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Nomenclatural problems raised by the recent description of a new anaconda species (Squamata, Serpentes, Boidae), with a nomenclatural review of the genus *Eunectes*

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Abstract

A recent paper proposing taxonomic changes in the South American snake genus *Eunectes* Wagler, 1830 (anacondas) is analysed. This paper raises an unusually high number of taxonomic and nomenclatural problems. The work does not rely on an explicit species concept, the analysis of the molecular data based on three mitochondrial genes is shown to be unreliable, and the validity of the 'clades' proposed in this work is questioned. The nomen proposed for a purported new species is a *nomen nudum* (nomenclaturally unavailable), and the designation of a 'lectotype' for the nominal species *Eunectes murinus* (Linnaeus, 1758) is invalid. We provide a review of the nomenclatural status of 18 nominal species (including four unavailable ones) once or still now referred to the genus *Eunectes*, we identify their 'types' (nomen-bearing specimens), we designate five lectotypes, which are all specimens figured and briefly described in ancient publications, and we explain the rationale behind this action, which will allow the subsequent designation as neotypes of recently collected specimens associated with precise type localities and molecular data. We show that the generic nomen *Eunectes* Wagler, 1830 does not apply to the taxonomic genus accommodating anacondas but, this nomen having been used for these giant and spectacular snakes for about 200 years and being well-known even outside the field of taxonomy, we argue that its traditional use should be maintained through an action of the International Commission of Zoological Nomenclature using its plenary power. Finally, we provide various recommendations regarding nomenclatural actions and publications presenting them.

Key words

Taxonomy, nomenclature, new species, species concept, nomenclatural availability, *nomen nudum*, diagnosis, type specimen, holotype, syntype, lectotype, neotype, *Eunectes*, anacondas.

Abbreviations and conventions

In the present work, we refer to the edition currently in force of the *International Code of Zoological Nomenclature* (Anonymous 1999) as 'the *Code*', and to its '2012 Amendment' (Anonymous 2012) as 'A-2012'. 'The Commission' designates the International Commission on Zoological Nomenclature. 'The LZC' designates the Linz Zoocode Committee (see Dubois *et al.* 2019).

We use "double curved quotation marks" to include exact citations of published texts, 'simple curved quotation marks' or **bold** to highlight terms or expressions, and "double straight quotation marks" to include unavailable nomina. In order to shorten the text and to point to precise concepts of zoological nomenclature, we use several technical terms different from those of the *Code* such as ***nomen*** (Dubois 2000) for 'scientific name', ***nominal-series*** (Dubois 2000) for 'groups of names', ***onymophoront*** (Dubois 2005*a–b*) for 'type-specimen', or ***onymotope*** (Dubois 2005*b*; Frétey *et al.* 2018) for 'type locality'. Upon their first mention in the text (in ***bold italics***) we provide a reference to a work where their justification, etymology and meaning are explained. They can also be retrieved on the *Zoonom* website[1].

The following abbreviations are used to designate the collections where some of the specimens mentioned below are preserved:

AMNH • American Museum of Natural History, New York, New York, USA.

ANSP • Academy of Natural Sciences of Drexel University, Philadelphia, Pennsylvania, USA.

MCNG • Universidad Nacional Experimental de Los Llanos Occidentales Ezequiel Zamora (UNELLEZ) Museo de Ciencias Naturales, Portuguesa, Venezuela.

MNHN • Muséum National d'Histoire Naturelle, Paris, France.

MPEG • Museu Paraense "Emílio Goeldi", Zoologia, Belém, Pará, Brazil.

NRM • Department of Vertebrate Zoology, Naturhistoriska Riksmuseet, Stockholm, Sweden (also known as the Museum Adolphi Friderici and the Museum Drottningholmense).

NMW • Naturhistorisches Museum Wien, Wien, Austria.

RMNH.RENA • Naturalis Biodiversity Center, Leiden, The Netherlands.

USNM • United States National Museum, Washington, District of Columbia, USA.

The following abbreviations are used to designate onymophoronts and the nominal species they refer to:

ONID • Onymophoront identifier.

H • Holotype.

P • Primary syntype.

S • Secondary syntype.

T • Tertiary syntype.

a • *Boa aboma*.

g • *Boa gigas*.

m • *Boa murina*.

q • *Boa aquatica*.

r • *Coluber raninus*.

s • *Boa scytale*.

1 <https://skosmos.loterre.fr/th63/en/>.

1. Introduction

Rivas *et al.* (2024) published a paper revisiting the phylogeny, biogeography and taxonomy of the genus *Eunectes* Wagler, 1830 (**Squamata**, **Serpentes**, *Boidae*, *Boinae*), accommodating the snakes known in English and other languages as 'anacondas'. They identified two 'clades' in this genus, 'green anacondas' and 'yellow anacondas'. In the first group, they included *Eunectes murinus* (Linnaeus, 1758) and a new species which they called "*Eunectes akayima*". In the second group, they recognised a single species, *Eunectes notaeus* Cope, 1862, of which they considered the nomina *Eunectes deschauenseei* Dunn & Conant, 1936 and *Eunectes beniensis* Dirksen, 2002 as invalid synonyms.

The Rivas *et al.* (2024) paper (cited below as REA) raises several taxonomic and nomenclatural problems. The taxonomic ones would require a larger discussion going much beyond this work, as similar problems are frequent in the recent literature (see e.g. Wheeler 2023). The REA paper does not mention the species concept adopted by its authors, if they indeed had one. This casts doubts on their rationale for the synonymisation of the three nominal species of 'yellow anacondas'. Concerning 'green anacondas', their "separation of two species based on their genetic divergence, time divergence, and branch length in both the Bayesian analysis and Maximum Likelihood trees" (REA: 16) relies only on data from three mitochondrial gene fragments, but is not supported by their (scanty) data on morphology and on five nuclear genes. No data are provided about potential gene flow between the two 'species' in the hypothesised contact zone between them (which was not identified and studied according to the paper—but see below under § 3). We therefore tend to think that their two 'species' of 'green anacondas' should rather be viewed as two potential lineages within a single species *Eunectes murinus* or at most as two subspecies of the latter (see e.g. Vences *et al.* 2024). We provide below (§ 2) a few more general comments on taxonomy that are relevant to the present case, but we do not present an alternative analysis of the data and new formal taxonomic conclusions. Anyway, the proposals of REA reflect a taxonomic opinion and taxonomy is not the focus of the present paper, in which we address mostly the severe nomenclatural problems raised by this work. They can be sorted into several categories, corresponding to the three stages of the ***Nomenclatural Process*** (Dubois 2005*b*, 2011; Dubois *et al.* 2019) leading to the recognition of the valid nomina to be used in the taxonomy of a zoological group, namely [1.1] nomenclatural availability of works, nomina and nomenclatural acts (***onomatergies***; Dubois 2013), [1.2] taxonomic allocation of nomina and [1.3] validity and correctness of nomina (Dubois 2011).

2. A few taxonomic considerations

The science of taxonomy is distinct from the issues of nomenclature considered here (Dubois 2010), and a complete assessment of anaconda species-delimitation would merit a distinct, in-depth analysis. However, a few aspects of the REA work deserve mention, because they relate directly to some of the nomenclatural shortcomings. In particular, the lack of a diagnosis or proper designation of type material stems in part from an inadequate approach to species delimitation (see Carstens *et al*. 2013), limiting both the proper evolutionary interpretation of historical speciation mechanisms and the proper allocation of types and nomina based on biologically meaningful diagnoses.

In the era of big data and genomics, systematics has returned to the historical ideals of 'integrative' taxonomy (Dayrat 2005; Padial *et al.* 2010), wherein multiple sources of data (e.g., behaviour, ecology, geography, phenotype, genomics) are combined using multiple analytical approaches to delimit, define, diagnose and describe species (Carstens *et al.* 2013; Vences 2020). This facilitates an

explicitly hypothesis-driven approach to species delimitation and taxonomy that incorporates direct tests of speciation mechanisms and elucidates evolutionary processes (Padial & Riva 2021; Pyron *et al*. 2023). Numerous authors have illustrated how such an approach both illuminates the ecological and evolutionary causes of biodiversity and facilitates more accurate, precise and descriptive taxonomies (Cadena & Zapata 2021; Dufresnes *et al*. 2023). Ideal analyses will include a variety of methods (Burbrink & Ruane 2021; Hillis *et al.* 2021), dense sampling from species boundaries (Chambers *et al.* 2022; Vences *et al.* 2024) and a holistic approach to drawing conclusions (Cicero *et al.* 2021; DeRaad *et al.* 2022).

While such labour-intensive sampling and computational effort can be challenging for poorly known taxa in remote areas, there are still minimum standards of evidence needed for proposing taxonomic novelty, particularly with respect to the description of a 'new' species. Indeed, anacondas are quite well-known and well-studied, and the dataset of REA contains substantial sampling with genetic work performed in multiple countries including the US, where ample facilities for genomic analyses are possible. We identify three primary drawbacks that strongly question the authors' proposal of a new species, which does not appear supported by the evidence presented under most recent or modern interpretations of molecular or morphological species delimitation, or any approach to integrative taxonomy.

First, they do not sample the full range of any species, nor the proposed contact zones between the 'new' taxon and their revised concept of *Eunectes murinus*. This makes it impossible to evaluate the evolutionary distinctiveness of these lineages, including their genomic integrity in secondary contact where hybrid zones might form. Furthermore, given the massive unsampled distances across multiple formations in the Dry Diagonal of South America and nearly the entire central portion of the Amazon Basin, they cannot rule out the presence of multiple additional undetected lineages. Such population structure or geographic genetic diversity could potentially impact both the taxonomic conclusions (i.e., one, two or more species) and the nomenclatural acts (i.e., the allocation of types and nomina).

Second, they base their conclusions almost entirely on mitochondrial data, finding essentially no divergence in any of the nuclear genomic markers. This is problematic for several reasons (Hillis *et al.* 2021). Mitochondrial genes evolve very quickly and are clonally matrilineally inherited, with one quarter the effective population size and proportionally faster coalescence times. This leads them to track the leading edge of geographic genetic diversity and population structure to a very fine degree, and attendant confounding impacts on species-delimitation models (Després 2019; Firneno *et al.* 2021). Clade-based structure from mitochondrial DNA alone is not sufficient evidence for species-level divergence between lineages, particularly when the authors admit that there is essentially no divergence in the sampled nuclear markers (REA: 16, section 4.2).

Similarly, the node-dating approach used by the authors is now known to be badly confounded by statistical artifacts that bias estimated ages for species (Budd & Mann 2023; Pennell 2023). This raises the strong suspicion that the ~ 10 Ma age estimated for these species is erroneous. The authors state: "We believe that the lack of support from nuclear genes for the separation of these clades is due to the low rate of variation at these loci, rather than a lack of separation between taxa." However, these markers (CMOS, RAG1, BDNF, ODC and NT3) are all known to have substantially non-null evolutionary rates over ~ 10 Ma intervals across squamates (Singhal *et al.* 2021), suggesting that the true divergence between these lineages must be much lower to explain a lack of variable sites across so many loci.

Indeed, the authors recover a root age of ~ 90 Ma for the most recent common ancestor (MRCA) of *Sanziniidae* and *Boidae* (Reynolds *et al.* 2014; Pyron *et al.* 2014). This node was dated to only ~ 67 Ma, and the MRCA of *Eunectes* to ~ 7 Ma, in a recent phylogenomic analysis across **Serpentes** incorporating substantially more genes and fossil calibrations (Title *et al.* 2024). Consequently, the true age of the mitochondrial lineages estimated by REA must be significantly younger, and the ~ 10

Ma estimate simply reflects the well-known artifactual tendency for upwardly-biased age estimates derived from mitochondrial data (see Harmon *et al.* 2021; Ho *et al.* 2005; Lovette 2004; Zheng *et al.* 2011). A much younger age would explain the lack of nuclear divergence, as the lineages are either not distinct or have diverged so recently that no such evolutionary signature is detectable in their genome, both of which are incompatible with delimiting multiple species from the sampled populations.

Third, the likely younger age of the lineages, if they are divergent at all, would explain the lack of phenotypic differentiation. The authors cite the concept of 'cryptic' speciation as an explanation for this, going so far as to state that "Therefore, even if we knew for sure that specimen # 319[2] in Linnaeus' collection was from Suriname, we would still not know which species it was, because both species are truly cryptic, and there is no way to tell from morphological data which species the type belongs to, as far as anyone can tell" (REA: 17). While such 'cryptic' (i.e., undifferentiated gross external morphology) speciation can occur, it is typically still detectable via numerous phenotypic traits and requires an explicit hypothesis of stabilising selection or test of convergent evolution to support (Pyron *et al.* 2024; Pyron & Beamer 2022; Wootton *et al.* 2023). In contrast, the anaconda exists over numerous ecologically divergent biomes, straining credulity that phenotypically divergent characters would not have evolved over the purported ~ 10 Ma divergence between Amazonian and Caatinga populations, for example. Rather, these data are likely best explained by an extremely recent divergence, if the two lineages are actually distinct.

REA consequently proposed a species delimitation model recognising two taxa which cannot be differentiated based on sampled characters from the external phenotype or nuclear genetic markers. The spatial distribution of these candidate taxa is also unknown given the sparse and incomplete geographic sampling. The two lineages are supported only based on mitochondrial DNA, but the estimated age of ~ 10 Ma is almost certainly in error based on a range of analytical and methodological issues. Most importantly, the potential for mitochondrial DNA to present artifactually biased estimates of population structure based on stochastically ephemeral spatial expansion of haplotypes during recent climatic shifts is well known in many taxa including snakes (Streicher *et al.* 2016).

Ultimately, REA did not provide any explicit tests of species status for "*Eunectes akayima*" based on integrated analyses from their data (Wiens 2004; Sukumaran *et al.* 2021). There are no tests of behavioural, ecological or physiological differentiation between the candidate species, or any proposals for establishing the presence of reproductive isolation (Hillis 2019). Without an explicit operational or theoretical species concept given (Queiroz 2007), it is therefore unclear under what criteria the authors reached their conclusion that speciation has occurred, and species delimitation is warranted (Burbrink *et al.* 2022; Pyron *et al.* 2023). As a consequence of this conceptual shortcoming, REA were unable to produce a robust diagnosis, contributing to the nomenclatural problems detailed below wherein type specimens are allocated improperly and "*Eunectes akayima*" is a *nomen nudum*.

This situation underscores the important and inextricable linkage of speciation and taxonomy. None is fully valid without the other, as fully-developed species delimitation and description must be based on 'integrative' datasets and explicit hypothesis testing of evolutionary scenarios regarding speciation. REA did not provide a meaningful test and rejection of the null hypothesis that the two mitochondrial lineages represent the same underlying species. Our review of their auxiliary data, including a lack of nuclear genetic and phenotypic differentiation, bolsters the case for accepting this null hypothesis and concluding that "*Eunectes akayima*" does not represent a distinct species or independent lineage. As a consequence, the resulting 'description' falls short of being *Code*-compliant: REA were not able to write a diagnosis that would have made their new nomen available, simply because of ambiguity in the underlying biological reality of the taxon being erected.

2 This number does not refer to the collection number of a specimen but, following Linnaeus' format, to the sum of the ventral and subcaudal scales.

3. Availability of work: registration in *Zoobank* and immutability of work

The journal *Diversity* where REA's paper was published is an 'online only' journal, having no paper printed version. From its foundation (Blanchard 1905) to 2011, the *Code* did not accept this mode of publication as providing nomenclatural availability to works including nomenclatural novelties (new nomina and onomatergies), but its 2012 Amendment allowed it, provided such publications follow several strict rules. The main reason for these constraining rules is that works having nomenclatural consequences must remain ***immutable*** and cannot be liable to change, as this could be a strong source of nomenclatural ambiguity, confusion and instability (e.g., concerning the spellings of nomina, type specimens, type localities or type genera).

According to Article 8.1.3.2 of A-2012, to be nomenclaturally available, a work must have a "fixed content and layout". This can be the case either because the work is accessible on the website of the periodical from the start only as a definitive version, or first under one or several provisional version(s) later replaced by a definitive one. Articles 9.9 and 21.8.3 state that any version of a work published online prior to its 'final version' is a 'preliminary version' which is nomenclaturally unavailable. In recent years however, following a paper by Krell (2015), some authors, editors and publishers considered some preliminary versions as available, if they only differed from the 'final version' by their 'metadata' (such as their pagination or issue number). As analysed in detail by Dubois *et al.* (2015*a*–*b*, 2022*b*–*c*), this approach is fully inappropriate for this purpose: the concepts of 'version of record' and of 'metadata' are not mentioned in A-2012 and are therefore not *Code*-compliant. As long as the final version has not been published, all these early versions qualify as 'preliminary versions' and are unavailable. Furthermore, if after the 'final version' new changes are implemented in the version(s) accessible on the periodical's website, these new versions will qualify as 'postfinal versions'. Their publication suggests that such a periodical is likely to publish further new versions of its taxonomic papers and that it does not comply with the requirement of immutability, and such papers will have to be considered permanently as unavailable (see Dubois *et al.* 2022*c*).

The problem here is that A-2012 does not provide any objective criterion allowing to recognise that a version of a work qualifies as a 'final version'. This is why the Linz Zoocode Committee (Dubois *et al.* 2022*c*: 109) proposed to modify Article 8.1.3.2 of this Amendment by adding that, in order to be duly ***promulgated*** (see Pavlinov 2014; Dubois 2020; Dubois *et al.* 2022*c*) and therefore available, an electronic version must be expressly labelled as 'final version'. In the absence of such a mention, discussions will always be possible regarding the category to which a version must be attached (preliminary, final or postfinal). However, for the time being this is only a recommendation of the LZC, not a rule of A-2012.

One possibility in this respect would be to take advantage of the fact that, as explained by Dubois & Frétey (2023: 21), as long as a work has not been postregistered, its entry in *Zoobank* is accessible only to the person who preregistered it, not to other users of *Zoobank*. As long as it is the case, the work cannot be stated to have been promulgated. As analysed in detail by Dubois *et al.* (2022*c*) and Dubois & Frétey (2023, 2024), to be nomenclaturally available, a work published online as an electronic version must comply, among other conditions, with the following prescriptions: [2.1.1] to have been published in an immutable format (such as PDF/A); [2.1.2] to have been preregistered in *Zoobank*; [2.1.3] to provide in the PDF of the work itself an evidence (LSID[3] of the work or at least one proxy of it, such as the LSID of a nomen introduced in it) that the work has been preregistered before publication; and [2.1.4] to have been postregistered in *Zoobank*, the *Zoobank* entry providing, once accessible online to all, several pieces of information regarding the work that could not be known before publication, such as its authorship and title, the name, issue and pages of the periodical in which it was published, its ISSN and the name of address of the internet site intended for its archiving.

3 'Life Science Identifier'.

These details may look like 'quibbles' to some, but they are not so in zoological nomenclature, because the availability or non-availability of a work may have considerable nomenclatural consequences. Even if ignored by the community for years, decades or even more (see e.g. Dubois *et al.* 2021), the sudden discovery or published statement that a work was unavailable may result in changes in the validity of some or many nomina used by biologists and by various actors in conservation to designate the taxa, and entail gratuitous (i.e., not caused by warranted taxonomic changes) instability which may be quite harmful to scientific communication. The 2012 Amendment being ineffective in this respect, we would tend to consider that the 'final version' of the work is that which was accessible on the website of its periodical or publisher at the date of postregistration of the paper, which is also for most periodicals the publication date of the issue including the paper mentioned on this website, if such a date exists. If this version is later replaced on this website by one or several new version(s), it or they would qualify in our opinion as 'postfinal versions', providing evidence that the work is not immutable and, therefore, that it could or should be considered nomenclaturally unavailable. However, we recognise that this interpretation is neither supported nor rejected by A-2012, which is silent in this respect.

This problem concerns the REA paper. On 16 February 2024, a first version of this paper was uploaded on the website of the journal *Diversity*[4], where we downloaded it. At this date and through 19 February 2024 inclusive, no entry for REA's work was accessible to visitors of *Zoobank* because the work had not yet been postregistered. This is because, as it was then mentioned in the website of the journal, it was intended to be incorporated in the issue **16** (2) of February 2024 of this journal, an issue which was stated to be "Forthcoming". On 20 February 2024 at 19:00 (Paris time), a change occurred in this website, where issue **16** (2), including 56 papers, was stated to have been published. Although this website only gives the date "February 2024" for the publication of this issue, the latter can be precisely dated 20 February. On the same day, an entry for this paper appeared publicly in *Zoobank*[5], with mention that it had been preregistered by "Jesus [*sic* for Jesús] Rivas" on 14 January 2024. The paper was, therefore, considered by the periodical itself to have been published on 20 February, and the version that could then be downloaded from the website, which differed in several respects regarding its content and layout from the preliminary version of 16 February, should in our opinion be considered as the final version of the work, providing its nomenclatural availability. However, this version in its turn was replaced on 21 February by a new version differing again in several respects from this 'final version'. In fact, according to the website of the journal[6], from 16 to 21 February, six different versions of this paper were uploaded successively on this website, most likely as a consequence of exchanges between colleagues, including the first author of the REA paper, on 'social networks': one [V1] in format 'PDF-VOR' entitled 'Version of record' on 16 February 2024 at 13:14; four in format 'PDF-VOR' entitled 'Updated version of record' respectively on [V2] 16 February at 13:38, [V3] 18 February at 09:12, [V4] 18 February at 10:16 and [V5] 18 February at 10:31; and one [V6] in format PDF entitled 'Updated version of record' on 21 February at 07:00. These seemingly useful details are given on the website using terms ('version of record', 'updated') that do not appear in the *Code* and are therefore irrelevant for nomenclatural purposes, but the *Code*-compliant terms 'preliminary version' and 'final version' are not mentioned. As documented in our Figure 1 showing the first pages of the versions [V1], [V5] and [V6], all these versions differ from each other in some aspects of their content and layout, some of which (such as the absence or presence of the mention "Check for updates" or of LSIDs) could not be considered to belong in the category of 'metadata' but are indeed part of their 'content'. The version accessible on the website at the stated date of publication was version [V5], which thus qualifies as 'final version' according to our rationale

4 <https://www.mdpi.com/1424-2818/16>.
5 <https://zoobank.org/References/a58a262e-2e07-48d3-b712-209ccdffd038>.
6 <https://www.mdpi.com/1424-2818/16/2/127/notes>.

above, so that the version [V6] is clearly a 'postfinal version'. It may be questioned if this permanent replacement of versions on the website will stop, so that this paper could finally be considered to exist in an immutable form and be deemed available in zoological nomenclature. This means that both its new nomen "*Eunectes akayima*" and its new nomenclatural act (designation of a 'lectotype') could be regarded as unavailable, but we consider this point as unsettled so far, as long as the Commission does not address this problem.

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Article

Disentangling the Anacondas: Revealing a New Green Species and Rethinking Yellows

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FIGURE 1. The first pages of three versions of the paper by Rivas *et al.* (2024) paper as downloaded from the website of this periodical: [1a] "Version of record" of 16 February 2024. The parts surrounded by a red line in the second and third versions have been modified from respectively the first and second versions.

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Disentangling the Anacondas: Revealing a New Green Species and Rethinking Yellows

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FIGURE 1. (Continued) [1b] "Updated version of record" of 18 February.

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FIGURE 1. (Continued) [1c] "Updated version of record" of 21 February.

Regarding the mention of the fact that this work had been preregistered in *Zoobank* before publication, from [V1] to [V5] this information was given in page 22 by the LSID of the publication. Only in the postfinal version [V6], the LSIDs of both the work and the new nomen also appeared in page 1. However, this information by itself is not sufficient to clearly provide availability to the work, as the latter did not comply with the requirement of "fixed content and layout" until this version [V6].

Another strangeness of this publication is that a remarkable change occurred in the HTML version of this paper on the website of its journal, also possibly following exchanges on 'social networks'. Upon its first appearance on this website, the Abstract of the paper was followed by its Keywords and then by its Introduction. But later[7] a new item appeared on this page between the Keywords and the Introduction: a colored figure, entitled "Graphical abstract", showing the ranges of the three species of *Eunectes* recognised by these authors and the "Green Anaconda Contact Zone" between the areas of their *Eunectes murinus* and their "*Eunectes akayima*". The problem here is that this figure does not appear in the paper itself and does not even refer to data or even to hypotheses provided in the paper. It contains brand new 'information' (at least on the 'opinions' of the authors regarding these distributions), but cannot in the least be qualified as an "abstract". Moreover, on this web page, it is possible to click on a checkbox entitled "Browse Figures": this provides access to 6 figures, starting with the "Graphical abstract" and continuing with the 5 figures that appear indeed in the PDF of the paper. Whether the presence, on the front page of the HTML version of the text of this paper, of this figure, absent in the work itself and providing new 'information', should be qualified as 'deception' or not, is open to question, but anyway we draw attention to this fact.

Finally, a case of strange misinformation should be mentioned regarding the *Zoobank* entries for this work and for its new nomen[8]. Although this is not acknowledged in *Zoobank*, these entries were apparently modified on 20 February, also probably as a consequence of exchanges on 'social networks'. In the entry for the work, its authorship is given as "Rivas, Jesus, Bryan G. Fry & Sarah Corey-Rvas [*sic*] 2024" *in* Rivas *et al.* (2024), and in the entry for the new species its authorship is given as "Jesus A. Rivas in Rivas & Fry, 2024". Both these statements are incorrect and misleading, as in the publication itself the authorship of the work is clearly given as "Rivas *et al.* (2024)" and, no distinct authorship being mentioned in the work for the new species nomen, it has the same authorship. Among others, this 'error' casts serious concerns and doubts about the reliability of the work in general.

4. Availability of the nomen "*Eunectes akayima*"

As mentioned above, in the *Zoobank* entry for the species "*Eunectes akayima*", Rivas claimed authorship for its nomen, but the REA paper did not do so. On page 18, this nomen was credited to "various Cariban languages" and considered as a "senior synonym", without stating clearly of which nomen or nomina, but probably of nomina currently treated as junior invalid synonyms of *Eunectes murinus*, the status of which is discussed below. Thus doing, REA seemed to follow the suggestion of Gillman & Wright (2020) and others, to replace available nomina given to taxa in a scientific context by vernacular names used in local populations for 'kinds' of animals, not for scientific concepts. REA argued that "the word '*akayima*' has been indigenously used to designate this species for at least hundreds (and perhaps even thousands) of years before the use of any of the other synonyms". This proposal is not *Code*-compliant, simply because it ignores some basic

7 We do not know exactly at which date, but we noticed this only on 25 February 2024.

8 <https://zoobank.org/NomenclaturalActs/a9a11e29-b346-455d-8564-a69f004a4e09>.

Articles of the *Code*, particularly Article 11, which states that, to be available, a nomen "must have been published" and Article 3.2 which states that "No name […] published before 1 January 1758 enters zoological nomenclature". Following REA's proposal would have devastating consequences in zoological nomenclature and should be bluntly rejected (see e.g. Palma & Heath 2021 and Ceríaco *et al.* 2023). The nomen "*akayima*" made its entry in the realm of zoological nomenclature only with the work of REA, but then only as a *nomen nudum*.

As a matter of fact, even if the work or REA is to be considered nomenclaturally available, its new nomen "*Eunectes akayima*" cannot be so. In zoological nomenclature, after 1930, to be duly promulgated and therefore available, a new nomen "must be accompanied by a description or a definition that states in words characters that are purported to differentiate the taxon" (Article 13.1.1). This means that a nomen first published without the explicit mention in words of diagnostic characters is unavailable, and qualifies as a *nomen nudum* (Dubois 1999, 2017*b*; Bauer *et al.* 2011; Dubois *et al.* 2018). This is without any possible doubt the case of the nomen "*Eunectes akayima*" in REA. This nomen was provided without any mention of diagnostic morphological characters for the new species, which was stated to be "morphologically cryptic" (REA: 17). Although the species was claimed to be supported by molecular characters, the only information reported was under the form of mean pairwise distances (averaged over all included sequences). No molecular synapomorphies or even purely phenetic molecular diagnostic sequences were provided. Two molecular trees, based on mitochondrial data, were presented, but no information was given on the molecular sequences on which they were based.

Beside this absence of diagnostic characters which makes the new nomen a *nomen nudum* or ***gymnonym*** (Dubois 2000), another problem, which by itself would not withdraw its availability, must be mentioned. Although, as required by Article 16.4, a holotype (MCNG 1042) was indeed designated for the purported new taxon, no molecular characters of this specimen were provided. While the designated paratype RMNH.RENA 20768, which has no nomen-bearing function, is recognisable in their phylogenetic analysis, the sequences associated with the holotype are not. The sequence numbers, which would be the only diagnostic characters for the new taxon, are actually not reported at all for the holotype in an identifiable manner. From the data provided in REA, it is not even clear whether the holotype formed part of their phylogenetic analysis.

Being a *nomen nudum*, this new nomen does not need to be discussed further in the second and third stages of the Nomenclatural Process, taxonomic allocation and validity of nomen. But then the newly proposed taxon is left without available nomen. This prompts the question, that was quickly rejected without serious discussion on page 18 of REA, whether there could exist already in the literature an available nomen that could be applied to this taxon if the latter was to be recognised as a valid species or subspecies by some authors. This led us to examine the evidence concerning the taxonomic allocation of all the nomina currently referred, either as valid or as invalid, to the genus *Eunectes* Wagler, 1830. In turn, this study led us to discover several long-standing nomenclatural errors in the generic nomenclature of these snakes and to devote work to their resolution.

5. Taxonomic allocation of the species nomina currently referred to the genus *Eunectes*

5.1. Introduction

The present discussion provides an opportunity to carefully review the status of all the nomina referring to species currently considered to be members of the genus *Eunectes* regarding their nomen-bearing specimens, which has never been done before, and to solve some of the problems they raise.

The solutions proposed below were devised in order to avoid disturbing the current status of the best known of these nomina, which have been used for two centuries or more in a given sense. Three nomina are of particular concern: [5.1.1] *Boa murina* Linnaeus, 1758, long considered to apply to the 'green anacondas', the distribution of which, as currently understood, covers a large part of South America; [5.1.2] *Boa scytale* Linnaeus, 1758, which has long been considered a synonym of the former; and [5.1.3] *Eunectes* Wagler, 1830, the nomen that has long been used as valid for the genus accommodating these snakes.

In the early years of zootaxonomy, authors did not explicitly designate the so-called 'type specimens' or ***onymophoronts*** (Dubois 2005*a–b*) of their new nominal species. These must be deduced from an examination of their texts. It should be remembered first that, in zoological nomenclature as regulated by the *Code*, the allocation of nomina to taxa is not made intentionally through the descriptions of specimens or diagnoses of the taxa but ***ostensionally*** (see Dubois 2005*b*, 2011) through their nomen-bearing types or ***onomatophores*** (Simpson 1940), which in the case of the nominal species are specimens, the onymophoronts. Second, for ancient texts which did not explicitly mention the specimens upon which new nominal taxa were erected, these specimens may be identified according to Article 72.4 of the *Code* which defines the concept of "type series" as follows:

> 72.4.1. The type series of a nominal species-group taxon consists of all the specimens included by the author in the new nominal taxon (whether directly or by bibliographic reference), except any that the author expressly excludes from the type series […], or refers to as distinct variants (e.g. by name, letter or number), or doubtfully attributes to the taxon.

The words "or by bibliographic reference" are often ignored by the authors who designate type specimens for nominal species, who think in error that they are confined, or so to say "imprisoned", for so doing in the small group of the remaining syntypes. Actually, even if referred to in the original work only by a bibliographic reference, type series of nominal species are series of specimens, i.e., technically in zoological nomenclature, syntypes. Nomina relying on onomatophores comprising several items (syntypes in the species-series, originally included nominal species in the genus-series) are ***synaptonyms*** (Dubois 2011), referable to one among several categories of ***symphory*** (Dubois 2005*b*). They can be of two kinds (for details see Dubois 2011): [4.1.1] if this series is composed of items that are considered by taxonomists to belong in the same biological taxon, they are ***homosynaptonyms***, i.e. they allow the unambiguous allocation of the nomen to a single taxon; [4.1.2] but if this series is considered to be taxonomically heterogeneous, they qualify as ***heterosynaptonyms***, i.e. they do not allow such an unambiguous allocation (they are *nomina dubia* or *incertae sedis*), and clarification of their status requires the designation from among them of a single onomatophore (lectotype for a nominal species, type species for a nominal genus).

Regarding the way to deal with the original type specimens of nominal species erected in the ancient literature, Dubois *et al.* (2014: 59–60) wrote:

> In zoological nomenclature, allocation of nomina to taxa is made exclusively by ostension, through onomatophores (name-bearing types). In the species-series, i.e., for taxa of ranks species or subspecies, onomatophores are onymophoronts (name-bearing specimens). Whenever a new species is described, its onymophoront(s) can be of two kinds only: a single specimen, the holotype […], or two or more specimens, the syntypes […]. In case of holotype, the taxonomic allocation is usually clear; it is not so only when this specimen is unidentifiable, the nomen being then a nyctonym, i.e., a particular case of *nomen dubium* (see Dubois 2011). In case of syntypes, a particular situation occurs when the original type-series is heterogeneous, i.e., when the syntypes are, or can be presumed to be, referable to two or more taxa as understood nowadays. In such cases, clarification of the nomenclatural situation requires to designate a unique onymophoront, i.e., either a lectotype

> […] or a neotype […].
>
> Some taxonomists believe in error that, when a nominal species had been created with several syntypes, and that all of them but one are now missing, the remaining specimen is *ipso facto* the lectotype of the nominal taxon. In some cases, this may cause nomenclatural problems, if this specimen happens to belong in a taxon different from that to which the nomen had traditionally been allocated, for example on the basis of the original illustration or of the type-locality. In fact, in such cases, the *Code* does not prescribe in the least to designate the remaining specimen as lectotype. Following such an 'implicit rule' would be similar to accepting designation of a type-species for a nominal genus 'by elimination', a mode of designation clearly declared invalid in Article 69.4 of the *Code*.
>
> Similarly, if a few specimens of the original type-species are still extant and available, the widespread idea that a lectotype designation should necessarily use one of them is not only wrong, not being supported by the *Code*. It is also pernicious because its following would result in some cases in 'obliging' taxonomists to designate ill-chosen specimens. A lectotype designation should be guided only by concern about nomenclatural clarity and robustness, and should not threaten the nomenclatural stability in the allocation of the nomen at stake, if indeed this stability exists, as in the four examples of nomina introduced by Linnaeus (1758) […]: *Rana esculenta*, *Rana arborea*, *Cyprinus gobio* and *Elephas maximus*[9]. If possible, it should even go further, i.e., in restricting the type-locality to a precise locality or to a small region[10].
>
> In many cases, when a type-series is heterogeneous, it will be much preferable to designate as lectotype, instead of a still extant specimen, a missing specimen (destroyed, lost, never collected or unavailable), but mentioned, described or figured in a work cited in the original publication as providing information on the new taxon. This will stabilise the allocation of the nomen and provide a precise type-locality. This is the procedure of virtual[11] lectotype designation, which relies on the distinction between three categories of syntypes first defined by Dubois & Ohler (1997): primary, secondary and tertiary.

These three categories of syntypes were defined as follows by Dubois & Ohler (1997*a*: 310) and Dubois *et al.* (2014: 47):

[T1] The primary syntypes of a nominal species-series taxon N are the specimens which had been examined, described and/or illustrated by the author A of the original description D of the taxon T him/herself.

[T2] The secondary syntypes of a nominal species-series taxon N are the specimens which had not been examined, described and/or illustrated by the author A, but by a previous author B in an earlier work W quoted in the original description D as a unique or partial basis for the recognition of the new taxon T.

[T3] The tertiary syntypes of a nominal species-series taxon N are the specimens which had been examined by neither authors A and B, but by a still earlier author C, quoted by author B in the work W quoted by A in the original description D of the new taxon T.

Dubois *et al.* (2014: 60) continued:

> Designation of a specimen now lost, but belonging in one of these three categories of syntypes (with a preference for primary over secondary, and secondary over tertiary syntypes, but no obligation to follow this preference) has two major advantages: (1) it avoids the designation as lectotype of the still extant specimen(s) that might cause a nomenclatural problem; (2) it allows to fix the type-locality (or onymotope) of the taxon to the locality of collection of the lectotype, which in some cases may allow clarifying the status of the nomen in current classifications. Once a lectotype has been designated for the taxon, all the other original syntypes have lost their 'nomen-bearing' status and can no longer be a cause of nomenclatural problems. The fact that the lectotype has been lost may, in its turn,

9 To which *Lacerta punctata* Linnaeus, 1758 should be added (see footnote 9).

10 Nowadays specimens that give access to molecular data should be given the priority for clarifying taxonomic issues.

11 The term 'virtual' evoking 'imaginary, non-existent' items, we replace it here by 'missing'.

be a cause of problems in some cases (e.g., the impossibility to carry out molecular studies on this specimen), but then, the fact that it is missing has 'opened the way' to the straightforward designation of a neotype, which was not possible, except through intervention of the Commission making use of its plenary powers, as long as the lectotype had been chosen among syntypes still in existence.

The four-step process in such cases, described already by Dubois & Ohler (1995*a–b*, 1997*a–b*), Kottelat & Persat (2005), Nemésio & Rasmussen (2009, 2011) and Dubois (2011)[12], and again above, can be summarised as follows: (1) first, to designate as lectotype one of the primary, secondary or tertiary syntypes that corresponds to the current use of the nomen, and if possible coming from a precise type-locality; (2) this results in a type-locality restriction for the nominal taxon; (3) if necessary, then, state that this specimen is now lost and why this raises nomenclatural problems; (4) then designate a neotype, originating from the restricted type-locality. In our opinion, this procedure is the most appropriate one to solve many nomenclatural problems associated with the taxonomic allocation of old nomina published in ancient works.

Besides, note that a '*nomen novum*', 'new replacement name' or ***neonym*** (Dubois 2000) is a nomen proposed expressly to replace **a single** available nomen, not several, except if these are objective synonyms (***isonyms***; Dubois 2000). Therefore, when a new nomen is published without explicit mention of a holotype, with a single available synonym and no reference to other specimens (syntypes), it is a neonym of it, but with several synonyms not being isonyms among them it is not a neonym but a brand new nomen or ***poieonym*** (Dubois 2017*a*) with several secondary syntypes which are the primary syntypes of these nominal taxa.

In the present paper, we review the status of the onymophoronts of all the nominal species currently or once referred to the genus *Eunectes*, and we take the necessary nomenclatural actions, in the light of the discussion above, allowing to solve the nomenclatural problems we identified.

We provide the collection numbers of onymophoronts known to be preserved or to have been preserved in the institutions the lists and abbreviations of which are given above under 'Abbreviations and conventions'. For the other 'missing specimens', currently considered to be lost or destroyed, we provide 'onymophoront identifiers' (ONIDs) starting with the letters H for holotypes, P for primary syntypes, S for secondary syntypes and T for tertiary syntypes, and including a lower-case letter referring to the nominal species of which they are onymophoronts.

For each specimen identified, we provide information on the 'type locality' or ***onymotope*** (Dubois 2005*b*; Frétey *et al.* 2018) from which it was stated to have been collected, as this information may be crucial for a proper allocation of the nomen to a taxon or lineage. Unfortunately, in many cases this information is missing or doubtful.

Our Table 1 presents various pieces of information concerning the available nominal species surveyed below.

TABLE 1. Onymophoronts of available species nomina once referred to the genus *Eunectes* Wagler, 1830.

OTS • Original nomen-bearing specimen (onymophoront): H, holotype; PS, primary syntype; SS, secondary syntype; TS, tertiary syntype.

RTS • Restricted nomen-bearing specimen (onymophoront): **L**, lectotype here designated; PL, paralectotype, following designation of lectotype made here; **H**, still holotype; S, still syntype (no lectotype designated).

Fig. • Figure in the present paper representing this specimen.

Onymotope • Type locality.

CS • Current situation of specimen: L, lost, destroyed or fate unknown; P, still present in an identified collection.

Gr. • Group to which the species is referred: GAN, 'northern lineage' of 'green anacondas'; GAS, 'southern lineage' of 'green anacondas'; NA, not anacondas; UA, anacondas not allocated to group; YA, 'yellow anacondas'.

Current valid nomen • For the species *Eunectes murinus* (Linnaeus, 1758), we precised if the specimen was from the 'northern' [NL] or 'southern' [SL] 'mitochondrial lineage' as defined by Rivas *et al*. (2014).

12 To which Bauer (2003) should be added (see footnote 8).

Nominal species	OTS	RTS	Fig.	Reference	Onymotope	Coordinates	CS	Gr.	Current valid nomen
Boa murina Linnaeus, 1758	SS: ONID Sm1	PL	-	Gronovius 1756	Unknown	Unknown	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
	SS: ONID Sm2	**L**	2	Seba 1735	America	Unknown	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
	TS: ONID Tm1	PL	3	Seba 1735	Unknown	Unknown	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
	TS: ONID Tm2	PL	4	Scheuchzer 1735	Unknown	Unknown	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
	PS: NRM Lin.9	PL	-	Linnaeus 1758	Unknown	Unknown	P	GAS	*Eunectes murinus* (Linnaeus, 1758)
Boa scytale Linnaeus, 1758	SS: ONID Ss1	S	-	Gronovius 1756	Suriname	Unknown	L	NA	*Erythrolamprus* sp.
	SS: ONID Ss2	S	5	Scheuchzer 1735	Suriname	Unknown	L	NA	*Erythrolamprus* sp.
	TS: ONID Ts1	S	-	Vincent 1726	South Africa	Unknown	L	NA	*Homoroselaps lacteus* (Shaw, 1802)
Coluber raninus Bonnaterre, 1790	H: ONID Hr1	**H**	-	Gronovius 1756	Unknown	Unknown	L	NA	*Liophis melanotus* (Shaw, 1802)
Boa gigas Latreille *in* Sonnini & Latreille, 1801	PS: ONID Pg1	**L**	-	Latreille *in* Sonnini & Latreille 1801	"Cayenne", Guyane	04°56'14" N, 52°19'34" W	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
Boa aboma Daudin, 1803	SS: ONID Sa1	**L**	6	Linnaeus 1758	"About half way between Cormoetibo Creek and Barbacoeba", Suriname; now near Wanhatti, Surinam	~ 05°76'96" S, 54°38'54" W	L	GAN	*Eunectes murinus* (Linnaeus, 1758)
Boa anacondo Daudin, 1803	SS: ONID Pn1	**L**	-	Latreille *in* Sonnini & Latreille 1801	"Cayenne", Guyane	04°56'14" N, 52°19'34" W	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
Boa aquatica Wied-Neuwied, 1823	PS: ONID Pq1	**L**	7	Wied-Neuwied 1823	Belmonte, State of Pará, Brazil	~ 03°07'40" S, 51°46'33" W	L	GAS	*Eunectes murinus* (Linnaeus, 1758)
Eunectes notaeus Cope, 1862	H: USNM 4707	**H**	-	Cope 1862	Paraguay River and tributaries	Between 19°38'–27°18' S and 52°–60° W	L	YA	*Eunectes notaeus* Cope, 1862
Epicrates wieningeri Steindachner, 1903	H: NMW 18929	**H**	-	Steindachner 1903	Altos, Paraguay	~ 25°14' S, 57°15' W	P	YA	*Eunectes notaeus* Cope, 1862
Eunectes barbouri Dunn & Conant, 1936	H: ANSP 20892	**H**	-	Dunn & Conant 1936	Probably Ilha de Marajó, State of Pará, Brazil	00°58'43" S, 49°34'54" W	P	GAS	*Eunectes murinus* (Linnaeus, 1758)
Eunectes deschauenseei Dunn & Conant, 1936	H: ANSP 20891	**H**	-	Dunn & Conant 1936	Probably Ilha de Marajó, State of Pará, Brazil	00°58'43" S, 49°34'54" W	P	YA	*Eunectes deschauenseei* Dunn & Conant, 1936
† *Eunectes stirtoni* Hoffstetter & Rage, 1977	H: MNHN VIV 7	**H**	-	Hoffstetter & Rage 1977	Los Mangos (elevation 440 m), near La Venta, Huila department, Colombia Fish Bed of the formation Villavieja, Colombia	03°19' N, 75°08' W	P	UA	† *Eunectes stirtoni* Hoffstetter & Rage, 1977
Eunectes beniensis Dirksen, 2002	H: AMNH 101924	**H**	-	Dirksen 2002	Trinidad, Beni, Bolivia	14°49'45" S, 64°54'05" W	P	YA	*Eunectes beniensis* Dirksen, 2002

5.2. Boa murina *Linnaeus, 1758*

5.2.1. Original description

Linnaeus' (1758: 215) entry for the species *Boa murina* reads as follows:

> 319. murina. 254–65. *Gron. muſ.* 2. *p*. 70. *n*. 44. Coluber 254–69.
> *Seb. muſ.* 2. *t*. 29. *f*. 1.
> *Habitat in America.*
> *Rufus maculis ſupra rotundatis.*

We interpret this text as providing evidence for this nomen being based on two secondary syntypes and two tertiary syntypes, to which a doubtful primary syntype should possibly be added.

5.2.2. Onymophoronts

5.2.2.1. Secondary syntype ONID Sm1

This specimen was described under Nr. 44 in Gronovius[13] (1756: 70) under the heading "Cenchris ſcutis abdominalibus CCLIV, & ſcutis caudalibus LXIX". Its scale counts (254 abdominal scutes, 69 caudal scutes) are mentioned in Linnaeus' account on *Boa murina*. Its dorsal body colour is described as red with round black spots. No locality of origin is mentioned. This specimen is not known to have been figured, and its subsequent fate is unknown.

5.2.2.2. Secondary syntype ONID Sm2

This specimen was figured by Seba (1735: 30, tab. 29, fig. 1) under the names "*Serpens, Teſtudinea, Americana; murium inſidiator*" and "*Serpent d'Amerique, à moucheture de Tortue; Mangeur de Rats*". Clearly the epithet *murina* was chosen by Linnaeus to allude to the stated habit of this snake of eating rodents. We agree with all previous authors that figure 1 of this plate, which is of good quality (see our Figure 2), depicts an anaconda. This species is stated to occur in "America" in the Latin-French version of Seba (1735: 30). Wallach (2011: table 1) stated that it could refer to any place in central or southern America and proposed without evidence to correct it into "Amazonia", a type-locality restriction which, not being based on a specimen of known origin, is not *Code*-compliant. In the Dutch version of the text of Seba, which we could not examine, according to Wallach (2011: 19) this specimen is stated to be from the "West Indies". This specimen was also mentioned by Gronovius (1756: 70) as a synonym of the species referred to above in § 5.2.2.1. Its subsequent fate is unknown.

13 In REA, the name of this author is spelt three times "Gronivious" and twice "Gronovius".

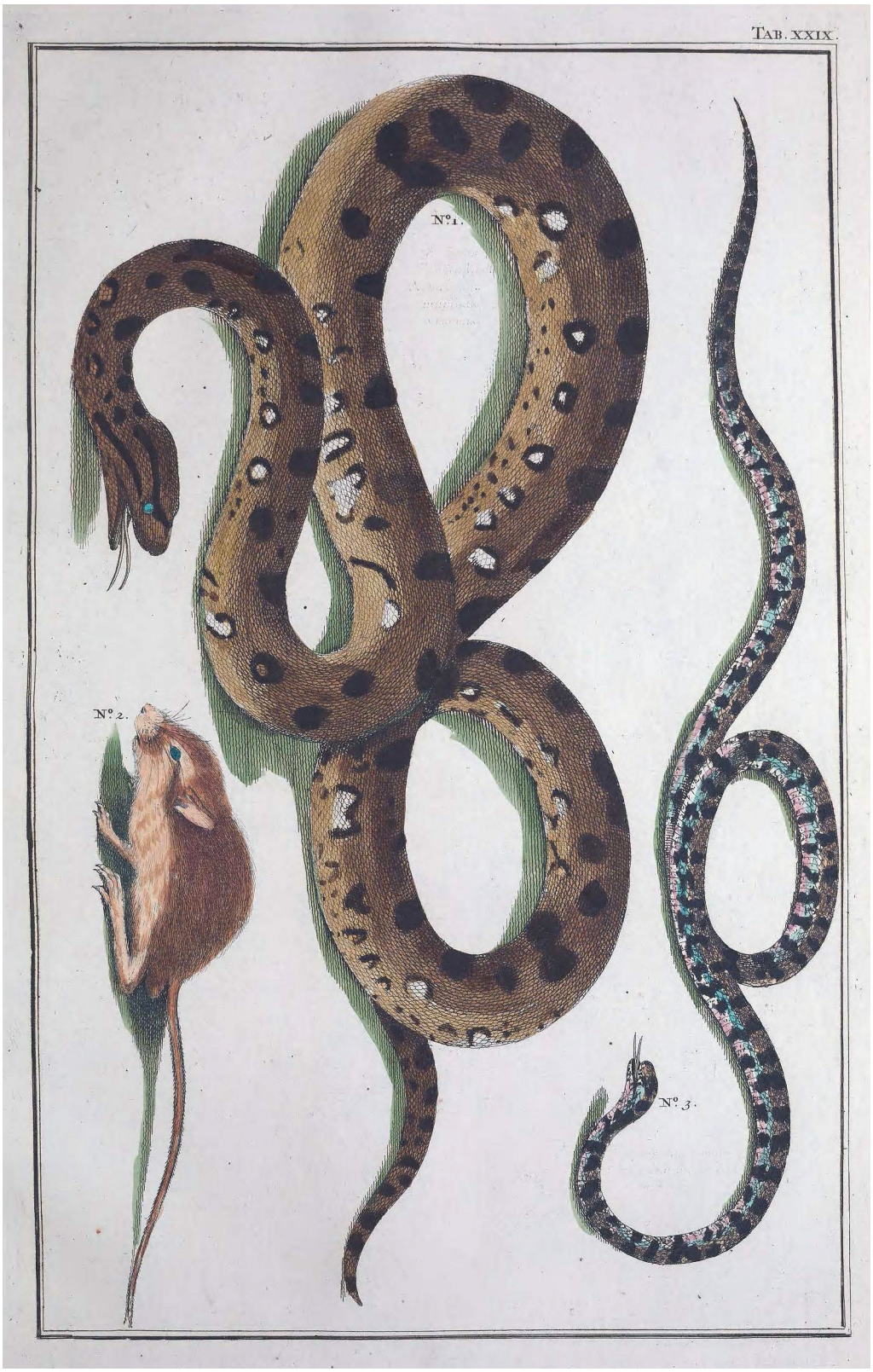

FIGURE 2. Facsimile of the plate 29 of Seba (1735), the figure 1 of which shows the specimen from "America" hereby designated as lectotype of the nominal species *Boa murina* Linnaeus, 1758.

5.2.2.3. Tertiary syntype ONID Tm1

This specimen was figured by Seba (1735: 24, tab. 23, fig.1) under the names "*Serpens, Guineënſis, rariſſima,* Argus *dicta*" and "*Serpent-Argus, de Guinée, extrêmement rare*", and cited by Gronovius (1756: 70) as a synonym of the species referred to above in § 5.2.2.1. We agree with all previous authors that the figure 1 of this plate, which is of rather good quality (see our Figure 3), depicts an anaconda. The specimen is stated to have originated from "Guinée", clearly in error. Wallach (2011: 11) proposed without evidence to correct its onymotope into "Amazonia", which is not *Code*-compliant. Its subsequent fate is unknown.

FIGURE 3. Facsimile of the plate 23 of Seba (1735), the figure 1 of which shows a specimen stated (clearly in error) to be from "Guinée" here referred to the nominal species *Boa murina* Linnaeus, 1758.

5.2.2.4. Tertiary syntype ONID Tm2

This specimen was figured by Scheuchzer (1735: 1086–1087, tab. 606, fig. A) under the title "Jeſ. Cap. XI. verſ. 8", and cited by Gronovius (1756: 70) as a synonym of the species referred to above in § 5.2.2.1. Scheuchzer (1735: 1087) gave the following description of this specimen: "Serpens craſſus capite & corpore, vertice fuſco, corpore liuido vel cinereo in dorſo bina ferie macularum ſubrotundarum fuſcarum, in ventre albidarum, ſed margine fuſco cinctarum pictis." ['Snake with a stout head and body, upper side brown, bluish or gray body with a pair of dark brown spots on the back, belly white with a brown painted edge.']. We agree with all previous authors that the figure A of this plate, which is of rather good quality (see our Figure 4), depicts an anaconda. No origin is mentioned for this specimen, which was deposited in the Linck collection of snakes in Leipzig as spirit specimen No. 817 but is not to be found nowadays in the Naturalienkabinett Waldenburg where 17 specimens of this collection are still present (see Bauer & Wahlgren 2013: 252), so that it must be considered lost.

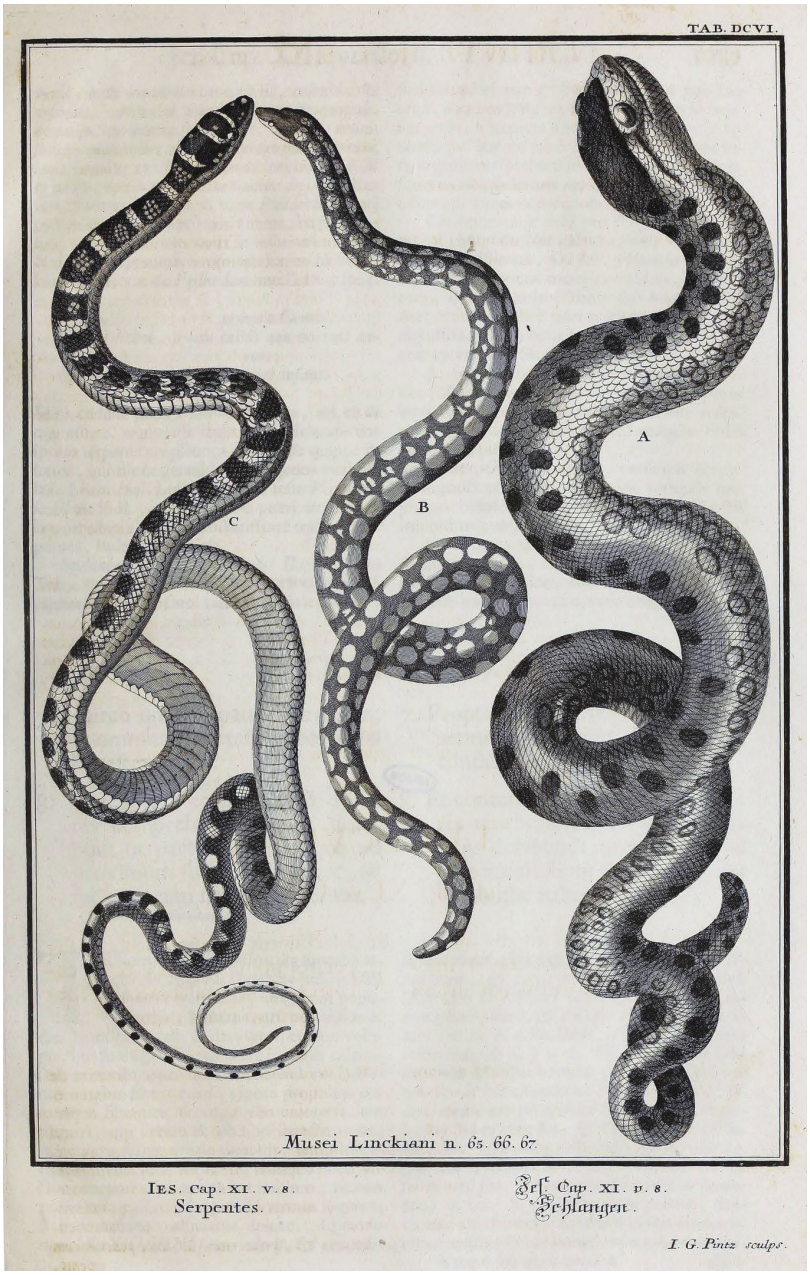

FIGURE 4. Facsimile of the plate 606 of Scheuchzer (1735), the figure A of which shows a specimen without stated origin here referred to the nominal species *Boa murina* Linnaeus, 1758.

5.2.2.5. Doubtful primary syntype NRM Lin.9

This specimen is still extant, being preserved in the Swedish Museum of Natural History collection in Stockholm. It was not mentioned in Linnaeus (1758), but was so in Linnaeus (1764: 42) and Linné (1766: 374 [‘274’]). In the 1764 work, a detailed description of this specimen was given and it was stated to have 254 or 258 abdominal scutes and 65 caudal scutes, whereas in the 1766 book the numbers 254 and 65 were given. Andersson (1899: 28) stated that this specimen measured 930 mm and had 255 ventral and 67 caudal scales. Both McDiarmid *et al.* (1999: 201) and Wallach *et al.* (2014: 287) considered, in error, this specimen as the holotype of *Boa murina*. The former wrote: “Holotype: ‘Gron. Mus.’ [NHRM no. Lin. 9].” The latter wrote: “Holotype, NHR Lin-9 (formerly MAFR), a 930 mm specimen (Mus. Drottn.).” REA (17) wrote about this specimen:

> The Adolphi Friderici Museum has a specimen labelled NRM 9, identified as *Boa murina*, which could be the specimen described by Linnaeus. The record of this specimen is unclear and there is no provenance for it, but it appears to be a specimen in Linnaeus’ collection and its scale number matches that of # 319 in Linnaeus’ *Systema Naturae*. Attempts to obtain tissue samples from this specimen were unsuccessful, which is to be expected given the low probability of obtaining usable DNA from such an old, formalin-fixed specimen[14]. It is likely that the specimen described by Linnaeus was from Suriname, as much of the trade to Europe came from this area (E. Åhlander pers. comm.).

The latter statement is only hypothetical and the specimen should be considered of unknown origin. The website of the Stockholm Museum[15] writes that Linnaeus identified this specimen in 1755, i.e., before the publication of the 10th edition of his *Systema Naturae*. This is compatible with the fact that this specimen was not mentioned in the first edition of the catalogue of the Museum Adolphi Friderici collection (Linnaeus 1754) but mentioned in its second volume (Linnaeus 1764), issued to cover a part of the collection that was not covered in the 1754 work, including 21 amphibians and reptiles. If we take this anonymous and unpublished information for granted, this specimen should be considered as being a primary syntype of the species, but, if not, it should not be accepted as belonging to the series of syntypes—hence the doubt expressed here about its status, in particular as Linnaeus did not use its scale counts in the diagnosis of this species.

5.2.3. Discussion and conclusion

The nomen *Boa murina* Linnaeus, 1758 has been used as valid constantly in the herpetological literature, either as its original combination or as its subsequent combination *Eunectes murinus*, for more than two and a half centuries, to designate a giant aquatic snake present in the northern part of South America. Wagler (1830: 167), erected the genus *Eunectes* but did not write the combination, as usual in his book. Gray (1830: 96) was the first one to use it, but with a grammatically incorrect ending for the epithet (*Eunectes murina*), and Duméril & Bibron (1844: 474) were the first authors to use the correct combination *Eunectes murinus*.

However, as shown by the review of its syntypes presented above, none of the latter is known to have been collected in a precise locality or even region of the South American subcontinent, and the nominal species lacks an onymotope. The finding by REA that this species seems to include

14 In fact, formalin fixation was not employed until the 1890s (see Musiał *et al.* 2016), so there is no probability that this specimen was formalin-fixed, although it might well have seriously degraded DNA.

15 <https://artedi.nrm.se/nrmherps/find.php?Category=scientificName&Precision=%3D&FormData=Eunectes+murinus&Ordering=default&Extent=All&MaxRecs=10&Verbosity=Full&Map=Map&Submit=Submit>.

two mitochondrial lineages ('northern' and 'southern'), which some authors might consider distinct taxa (subspecies or species), suggests that the nomen *Boa murina* should be attached to a specimen of precise origin and referred to one of these two lineages by molecular data. REA (17) suggested to attach it to the 'southern lineage' because of its larger distribution and because much of the trade between Brazil and Europe in the 18th century involved the Guyanan region. However, the specimen they chose for this purpose, MPEG 27428, was not from the Guyanan region but from the neighbouring Brazilian state of Pará. They designated this specimen as "lectotype" of *Boa murina*, which is invalid for several reasons. [5.2.3.1] First, the lectotype of a nominal species may be designated only among the syntypes of the latter, which was not the case. [5.2.3.2] Then, in order to validly designate a neotype for a nominal species, it is necessary to provide evidence that all the original holotype or syntypes has/have been destroyed or lost. REA considered that the specimen NRM Lin.9 "could be the specimen described by Linnaeus": if so, it would be the holotype or a syntype of this nominal species and, as it is still extant, the conditions for the designation of a neotype would not be fulfilled. [5.2.3.3] Finally, if these conditions are met, Article 75.3 of the *Code* lists a series of criteria for a neotype designation to be valid, including a statement of diagnostic characters (Article 75.3.2) and descriptive information ensuring recognition of the specimen designated (Article 75.3.3), and none of these conditions were met in REA's paper—as in many other recent papers (see e.g. Dubois *et al.* 2022*a*).

Therefore, REA's paper has not settled the nomenclatural status of the nomen *Boa murina*, and this status should be clarified in order to address the new situation created by the distinction of two lineages among the populations so far designated by this nomen. As discussed above, four of the original syntypes of this nominal species are now lost, but the specimen NRM Lin.9, which is still extant, is likely to be a primary syntype. Therefore, the conditions do not exist for the designation of a neotype (except by the Commission), but those for the designation of a lectotype are met. A first idea that could come to mind would be to choose the latter specimen for this purpose, but we think this would not be a good solution. This would attach this nomen to a specimen without origin, which apparently cannot be sequenced and will therefore remain unallocated to either of the two lineages—unless a thorough morphological and morphometrical analysis, which is currently missing, identifies characters to diagnose them from one another. As noted above under § 5.1, for the designation of a lectotype for a nominal species, some syntypes of which are lost and others still extant, the *Code* does not prescribe that an extant specimen must be chosen. As explained in detail by Dubois *et al.* (2014), the recourse to the procedure consisting in the designation as lectotype of a lost specimen, and then its replacement, through neotype designation, by an extant specimen having a known onymotope and allowing molecular investigations, is an excellent solution to this kind of problem, and we decided to implement it in the present case. None of the syntypes of this species has a precise onymotope, but one of them, ONID Sm2, was stated by Seba (1735) to have originated from "America". Although as we have seen this information is highly imprecise, it is compatible with the known distribution of the species, and we chose this specimen as lectotype.

Accordingly, we hereby **designate** the specimen ONID Sm2, figured in Seba (1735: 30, tab. 29, fig. 1), secondary syntype of *Boa murina* Linnaeus, 1758, as **lectotype** of this nominal species. In order to comply with Article 74.7.3 of the *Code* as emended by the declaration 44 of the Commission (Anonymous 2003; Dubois *et al.* 2022*a*: 47), we hereby declare that this designation is deliberate and, although this is no longer required by the *Code*, that it is scientifically justified (see above). Following this designation, all the other original syntypes of this nominal species have now become paralectotypes and have lost their status of nomen-bearers.

The specimen ONID Sm2 being lost, it would now be possible to designate a neotype for this nominal species. This would allow the restriction of its type-locality in a way compatible with its originally stated provenance, and to choose a recently collected specimen which would allow for molecular investigations. REA ('Supplemental material') reported having sequenced the specimen

MPEG 27428 from the State of Pará, Brazil, but they designated it as "lectotype" of *Boa murina*, which is invalid as it was not part of the original syntypes. This designation could not be just transformed into a neotype designation, as REA did not provide information necessary to comply with the 'qualifying conditions' for neotype designation (see Dubois *et al.* 2022*a*: 47), particularly a statement of diagnostic characters, as the meristic data provided by REA (2024: 14) in their table 6 are insufficient for this purpose, and evidence that the characters of the neotype are consistent with those of the lectotype. Furthermore, in order to attach this nomen to one of the two lineages of this group, molecular data should have been obtained from the specimen chosen. Likewise, the geographic origin of this specimen is not precise enough as requested by the state of the art of 21th century taxonomy. Therefore, the conditions are not met to implement a neotype designation here, but we suggest it should be done whenever possible in order to stabilise the nomenclatural status of this nomen.

We provide below in Appendix 1 additional comments on the procedure of designation of missing specimens as lectotypes.

5.3. Boa scytale *Linnaeus, 1758*

5.3.1. Introduction

The nomen *Boa scytale* Linnaeus, 1758 has been considered a subjective synonym (***doxisonym***; Dubois 2000) of *Boa murina* Linnaeus, 1758 since the work of Gravenhorst (1807: 416)—not of Duméril & Bibron (1844: 528) as stated by McDiarmid *et al.* (1999: 200). As these two nomina had been established in the same work, the decision to afford precedence to one of them required a first-reviser action. Gravenhorst (1807: 416) took this action in treating *Boa murina* as valid and *Boa scytale* as its invalid synonym. Merrem (1820: 86–87), Gray (1830: 96), Schlegel (1837: 380) and Duméril & Bibron (1844: 528) made the same explicit choice. Therefore, as long as these two nomina are deemed to apply to the same biological species, the first one will be the valid one. All authors since then have accepted this fact, except Stull (1935: 403), who considered the epithet *scytale* as the valid nomen, possibly, as noted by Stejneger (1935: 144) on the basis of the so-called rule of "page priority" which was not present in the *Règles Internationales de la Nomenclature Zoologique* in force then (Blanchard 1905)[16].

Despite being currently considered invalid, the nomen *Boa scytale* plays an important nomenclatural role, as it is the type species of the nominal genus *Eunectes* (see § 6 below). Therefore, it is crucial to establish accurately its nomenclatural status, and this requires the identification of its onymophoronts.

5.3.2. Original description

Linnaeus' (1758: 214) entry for the species *Boa Scytale* reads as follows:

> 276. Scytale. 250–26. *Gron. muf*. 2. *p*. 55. *n*. 10.
> *Scheuch. facr*. *t*. 737. *f*. 1.
> *Habitat in America.* †
> *Color ex albo nigroque undulatus. Squamae capitis majores.*

16 Actually, as noted by Dubois (2011: 17), a Rule of "page" or "line" precedence once existed, from 1948 (Anonymous 1950) to 1953, in these *Règles* that were in force before the *Code*, but it was suppressed in 1953 (Hemming 1953: 66–67).

We interpret this text as providing evidence for this nomen being based on two secondary syntypes and one tertiary syntype. No primary syntype is known to be still in existence.

In the 12th edition of the *Systema Naturae*, Linné (1766: 274) significantly modified his account of the species:

> 323. Scytale. 250–70. B. *Scheuch. ſacr. t.* 737. *f.* 1.
> *Gron. muſ.* 2. *p.* 55. *n.* 10.
> *Habitat in* America, *conſtringit & deglutit Capras, Oves &c.·*
> Corpus *cinereo-glaucum: maculis dorſalibus orbiculatis nigris. Lateralibus annulatis, nigris diſco albo; Ventralibus oblongis quaſi e punctis nigris concatenatis.*

This new version of the account could indeed be interpreted as pointing to a species of snake different from that of the 1758 edition, but the bibliographic references, and therefore the syntypes on which the nomen is based, remain the same, no reference being added or deleted. It is in error that Stejneger (1935: 144) stated that Linné (1766) had "drop[ped] the reference to Gronovius No. 10". Anyway, except in the very rare cases where he/she explicitly writes doing so purposefully, no change introduced by an author in the definition, content or onomatophore of a nominal taxon, even introduced by him/herself, or in its spelling, results in the erection of a new taxon and in the introduction of a new nomen, as otherwise thousands of such invalid junior homonyms would have to be recognised across the whole of zoological taxonomy. The changes he made to this account cannot be interpreted as meaning that Linné (1766) had established a new nominal species (an invalid junior homonym of his 1758 species), but just that he had modified its diagnosis, which has no nomenclatural consequences. Let us remind again that, in zoological nomenclature, the allocation of nomina to taxa is made through specimens, not through descriptions, definitions or diagnoses.

5.3.3. Onymophoronts

5.3.3.1. Secondary syntype ONID Ss1

This specimen was described under Nr. 10 in Gronovius (1756: 55) under the heading "SCYTALE ſcutis abdominalibus CCL, & ſcutis caudalibus XXVI". Its scale counts (250 abdominal scutes, 26 caudal scutes) are mentioned in Linnaeus' account on *Boa scytale*. Its colour pattern is described as alternating black and white. The species is stated to inhabit Suriname. This specimen is not known to have been figured, and its subsequent fate is unknown.

We propose the following English translation of the original Latin text of Gronovius:

> Scales on head very large, with multiple corners, various shapes on head.
> Scales of body and tail covered by transverse ridges.
> Tail thick, cylindrical.

> 1. Head oblong, narrow, almost cylindrical; anteriorly rounded-obtuse, convex above, covered with polymorphic scales: apparently from the snout to the eyes there are two pairs of square scales, and these are followed by a central cordiform one, with a sharp point facing posteriorly; on both sides of this central one is a single small one, under which the eye is situated; posteriorly there are two very large triangular scales covering the whole dorsal part of the head: the sides of the head are convex and straight.
> 2. Lower jaw much shorter than the upper.
> 3. Eyes very small, positioned on the sides of the head, rounded.

4. Trunk long, very thin, indistinguishable from the head, keeping the same width almost to the anus, covered below with 250 scales.

5. Tail very short and very thick, thinner than the trunk, terminating by a sharp tip, and below furnished with twenty-six scales.

6. Inhabits Suriname.

7. Colour of the rings alternating between white and black.

This description does not fit with an anaconda, but might possibly apply to a similar species described and figured by Scheuchzer (1735), reported below in § 5.3.3.2[17].

5.3.3.2. Secondary syntype ONID Ss2

This specimen figured by Scheuchzer (1735: 1493, tab. 737, fig. 1) under the title "Act. Cap. XXVIII. verſ. 3.4.5.6", and cited by Gronovius (1756: 70) as a synonym of the species referred to above in § 5.3.3.1. Scheuchzer (1735: 1493) gave the following description of this specimen:

TAB. DCCXXXVII. Fig. 1. Serpens Surinamenſis, punctis nigris, albo colore interſectis, & taeniis nigricantibus plerunque bifurcatis pictus.

Serpens Surinamenſis cinereis variis annulis ſubnigris intermixta linea alba.

Serpens minor egregie variegatus & taeniatus. Ex Promontorio Bonae Spei. *Vinc. Cent.* VI. 125.

This specimen, originating from Suriname, was deposited in the Linck collection of snakes in Leipzig (likely spirit No. 483 or 484) but is not to be found nowadays in the Naturalienkabinett Waldenburg where 17 specimens of this collection are still present (see Bauer & Wahlgren 2013: 252), so that it must be considered lost.

We agree with all previous authors that the figure 1 of this plate (here reproduced in Figure 5) does not represent an anaconda. Duméril & Bibron (1844: 529) referred it to the species for which, as shown by Vanzolini & Myers (2015), Wied-Neuwied (1820: 110) had erected the nomen *Coluber venustissimus*, currently or recently treated as a subspecies (e.g., Marques *et al.* 2016: 115) or a synonym (e.g., Wallach *et al.* 2014: 281) of *Erythrolamprus aesculapii* (originally described as *Coluber aesculapii* Linnaeus, 1758). Linck (1783) considered the illustrated specimen to represent *Coluber aeſculapii.* It is still unclear if this specimen was indeed a specimen of this species or subspecies (Curcio 2008, **1**: 10, 176) or of another taxon of the genus *Erythrolamprus* Boie, 1826 (*Xenodontinae*), but it was clearly not a member of the *Boidae*.

5.3.3.3. Tertiary syntype ONID Ts1

This specimen is mentioned in the work of Vincent (1726: 43) cited in the text of Scheuchzer (1735) just examined above, which writes: "125. Serpens minor, egregie variegatus et taeniatus. Ex promontorio bonae Spei." It refers to a small snake with black and variously colored bands or circles from the Cape region of South Africa. We think that it is likely that the South African snake involved, small and slender and having "variously colored bands", present in the areas of the Cape accessible to Europeans at the time, was a member of the genus *Homoroselaps* Jan, 1858 (*Atractaspididae*), specifically *Homoroselaps lacteus* (Linnaeus, 1758). It would also be possible, but less likely, that, should this specimen have originated from South America, it could represent a specimen of *Helicops* Wagler, 1830 (*Xenodontinae*), an aquatic watersnake also from the Neotropical region, considering its banded pattern and minute eyes, the latter character also present in anacondas. Anyway, these

17 It is very unlikely that it was the same specimen. There is no indication that any exchanges were made between Linck and Gronovius.

brief descriptive notes do not permit certainty of the identification of this specimen, but it clearly has nothing to do with the South American anacondas. Note that Wallach *et al.* (2014: 329) stated, in error, that the type species of *Homoroselaps* was *Coluber lacteus* Linnaeus, 1758. Type species of genera are nominal species, not taxonomic species. The type species of this genus, by original monotypy, is *Coluber hygeiae* Shaw, 1802, which was synonymised with *Coluber lacteus* by Jan (1857: 50) himself, before using the nomen *hygeiae* as valid in his new genus!

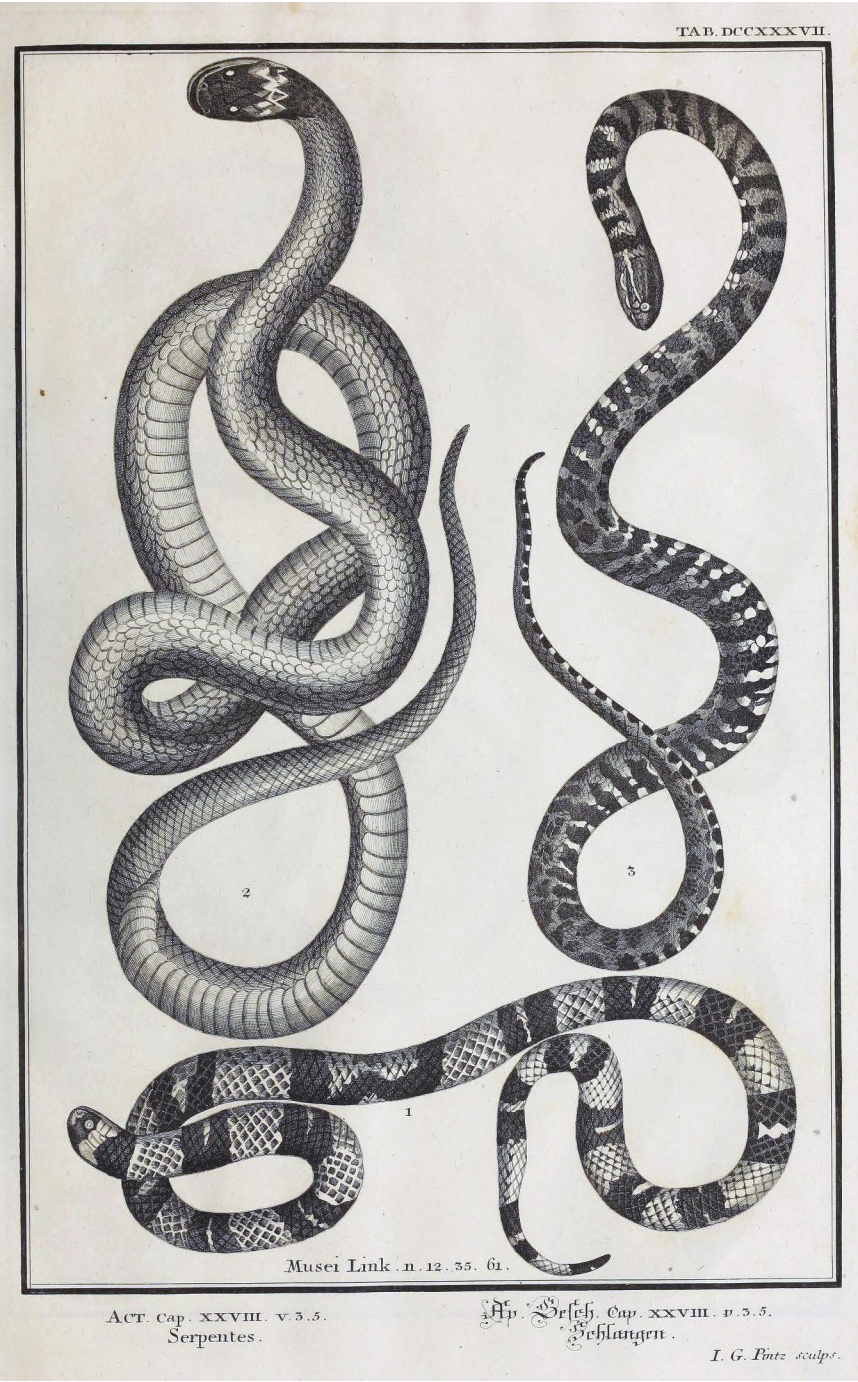

FIGURE 5. Facsimile of the plate 737 of Scheuchzer (1735), the figure 1 of which shows a specimen from "Suriname" here tentatively referred to the nominal species *Coluber venustissimus* Wied-Neuwied, 1821.

5.3.4. Discussion

The data above confirm what had been suggested previously by several authors (e.g., Schneider 1801; Daudin 1803; Schlegel 1837; Duméril & Bibron 1844; Smith & Gloyd 1964): none of the three syntypes of the nominal species *Boa scytale* Linnaeus, 1758, which are now lost, belonged in the genus *Eunectes*. Unfortunately, no specimen that could have been in the hands of Linnaeus in 1758 when he named this species is known to exist, as, if it were so and if this specimen could be referred to *Eunectes murinus* as currently understood, it could have been designated as lectotype of *Boa scytale*, which would have solved the nomenclatural problem.

In order to respect the *Code*, it is impossible to designate as missing lectotype a specimen that was not known to Linnaeus (1758) and that would belong in the genus *Eunectes*, let alone in the species currently known as *Eunectes murinus*. Two of the syntypes of this nominal species seem to have belonged in a species or subspecies of *Erythrolamprus*, probably that to which the nomen *Coluber venustissimus* Wied-Neuwied, 1820 applies, while the third one probably belonged in the genus *Homoroselaps*. The least disturbing choice, designating as lectotype the only figured specimen, the secondary syntype ONID Ss2, would result in making *Eunectes* Wagler, 1830 a junior isonym of *Erythrolamprus* Boie, 1826, whose type species (by original monotypy) is also *Coluber venustissimus*. This would not raise any nomenclatural problem concerning the genus *Erythrolamprus*, as its nomen is senior to the nomen *Eunectes*, but this would entail a major one concerning the latter genus, the valid nomen of which would have to change.

The nomen *Eunectes* has been used continuously for anacondas in hundreds of publications, including in the 'popular literature', for almost 200 years, and we consider that it should be 'protected', which could be done through a change of its type species. However, such a nomenclatural act cannot be made by individual zoologists and the only possibility to do it would be through an action of the Commission using its plenary power. This question is discussed below in § 6.

5.4–5. "Boa albida *Boddaert, 1783*" *and* "Boa glauca *Boddaert, 1783*"

Starting with Gmelin (1789: 1084) and Suckow (1798: 165–166), and until Wallach *et al.* (2014: 287) for the second one, many authors have credited Boddaert (1783: 17) with the authorship of two new *nomina nova* for the two snake species of Linnaeus above: respectively "*Boa albida*" for *Boa scytale* Linnaeus, 1758 and "*Boa glauca*" for *Boa murina* Linnaeus, 1758. However, this interpretation is wrong. In his work, Boddaert (1783) presented the accounts on the species in a way unusual after 1758 but reminiscent of pre-Linnaean works, giving first a diagnosis of the species (using italics at least for the generic substantive), followed in the next line by the scientific nomen he adopted for the species (without italics but with small capitals for their authors' abbreviated names). Therefore, he did not create these new nomina. When citing them, Gmelin (1789: 1084) cited the whole diagnosis, so that it is not clear if he considered them as species nomina as defined in Linnaeus (1758), but Suckow (1798: 165–166) did mention them as binomina in their respective synonymies. He thus published them as synonyms (Article 11.6), qualifying as ***kalyptonyms*** (Dubois 2022*b*). As these nomina were never subsequently adopted as the valid nomina of taxa or treated as senior homonyms before 1961 (Article 11.6.1), they qualify as ***doulonyms*** (Dubois 2022*b*) and will remain permanently unavailable. They may, however, be mentioned in their respective synonymic lists, provided they are duly recognised as unavailable.

5.6. Coluber raninus *Bonnaterre, 1790*

The mention of the nomen *Coluber raninus* Bonnaterre, 1790 in the synonymic list of *Eunectes murinus* of Wallach *et al.* (2014: 287) is puzzling. Bonnaterre (1790: 51) had apparently examined no specimen of this species and had based this nomen only on the account under Nr. 34 by Gronovius (1756: 66) of a specimen called "COLUBER ſcutis abdominalibus CXLIX, & ſquamarum caudalium paribus LXXX". This specimen, which is now lost, is therefore the holotype (ONID Hr1) of this nominal species by original monotypy. Its description and scale counts (149 abdominal, 63 caudal) do not fit at all with Linnaeus' anaconda species. The nomen *Coluber raninus* Bonnaterre, 1790 was used as valid by Merrem (1820: 106), referring to the same account of Gronovius (1756). Inexplicably, Wallach *et al.* (2014: 287) recognised a distinct nominal species "*Coluber raninus* Merrem, 1820" as a junior invalid synonym of *Liophis melanotus* (Shaw, 1802) (*XENODONTINAE*). Their confusion may be explained by a quick reading of Bonnaterre's text in which he said that he had called this species, which feeds on frogs, *raninus*, by similarity with Linnaeus' choice of the nomen *murina* for a species feeding on rats! Bonnaterre's nomen should be removed from the synonymic list of *Eunectes murinus* and should replace Merrem's nomen in the synonymy of *Liophis melanotus*.

5.7. Boa gigas *Latreille* in *Sonnini & Latreille, 1801*

Latreille (*in* Sonnini & Latreille, 1801: 136) described as *Boa gigas* a species which he considered close to *Boa constrictor* Linnaeus, 1758, but reaching larger sizes (up to 30 pieds, i.e. about 10 m), that he 'conjectured' to live in Guiane (now Guyana or French Guiana). He wrote that he had examined several specimens (which are primary syntypes) and he described some intraspecific variation. His description and scale counts (250 abdominal, 60–68 caudal) fit with anacondas. He stated that there was in the MNHN collection the skin of a specimen brought back from Cayenne, but all the specimens on which his description was based are now missing in this collection. We hereby **designate** the (now lost) skin of the specimen from Cayenne (primary syntype ONID Pg1) as missing **lectotype** of *Boa gigas*, which allows the fixation of its onymotope. For purposes of synonymy (i.e., in order not to threaten the senior nomen *Boa murina*), we refer this specimen to the species *Eunectes murinus*. However, according to REA (12), both mitochondrial lineages that they distinguished in *Eunectes murinus* occur in French Guiana, so that the real status of this lost specimen will remain unknown and it would be inappropriate to designate for this nominal species a neotype from this region without having obtained from it molecular data that would clearly allocate it to the 'southern mitochondrial lineage'.

5.8. Boa aboma *Daudin, 1803*

Starting with Duméril & Bibron (1844: 529), the nomen *Boa aboma* Daudin, 1803 has been considered a synonym of *Boa murina* Linnaeus, 1758.

Daudin's (1803: 132) account of his new species was based on several specimens (syntypes) and descriptions of South American giant snakes, all now lost. They included those (without known origin) shown in the figures 1–2 of his plate 59 and in figures 1–2 of his plate 62, as well as a 'famous' specimen from "Suriname", mentioned under the uninomen *aboma* by Stedman (1799*a*: 231, 233; 1799*b*: 1, pl. 14). The book cited by Daudin (1803: 132) was the French translation, with a watered down title (not mentioning that the expedition was "against the revolted negroes"), of the original English book (Stedman 1796: 175, 177, pl. 19), where Stedman (1796: 170–177; 1799*a*: 225–234)

gave a lively report (copied by Daudin 1803: 135–143) of his finding and killing of a snake measuring "twenty-two feet and some inches" (Stedman 1796: 173) between Cormoetibo Creek and Barbacoeba (Stedman 1796: 170), shown in the plate 19 of the British edition, reproduced in plate 14 of the French edition of the plates and here in Figure 6. This lost specimen (ONID Sa1) originated from a precise locality, now situated in Guyana, in the area of distribution of the 'northern mitochondrial lineage' of *Eunectes murinus* according to REA (12, 16: figure 5). We hereby **designate** this specimen ONID Sa1 as **lectotype** of this nominal species. In the current state of knowledge, this specimen should be referred to the species *Eunectes murinus*, but if the 'northern mitochondrial lineage' of *Eunectes murinus* was to be later recognised as a distinct taxon (subspecies or species), the nomen *Eunectes aboma* would be available for it. For the potential designation of a neotype for it, we reiterate here the recommendation given above for the nomen *Boa gigas*.

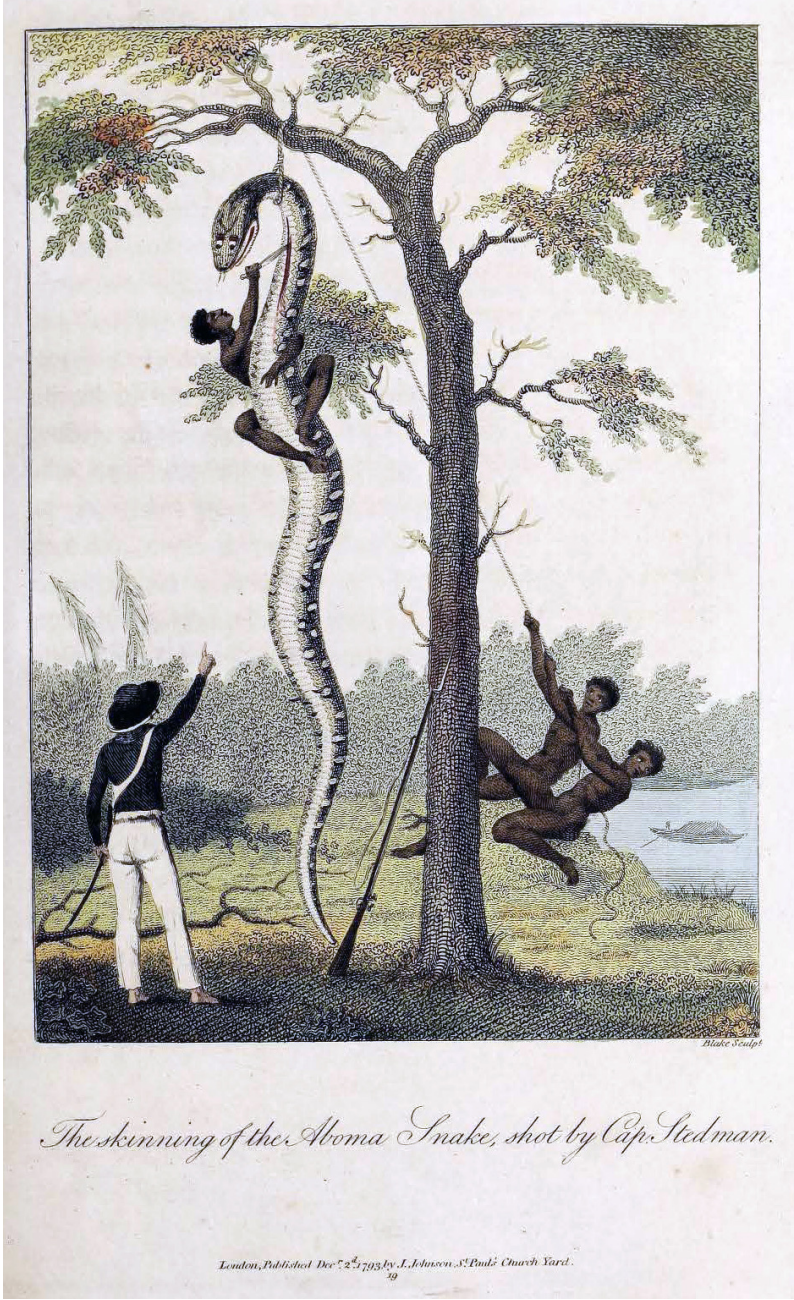

FIGURE 6. Facsimile of the plate 19 of Stedman (1796), which shows a specimen from "between Cormoetibo Creek and Barbacoeba" in Suriname, hereby designated as lectotype of the nominal species *Boa aboma* Daudin, 1803 and referred to the nominal species *Boa murina* Linnaeus, 1758.

5.9. Boa anacondo *Daudin, 1803*

The new nomen *Boa anacondo* was expressly presented by Daudin (1803: 162) to replace Latreille's name "*Boa géant*", as the qualification of 'giant' did not apply 'exclusively' to this species. However, the French name he cited is not nomenclaturally available. Had he mentioned instead the available nomen *Boa gigas*, his nominal species *Boa anacondo* would be a neonym for the latter but, as this is not the case, the status of this nomen must be established by looking at the sources he mentioned in his synonymic list (161). As in the preceding case, this list was based on several specimens (syntypes) and descriptions of South American giant snakes, all now lost. Among them was Latreille's (*in* Sonnini & Latreille, 1801) description of *Boa gigas*, even if the latter binomen was not mentioned by Daudin (1803). In order to stabilise the status of the nomen *Boa anacondo*, we hereby **designate** the specimen ONID Pg1, which is a primary syntype of the nomen *Boa gigas* and a secondary syntype of *Boa anacondo*, as **lectotype** of the latter, making both nomina objective synonyms.

5.10. Boa aquatica *Wied-Neuwied, 1823*

Wied-Neuwied (1823: unnumbered plate entitled "Boa aquatica" and text on unnumbered page entitled "Boa aquatica. Max. Die Sucuriuba, der Sucuriu") proposed the new nomen *Boa aquatica* for a snake species that he considered synonym of the four nomina *Boa Scytale*, *Boa anacondo*, *Boa gigas* and *Boa murina* examined above. As we have seen, these four nomina are not all isonyms, so his new nomen cannot be a neonym for either of them, or "a generalized substitute name" as stated by Vanzolini & Myers (2015: 41), a situation not recognised by the *Code* (see § 5.1 above). Instead, all the syntypes of these four nomina are collectively secondary syntypes of *Boa aquatica*, but the latter has also a primary syntype (ONID Pq1), a young specimen of about 2.8 m ("9 Fuſs 5 Zoll 9 Linien") from the river Belmonte, State of Pará, Brazil, figured in Wied-Neuwied (1823) in a plate reproduced in our Figure 7. This specimen was not found by Vanzolini & Myers (2015). As it has a precise type-locality, we hereby **designate** it as missing **lectotype** of *Boa aquatica* Wied-Neuwied, 1823. According to the distribution data of the specimens stated to have been sequenced by REA, this specimen is likely to have belonged in the 'southern mitochondrial lineage', for which the nomen *Boa murinus* would have priority if a formal taxon was to be recognised for this lineage. For the potential designation of a neotype for it, we reiterate here the recommendation given above for the nomen *Boa gigas*.

5.11. "Boa lateristriga *Boie, 1827*"

As discussed below in § 6, when he established the genus *Eunectes*, Wagler (1830: 17) mentioned five nominal species, one of which, "*Boa lateristriga* Boie, 1827", had been introduced by F. Boie (1827: 515) for a snake species from the "indischen Archipelagus", without description and thus as a *nomen nudum*. Like many others, this nomen had been proposed by his brother H. Boie in the manuscript of his *Erpétologie de Java*, that was never published (see Denzer *et al.* 2023). This nomen was not mentioned in McDiarmid *et al.* (1999) and Wallach *et al.* (2014). After Wagler (1830), it was later mentioned by Gray (1830: 96), who apparently considered it to apply to a valid species of the genus *Eunectes* but emended it into "*Eunectus lateristrigota*", which remains however a *nomen nudum*. It was then mentioned as an invalid synonym of *Epicrates cenchria* (Linnaeus, 1758) by Gray (1849: 95), which referred to a plate (t. 26) in Boie's unpublished manuscript (which suggests

that Gray had seen it during one of his visits to the Rijksmuseum in Leiden), and by Mellado (1851: 456) as a second species of *Eunectes* beside *Boa scytale*, but again as a *nomen nudum*. The mention by Mellado of this nomen as valid cannot be construed as having validated it as a ***lysonym*** under Article 11.6 (see Dubois 2022*b*) because its publication by Gray (1849) as a synonym was not its **first** publication, as required by this Article.

For completeness, we analysed the relevant part of H. Boie's manuscript to evaluate whether he was actually describing an anaconda. The full description is provided in our Figure 8. While the description contains few statements that partially agree with the characters described for snakes of the genus *Eunectes*, such as its numbers of scales (250 ventralia and 50 subcaudalia) and its minute

FIGURE 7. Facsimile of the unnumbered plate entitled "Boa aquatica" of Wied-Neuwied (1823), which shows a specimen from the river Belmonte, State of Pará, Brazil here referred to the nominal species *Boa murina* Linnaeus, 1758.

eyes (“oculis minutis”), most other characters do not. The head is described as being whitish with five rusty coloured stripes (“capite albido lineis longitudinalibus ferrugineis quinque”), the round dorsal spots as faint (“maculis rotundis palidis” [*sic* for pallidis]) and the sides as showing a striped pattern (“lateribus longitudinaliter striatus”). Judging from the colour and pattern description and the excellent figure, "*Boa lateristriga*" was not intended for a species of *Eunectes*. A further argument against the inclusion of this species in *Eunectes* is that the specimen had been described in a manuscript dealing with the herpetology of Java and neighbouring regions.

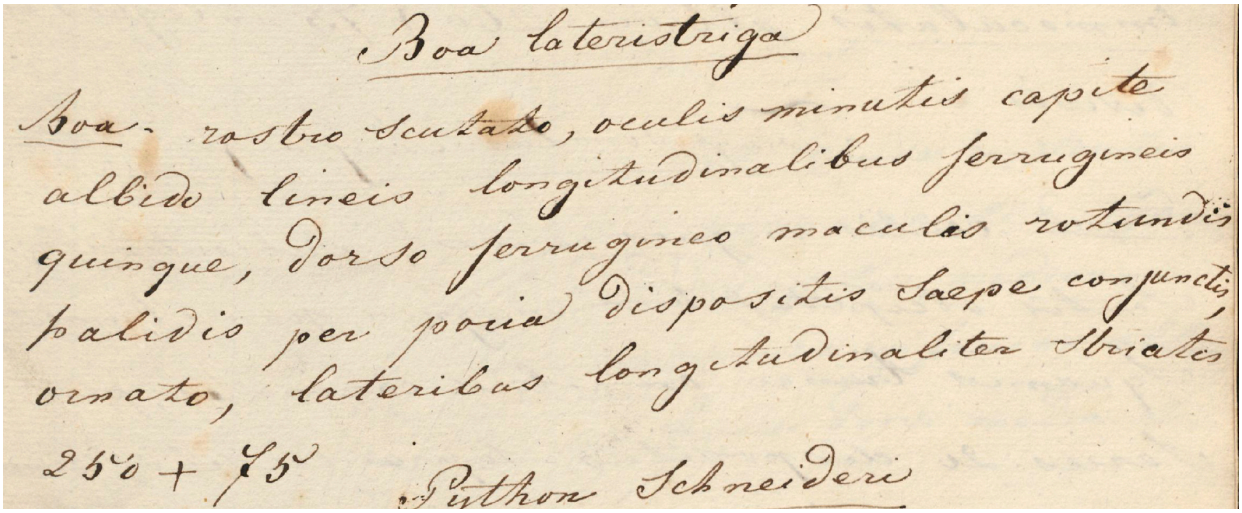

FIGURE 8. Facsimile of the diagnosis of the species "*Boa lateristriga*" in the unpublished manuscript of H. Boie entitled *Erpétologie de Java*.

FIGURE 9. Facsimile of the plate 26 showing the species "*Boa lateristriga*" in the unpublished manuscript of H. Boie entitled *Erpétologie de Java*.

The Naturalis collection in Leiden is in the possession of a plate (numbered pl. XXVI in the top right corner, 27 in the top left corner) by the artist Pieter van Oort (signed PvO in the lower left corner), reproduced in our Figure 9, that illustrates a pythonid or boid snake under the name *Boa lateristriga* and that was meant to be published in the *Erpétologie de Java.* This plate reflects the colour and pattern of H. Boie's description of the species, but shows only 28 subcaudalia as opposed to the 50 mentioned in the description. Such low numbers of subcaudalia are representative of short tailed pythons like *Python curtus* (Schlegel, 1872), *Python breitensteini* Steindachner, 1881 and *Python brongersmai* Stull, 1938. On the other hand, the illustrated specimen shows a coloration and pattern that are similar to the general appearance of species of the genus *Epicrates* Wagler, 1830. According to its ventral and subcaudal scale counts, it could match either *Epicrates assisi* Machado, 1945 or *Epicrates crassus* Cope, 1862.

In our Table 2 we compared data of pholidosis and coloration for several species of the genera *Python* Daudin, 1803 and *Epicrates* Wagler, 1830. Owing to the discrepancy between the description and the illustration, as well as to Boie's assignment of the species to the genus *Boa* Linnaeus, 1758, it is not possible to identify the species unambiguously. Unfortunately, no specimen is registered under the name *Boa lateristriga* in the handwritten catalogue of the Naturalis collection nor was a specimen found during a recent survey of the boid snakes in this collection (E. Dondorp, personal communication).

TABLE 2. Some characters of the external morphology of 6 species of *Boidae* and *Pythonidae* and of the species "*Boa lateristriga* Boie, 1827" (the latter according to its unpublished original description and illustration of H. Boie).

Character	*Eunectes murinus* (Linnaeus, 1758)[1]	*Epicrates cenchria* (Linnaeus, 1758)[2]	*Epicrates crassus* (Cope, 1862)[2]	*Epicrates assisi* (Machado, 1945)[2]	*Python curtus* (Schlegel, 1872)[3]	*Python bivittatus* Kuhl, 1820[4]	"*Boa lateristriga* F. Boie, 1827"[5]
Ventrals	243–259	246–279	214–247	240–260	155–159	253–294	250
Subcaudals	61–78	45–68	33–52	40–60	27–29	63–72	50 (28)
Dorsal scale rows at midbody	58–74	39–54	32–54	42–56	54–60	63–70	?
Dorsal black head stripes	Absent	Present, three (two dorsolateral, one vertebral)	Present, three (two dorsolateral, one vertebral)	Present, three (two dorsolateral, one vertebral)	Absent	Present, single (vertebral)	Present, three (two dorsolateral, one vertebral)
Length of dorsolateral black head stripes	-	Reaching dorsals	Reaching dorsals	Not exceeding corner of mouth	-	Reaching dorsals	Reaching dorsals
Dorsal pattern	Black ocelli over green background	Black rings with light center	Dark brown or black rings with pale brown center	Dark brown or black rings with pale brown center	Irregular cream blotches over black or dark brown background	Square brown blotches over cream background	Dark brown or black rings with pale brown center
Dorsolateral pattern	Black rings with cream or yellow center	Dark brown rings with dorsal portion white bordered	Dark brown rings with dorsal portion white bordered	Dark brown rings with dorsal portion white bordered	Irregular light brown or red circular blotches	Square light brown blotches over cream background	Dark brown rings with dorsal portion white bordered
Minute eyes	Present	Present	Present	Present	Absent	Absent	Present
Continent of occurrence	South America	South America	South America	South America	Asia	Asia	Asia, possibly in error
Type locality	"America"	"Surinam"	Gardosa, Rio Parana, Paraguay	Campina Grande, Paraíba, Brazil,	Sumatra, Indonesia	?	"Java"

[1] Dirksen 2002.

[2] Passos & Fernandes 2008.

[3] Zug *et al.* 2011.

[4] Malsawmkimi 2022.

[5] H. Boie's unpublished *Erpétologie de Java*.

5.12. Eunectes notaeus *Cope, 1862*

The species *Eunectes notaeus* was described by Cope (1862: 70) on the basis of a single specimen, its holotype (USNM 4707), from the "Paraguay River and confluents", now presumed lost (Reynolds & Henderson 2018: 22). The validity of this species of 'yellow anacondas' has never been challenged since then.

5.13. Epicrates wieningeri *Steindachner, 1903*

The species *Epicrates wieningeri* was described by Steindachner (1903: 15) on the basis of a single juvenile specimen of 59 cm from Altos, Paraguay, its holotype (NMW 18929), which is still present in the Wien Museum (Georg Gassner and Silke Schweiger, personal communication). This nomen was synonymised with *Eunectes notaeus* first by Amaral (1929: 9) and again by Dunn & Conant (1936: 505).

5.14. Eunectes barbouri *Dunn & Conant, 1936*

The species *Eunectes barbouri* was described by Dunn & Conant (1936: 504) on a basis of a living holotype kept in the Philadelphia Zoological Garden which had been "in all probability collected on the island of Marajo at the mouth of the Amazon", and which differed from *Eunectes murinus* in that it had a double row of small ocelli instead of a double row of rather large, circular, solid dark spots on the back. Amaral (1949: 151) doubted the validity of the species. Strimple *et al.* (1997) reported that upon its death the holotype was deposited in the collection of the Academy of Natural Sciences of Philadelphia under the number ANSP 20892 (see also Stimson 1969: 22). Dunn & Conant (1936: pl. 14 fig. 1) provided a photograph of this specimen in life, drawings of this specimen were given in figures 2–3 of Dirksen & Böhme (1998*a*: 48–49), photographs of the head and skin, and a detailed picture of the ocelli, by Dirksen & Böhme (1998*b*), and a photograph of the head in figure 43 of Dirksen (2002: 84). Strimple *et al.* (1997) compared this specimen with nine specimens from various origins considered to belong in the species *Eunectes murinus* and showed that in all studied meristic characters it fell within the range of the latter, and consequently synonymised *Eunectes barbouri* with it. Given the locality where it is supposed to have been collected, this specimen is likely to belong in the 'southern mitochondrial lineage' of *Eunectes murinus*, which could perhaps be tested by attempts at sequencing it. REA did not report having tried to do it, nor did they mention the nomen *Eunectes barbouri* even once, even in their supplemental material, while they sequenced another specimen from the same Brazilian State and designated the latter as holotype of their purported new species.

5.15. Eunectes deschauenseei *Dunn & Conant, 1936*

The species *Eunectes deschauenseei* was described by Dunn & Conant (1936: 505) on the basis of a living holotype kept in the Philadelphia Zoological Garden which had been "very probably collected on the island of Marajo". Dunn & Conant (1936: pl. 14 fig. 2) provided a photograph of this specimen in life. This specimen has since then been deposited in the Academy of Natural Sciences of Philadelphia under the number ANSP 20891 (Stimson 1969: 22). This species was considered valid until Rivas *et al.* (2024: 1) synonymised it with *Eunectes notaeus*, except that Amaral (1949: 151) had already doubted its validity.

5.16. † Eunectes stirtoni *Hoffstetter & Rage, 1977*

The fossil species *Eunectes stirtoni* was erected by Hoffstetter & Rage (1977: 180) on the basis of a prootic process (holotype MNHN VIV 7) discovered in a Colombian Miocene formation at Los Mangos, near La Venta, Huila department, Colombia Fish Bed of the formation Villavieja (03°19' N, 75°08' W, elevation 440 m). The minimum age of the fossil was estimated at 12.375 Ma and was used as a calibration point for the divergence between the boid genera *Eunectes* Wagler, 1830 and *Epicrates* Wagler, 1830.

5.17. Eunectes beniensis *Dirksen, 2002*

The species *Eunectes beniensis* was described by Dirksen (2002: 169) on the basis of five specimens, one of which (AMNH 101924), from "Trinidad, Beni, Bolivia", was designated as its holotype. This species was considered valid until Rivas *et al.* (2024: 1) synonymised it with *Eunectes notaeus*.

5.18. "Eunectes akayima *Rivas, Quintana, Mancuso, Pacheco, Rivas, Mariotto, Salazar-Valenzuela, Baihua, Baihua, Burghardt, Vonk, Hernandez, García-Pérez, Fry & Corey-Rivas, 2024*"

As discussed in detail in this paper, this nomen is unavailable and should not be considered in any taxonomic revision of the genus *Eunectes*.

6. Nomenclatural problems regarding the valid genus nomen for anacondas

The genus *Eunectes* was established by Wagler (1830: 167) to accommodate five nominal species: *Boa murina* Linnaeus, 1758; *Boa scytale* Linnaeus, 1758; *Boa anacondo* Daudin, 1803; *Boa aquatica* Wied-Neuwied, 1823; and "*Boa lateristriga* Boie, 1827". The first of these nomina is currently considered the valid nomen of a species of *Eunectes*, the next three as its subjective synonyms (McDiarmid *et al.* 1999: 200; Wallach *et al.* 2014: 287), and the nomen "*Boa lateristriga*" was a *nomen nudum* (see § 5.11 above), and as such was not available for type-species designation.

Fitzinger (1843: 24) explicitly designated *Boa scytale* as type species of the genus *Eunectes* Wagler, 1830. As we have seen in § 5.3.1 above, the nomina *Boa murina* Linnaeus, 1758 and *Boa scytale* Linnaeus, 1758 are currently considered by all authors as subjective synonyms, but they remain distinct nomina. Because of their accepted doxisonymy, some recent authors (e.g., Wallach *et al.* 2014: 286) stated that the type species of this nominal genus was *Boa murina*, but this is incorrect: once again, type species of genera are nominal, not taxonomic species, and *Boa scytale* remains the type species of *Eunectes*.

Therefore, it is nomenclaturally important to ascertain if, on the basis of its original onymophoronts, the nomen *Boa scytale* could indeed apply to this genus, and if so to which of its species. However, as we have seen in § 5.3.4, it has long been known that the nomen *Boa scytale* was based on specimen(s) that were not anacondas but belonged to widely different groups of snakes, here considered to be the genera *Erythrolamprus* Boie, 1826 (*Xenodontinae*) and *Homoroselaps* Jan, 1858 (*Atractaspididae*). The question here is whether, despite this, an appropriate designation of lectotype or neotype could allow the maintenance of the well-know nomen *Eunectes* as the valid one for anacondas.

Smith & Gloyd (1964: 281) tried to overcome the problem as follows:

> The name *Boa scytale* Linnaeus, 1758, has generally been accepted as a junior synonym, by common consent, of *Boa murina* Linnaeus, 1758 = *Eunectes murinus* (Linnaeus). The materials justifing [*sic*] this allocation are merely the descriptions given with the name in Linnaeus (caudals entire, no rattle, head scales large, "color ex albo nigroque undulatus"), since the only other data (references to Gronovius and Scheuchzer) pertain to the species now known as *Erythrolamprus venustissimus*. Since no type has been found, the name is here restricted in application to the species represented by the type of *Boa murina* Linnaeus; it should be added to the list of synonyms of that name given by Dunn and Conant (1936, Proc. Acad. Nat. Sci. Philadelphia, 88: 503).

Unfortunately, this approach to the nomenclatural problem is not *Code*-compliant. Synonymy in zoological nomenclature cannot be established "by common consent" and the taxonomic allocation of a nomen cannot be "restricted in application" by transfer of the type of a nominal species to another one. As we have seen above in § 5.3, none of the syntypes of *Boa scytale* was an anaconda, and the only possibility offered by this situation would be to fix the status of this nomen through the designation for it of a lectotype referred to a species of *Erythrolamprus* Boie, 1826 or of *Homoroselaps* Jan, 1858, making the nomen *Eunectes* Wagler, 1830 a synonym of the chosen generic nomen. This would threaten a two-century old nomen, used as valid for such a long period and for a widely known group of snakes. We consider this situation as unacceptable, and we plan to address an application to the Commission asking for the invalidation of Fitzinger' (1843) designation of *Boa scytale* as type-species of *Eunectes* and the designation instead of *Boa murina* as type-species of this nominal genus. This point is further discussed below under § 7.2.

7. Discussion and conclusion

7.1. An overflow of taxonomic and nomenclatural errors

The paper of Rivas *et al.* (2024) naming a new giant South American snake in the MDPI journal *Diversity* was celebrated in 'social media' as an outstanding discovery. From a scientific point of view however, it is a much less glorious event, which awoke emotion in the herpetological, and more widely in the taxonomic community, but just because it is an incredible collection of taxonomic and nomenclatural errors. The fact that this highly unprofessional work could go through the peer-review process and be published in a periodical from a well-known publishing house casts strong doubts on the professionalism of the latter, which shares with the authors themselves the responsibility of this failure.

We provided above a number of reasons why this paper should never have been published as it is. A more detailed rebuttal is not warranted, as their mere listing is sufficiently impressive to send this message. Besides its confused and confusing plan and its unclear writing style, these weaknesses concern two main domains: taxonomy (the recognition and classification of taxa) and nomenclature (their naming).

[7.1.1] From the taxonomic point of view, this paper: [7.1.1.1] presents (in its 'Supplemental material', not in the paper itself) a list of "genetic samples" (i.e. of specimens used for molecular sequencing of three mitochondrial markers), but no connection of their numbers with collection specimens except for seven of them; [7.1.1.2] does not present a list of specimens examined for morphology, and just gives a list of 13 meristic characters for four specimens; [7.1.1.3] does not state the concept of species used by the authors; [7.1.1.4] considers that distances computed from sequence

data based on three mitochondrial genes are sufficient to erect a new species, even if not supported by nuclear and morphological data; [7.1.1.5] does not present any information on the potential contact and hybridisation zone hypothesised to exist between the two 'species'; [7.1.1.6] does not provide any figure of the purported new 'species', any description of its holotype, any diagnosis of the new 'species' or even non-molecular clue for the identification of these two 'species', either in the field or from voucher specimens.

[7.1.2] From the nomenclatural point of view, this paper: [7.1.2.1] raises concern regarding its nomenclatural availability under Articles 9.9 and 21.8.3, as the version accessible online on its periodical website at the stated date of its publication was subsequently replaced by an "updated" version, suggesting the possibility that still more "updated" versions might replace the latter again; [7.1.2.2] does not provide "a description or definition that states in words characters that are purported to differentiate the taxon" (Article 13.1), so that the new nomen proposed is a *nomen nudum*; [7.1.2.3] does not provide any evidence that the designated holotype (Article 16.4) was indeed used as source of information to define the taxon; [7.1.2.4] credits the authorship of the new nomen to pre-Linnean unreferenced, anonymous and unpublished sources, instead of claiming this authorship if this nomen was indeed intended to be used in the scientific discipline of taxonomy.

In the present work, we addressed the nomenclatural problems listed above and proposed solutions for all of them. As for taxonomy, given the scarcity and incompleteness of the data provided in REA's paper, we think they do not allow a clear taxonomic decision, and we take no stand on the taxonomic status of the two mitochondrial lineages presented, i.e. on whether they should be recognised as distinct taxa (species or subspecies) or as a single taxon. We just designate them informally as 'lineages', a term to which we afford no taxonomic meaning. We do the same for the 'clades' of 'green' and 'yellow' anacondas.

7.2. New nomenclatural proposals and recommendations regarding taxonomy

In zoological nomenclature, the allocation of nomina to taxa is not made intensionally through descriptions, definitions or diagnoses, or extensionally through lists of included specimens or nominal taxa, but ostensionally through onomatophores, the so-called "name-bearing types" (Dubois 2005*b*, 2011). However, this concept of 'nomenclatural type', as distinct from that of 'taxonomic type', was absent at the onset of zoological nomenclature, at the time of Linnaeus, and was distinguished from the latter only progressively (Dubois 2022*a*): first under the form of "type species of genera" (Denys de Montfort 1808, 1810; Latreille 1810) and of "type specimens of species" (Denys de Montfort 1808, 1810), and thereafter of "type genera of families" (Cuvier 1814). When dealing with taxonomic works of the 18th or early 19th century, the identification of the "types" must often rely on indirect data, as they were rarely mentioned by the authors. In these ancient works, all the specimens that had been used by the original author to define and name the new species must be considered. This includes both the specimens that he had examined himself and the specimens that had been examined by the authors of the works cited as synonyms of his new species. For this purpose, a variety of pieces of evidence may be used, such as express mention or illustration by the author of the new nomen of particular specimens or external evidence of the presence of specimens in a collection he is known to have used for his research (but only if hints exist that they were already there at the time of publication of his work). Beside the original description itself, such indications may be found in the works cited in its synonymy, in published catalogues of types and other specimens of museums, universities and other institutions, in unpublished catalogues, archives, in correspondences between colleagues, etc.

The present paper started with a critical analysis of the REA work, but we soon discovered the existence of various other problems in the taxonomy and nomenclature of anacondas, which led us

to re-examine a number of old texts dealing with these snakes. Several ancient texts proved to pose problems regarding the taxonomic allocation of their new nomina. In order to solve them, we tried to trace all the original syntypes of nomina proposed since 1758, and in some cases to designate 'missing lectotypes' for them, following a procedure already used with success for other problematic species. Although now lost, such lectotypes can serve a crucial purpose in zoological nomenclature: that of fixing the onymotope (type-locality) of the nominal species. For such fixations, when possible we chose specimens having precise localities, and allowing for the maintenance of stability in the use of the nomen, particularly in view of the fact that two molecular lineages are now distinguished in the species long known as *Eunectes murinus*. In the only case where this was not possible without disturbing this stability (for the nomen *Boa scytale* Linnaeus, 1758), we refrained from designating a lectotype and made another proposal. Accordingly, we designated missing lectotypes for four nominal species which we consider to be based on specimens of the 'southern lineage' (*Boa murina* Linnaeus, 1758, *Boa gigas* Latreille *in* Sonnini & Latreille, 1801, *Boa anacondo* Daudin, 1803 and *Boa aquatica* Wied-Neuwied, 1823) and one which we consider to be based on specimens of the 'northern lineage' (*Boa aboma* Daudin, 1803). If recognised taxonomically, the 'southern lineage' should therefore bear the nomen *Eunectes murinus* (Linnaeus, 1758) and the 'northern lineage' the nomen *Eunectes aboma* (Daudin, 1803).

We wish to stress here that the name 'aboma' was reported by Stedman (1796: 175) to be the local name given to these snakes by the inhabitants of "the colony of Surinam", thus coincidently meeting the wish of REA of giving these snakes a local name, but we insist that since Daudin (1803) this nomen belongs in the scientific realm of taxonomy and does not qualify any more as a "vernacular name".

For the time being, our lectotype designations are enough to clarify provisionally the nomenclatural status of the nomina referred in our Table 1 to the species *Eunectes murinus*, but, if two distinct taxa were to be formally recognised in the future for the two mitochondrial lineages, it would be better, to avoid discussions and instability, if these nomina could be allocated to them through molecular data (unless in the meanwhile morphological diagnostic characters were discovered). It would then be appropriate to replace these lectotypes by recent neotypes, but then these neotypes should be designated with full respect of the 'qualifying conditions' of Article 75 of the *Code*, including statement of the diagnostic characters of the species, as well as of data and descriptions allowing to ensure recognition of the neotype. This will therefore require access to and study of a voucher specimen to determine these characters and give a, partial at least, description of the specimen, which means that such a designation of neotype cannot be made only on the basis of molecular sequences or distances, as done by REA for their "lectotype" of *Eunectes murinus* and their holotype of "*Eunectes akayima*".

Such a neotype designation, although desirable, is not an immediate urgency concerning the nomen *Boa aboma*, but unfortunately it is so for the nomina *Boa murina* and *Boa scytale*. As we have seen, none of the syntypes of the latter nominal species were members of the genus *Eunectes*, but these syntypes belonged to several (at least two) species from different genera. Therefore, for the time being the nomen *Boa scytale* is a *nomen dubium* or *incertae sedis*, but the designation of any of them as lectotype would attach this nomen to a species being clearly not an anaconda. This nomen not having been used as valid since the work of Stull (1935), this would not have severe consequences—if it was not that of the type species of the genus *Eunectes*. As we have seen, we consider that the latter nomen should, by all means, be protected and conserved for this well known, spectacular genus. According to the *Code*, this action cannot be done by the individual or collective action of taxonomist(s), and it can be carried out only by the Commission, acting under its plenary power. Several actions could be considered to reach this result, but we think the simplest and more straightforward one would be to "suppress" (i.e., remove availability to; see Dubois 2000) the nomen *Boa scytale* and to invalidate its designation by Fitzinger (1843) as type species of *Eunectes*, and to replace it for this purpose by *Boa*

murinus, which already has priority over *Boa scytale*. This would stabilise the nomen *Eunectes* in its traditional sense and avoid the creation of instability in the genus *Erythrolamprus* or *Homoroselaps* by making the nomen *Boa scytale* the senior synonym of a nomen considered valid so far. This solution appears to be the best one but, to implement it, it will be necessary to have access to a specimen of known mitochondrial sequences and be able to describe and figure it.

7.3. Comments on the choice of periodicals for the publication of taxonomic papers

The term 'revolution' is currently often overused and misused, for minor changes that have nothing to do with this term. However, its use to designate the onset of electronic publication and its online diffusion is fully justified, being of a similar nature as the printing revolution in the 15th century. In the domain of scientific publication, it took only a few decades for this 'digital revolution' to drastically modify the way scientists publish their works. This had considerable impacts, not only concerning the current publication process of works but also in other domains such as the partial or total destruction of scientific libraries and archives holding paper publications all over the world, ignoring the risks of collapse of electronic archives and of online communication systems in case of major war, a scenario that cannot be dismissed nowadays with any certainty (see Dubois *et al.* 2022*c*; Wild 2024).

An important consequence of this revolution in scientific publication was that this domain, which was quite disregarded by big companies (except a few of them) at the time of paper publications, suddenly attracted the interest of many more actors, as this domain quickly became very lucrative, with a good rate of return without requiring major investments, as paper, printing, binding and mailing printed works is costly, and as scientists collaborate for free for the review process and the editorial process. This resulted in an unprecedented burst of scientific journals. The quality of the editorial work of these online periodicals is now extremely variable, from the very best to the very worst. This has soon resulted in the appearance of a new international movement of watch and evaluation of the scientific quality of journals, of the seriousness and thoroughness of the work of editorship, peer-reviewing and publishing of papers. One of the expressions of this movement of distrust towards periodicals was the emergence of the concept of 'predatory journals' (Anonymous 2019, 2023; Grudniewicz *et al.* 2019), which is not clearly relevant to the present discussion, but to which scientists can be grateful to have introduced the concept of "Think, Check, Submit" to guide authors in the choice of the journals to submit their works (Grudniewicz *et al.* 2019: 2011).

This concept has a general value for all scientists in all domains, but it is particularly important in taxonomy, for two distinct reasons. [7.3.1] The discipline of taxonomy has been neglected and marginalised in biology for more than half a century, although it is of crucial importance in our "century of extinctions" (Dubois 2003). Its concepts are misunderstood by a large part of the community, even among biologists studying biodiversity, ecology and evolution, largely because of an unwarranted confidence in technological solutions, particularly nucleic acid sequencing, to replace manpower, well-curated collections of specimens and both theoretical and practical training in the fundamental discipline of taxonomy (Engel *et al.* 2021; Wheeler 2023). For this reason, the taxonomic impediment has increased and it has become more and more difficult to find competent referees for taxonomic papers, and the choice of a journal plays a growing role in the quality of the review process of a paper, hence in its final quality. [7.3.2] The recent burst of electronic publication in nomenclature poses particular problems which do not exist in other scientific domains, because of the need of permanency in the content and format of works introducing nomenclatural novelties in order for the latter to be validly promulgated. Unfortunately, the 2012 Amendment of the *Code* which allowed the electronic publication of such novelties contains a number of unclarities, ambiguities and shortsightedness that have been responsible for the publication of many nomenclatural mistakes in the last decade (Dubois *et al.* 2013, 2015*a–b*, 2022*c*; Dubois & Frétey 2023, 2024). For this reason, the

choice of the periodical is particularly important for taxonomic papers introducing new nomina and onomatergies, in order to be sure that the periodical respects this Amendment regarding immutable final version, pre- and postregistration, archiving, etc.

The REA paper is a textbook case illustrating the ideas above. It is a bundle of errors in both fields of taxonomy and nomenclature, and it would probably have avoided at least part of them if it had been submitted to a journal and editors having a 'professional' approach to taxonomic research and works. It could serve as a lesson for all taxonomists, inciting them to devote some attention to the achievements of the periodicals that they contemplate for their papers to avoid making the bad choices. Following the precept "Think, Check, Submit" should become a habit for taxonomic papers, particularly those erecting new taxa and establishing new nomina. For such papers, it is much more important to publish their findings and proposals in a 'professional' manner, even if it requires more work and takes more time, ensuring them a long life, than publishing them quickly after review by editors or referees incompetent in taxonomy—even if this may generate a 'buzz' for a while in 'social networks' if the new species described is spectacular.

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APPENDIX 1. The nomenclatural function of onymophoronts and the designation of missing specimens as lectotypes

While preparing this paper, some of our colleagues suggested that, rather than the missing specimen ONID Sm2, we should designate NRM Lin.9 as lectotype of *Boa murina* Linnaeus, 1758, on the ground that it is still extant in the Stockholm Museum and that it might be sequenced, which would call attention to the value of ancient museum collections. This case is reminiscent of that of the nomen *Elephas maximus* Linnaeus, 1758, analysed in detail by Dubois *et al.* (2014, 2015*a*: 17–18), in which the designation as lectotype of a syntype of doubtful origin had been chosen, mostly in order to promote the use of molecular techniques in nomenclature, in order to solve an 'imaginary' nomenclatural problem that could have been solved much more easily and completely through designation of a missing syntype of known origin.

In the present case however, a real nomenclatural problem exists, inasmuch as two different 'mitochondrial lineages' have been stated to exist in the species long known as *Eunectes murinus*. In the current state of knowledge, it is impossible to attach the latter nomen to either of these two 'lineages', because no morphological character is known to distinguish

them and none of the five identified syntypes is linked to a known origin or to molecular data. The nomenclatural status of this nominal species rests on four syntypes which are now missing and a fifth extant one whose status of syntype is uncertain, as its scale counts were not taken into account by Linnaeus (1758: 215) in the diagnosis of the species and as Linnaeus only reported it in 1764. Even if this status were confirmed and if mitochondrial sequences could be retrieved from it (which is highly conjectural), it would remain of unknown origin.

Given these facts, two questions may be asked: [1] what is the function of onymophoronts in taxonomy?, and [2] what do we expect, from a scientific point of view, from the designation of a lectotype for the nominal species *Boa murina*?

[1] The first question has been discussed in many publications already, and may be summarised as follows. Contrary to what was believed in the early days of taxonomy, the main function of so-called 'type specimens' is not to be 'typical' and to furnish the diagnostic characters of the taxon for which the nomen to which they were attached was coined, but 'just' to provide an objective connection between this nomen and this specimen, and through the latter with a natural population of animals. In other words, in the ostensional nomenclatural system of the *Code*, their function is to act as onymophoronts (nomen bearers), not as semaphoronts (character bearers) used for the definition of taxa—and this is why the ambiguous term 'type' is misleading to designate them. Of course, these specimens do bear characters, and often these characters are used to allocate these specimens to taxa, which may be useful, particularly when several species can occur in the locality where they had been collected, but both functions (definition of taxa and allocation of nomina to taxa) are distinct, the first one being taxonomic and the second one nomenclatural. The first function is often played by a series of specimens, the ***hypodigm*** (Simpson 1940), while the second one is played by the onymophoront(s). The latter is/are also part of the hypodigm, but play(s) a particular function that is not played by its other members such as paratypes, paralectotypes or 'other specimens' originally referred to the taxon.

As such, onymophoronts are not used to **define** taxa, i.e., to diagnose them and provide their coverage and limits (which they can of course **contribute** to do through their second function as members of the hypodigm), but to **name** them in an unambiguous manner. Onymophoronts may bear some of the diagnostic characters of the species, but may also well be devoid of any of them: this is the case for example for species recognised on the basis of behavioural, bioacoustics, cytogenetic or physiological characters, that cannot be observed in collection vouchers.

In modern taxonomy of good quality, descriptions of new species are not limited to that of their holotype (which they usually include), but also present data on morphology and sometimes internal anatomy, variation among specimens, morphometrical data, sex dimorphism, photographs, sound or video recordings, behaviour, chromosomes, etc., and of course molecular data. All these pieces of information are often provided through the careful study of series of specimens, in which the holotype may play a negligible part.

This was not the case for many species described and named in the 18th and even 19th centuries, which relied only on a few specimens to which only limited data were attached.

Ancient types play a crucial role in nomenclature, as they often allow an objective allocation of nomina to taxa, but their role often stops there: they do not provide much information on the taxa they designate. In fact, in these old works, their role is mostly to provide two pieces of information: they attach the nomen to a specimen and through it to a natural population of animals, which is the basis for the recognition and naming of a taxon. In the vast majority of cases, the original nomen-bearers of a nominal-species play fully their role: they allow the proper allocation of nomina to taxa, through their characters and the information attached to them, particularly their locality of origin, but in a few cases they provide ambiguous information or no such information at all. The present discussion is devoted to such cases.

The concept of type-locality (onymotope) is often misunderstood. Article 76 of the *Code* defines the 'type locality' as "the geographical (and, where relevant, stratographical) place of capture, collection or observation of the name-bearing type". It is therefore tightly linked to the concept of type specimen. Under a strict reading of the *Code*, no type-locality can be designated or 'restricted' arbitrarily, for example guessed from the known or assumed geographical distribution or frequency of a taxon, without being based on the origin (known, or deduced for example from the itinerary of its collector) of its onymophoront(s). Many so-called 'restrictions' of onymotopes not linked to specimens by taxonomists of the past are not *Code*-compliant and can be ignored by taxonomists today. This important point must be taken into account in this discussion.

In many cases, the original specimens which had been used to describe and name a taxon have been lost, or provide little

information because they are damaged, incomplete, etc. This does not remove their function of nomen-bearing specimens, but this often complicates the work of recent taxonomists, who face difficulties for the allocation of these specimens to the taxa recognised now with modern methods. Nomina relying on such onymophoronts thus often turn out to be *nomina dubia*, which some taxonomists (e.g., Dayrat 2005) consider to be major problems in zoological nomenclature. When the original specimens are lost, the *Code* allows their replacement, if this is necessary to establish the taxonomic allocation of a nomen, by a recently collected specimen designated as neotype. However, the *Code* specifies that a neotype can be designated only when all the original onymophoront(s) (holotype or syntypes) is/are now lost. In the absence of an action by the Commission under the plenary power, it is impossible for taxonomists to do it as long as at least one of them is still extant and accessible for study. In this case, if there was only a holotype, it remains the onymophoront of the species, but, if there were several syntypes, the *Code* allows to designate one of them as lectotype. Then, and this is very important, it does not oblige taxonomists to choose a syntype being still extant, if this complicates rather than simplifies the work of allocation of the nomen to the taxon. The procedure, described above in § 5.1, of the transitional designation of a missing lectotype for a nominal species, often allows for the nomenclatural problem to be solved much more satisfactorily than by the designation of an extant but poorly informative old specimen. It may be followed in a second step by the designation as neotype of a recently collected specimen that will permit a complete description, with photographs, measurements and other information, including molecular data, similar to modern descriptions of new species based on recent material. It therefore allows, so to speak, for the 'rejuvenation' of the onymophoront of the taxon, facilitating a much better taxonomic work than the original old specimen. In some cases, this may be viewed as a 'blessing' when it permits the disentanglement of a nomenclatural situation that had long been 'blocked'.

[2] Now, if we turn to *Eunectes murinus*, the situation is as follows. If we had chosen NRM Lin.9 as lectotype, the nomen would have been based on a specimen completely devoid of information on its origin, and whose morphology would not have allowed it to be associated with either of the two 'lineages' proposed in this taxon. If molecular data could be obtained from this specimen, it could possibly be allocated to one of these 'lineages', but that is all. This would not tell us where it came from and thus to identify a type-locality for this taxon. Worse still, if, as it is quite possible, the nucleic acids of this specimen were too degraded to allow its association with a 'lineage', this specimen would carry almost no useful taxonomic information on its origin and characters. This designation would then serve no function of clarification of the nomenclatural situation at all, but a major consequence of this designation would be that the onymophoront of this nominal species would not be lost, so that no better chosen neotype could be designated to replace it, except through an action of the Commission.

Now, let us compare this situation with that we chose. We designated as lectotype the only syntype that had a (very imprecise) origin, 'America', which is better than nothing, and a general morphology of *Eunectes murinus*, without more details. This designation removes the nomen-bearing function from all other syntypes, which become paralectotypes, including the extant specimen in Stockholm, which carries little information. Now, the specimen we chose being lost, this will allow taxonomists to designate a neotype, and for this complete freedom will exist to choose a specimen, agreeing with the (very imprecise) original description, but accompanied by various pieces of information: restricted type-locality, morphology and many other characters, but also mitochondrial sequences allowing to refer it to one of the two 'lineages'. Sequencing a recent specimen would in most cases be easier and more reliable than a 250-year old voucher, and this would allow to provide this species with a serious modern description.

This case has some generality. For very old nomina, in many cases the choice of an extant 'surviving' original syntype, without locality and with degraded DNA and RNA, as lectotype is much worse than that of a missing specimen, because it 'imprisons' taxonomists in this choice without bringing more clarity in the allocation of the nomen. Such a decision, which is irreversible by working taxonomists, 'freezes' the situation in an uncomfortable dead end from which sometimes only an action of the Commission will allow to escape, whereas the designation of a well-chosen missing specimen would have left the situation open. This latter decision may allow, in a second step, a clever choice of neotype, taking advantage of all the information that has been gathered on the taxonomic group involved, this choice allowing taxonomic clarity and unambiguity (e.g, through avoiding the designation of a specimen from a hybrid zone between two taxa) and stability. It will allow a type-locality for the taxon to be restricted and fixed objectively, so that topotypes may later be collected (if still present in the locality or its neighbourhood) for a more detailed study of the taxon.

Although these arguments and this procedure have been explained and applied since 1995, it is clear that taxonomists are still reluctant to implement it. Why? The main reason might be a kind of misguided 'respect' for old specimens, not because of the help they can bring to taxonomic research, but simply because they are old and had been studied, and sometimes collected, by famous zoologists of the past. To this, in the recent years, may have been added the idea that using techniques like molecular sequencing will help to promote taxonomy, an often underestimated and misunderstood science (Wheeler 2023), in showing that this discipline is 'modern' (see Dubois *et al.* 2014). Our point of view is different. We think that the real function of the study of type specimens is not to advertise the modernity of taxonomy or of collections, which should of course be done but by other approaches, but to facilitate the work of taxonomists in contributing efficiently to the resolution of taxonomic and nomenclatural problems. These specimens provide objective links between nomina, specimens and populations, thus avoiding arbitrary (and thus labile) taxonomic and nomenclatural decisions and, as far as possible, maintaining nomenclatural stability.

Zoological nomenclature can work smoothly and efficiently only if the rules of the *Code* and the decisions of the Commission, both of which may in some cases be considered questionable or inappropriate, are respected by all taxonomists. If they do not agree with them, they should apply to the Commission to ask for their being changed, but they should not ignore them deliberately, even if they are a numerous group. Otherwise, the risk of nomenclatural chaos, which would be detrimental to biology as a whole, would be great. Nevertheless, within the framework of the *Code*, they should make intelligent choices guided the concern for taxonomic quality and universality. The appropriate choice of lectotypes among syntypes is one of the situations in which good or bad decisions can be taken. It should be driven by the need to facilitate the nomenclatural work, not by external motivations like promotion of molecular sequencing or other modern techniques, or even of collections.

The undue and sometimes blind respect for old specimens amounts sometimes to their fetishisation. Taxonomists have full respect for the work of taxonomists of the past, which is shown, in particular, by their use of priority to establish the validity of nomina and nomenclatural acts, but they must face the fact that some old specimens are a nuisance for taxonomy when they are unrecognisable or when they provide incomplete information. In many cases, when holotypes or syntypes are all still extant but do not allow the situation to be clarified, there will be no other choice to solve a nomenclatural problem than to apply to the Commission, which may take a long time before the case is solved—if it indeed is solved. But in cases where the *Code* allows for the setting aside of useless or confusing onymophoronts through the designation of missing specimens as lectotypes, this unwarranted deference for 'historical' specimens may have negative consequences. Nomenclature is not history of science. In some cases, we will never know which species was indeed in the hands of an ancient author, but this should not paralyse us. Appropriate choices or other actions respecting the *Code* should allow us to remove the doubts and go forward.

The designation of missing specimens as lectotypes is not the final stage of the procedure described and supported here. It allows for the provisional stabilisation of an ambiguous situation, but the final stabilisation will require the designation of an appropriate specimen as neotype. In such cases, taxonomists should sometimes refrain the temptation to act quickly if no appropriate specimen is known to exist or to be accessible. This is the case here: we deliberately did not designate a neotype for *Boa murina* because we do not have access to a specimen appropriate for this choice. This should be done later by the first authors having such an access. When this is done, it will be time to apply to the Commission for suppression of the nomen *Boa scytale* and designation of *Boa murina* as type species of *Eunectes*, which requires first to have fixed an appropriate onymophoront for *Boa murina*.

Good and long-lasting taxonomic work sometimes requires patience rather than impatience or premature actions.