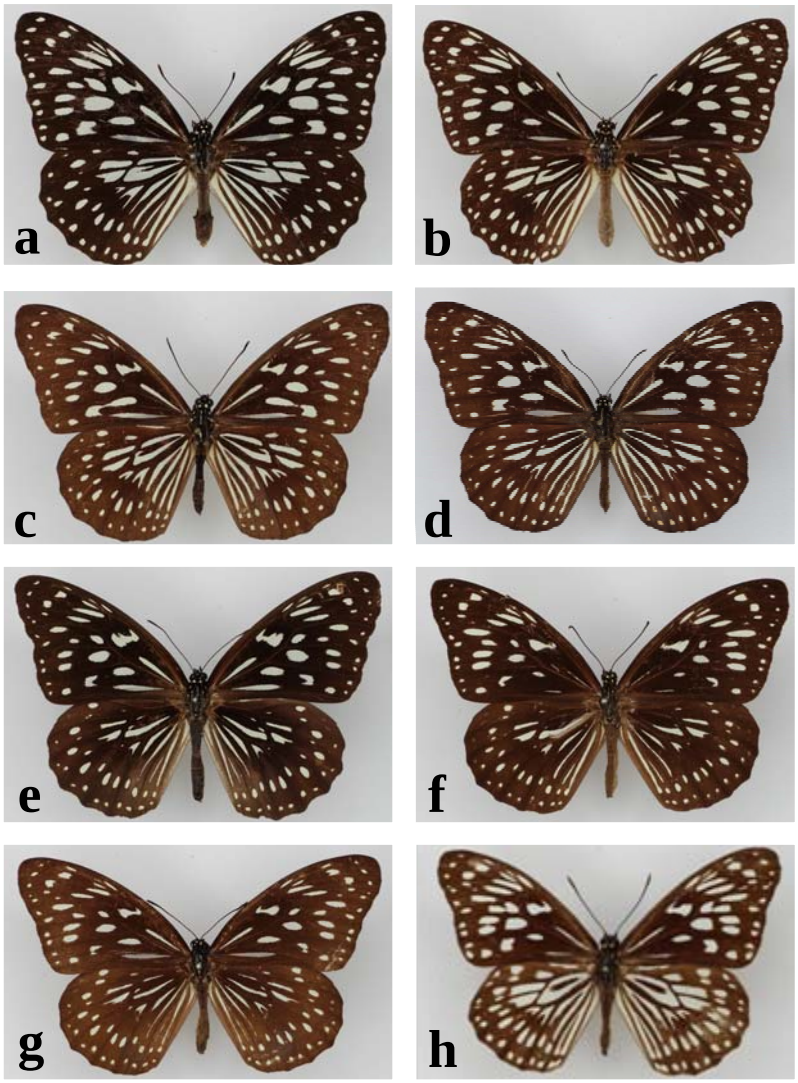

Figure 4. Examples of 7 of the 20+ currently recognised subspecies of *Tirumala hamata* (all specimens in NHMUK; all females; not to scale). **a** *T. hamata hamata* Australia, Queensland, Westwood, nr Rockhampton, 8.iii.1924, *GH Wilkins* [NHMUK 010242199]; **b** *T. hamata hamata* Australia, Port Darwin, vi.1890, *JJ Walker* [NHMUK 010242198]; **c** *T. hamata neomelissa* Indonesia, Java, 1904, ex *J Waterstradt, ex Oberthür* [NHMUK 010242197]; **d** *T. hamata nigra* Indonesia, ex *J Waterstradt, ex Oberthür* [NHMUK 010242196]; **e** *T. hamata subnubila*, paratype, Papua New Guinea, Aroa River, *AS Meek* [NHMUK 010242200]; **f** *T. hamata neptunia* f. protoneptunia, Fiji, Mango, Tairuni, ix. 1882, *Woodford* [NHMUK 010242201]; **g** *T. hamata moderata*, Vanuatu, Espiritu Santo, *Woodford* [NHMUK 010242203]; **h** *T. hamata angustata* Tonga, Tongatabu [NHMUK 010242202].

Figure 5. Original sketch of “Euplaea hamata Macleay” made by Phillip Parker King, *ca* 1820. This can be considered an iconotype representing one of the potentially numerous syntypes (King 1826: 195); it appears to be a male, but this is not certain. Remarkably, given this is presumably a free-hand drawing, the fwl/M1+M2 ratio of 3.25 (mean of left forewing at 3.56, and right forewing at 2.93), is only a little below the observed mean value for *Tirumala hamata hamata*, but outside the observed range for *T. h. neomelissa* (Table 1, Appendix 2). Note that below the Blue Tiger there is in addition an excellent but only faint pencil outline sketch of the Common Australian Crow, *Euploea corinna* (Macleay, 1826), which can also be regarded as an iconotype. Image scanned from a transparency, and reproduced here with permission of the State Library of Western Australia, where it is curated as “Scenes of North West Australia”, no. 23B/11. The original is in the Art Gallery of Western Australia.

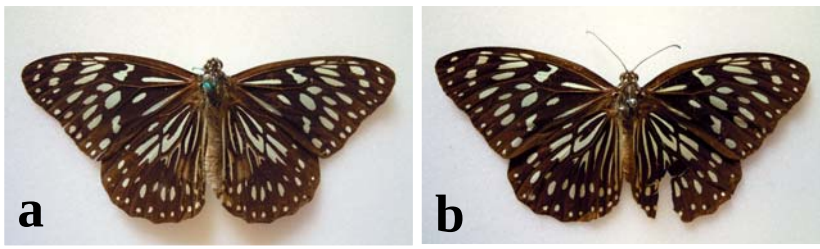

Figure 6. Dale specimens of *Tirumala hamata hamata* in Oxford University Museum of Natural History: **a** male (no written labels); **b** female (labelled "Euplea hamata McL."). It is possible that one or both of these specimens could also be from Cook's First Voyage.

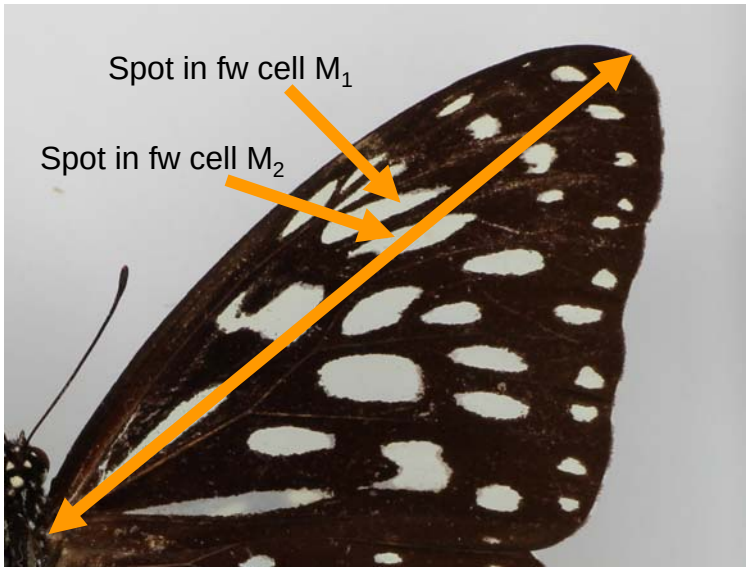

Figure 7. Forewing of *Tirumala hamata* indicating location of basal pale (blue) spots in cells M1 and M2. Double headed arrow indicates forewing length. (See text and Appendix 2, Table 1.)