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Rafetus vietnamensis LE, LE, TRAN, PHAN, PHAN, TRAN, PHAM, NGUYEN, NONG, PHAN, DINH, TRUONG AND HA, 2010 — ANOTHER INVALID NAME FOR AN INVALID SPECIES OF SOFTSHELL TURTLE (REPTILIA: TESTUDINES: TRIONYCHIDAE)

Balázs Farkas,[1] Minh Duc Le,[2] and Truong Quang Nguyen[3]

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The description of *Rafetus vietnamensis* Le et al., 2010 is reviewed. As the name was based on the same type material as *Rafetus leloii* Ha, 2000, we declare *R. vietnamensis* an objective synonym of *R. leloii*. Simultaneously, no characteristics presented by Le et al. distinguish their *R. vietnamensis* from *Rafetus swinhoei* (Gray, 1873), which confirms our view that they constitute the same biological entity.

Keywords: nomenclature; taxonomy; morphology; *Rafetus vietnamensis*; *Rafetus leloii*; *Rafetus swinhoei*; Vietnam.

INTRODUCTION

Recently, Le et al. (2010) proposed the name *Rafetus vietnamensis* for Vietnamese softshell turtles described a decade earlier by one of the co-authors as *Rafetus leloii* Ha, 2000 — shown to be indistinguishable from *Rafetus swinhoei* (Gray, 1873) by Farkas and Webb (2003) and Le and Pritchard (2009). The work of Le et al. (2010) violates the provisions and recommendations of the International Code of Zoological Nomenclature (ICZN, 1999), hereafter termed the "Code," at several points, and is full of inconsistencies. In the present account we wish to pinpoint these shortcomings and declare *Rafetus vietnamensis* as invalid *per se*.

Institutional acronyms follow Sabaj Pérez (2010), with the addition of BLF (Balázs Farkas collection, Gyúró, Hungary) and CPNP (Cuc Phuong National Park collection, Nho Quan, Ninh Binh Province, Vietnam). In order to avoid any possible confusion we continue to use BMNH for the Natural History Museum (formerly British Museum [Natural History]), London, United Kingdom and RMNH for the Nederlands Centrum voor Biodiversiteit Naturalis (formerly Rijksmuseum van Natuurlijke Historie), Leiden, the Netherlands.

[1] Bercsényi u. 21, 2464 Gyúró, Hungary; e-mail: farkasbalazs@yahoo.com

[2] Faculty of Environmental Science, Hanoi University of Science, 334 Nguyen Trai, Hanoi, Vietnam; Centre for Natural Resources and Environmental Studies, Hanoi National University, 19 Le Thanh Tong, Hanoi, Vietnam; e-mail: minhl73@yahoo.com

[3] Institute of Ecology and Biological Resources, 18 Hoang Quoc Viet, Hanoi, Vietnam; current address: Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany; e-mail: nqt2@yahoo.com

NOMENCLATURAL CONSIDERATIONS

According to the Principle of Priority (ICZN, 1999: Art. 23), "the valid name of a taxon is the oldest available name applied to it." As argued by Farkas and Webb (2003), Ha's (2000) description of *Rafetus leloii* meets the minimum requirements of the Code by fixing a name-bearing type (ICZN, 1999: Art. 16.4) and providing a brief, albeit defective diagnosis (ICZN, 1999: Art. 13.1.1), thus the name *R. leloii* Ha, 2000 is to be considered nomenclaturally available and in no need of replacement.

According to the Principle of Typification (ICZN, 1999: Art. 61), "the fixation of the name-bearing type of a nominal taxon provides the objective standard of reference for the application of the name it bears." Since *R. leloii* and *R. vietnamensis* share the same type series (and referred specimens), they clearly represent the same biological entity. "If an author proposes a new species-group name expressly as a replacement (...) for an earlier available one, then the two names are objective synonyms; both the nominal taxa they denote have the same name-bearing type despite any simultaneous re-

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striction or application of the new replacement name (...) to particular specimens" (ICZN, 1999: Art. 72.7). By selecting the "allotype" of *R. leloii* as the holotype of *R. vietnamensis*, and relegating the holotype of *R. leloii* to the status of a referred specimen of *R. vietnamensis*, Le et al. (2010: 950) — intentionally or unintentionally — emphasize that they believe their *R. vietnamensis* to constitute a new, distinct taxon. However, this "suggestion" is later contradicted by their own statement that "data from all different specimens from Hanoi, Thanh Hoa and Hoa Binh, representative for Red River (Song Hong), Ma River (Song Ma) and Da River (Song Da), respectively, are the same (and) the giant freshwater soft-shelled turtles found in Northern Vietnam are identical and unique" (Le et al., 2010: 953; see also our discussion of specimen NMW 30911 under *Molecular results*). By employing the abbreviation "sp. nov.," Le et al. (2010: 950) again corroborate their intention to name a new species rather than to propose a replacement name (*nomen novum*) (ICZN, 1999: Rec. 16A). On the other hand, they remark (Le et al., 2010: 953) that "the most reasonable scientific name (...) is *Rafetus vietnamensis*," the name *R. leloii* (mis-spelled as "*R. leleoii*") being "more related to the Sword Legend of Hoan Kiem Lake written by Le Loi rather than taxonomy," and as such infringe another principle of the Code, which expressly states that "the availability of a name is not affected by inappropriateness" (ICZN, 1999: Art. 18).

On a side note, Le et al. (2010: 950) indicate *Rafetus leloii* Ha, 2000 as the type species of the genus *Rafetus*, but also list *Rafetus hoankiemensis* "VIR (an abbreviation of the newspaper Vietnam Investment Review), 2000," a *nomen nudum*, and *Rafetus vietnamensis* "sp. nov." under the same heading. The actual type species of *Rafetus* Gray, 1864 is *Testudo euphratica* Daudin, 1802 by monotypy (Gray, 1864: 81).

Making matters worse, the family name Trionychidae is mis-spelled twice, first as "Tryonychidae" (Le et al., 2010: 950), later as "Tryonichidae" (p. 952, caption to Fig. 5).

DIAGNOSTIC CHARACTERISTICS

According to Le et al. (2010: 950), members of the genus *Rafetus* differ "significantly from all the described genera in (...) body size, living conditions, appearance, skull morphology and DNA sequence." As universally accepted, the genus *Rafetus* contains two living species, *R. euphraticus* and *R. swinhoei* (Meylan, 1987; Fritz and Havaš, 2007; Turtle Taxonomy Working Group, 2007, 2009; Rhodin et al., 2008). *Rafetus euphraticus* is known to reach a total carapace length of "only" 680 mm (Taskavak, 1998), and as such is clearly surpassed in size by (most) members of the genera *Amyda*, *Chitra*, *Nilssonia sensu* Praschag et al. (2007), *Pelochelys* and *Trionyx* (for a full overview see Pritchard [2001]). For *R. swinhoei* — taking only Chinese specimens into account — the largest shell on record measures 860 mm (Le and Pritchard, 2009). However, with a maximal (curvature) carapace length of 1095 mm (Ha, 2000), the specimen in the Hoa Binh Museum — the paratype of *Rafetus leloii* Ha, 2000 — is still in the same range as *Chitra* and *Pelochelys* species (1000 – 1220 mm; cf. Pritchard, 2001). All other known specimens of "*R. vietnamensis*" are smaller (Le and Pritchard, 2009; as *R. swinhoei*).

Admittedly, urban lakes such as Ho Hoan Kiem are not typical habitats for any species of softshell turtle. However, an adult *Amyda cartilaginea* was recently recovered from the same waterbody (T. Q. Nguyen, personal observation), and this species is often kept in temple ponds and other artificial environments throughout Southeast Asia. Additional habitat types frequented by *R. vietnamensis* include rivers and swamps — also not highly unusual for a trionychid.

The differences in external and skull morphology are indisputable — unfortunately, Le et al. (2010) waste no space on commenting upon them. In addition, the most easily observed diagnostic features of the genus *Rafetus* — reduced eighth pleurals and maximum two plastral callosities — are not mentioned by Le et al. (2010). The conclusions of their DNA analysis will be discussed under *Molecular results*.

MORPHOLOGICAL DESCRIPTION

Although Le et al. (2010: 950) designate the skeleton exhibited in Hung Ky Pagoda (a branch of the Hanoi Museum), Hanoi (the abbreviation "HK1" used by the authors is not an effective registration number; Ha [2000] attributed "RHK 02-1968" to the same specimen) as the holotype of *Rafetus vietnamensis*, they provide no actual description of this individual. It is illustrated in a small dorsal view photograph and a diagrammatic line drawing based on the same picture only (p. 951, Fig. 1). Neither figure shows any of the "somewhat bizarre errors" in the placement of certain bones mentioned by Pritchard (2001) and Le and Pritchard (2009), and seen in our Figure 1, which strongly suggests that the illustrations are corrupted. The apparent "suture" on the left seventh pleural must be an artifact of preservation (Fig. 4A). In any case, Le et al. (2010) stress that this

Fig. 1. Incorrectly assembled skeleton of a large female softshell turtle from Hoan Kiem Lake, Hanoi, exhibited in Hung Ky pagoda, Hanoi, the holotype of *Rafetus vietnamensis* Le et al., 2010. Photo by T. Q. Nguyen.

Fig. 2. Large stuffed softshell turtle originating from Hoan Kiem Lake and put on public display in Ngoc Son temple, Hanoi, the holotype of *Rafetus leloii* Ha, 2000. Photo by T. Ziegler.

skeleton "is the most representative for all specimens because of its completeness." The only "morphological parameters" given by the authors (p. 951, caption to Fig. 1) are bony disk size (580 × 640 mm), skull size (150 × 236 mm) and total skeleton length (1686 mm). For the same specimen Ha (2000) furnished the following measurements: 545 mm bony disk length, 510 mm bony disk width, 236 mm maximal skull length, 150 mm maximal skull width, and 160 mm basicranial length. Pritchard (2001) estimated the bony carapace length as about 600 mm (repeated in Le and Pritchard, 2009), whereas Farkas and Webb (2003), on the basis of a metric scale included in Ha's (2000) dorsal view photograph, calculated a skull width of approximately 160 mm. Otherwise, Le et al. (2010) provide only estimations based on this and two other individuals — referred to by the abbreviations "NS1" for the stuffed adult specimen from Hoan Kiem Lake exhibited in Ngoc Son Temple, Hanoi, the holotype of *Rafetus leloii* ("RHK 01-1967" of Ha [2000]; see Fig. 2) and "QL1" for another mounted adult specimen from Quynh Lam Swamp near the city of Hoa Binh on display at the Hoa Binh Museum, the paratype of *R. leloii* ("RHK 03–1993" of Ha [2000]; the extracted skull is illustrated by Le et al. [2010: 951, Fig. 3D] but its domicile remains unknown) — , which are also inconsistent within their "description": 1500 – 2000 mm total body length and 170 – 220 kg body weight (p. 950) vs. 1700 – 2000 mm total body length and 120 – 220 kg weight (p. 951), respectively. As Pritchard (2001) gives bony disk lengths of circa 635 mm for the same duo of stuffed specimens (for discrepancies in measurements reported by various authors see Farkas and Webb [2003: 109]), their "total body length" must be well under 2000 mm.

Neither the diagnosis, nor the description mentions any specific morphological characteristic distinguishing *R. vietnamensis* from *R. swinhoei*. The only clue given by Le et al. (2010) is the size of the head, which in *R. vietnamensis* "is significantly larger and the snout is less protruded than that of *Pelochelys bibroni* and *R. swinhoei*." No comparative material or referred literature is listed, and the statement is not backed by hard data. The genera *Pelochelys* and *Rafetus* are known to differ markedly in a number of features (e.g., Meylan, 1987; Farkas and Fritz, 1998; Pritchard, 2001; Nguyen et al., 2007), but "head size" is not an easy to quantify characteristic. Although reference material of matching dimensions is apparently non-existent in museum collections and the available data are practically incomparable, skulls of *Pelochelys cantorii* we have been able to personally examine were, indeed, flatter and narrower relative to bony disk length than any *Rafetus* skull, and had a much wider postorbital bar relative to orbit diameter. On the other hand, while skull width relative to basicranial/skull length is extremely variable within each (purported) taxon, as a whole it is not appreciably different between *Pelochelys bibroni*, *P. cantorii*, *R. swinhoei*, and/or *R. vietnamensis* (Table 1).

To illustrate their point, Le et al. (2010: Fig. 3) present a set of skulls of Chinese and Vietnamese *Rafetus* in small color photographs. Even though the Shanghai specimen (Fig. 3A) is not identified in the caption it is most probably the holotype of *R. swinhoei* (BMNH 1947.3.6.13), shown by Nguyen et al. (2007) to be essentially indistinguishable from IEBR NQT85 collected at Bang Ta, Ha Tay (now Hanoi) (our Fig. 3A). Another skull originating from Quang Phu, Thanh Hoa Province and deposited at the Institute of Biotechnology, Hanoi (our Fig. 3B) is even more similar to BMNH

Fig. 3. Dorsal, ventral, and lateral aspects of Vietnamese *Rafetus* skulls collected at Bang Ta, Ba Vi, Hanoi (IEBR NQT85; A) and Quang Phu, Thanh Hoa Province (Institute of Biotechnology, Hanoi; B). Not to scale. Note that the maxillae are completely separated by the vomer in A, whereas they are in contact in B. Photos by T. Q. Nguyen.

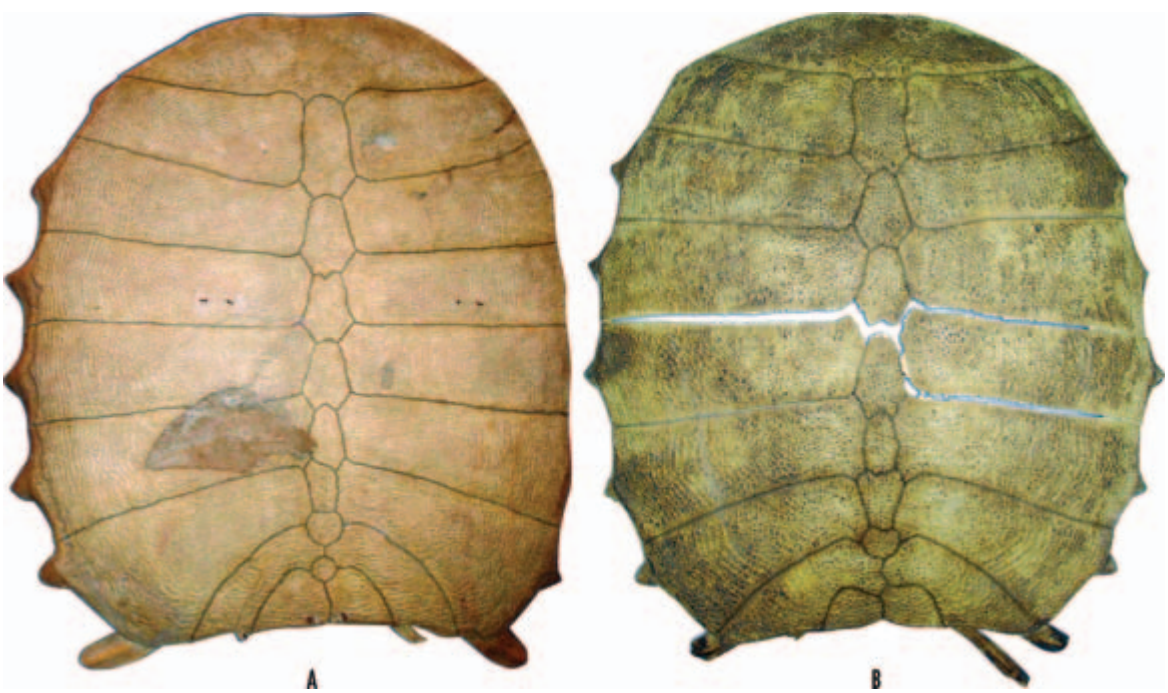

Fig. 4. Bony disks of the holotype of *Rafetus vietnamensis* Le et al., 2010 (A) and VNUH T91 (Ma River, Thanh Hoa Province; B) with sutures digitally enhanced. The apparent suture on the left seventh pleural of A is probably an artifact of preservation. Not to scale. Photos by T. Q. Nguyen.

1947.3.6.13, except that it is much larger. The fact that the maxillae are in partial contact along the midline in this specimen whereas they are entirely separated by the vomer in the type of *R. swinhoei* is an intraspecific variation well-documented in the related *R. euphraticus* (Farkas and Fritz, 1998; Taskavak, 1999).

Other generalized (trionychid) features of *R. vietnamensis* mentioned by Le et al. (2010: 951) are a head "situated on a long neck with a heavy double hole proboscis nose," and "a wide and blunt" skull "with blunt curved maxillary arches." Their Fig. 3 of partial skulls was also meant to illustrate that "these turtles cannot retract their head back into the carapace. "

Our Fig. 4 shows some noteworthy albeit not exceptional variations in carapace morphology within Vietnamese *Rafetus*, such as the presence of an isolated eighth neural in the holotype of *R. vietnamensis* (A; counting the fused first and second neurals as two elements in conformity with Meylan [1987]). The reduced eighth pleurals are diagnostic for members of the genus *Rafetus*. Reversal in neural orientation occurs consequently at neural 6, whereas pleurals 7 and 8 meet along the midline in both specimens.

Other "morphological characteristics" of *Rafetus vietnamensis* are a "low profile shell with an elongated shape that is covered by the leathery skin resulting in a flap like appearance" and an immaculate gray-green "skin color (...) on the upper side (...) without any texture" and an "always pinkish (...) skin color (on) the under side" (Le et al., 2010: 950 – 951). While individual color pattern variation is poorly documented in *R. swinhoei*, it appears that the bright yellow head and carapace markings of juveniles gradually turn into variegations and the carapace pattern fades entirely in senile

TABLE 1. Selective Measurements (in mm) of *Pelochelys* and *Rafetus* Species for Comparison

Species	Collection	Basicranial length (BL)	Skull length (SL)	Skull width (SW)	BL/SW	SL/SW	Bony disk length (DL)	DL/SW
Pelochelys bibroni	AMS 3425 and 131315[1]	133	178	106	1.25	1.68	420	3.16
Pelochelys bibroni	LSUMZ 44755[2]	~130	~164	97	1.34	1.69	—	—
Pelochelys bibroni	USNM 231523[3]	119	147	94	1.27	1.56	—	—
Pelochelys cantorii	BLF 1059	111	140	83	1.34	1.69	410	4.94
Pelochelys cantorii	BLF 1105	107	~137	88	1.22	~1.56	363	4.13
Pelochelys cantorii	CPNP unnumbered	—	123	75	—	1.69	355	4.73
Pelochelys cantorii	HNUE 0901	—	143	82	—	1.74	—	—
Pelochelys cantorii	NMB 183	57	75	41	1.39	1.83	194	4.73
Pelochelys cantorii	RMNH.RENA 21839	75	94	59	1.27	1.59	—	—
Pelochelys cantorii	RMNH.RENA 40248	113	142	89	1.27	1.60	—	—
Rafetus swinhoei	BMNH 1946.1.22.9 and 1947.3.6.13[3]	92	113	68	1.35	1.66	195	2.87
Rafetus swinhoei	Fudan University[4]	—	—	127[5]	—	—	500	3.93
Rafetus swinhoei	GQH unnumbered[6]	—	—	140[7]	—	—	563	4.02
Rafetus swinhoei	KTZ unnumbered[8]	160	213	123	1.30	1.73	—	—
Rafetus swinhoei	Holotype of *Pelochelys taihuensis*[9]	—	~185	112	—	1.65	—	—
Rafetus "*vietnamensis*"	Hoa Binh Museum	—	250	170	—	1.47	633	3.72
Rafetus "*vietnamensis*"	Hung Ky Pagoda	—	233	169	—	1.38	545	3.22
Rafetus "*vietnamensis*"	HNUE unnumbered	—	230	141	—	1.63	446[10]	3.16
Rafetus "*vietnamensis*"	IEBR NQT85	—	217	108	—	2.01	—	—

[1] Neotype of *Pelochelys bibroni* (Owen, 1853), mounted specimen with skull extracted, both bearing a different registration number, data from Webb (1995).
[2] Data from Webb (1995).
[3] Holotype of *Rafetus swinhoei* (Gray, 1873), fluid-preserved specimen with skull extracted, both bearing a different registration number; measurements taken from photographs as the skull is presently unavailable for study.
[4] Register number unknown, data from Le and Pritchard (2009).
[5] Head width of mounted specimen.
[6] Personal collection of G. Q. Huang, Suzhou, China, data from Le and Pritchard (2009).
[7] Head width of mounted specimen.
[8] Personal collection of K. T. Zhao, Suzhou, China, data from Le and Pritchard (2009).
[9] Unlocated, data from Zhang (1984).
[10] According to personal communications with K. Tran and N. N. Le, Hanoi, this skull and the carapace VNUH T91 probably derive from the same specimen.

specimens (Pritchard, 2001; Farkas and Webb, 2003; our Fig. 5). The plastron coloration may undergo similar ontogenetic changes: the irregular dusky markings of juveniles (Farkas, 1992; Vetter and van Dijk, 2006) disappear with age, and the venter becomes uniformly pinkish or yellowish. An age-related alteration/loss of pattern is widespread among trionychids.

MOLECULAR RESULTS

Based on their molecular analysis, Le et al. (2010: 953) conclude that "the giant freshwater soft-shelled turtles found in Northern Vietnam are identical and unique," but are at the same time distinct from the specimen housed in the Naturhistorisches Museum Wien, Austria (NMW 30911), which they identify as *R. swinhoei*. However, this section contains a number of issues that require further clarification. Le et al. (2010) do not provide full details of standard procedures employed in their study. For example, information on extraction protocols, primers and PCR conditions is not available anywhere in the paper, making it difficult to verify the results. Methods used for phylogenetic analysis are also not specified. More importantly, sequences of specimen NMW 30911 were never released and/or uploaded to GenBank. Subsequent repeated contact to the senior author, Le Tran Binh, to obtain these sequences remained unsuccessful. It is therefore impossible for us to confirm the authenticity of the data. We currently investigate this problem by sequencing DNA from the same sample.

It is also crucial to emphasize potential errors of molecular analyses performed by Le et al. (2010). Specimen NMW 30911 originated from northern Vietnam, though not collected by Gray, as stated by Le et al. (2010: 953). This specimen, rediscovered and described by Farkas (1992), shows no significant morphological divergence compared with other specimens of *R. swinhoei*. Yet, using molecular data, Le et al. (2010) show that it is closely related to the genus *Pelodiscus* of the clade *Amydona sensu* Engstrom et al. (2004), while other samples collected in the same geographic range are placed with *Rafetus euphraticus* of the clade *Apalonina sensu* Engstrom et al. (2004). This arrangement, which renders the genus *Rafetus* paraphyletic, is unlikely given the previous results strongly supporting its monophyly (Le and Pritchard, 2009). In addition to defects identified by Le and Pritchard (2009) regarding cytb and ND4 (NADH4) sequences uploaded to the EMBL database, we found other inconsistencies in the study of Le et al. (2010). While their Fig. 4 consists of a sole map that depicts the number of records and localities of "giant freshwater soft-shelled turtles in Vietnam," Le et al. (2010: 952) refer to Figs. 4A – C for corroborating their phylogenetic conclusions derived from 16S, cytb, and ND4. Furthermore, although only two 16S sequences are indicated in the paper under accession numbers AJ607405 and AJ607406 (note that all accession numbers mentioned by Le et al. pertain to nucleotide sequences labeled "Vietnamese freshwater turtles" that are not closer identified to genus or species in the EMBL database), their cladogram (p. 952, Fig. 5) based solely on data from 16S sequences depicts three terminals for Vietnamese *Rafetus*. In the same tree *Amyda* clusters with *Aspideretes*, *Nilssonia*, *Dogania*, and *Palea* (according to Praschag et al. [2007] *Nilssonia* actually includes *Aspideretes* spp.), but *Apalone ferox* is widely separated from *Apalone mutica* and *Apalone spinifera* (abbreviated as "*A. spiri*," with "*As. emoti*" [= *A. spinifera emoryi*?] constituting an independent entry) and the strong *Apalone – Rafetus* association supported by both Meylan (1987; his subtribe *Apalonina*) on morphological, and Engstrom et al. (2004; their clade *Apalonina*) as well as Le and Pritchard (2009) on molecular grounds is entirely lost. No bootstrap values are given and the authors' motivation for selecting *Caiman crocodilus* (mis-spelled as "*Caman crocodiulus*" in the bottom of p. 952) as an outgroup (together with *Carettochelys insculpta*) remains unexplained.

CONCLUSIONS

Le et al. (2010) have caused considerable confusion with their description of *Rafetus vietnamensis*, in which taxonomic information is incomplete, irrelevant or defective, and hard data are either lacking or wrongly interpreted. As the names *Rafetus vietnamensis* and *Rafetus leloii* unambiguously refer to the same biological entity, we declare *R. vietnamensis* an objective synonym of *Rafetus leloii*. Since Le et al. (2010) have not come forward with any new evidence to warrant the recognition of *R. leloii*, we conclude (again) that it is a subjective synonym of *Rafetus swinhoei*. Further study is needed to confirm the differentiation of the various populations within the species' range. To this end, comparison between Vietnamese and Chinese samples of *R. swinhoei* is particularly important.

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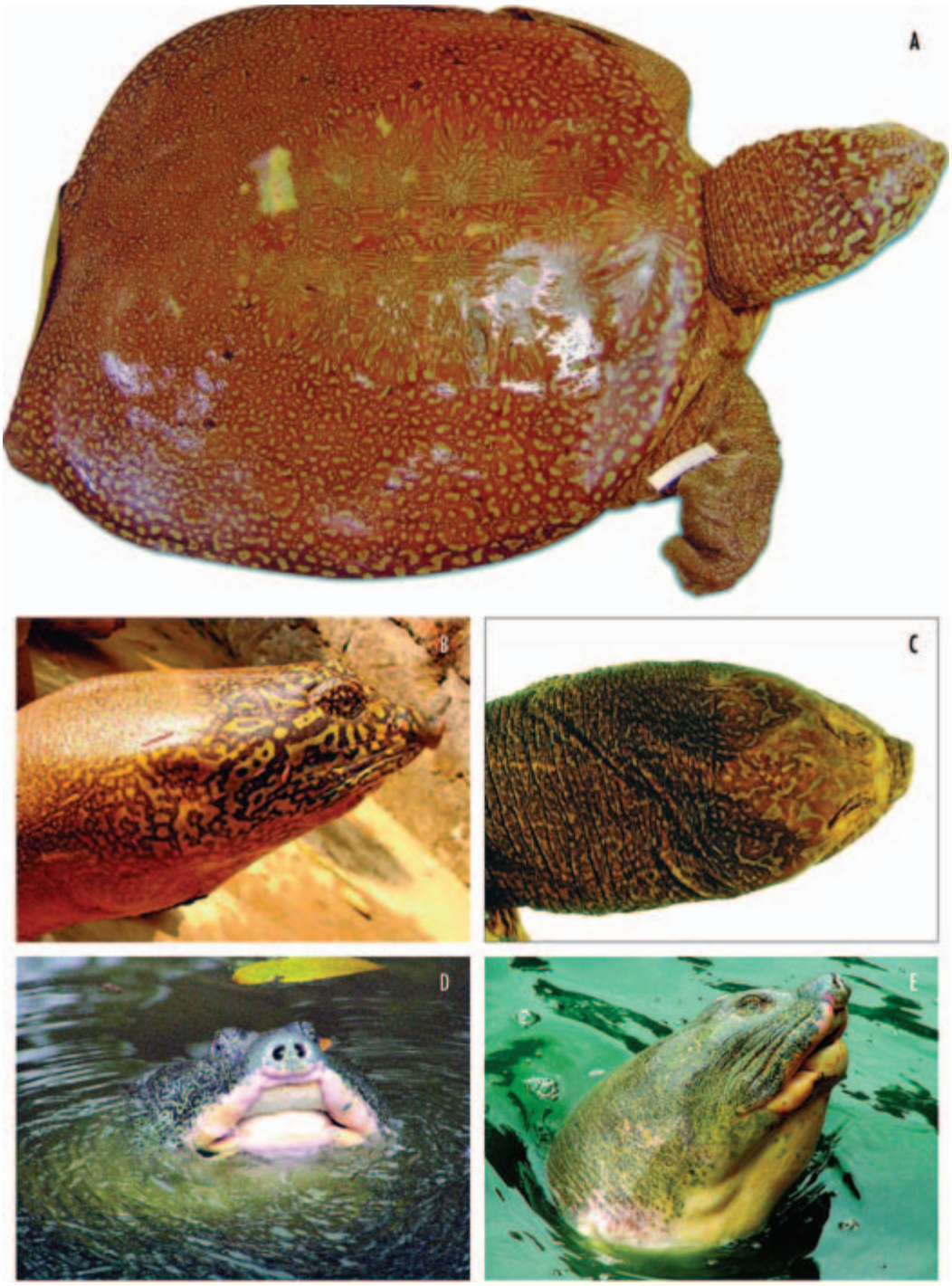

Fig. 5. Ontogenetic changes in head pattern of *Rafetus swinhoei*: A, holotype of *Oscaria swinhoei* Gray, 1873 obtained in Shanghai, China (BMNH 1946.1.22.9; photo by L. H. S. Nguyen); B, specimen caught at Dong Mo, Son Tay, Hanoi, Vietnam (photo by T. McCormack); C, specimen of unknown source believed by Niekisch et al. (1997) to have originated from Vietnam (ZMB 36437; photo by F. Höhler, courtesy U. Fritz); D, adult formerly in the Shanghai Zoo, purportedly from Gejiu, Yunnan, China (cf. Zhao and Adler, 1993; Le et al. [2010: 953] state that this individual was "reported to be collected from the riverhead area of Red River of Vietnam" and wrongly attribute locality information to Meylan [1987]; photo by J. Thorbjarnarson, courtesy G. Schipper); E, very large adult photographed in Hoan Kiem Lake (photo by T. Q. Nguyen collection). Not to scale. Note the gradual transformation of intense yellow blotches first to a marbled pattern and later to black vermiculations on a light ground.

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