On the proposed replacement neotype of *Telegonus fulgerator* (Walch) (Lepidoptera; Hesperiidae): a reply to Zhang et al. (2022)

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Abstract

In this paper we respond in detail to a recently published criticism of our previous designation of a neotype for the neotropical butterfly *Telegonus fulgerator* (Walch). It is our view that these criticisms are largely based on subjective claims that lack solid evidence, and conclude that there is no compelling reason for invalidating our neotype.

Key words: COI barcodes, cryptic species, ICZN Code, taxonomic stability, type locality, wing maculation

Introduction

Recently, Zhang et al. (2022) designated a replacement neotype for the hesperiid butterfly *Telegonus fulgerator* (Walch, 1775) (Hesperiidae: Eudaminae), a taxon now known to consist of at least ten cryptic lineages that were given informal "species" names based on molecular studies utilizing a segment of the mitochondrial cytochrome *c* oxidase subunit I (COI; or *cox1*) gene (Hebert et al., 2004), commonly referred to as the barcode region (Hebert et al., 2003). Although a neotype of *T. fulgerator* had previously been proposed by us (Pfeiler & Nazario-Yepiz, 2020), Zhang et al. (2022) criticized our proposal claiming that it violated several qualifying conditions for naming neotypes in Article 75.3 of the International Commission on Zoological Nomenclature Code (ICZN, 1999), and thus was invalid. Here, we respond to each of their criticisms.

The need for designating a neotype for *T. fulgerator* arises from the fact that the holotype examined by Walch is apparently lost (Steinhauser, 1987; Pelham, 2008; Brower 2010). In addition, Brower (2010) provided formal species names, and designated holotypes and type localities, for each of the ten previously undescribed cryptic lineages of *T. fulgerator* (Hebert et al., 2004) based solely on diagnostic nucleotide differences in COI barcodes. Without a neotype of *T. fulgerator*, and not knowing which (if any) of Brower's newly described species corresponded to *T. fulgerator*—a name in use for almost 250 years—was at risk of becoming a *nomen dubium* (Pfeiler & Nazario-Yepiz, 2020).

Neotypes and the ICZN Code

Of the seven qualifying conditions for the naming of neotypes in Article 75.3, Zhang et al. (2022) claimed that we violated four. A summary of each qualifying condition, the corresponding criticism(s), and our rebuttals follow.

Article 75.3.1. [Include] a statement that [the neotype] is designated with the express purpose of clarifying the taxonomic status or the type locality of a nominal taxon.

Although Zhang et al. (2022) claim that we did not include this statement in our paper, they are mistaken and their claim is baseless. We clearly stated that our purpose in naming a neotype was to stabilize the taxonomic status of *T. fulgerator* in: (1) the Abstract; (2) the last sentence of the Introduction; and (3) twice in the last section of the Discussion.

We also stated that the type locality for our neotype is Tamaulipas, Mexico. A type locality was not mentioned in the original description (Walch, 1775), as was pointed out by us previously (Pfeiler & Nazario-Yepiz, 2020) and by Zhang et al. (2022).

Article 75.3.4. [Include] the author's reasons for believing the name-bearing type specimen(s) (i.e. holotype, or lectotype, or all syntypes, or prior neotype) to be lost or destroyed, and the steps that had been taken to trace it or them.

Zhang et al. (2022) claim that we failed to satisfy this article. Our reason for believing the holotype is lost is based on statements documented in the scientific literature. We cited the comprehensive catalogue on species names for Lepidoptera in the USA and Canada (Pelham, 2008) which states that the holotype is "probably lost", a conclusion previously stated in Steinhauser (1987). Also, Brower (2010), following the opinion of one of the authors (GL) of Zhang et al. (2022), stated that the holotype is "lost". We were criticized for including only the Pelham citation, but it is clear that a consensus of distinguished Lepidoptera taxonomists cited above had previously considered that the holotype of *T. fulgerator* was lost. Zhang et al. (2022) were also unable to locate a holotype during their museum searches, providing further evidence supporting the view that it is lost.

Article 75.3.4 is intended to ensure that an author does not arbitrarily propose a neotype without any evidence that the holotype is lost, and we provided this evidence. The fact that we relied on published literature, and did not conduct what most probably would have been an unsuccessful holotype search of European museums, is not grounds for invalidating our neotype.

We stated that our neotype is deposited in the C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, CO. (Museum ID: CSUPOBK–1130). The COI barcode (623 base pairs), and a photo of the female neotype, is available in the Barcode of Life Data Systems (BOLD) (Ratnasingham & Hebert, 2007; BOLD record ABLCW845-10); the photo is also available in our paper (Pfeiler & Nazario-Yepiz, 2020). Given the wording in Article 75.3.4, one could argue that it was Zhang et al. (2022) who violated this article because our "prior neotype" is not "lost or destroyed".

Article 75.3.5 [in part]. [Include] evidence that the neotype is consistent with what is known of the former name-bearing type from the original description and from other sources.

Zhang et al. (2022) claim that our neotype is not consistent with the original description of the former name-bearing type. They base this criticism mainly on the fact that the original description states that there are three subapical white spots on the forewing (Walch, 1775) whereas our proposed neotype shows four spots. The poorly-illustrated holotype from (Walch, 1775) also suggests three subapical spots (Fig. 1.1; note that three apparent spots are more evident on the right forewing that is not shown in the figure). Examination of photos in BOLD, however, reveals that the number of subapical spots is a variable trait in species of the fulgerator complex. In addition, the size of these spots can sometimes be so small that they could easily be overlooked (Fig. 1.2). In addition to the small third spot shown in Figure 1.2, the uppermost spot is also tiny in two BOLD specimens of *T. audax* from Costa Rica (EPAF356-03 and MHAHG475-06), as well as in a specimen of the fulgerator complex from Trinidad (Cock, 1988), also suggesting only three spots. We have used the examples of *T. audax* above and in Figure 1, a species which usually possess four subapical spots (sometimes with a fifth lower tiny spot; Fig. 1.3), because the barcode of the proposed replacement neotype of Zhang et al. (2022) possesses the diagnostic nucleotide substitution of this putative species (Brower, 2010). The proposed replacement neotype also resolves with *T. audax* on phylogenetic analysis (see below).

Fig.1

Whether Walch's holotype possessed an additional small subapical spot that was not scored cannot be determined, given that the specimen is lost and the poor illustration of the holotype is inconclusive, but we suggest that the possibility exists. Given these uncertainties, we consider that differences in number of subapical spots between out neotype and the replacement neotype of Zhang et al. (2022) is a weak argument for suggesting that our neotype is invalid.

In an attempt to provide support for their proposed neotype and type locality, Zhang et al. (2022) state that "the lack of the fourth [subapical] spot is characteristic of South American specimens [of *T. fulgerator*]". This statement is incorrect because the number of easily-scored spots in South American specimens is also variable. In the original description of *T. fulminator* (Sepp, [1841]) (as *Papilio fulminator*)—currently considered a junior synonym of *T. fulgerator*—an excellent illustration by H.J. Scheller of life history stages of specimens from Suriname clearly shows four subapical spots on both dorsal and ventral forewings. Photos available in BOLD of other specimens of the fulgerator complex from Colombia and Ecuador also show four (or five, as in Fig. 1.3) subapical spots. In addition, BOLD photos of three specimens of *T. fulgerator* from northern Argentina from the study of Lavinia et al. (2017) show one with four subapical spots, and the other two with three spots. The first author (EP) has recently examined a photo of a reared specimen of the fulgerator complex from Suriname that also possessed four distinct subapical spots (H.B.P.E. Gernaat, personal communication).

Zhang et al. (2022) stated that our neotype did not agree with the position of the spot in forewing cell M_3-CuA_1 of the holotype, which is offset distad from the discal band (Fig. 1.1). The size and position of this spot, however, is also variable in the fulgerator complex, and is sometimes placed very near the discal band, as in our neotype. None of the 78 photos of *T. audax* examined in BOLD (currently listed under *Astraptes audax*), or even the proposed replacement neotype of Zhang et al. (2022), show the extreme offset position of this spot seen in the poor illustration in Walch (1775) (Fig. 1.1). In addition, Zhang et al. (2022) also point out the poor quality of Walch's illustration. We consider the criticism of Zhang et al. (2022) on the position of this spot in our neotype unwarranted.

In support of a South American origin for Walch's holotype, Zhang et al. (2022) claim that a greenish overscaling on dorsal areas of the body (thorax and abdomen) and wing bases distinguishes South American *Telegonus* from the blue colour of North American *T. azul*, a specimen of which is designated as our neotype. This difference in structural colour, however, is

not diagnostic as they infer. Photos of *T. azul* in Warren et al. (2017) show greenish hues especially in the head region and anterior thorax. Also, in the original description of *T. azul* (as *Goniloba azul*) Reakirt (1866 [1867]) stated that the basal third of the wings were "shining blue", but that the head region was "lustrous green". Also, greenish scaling in South American specimens is sometimes reduced, or not apparent. Therefore, a difference in iridescent colour is not a reliable character for separating South American *Telegonus* from North American *T. azul*.

Article 75.3.6 [in part]. [Include] evidence that the neotype came as nearly as practicable from the original type locality.

As pointed by us (Pfeiler & Nazario-Yepiz, 2020), and also by Zhang et al. (2022), no mention of a type locality was given for the holotype described by Walch. Given the wide geographic distribution of the *T. fulgerator* (sensu lato) in the neotropics (Godman & Salvin, 1887–1901), we argued previously that Walch's specimen could have been collected anywhere within this range, from northern Mexico to northern Argentina. It is also unknown who collected the specimen, information that might provide a clue as to locality. In order for Zhang et al. (2022) to criticize us on not choosing a neotype from near the original (unknown) type locality they had to create a scenario, based on circumstantial evidence, that limited the type locality to northern South America, preferably Suriname or Guyana. As we mentioned above, the type locality of our neotype is Tamaulipas, Mexico, approximately 5000 km north of Suriname. The 'evidence' provided in Zhang et al. (2022) for a type locality in the region of Suriname included: (1) eighteenth- and early-nineteenth-century European taxonomists described numerous species collected from this region; (2) that the person who provided specimens for Walch for his other publication *may have* [italics ours] purchased them [from an unknown collector at an unknown locality], *but most probably Suriname* [italics ours]; (3) that other workers mentioned the presence of *T. fulgerator* in South America, including Suriname, in their publications beginning shortly after Walch's description; and (4) that the only other species described along with *T. fulgerator* by Walch, currently considered a junior synonym of *Archaeoprepona demophon* (Linnaeus), is "...a South American taxon, mostly from the Guianas". However, *A. demophon* also occurs in the neotropics of Mexico and Central America (Lotts & Naberhaus, 2021). It is worth noting that *T. fulgerator* (as *Thymele fulgerator*) was also used for specimens collected

during the late nineteenth century in Mexico and Central America (Godman & Salvin, 1887–1901). The 'evidence' provided in Zhang et al. (2022) for a South American type locality is circumstantial or misleading, and does not provide definitive grounds for invalidating our neotype.

DNA barcodes

As mentioned in the Introduction, the only diagnostic characters that currently separate the ten described species of the cryptic fulgerator complex (Brower, 2010), and including our proposed neotype, are based on diagnostic nucleotide sites, or combination of sites, in COI barcodes. There is an ongoing "minimalist" controversy over describing new species based solely on mitochondrial DNA barcodes (Zamani et al., 2022a,b), but we agree with (Zamani et al., 2022b) that in some cases "...a barcode-only *diagnosis* could be acceptable".

Zhang et al. (2022) provided a COI barcode, as well as a whole-genome sequence, for their proposed neotype, but made no attempt to compare their barcode to the diagnostic barcodes currently available for the ten species of the fulgerator complex. We incorporated the barcode sequence from Zhang et al. (2022) into our earlier data set on the fulgerator complex (Pfeiler & Nazario-Yepiz, 2020) and found that it clustered with *Telegonus audax* on phylogenetic analysis (not shown), and importantly, possessed the single diagnostic "C" nucleotide at position 358 (= position 361 of Brower) that identifies it as *T. audax* (Brower, 2010). To provide taxonomic stability, and following the recommendations of the ICZN, the fact that the proposed neotype of Zhang et al. (2022) would have placed a valid species name into the synonymy of *T. fulgerator* is an important nomenclatural change that should have been discussed by them.

Concluding remarks

We have provided evidence that counters the claims of Zhang et al. (2022) that we violated four qualifying conditions in Article 75.3 of the ICZN Code, by showing that these claims were either false or misleading, and were based on their subjective opinions and preferences. In addition, the last sentence of Zhang et al. (2022)—"Our neotype designation will enable rigorous taxonomic studies of this taxonomic group, not possible before"—is also misleading because it implies that

our neotype designation prevents them from conducting in-depth genomic studies on systematics and relationships in the fulgerator complex. Our original neotype, however, stabilized the name *T. fulgerator*, and allows them, and other workers, to conduct further studies on unidentified cryptic lineages and to determine how many of the putative species diagnosed with barcodes by Brower (2010) are actually valid. In fact, by proposing their own neotype, and attempting to invalidate ours, Zhang et al. (2022) have destabilized the taxonomy of the complex. Because Zhang et al. (2022) have provided no objective evidence to back up their claims that we violated the ICZN Code, we conclude that there is no compelling reason for invalidating our original neotype. Zhang et al. (2022) also violated the priority provision of the Code (Article 75.4) which states that the first neotype designation for a nominal species-group is valid—if the provisions of Article 75 were followed—and that any subsequent designation is invalid unless made by the ICZN.

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Disclosure Statement

The authors report there are no potential conflicts of interest to declare.

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Figure Legend

Fig. 1. Dorsal forewings of the fulgerator complex specimens showing subapical spots (black arrows) and the small spot in cell M3-CuA1 near the discal band (white arrows) mentioned in Zhang et al. (2022). **(1.1)** Original illustration of *Papilio fulgerator* from Walch (1775); **(1.2)** *Telegonus audax* (male) from the Area de Conservación Guanacaste (ACG), Guanacaste Province, Costa Rica (06-SRNP-48008) showing the third subapical spot below the costal margin reduced in size; **(1.3)** Holotype (female) of *T. audax* (Brower, 2010) from the ACG (01-SRNP-1413; type locality: Alajuela Province. Costa Rica; specimen deposited at University of Pennsylvania) showing a much reduced fifth subapical spot. Photo credits: 1.2 and 1.3, Janzen & Hallwachs (2009).

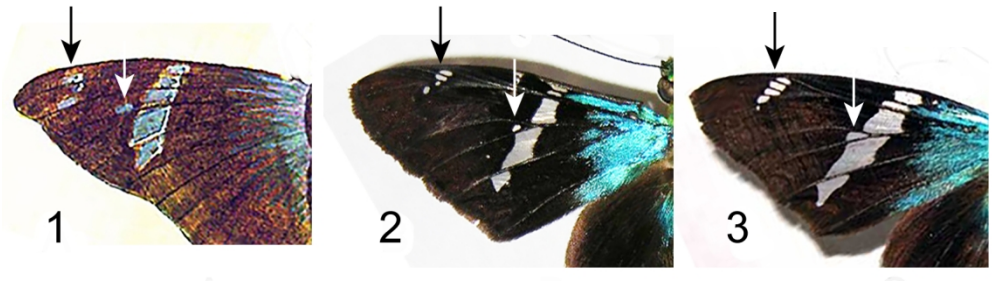

Fig. 1

145x40mm (300 x 300 DPI)