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The tale of the headless turtle

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Pelomedusoides is the most diverse clade of side-necked turtles and there is an extensive fossil record (de Broin, 1988; Lapparent de Broin, 2000; Gaffney *et al.*, 2006, 2011) that dates back at least to the Barremian (Lower Cretaceous) (Romano *et al.*, 2014). Its large fossil record evidences a greater diversity in the past, particularly at the end of the Mesozoic, and exhibits a good sampling of species that are represented by skull material (Gaffney *et al.*, 2006, 2011). As a consequence, the most complete and recent phylogenetic hypotheses for this clade (*e.g.* Romano *et al.*, 2014; Cadena, 2015) are based on matrices comprising a great amount of cranial characters derived largely from Gaffney *et al.* (2006, 2011). In addition, it is well established that shell characters show a lot of phenotypic plasticity, even in the fossil species (Romano, 2008; Gaffney *et al.*, 2006, 2011). In most cases it consequently is not justified to rely on “diagnostic features” of poorly informative shell-only material for describing a new species. Because of that, most authors remark new morphotypes in the literature when such aberrant specimens are recovered, but do not make any nomenclatural act by proposing a new yet poorly supported species (*e.g.* Romano *et al.*, 2013; Ferreira & Langer, 2013; Menegazzo *et al.*, 2015). Unfortunately, such a supposedly new bothremydid turtle (Pleurodira: Bothremydidae) from the Early Paleocene of Brazil was recently described based on poorly diagnostic remains (Carvalho *et al.*, 2016; hereafter CGB, for the authors initials) and a correction of this unfounded nomenclatural act is required. In addition I present some comments on shell only material from Brazil in order to guide splitter-taxonomists to stop describing poorly preserved fossil specimens as new species.

Describing a new species is a hypothesis accompanied by a nomenclatural act that influences the current taxonomy of a given group. The hierarchical nomenclature associated to a new species, meaning its generic allocation, should reflect the current taxonomy and not be arbitrary. Yet, CGB did not only describe a new species of bothremydid turtle based on a few fragmentary postcranial remains, but even erected a new genus for it: *Inaechelys pernambucensis*. Surprisingly, CGB ignored a recent report of an incomplete unnamed fossil bothremydid from the same strata, *i.e.*, the Maria Farinha Formation at Paraíba Basin (Oliveira *et al.*, 2015).

In the diagnosis for this new genus and species CGB state that it differs from *Rosasia soutoi* (p. 495) by a: (1) pentagonal shaped entoplastron, (2) straight contour of anterior lobe cranial margin, (3) abdominal shield midline notably smaller than the femoral shield midline, and (4) contact between plastron plates strongly serrated. All mentioned features are based on a single specimen, DGEO-CTG-UFPE 6174, an almost complete plastron associated with two dermal plates of the carapace. These specimens would consist on an ambiguo type (*i.e.*: “an inadequately described type”, see Evenhuis, 2008), since CGB failed to properly define the holotype because the type series seems to be represented by four separate materials (DGEO-CTG-UFPE 6171-6174) that could belong to different individuals. Of course, if the four separate materials represent the same individual, it should have received only one collection number. Moreover, CGB admit (on page 449) that the posterior part of the plastron has suffered diagenetic compression. Indeed, this specimen is apparently severely damaged and some of the sutures and scute scars are hard to identify. Having a closer look at these four supposedly diagnostic differences reveals the following:

(1) The posterior portion of the entoplastron of DGEO-CTG-UFPE 6174 has several cracks, which puts the “pentagonal” shape of the entoplastron likely to be a diagenetic artifact. The anterior portion of the entoplastron reveals the impression of a slight suture (Carvalho *et al.*, 2016, figure 4A), which would lead to the conclusion that the entoplastron has a diamond shape, as in most Pelomedusoides. The available evidence hardly justifies this interpretation as a reliable diagnostic trait.

(2) The supposed straight contour of the anterior lobe of the plastron appears to be a misinterpretation due to the fact that this part is broken (Carvalho *et al.*, 2016, figure 4A). The overall shape appears short, wide, and with a semicircular anterior outline, as it is the case in most Bothremydidae (Gaffney *et al.*, 2006). Moreover, interspecific variability on this character is observed in many side-necked turtle represented by several specimens. Also this character consequently fails to be justified as unambiguously diagnostic.

(3) CGB pointed that the abdominal scute (“shield”) midline is notably smaller than the femoral scute midline in specimen DGEO-CTG-UFPE 6174, if compared to *Rosasia soutoi*. The ratio of abdominal length/femoral length for this specimen is 0.63, whereas 0.95 for the partially restored plastron of *R. soutoi* figured by Gaffney *et al.* (2006, figure 261, p. 550). However, this ratio appears to be highly variable also within a species, including *R. soutoi* (ranging from 0,96 to 1,02; Adán Pérez-García, pers. comm.). Also, considering 14 topotypes of the fossil podocnemidid *Bauruemys elgans* (data from Romano & Azevedo, 2007 plus two additional specimens), the abdominal/femoral ratio ranges from 0.70 (specimen MN 6795-V; minimum observed) to 0.92 (PUC RCL 101; maximum observed), with an arithmetic mean of 0.82 (see supplementary information). Given such a huge variation in abdominal/femoral length ratio within a single population, the variation between specimens from different localities and with temporal hiatus can be expected to be greater. Therefore, using two plastral scutes proportions as a diagnostic feature is at best highly questionable to be considered to support a new species.

(4) Finally, the “contact between plastron plates strongly serrated” is also problematic. First, the plastron DGEO-CTG-UFPE 6174 is damaged and some sutures are difficult to interpret. Second, the fusion of shell plates in extant turtles is quite common (*e.g.* Rhodin & Mittermeier, 1977) and might be related to age and growth. This condition is also present in most bothremydids. However, such phenomena have not been studied in Bothremydidae due to the lack of ontogenetic series, but the diagnostic value remains questionable.

This sums up to two unreliable interpretations of a diagenetically altered fossil and two questionable interpretations of common shell variability. CGB then scored *Inaechelys pernambucensis* as a new terminal taxon in the matrix of Romano *et al.* (2014)—without actually listing it among the references. They completely ignored the revision of this dataset and the corrections made by Cadena (2015), which even though these modifications did not challenge the initial phylogenetic hypothesis proposed by Romano *et al.* (2014) should be considered. CGB claim that “...Our phylogenetic analysis results... support *Inaechelys pernambucensis* as a new species.” (p. 501). This circular argument is a major flaw in CGB's analysis: by adding *Inaechelys pernambucensis* as a terminal taxon to a species matrix it is already implied that it is a species. None of the subsequent analyses consequently can support it as a new species. Only specimen-based analyses can reveal whether a new specimen actually clusters within or without an already known species, which is represented by several specimens that may or may not bracket the new specimen or that may collapse with it in a polytomy. As used by CGB, the new specimen will always cluster in a false dichotomy with one of the pre-existing species, which may or may not be different from the new specimen.

Moreover, CGB state that “*Inaechelys* formed a monophyletic group with *Rosasia*, where both taxa share the secondary loss of character 164 (short anterior lobe).” (p. 500). CGB were able to score only 14 character states for *Inaechelys pernambucensis* using the character matrix of Romano *et al.* (2014), the remaining characters had to be treated as missing data. Characters 123 and 124 were scored with state 1 in *Inaechelys pernambucensis* and “?” in *Rosasia soutoi*. Characters 158-162, 164-167, 170, 172, and 174 are identical for both “species”.

It has been a problem in taxonomy for centuries of how to delimitate genera and it certainly is difficult to establish a satisfying concept for the genus (Lambertz & Perry, 2016), but there should be at least some context of justification whenever a new genus is erected. The descriptive data is at best ambiguous and the only difference that separates the new genus in the cladistic analysis rests on two questionmarks. According to Gaffney *et al.* (2006) and CGB, character 123 concerns the retroarticular process of the lower jaw, which seems dubious as being coded with 1 given that only postcranial remains are described. Similarly, character 124 refers to cervical ribs, which also are inaccessible for study. So, characters 123 and 124 should be coded as “?” for *Inaechelys pernambucensis* (as it is in *R. soutoi*). Character 158 refers to presence and morphology of mesoplastra. Although this bone is not present in DGEO-CTG-UFPE 6174, parts of its sutures with hyo and hypoplastra are. Thus, it can be scored, but not as state “1” (“present, wider than long”, as observed in *Rosasia*) as coded by CGB. The more appropriate coding would be treat as polymorphic for states 1 and 2 (“present, roughly equidimensional”) or as missing, because it is not possible to identify mesoplastra morphology. It is important to highlight, however, that the aforementioned changes on CGB matrix would not impact the phylogenetic reconstruction. All other character states were scored correctly by CGB based on DGEO-CTG-UFPE 6174 illustration. Thus, there is no evidence and it is logically inconsistent to suppose that *Inaechelys pernambucensis* should be treated as a new genus and a new species. Even so, given the identical character coding, which differs only by two or three unknown sates, it is the only possible solution in a parsimony based analysis to recover “*Inaechelys pernambucensis*” as sister to *Rosasia soutoi*, which as explained above does not tell us anything about the specific yet the generic identity. In other words, *Rosasia* and *Inaechelys* recovered as sister groups is merely a methodological artifact due to the inclusion of two logically identical terminals in the matrix.

Interesting, there is another Brazilian example of unnecessary phylogenetic analysis including shell-only material into a previously published morphological matrix (Menegazzo *et al.*, 2015). Their “Santo Anastácio Form” (specimen

URP RT-1) is also logically identical to other terminal in the matrix, “*Podocnemis*” *brasiliensis*; illustrating the same problem described above. Fortunately, they conclude that “Santo Anastácio Form” is “...possibly junior synonyms of “*P.*” *brasiliensis*...” (Menegazzo *et al.*, 2015, p. 26). On the other hand, their conclusion of *Cambaremys langertoni* being also a potential junior synonym of “*Podocnemis*” *brasiliensis* is inconsistent and, indeed, conflicting to the phylogenetic hypothesis they presented, on which *C. langertoni* is recovered as sister to *Portezueloemys patagonica*. Thus, it is better to consider *Cambaremys langertoni* as *nomen dubium* (Gaffney *et al.*, 2011) or junior synonym of *Roxochelys wanderleyi* (Romano *et al.*, 2013), since Menegazzo *et al.* (2015) presented a “frequency differences consensus tree” instead of a strict consensus topology.

In conclusion, until evidence to the contrary becomes available, the specimen described by CGB is considered congeneric with *Rosasia*. *Inaechelys* Carvalho, Ghilardi & Barreto, 2016 hence is considered a junior synonym of *Rosasia* Carrington da Costa, 1940. *Rosasia pernambucensis* (Carvalho, Ghilardi & Barreto, 2016) n. comb. is considered a *nomen dubium* given the lack of consistent diagnostic features. This synonymy should be considered with caution because it is based on the putative secondary loss of character 164 in *Rosasia* (“short anterior lobe”; see CGB, p. 500) and the same character scoring of “*Inaechelys*” and *Rosasia* in Gaffney *et al.* (2006) dataset. By taking into account this synonymy, it expands the chronological and geographical range of *Rosasia* from the Campanian-Maastrichtian (Upper Cretaceous) of Portugal to the Danian (Paleocene) of northeastern Brazil. The new record furthermore is not the first definite coastal pleurodire from Brazil. It is long known (*e.g.* Wood, 1984) that certain bothremydids (and other Pelomedusoides, such as Araripemydidae) inhabited more brackish and coastal environments. Such forms (as *Cearachelys* and *Atolchelys*) would be able to move around in shallow water and it is expected to find bothremydids in circum Tethyan and proto Atlantic faunas favored by continental shelves (see Wood, 1984). Indeed, Rabi & Sebök (2015) already identified episodic faunal links between Europe and Gondwana during Upper Cretaceous and CGB ignored this previous observations.

In summary, the reckless initiative of describing new fossil turtle species based on fragmentary shell material lacking heterobathmy of characters with its sister group, (as provided by autapomorphies) or, at least, a robust exclusive character combination should be avoided. Such practice adds little to the understanding of the evolutionary history of a given clade, but on the other hand increases taxonomic instability of the group by adding unnecessary synonyms to the game. Some species from the Upper Cretaceous of Brazil, such as *Apodichelys lucianoi*, *Roxochelys harrisi*, “*Podocnemis*” *brasiliensis*, and *Cambaremys langertoni* are examples of species based on incomplete shell-only specimens that are difficult to compare to other well established species and, therefore, are considered *incertae sedis* or *nomina dubia* (see Oliveira & Romano, 2007; Gaffney *et al.*, 2011; Romano *et al.*, 2013). Another recent synonym of *Araripemys arturi* was almost instantly and independently identified by Gaffney *et al.* (2006) and Oliveira & Keller (2007). Thus, even good descriptions of fragmentary new specimens, as presented by CGB, should avoid proposing new species unless well established autapomorphies can be identified. It cannot be expected that taxonomic work on extinct turtles can adhere to a similar standard as that of extant taxonomic work, leading to introduction of many missing data for some fossil species, but a good starting point would be checking the matrix before running searches for most parsimonious trees.

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Supplementary information

Bauruemys elegans abdominal length/femoral length ratios observed (see text for details): MN 4327-V (0.80), MN 6674-V (0.80), MN 6761-V (0.80), MN 6762-V (0.72), MN 6790-V (0.85), MN 6795-V (0.70), MN 6796-V (0.75), MN 6797-V (0.89), MN 6800-V (0.79), MN 6807-V (0.78), MN 7015-V (0.88), MN 7016-V (0.85), PUC RCL 101 (0.92), and PUC RCL 102 (0.90). Institutional abbreviations: MN - Vertebrate paleontology collection of the Museu Nacional, Universidade Federal do Rio de Janeiro; PUC RCL - Reptile paleontology collection of the Pontifícia Universidade Católica de Minas Gerais.

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