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Short communication

A potentially diverse fauna of springtail-hunting scydmaenines during the late Mesozoic (Coleoptera, Staphylinidae, Scydmaeninae)

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ABSTRACT

The extinct ant-like stone beetle genus *Cascomastigus* Yin & Cai was recently established to accommodate *C. monstrabilis* Yin & Cai from the mid-Cretaceous Burmese amber. This species developed a highly specialized antennal 'setal trap', and was hypothesized to enroll these into predation on fast-moving preys, particularly springtails. However, only a single species of *Cascomastigus* has been known so far, and the paleodiversity of this peculiar group remains underexplored. Here we described another species, *Cascomastigus minor* Yin, Cai and Huang sp. nov., also from Burmese amber. The new species is distinctly smaller than *C. monstrabilis*, and may be further separated by the relatively longer antennomeres III, and much stouter maxillary palpomeres IV. Our new find highlights the paleodiversity of the genus *Cascomastigus* during the late Mesozoic.

1. Introduction

Extensive explorations of mid-Cretaceous Burmese amber (Burmite) have opened a vivid window into the late Mesozoic, and have yielded a rich beetle fauna, particularly those belonging to the family Staphylinidae (Ross, 2017). Recent continuous discoveries of major lineages of Scydmaeninae (a subfamily of Staphylinidae) in Burmese amber unveiled a long morphological stasis, and an early, pre-Cenomanian radiation of the group (Cai and Huang, 2016; Jałoszyński and Peris, 2016; Jałoszyński et al., 2016, 2017a,b; Yin et al., 2017a,b, 2018), and by discoveries of stem scydmaenines with associated morphological specializations, it was possible to recover their specific ecological adaptations.

The recently described genus *Cascomastigus* Yin and Cai, 2017 (in: Yin et al., 2017a) was proposed to hold a single extinct species, *C. monstrabilis* Yin and Cai, 2017, based on two specimens entombed in Myanmar amber (Yin et al., 2017a). The beetle possesses exaggerate thick and long bristles arranged in two longitudinal rows on the antennal scapes and pedicels, which were hypothesized to function as a 'setal trap' when the pedicels are bent ventrally. These structures are perfectly analogous to those of modern *Loricera* carabid beetles. Since members of *Loricera* mainly feed on springtails and trap them by using the bristles-armed antennae (Hintzpeter & Bauer, 1986), it is very likely that the similar trap in *Cascomastigus* was used for a same purpose. Specimens like *Cascomastigus* that can be used to interpret particular predator-prey relationships are extremely rare, and lack of such material also hampers our estimation of the paleodiversity of these groups. In this paper, we report the discovery of another species of the genus *Cascomastigus* with similar antennal structures from Burmese amber, which suggests *Cascomastigus* may represent a thrived and widespread linage of the Scydmaeninae in tropical forests during the mid-Cretaceous.

2. Material and methods

The amber piece containing the holotype was obtained from the Hukawng Valley in northern Myanmar (Fig. 1). The age of Burmese amber has been established as earliest Cenomanian (98.79 ± 0.62 Ma) based on recent U-Pb dating of zircons (Shi et al., 2012), which

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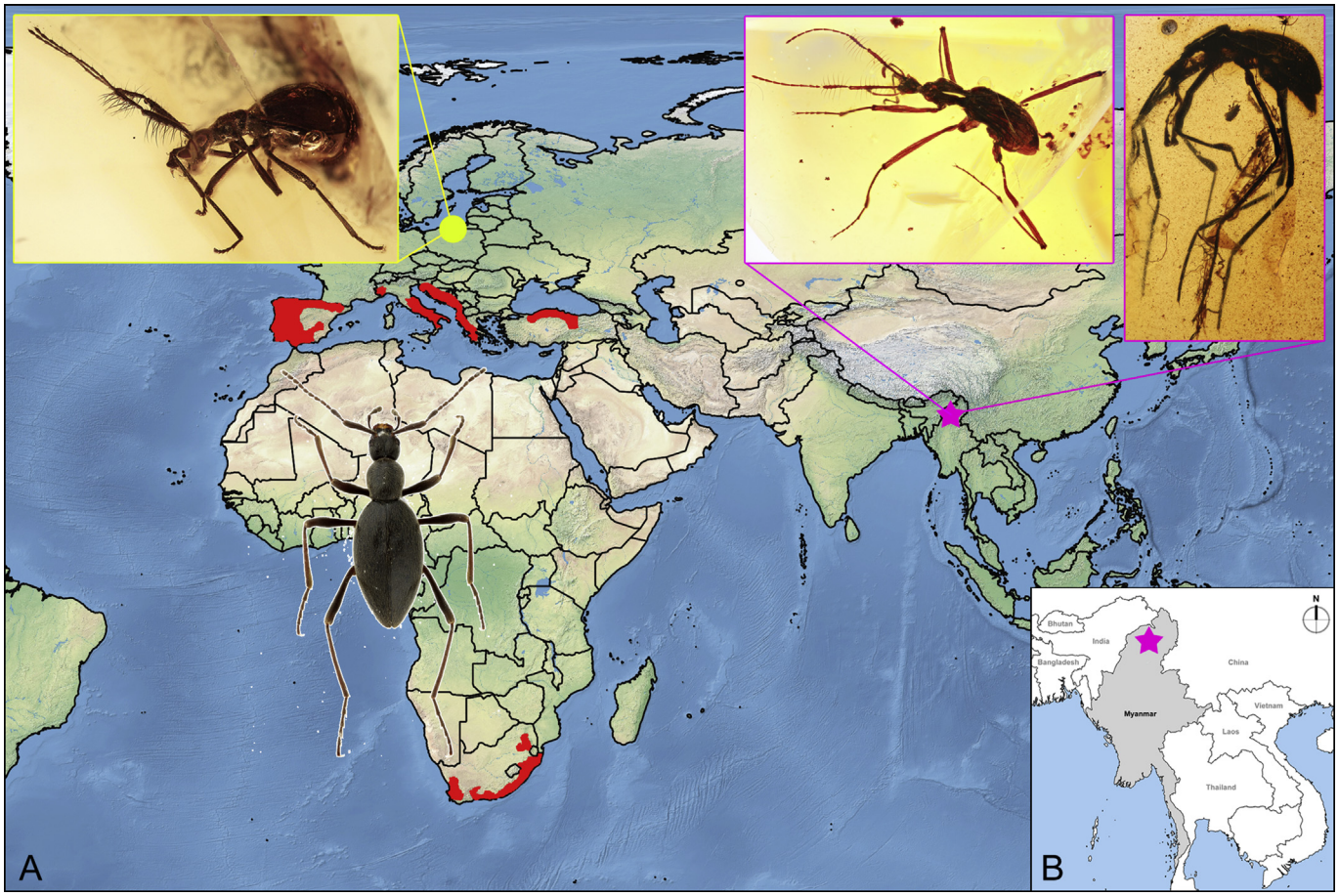

Fig. 1. A. Distribution of extinct and modern Mastigini. Distribution of Recent Mastigini is highlighted in red. Fossil localities of Mastigini are indicated in yellow circle for *Baltostigus* (Baltic amber), and in pink star for *Cascomastigus* (Burmese amber). B. Location (pink star) of the Burmese amber deposit in the present-day Myanmar. The base map was obtained from. http://www.simplemappr.net, an on-line tool for creating maps that can be freely used for publications and presentations (Shorthouse, 2010). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article).

corresponds with a general age predicted by Grimaldi et al. (2002) and Smith and Ross (2018) based on key bioinclusions. However, other workers have argued for slightly older ages, albeit at times on less than solid reasoning, either within the late Albian (Cruickshank and Ko, 2003; Ross et al., 2010), or right at the Albian-Cenomanian boundary (Rasnitsyn et al., 2016). The holotype (NIGP167912; Fig. 2A) and one unsexed specimen of *Cascomastigus monstrabilis* (NIGP167913; Fig. 2D) used for comparative purposes are housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China (NIGP). The amber containing the holotype was cut using a handheld engraving tool with a diamond blade, and polished using sandpapers of different grits and rare earth polishing powder.

All images were made using a Canon 5D Mark III camera with a Canon MP-E 65 mm macro lens or a Canon G9 camera mounted on an Olympus CX31 microscope. Zerene Stacker Ver. 1.04 was used for image stacking. All images were modified and grouped in Adobe Photoshop CS5 Extended.

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3. Systematic palaeontology

Order Coleoptera Linnaeus, 1758
Family Staphylinidae Latreille, 1802
Subfamily Scydmaeninae Leach, 1815
Supertribe Mastigitae Fleming, 1821
Tribe Mastigini Fleming, 1821

Genus *Cascomastigus* Yin and Cai, 2017 (in: Yin et al., 2017a)

Cascomastigus minor Yin, Cai and Huang, sp. nov.
urn:lsid:zoobank.org:act:B599B5D9-25B3-4A0C-A454-193FE8DEE4AD

Etymology. The specific epithet '*minor*' refers to the small body size of the new species.
Type material. Holotype, NIGP167912; a complete adult preserved in a semi-transparent piece of amber, sex undetermined (housed in NIGP).
Type locality and horizon. Hukawng Valley (26°21′33.41″N, 96°43′11.88″E), Kachin State, northern Myanmar (Fig. 1); lowermost Cenomanian (98.79 ± 0.62 Ma), Upper Cretaceous (but also possibly of older age after recent discoveries, see 'Material & methods' above).
Description. Body (Fig. 2A) elongate and uniformly darkish reddish-brown, including vestiture; body length 4.0 mm. Length of head from anterior margin of clypeus to base of occipital constriction 0.68 mm; occipital constriction deep and distinct, postocular margins narrowing posteriorly, more than twice as long as compound eye diameter; compound eyes prominent, slightly oval and convex, vertex slightly impressed; frons in lateral view forms a distinctly obtuse angle with vertical plane, its posterior margin delimited by antennal sockets, median part of frons slightly impressed and

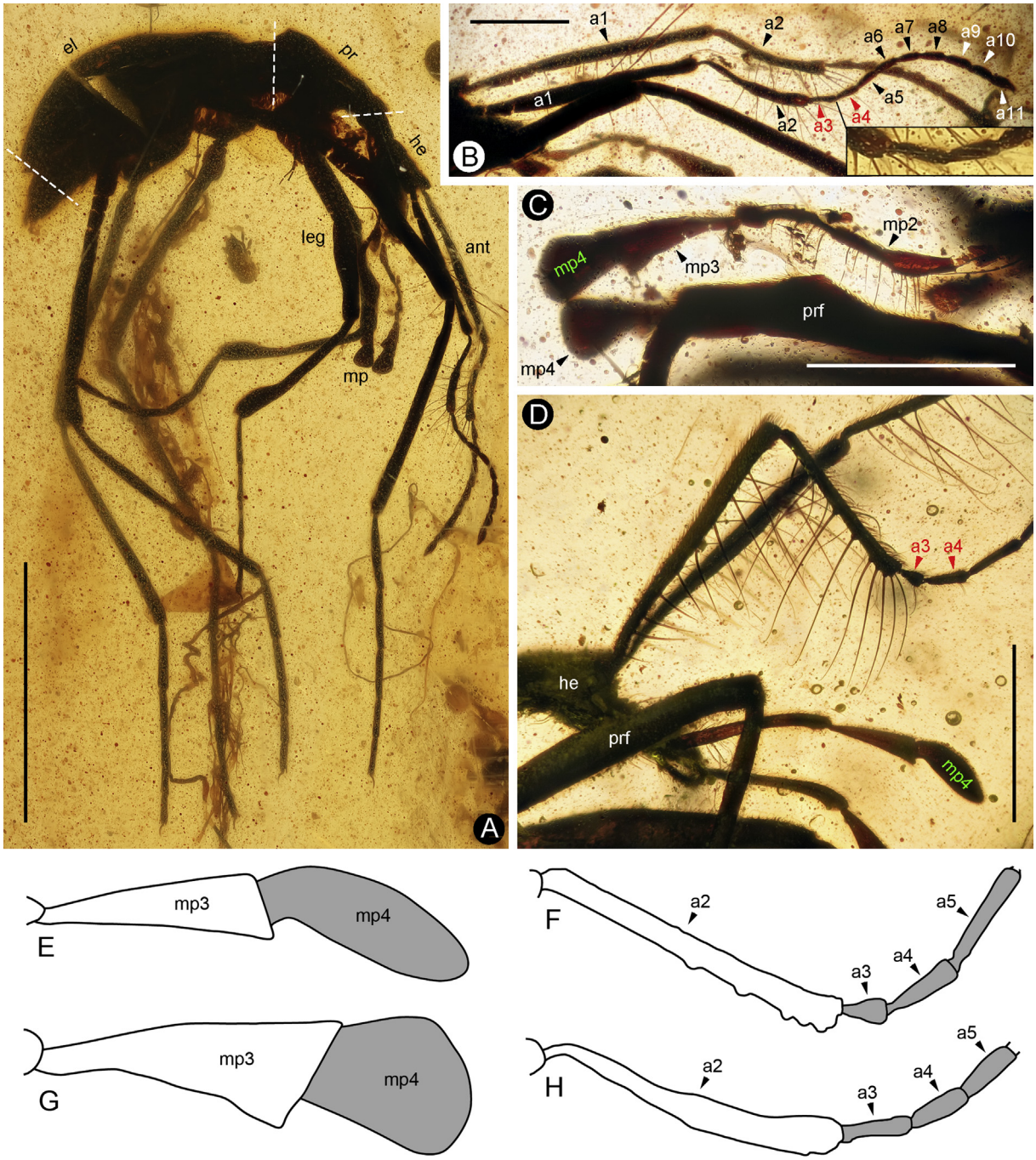

Fig. 2. Diagnostic characters of *Cascomastigus minor* sp. nov. (A–C, G–H) and *C. monstrabilis* Yin and Cai (D, E–F). A. Lateral habitus. B. Antennae. C. Maxillary palpi. D. Lateral profile of the head, showing antennomeres I–IV and maxillary palpus. E, G. Line drawings of maxillary palpi III–IV, showing different forms of apical palpomeres (shaded in grey, setae omitted). F, H. Line drawings of maxillary palpi II–V, showing different proportions (shaded in grey, setae omitted). Abbreviations: a1–11, antennomeres I–XI; el, elytra; he, head; mp, maxillary palpus; mp2–4, maxillary palpomeres II–IV; pr, pronotum; prf, profemur. Scales bars: 2.0 mm in A, D; 1.0 mm in B, C.

covered with dense and short and two very long setae; maxillary palpus (Fig. 2C) with minute and weakly elongate palpomere I, strongly elongate and slender palpomere II, subtriangular and elongate palpomere III broadest at apex, and stout palpomere IV narrowed at base and rounded at apex; lengths of palpomeres II–IV: 0.76 mm, 0.31 mm, and 0.20 mm; labial palpus not clearly visible in available specimens. Antenna (Fig. 2B) shorter than body, length 2.95 mm, lengths of antennomeres: I 1.23 mm, II 0.63 mm, III 0.12 mm, IV 0.11 mm, V 0.12 mm, VI 0.11 mm, VII 0.11 mm, VIII 0.12 mm, IX 0.14 mm, X 0.11 mm, XI 0.15 mm; relative lengths of antennomeres I–XI: 100: 51: 9.8: 8.9: 9.8: 8.9: 8.9: 9.8: 11.3: 8.9: 12.2; scape strongly elongate, 1.81 times as long as head, 1.27 times as long as pronotum, and more than half elytral length; with two lateroventral rows of robust bristles; pedicel about half as long as scape, also with two lateroventral rows of long bristles; antennomeres III and IV subequal in length, all flagellomeres strongly elongate, with dense, short and suberect setae. Pronotum elongate, length 0.97 mm; anterior margin arcuate, posterior margin truncate. Elytra much more convex than pronotum, with highest and broadest point located distinctly behind middle, length 1.97 mm; each elytron

longitudinally striate (number of striae cannot be clearly seen); vestiture composed of sparse, short and suberect setae directed posteriorly. Hind wings not visible, presumably absent. Details of mesoventrite not visible, except putative presence of prominent mesocoxal projection. Metaventrite not clearly observable. Abdomen about as long as metaventrite. Legs long and slender; large coxae subconical; trochanters lengthy semi-rounded, trochantero-femoral junction strongly oblique; femora indistinctly clavate, covered with dense, short and nearly recumbent setae; all tibiae slender, slightly curved, as long as to slightly shorter than corresponding femora, densely covered with short and nearly recumbent setae; each tarsus distinctly longer than half length of corresponding tibia, all tarsomeres distinctly cylindrical, slightly broadened apically, tarsomere I longest, with two symmetrical, curved and pointed claws; lengths of femora/tibiae/tarsomeres I–V: first pair 1.45/1.13/0.38, 0.28, 0.25, 0.15, 0.3 mm, second pair 2.13/1.80/0.58, 0.45, 0.38, 0.30, 0.28 mm, third pair 1.75/1.80/0.50, 0.33, 0.25, 0.20, 0.23 mm; length of pretarsal claws 0.11 mm.

Key to *Cascomastigus* species

1 Body large-sized, length over 6.5 mm; maxillary palpomere IV (Fig. 2D, 2E) distinctly elongate, strongly bent at base; antennomere IV (Fig. 2D, 2F) about 1.5 times as long as antennomere III, antennomere V much longer than antennomere IV..... ***C. monstrabilis***

– Body medium in sized, length below 4.5 mm; maxillary palpomere IV (Fig. 2C, 2G) rather stout, straight and truncate at base; antennomeres III–V (Fig. 2B, 2H) subequal in length..... ***C. minor* sp. nov.**

4. Discussion

The new species can be attributed to the extinct genus *Cascomastigus* based on the presence of deep and complete grooves of the elytra, a putative synapomorphy of the genus not found in any other extinct and extant Mastigini (or the whole Scydmaeninae). Currently *Cascomastigus* holds only one species, *C. monstrabilis* from Cretaceous Burmese amber. *Cascomastigus minor* sp. nov. can be readily separated from *C. monstrabilis* by the much smaller body size (4 mm *vs*. 6.88 mm), the fourth maxillary palpomere is rather stout and short, with a constricted base and a rounded apex (Fig. 2C, 2G), and the antennomeres III–V are subequal in length (Fig. 2B, 2H). While in *C. monstrabilis* the maxillary palpus IV is much more elongate, and strongly curved at the base (Fig. 2D–E), and the antennomere IV is more than 1.5 times, and antennomere V about 2.5 times as long as III (Fig. 2D, 2F). The maxillary palpomeres III of *C. minor* appears to be mediate in form between *C. monstrabilis* (elongate, strongly bent basally) and two *Baltostigus* species from Eocene Baltic amber (axe-shaped, distinctly broader than long; Jałoszyński, 2016: figs 2–3), and looks more similar to members of extant Mastigini, e.g., *Stenomastigus* Leleup, 1968 and *Mastigus* Latreille, 1802 (e.g., Leleup, 1968). Nevertheless, *C. minor* strongly differs from all Recent Mastigini in having well-developed long bristles on the first two antennomeres (the bristles are reduced in all extant mastigines to thin, sparsely spaced setae), and displaying distinct striae on the elytra. Yin et al. (2017a) hypothesized that the specialized bristles scattered on the antennomeres I and II of *Cascomastigus* may play a critical role and form a 'setal trap/cage' when hunting fast-moving preys, particularly springtails. This theory on the function of long antennal bristles seems to be more plausible over chemical detection purposes, because the latter could barely explain why all the bristles are ventrally directed, and the laterooventrally faced sockets at the bases of the setae function to limit the bristles to bend upwards.

Note that two generic names for taxa exhibiting extremely similar external morphology, probably of the same group, were recently established between a short interval (Yin et al., 2017a; Jałoszyński et al., 2017b), and the respective type species *Cascomastigus monstrabilis* and *Clidicostigus arachnipes* Jałoszyński, Brunke & Bai may deem to ascribe a same species, judged from the original descriptions and figures. Given the ongoing controversy with the availability date of electronic 'pre-publications' for the purposes of zoological nomenclature (e.g., Dubois et al., 2013, 2015a,b; Cranston et al., 2015; Krell, 2015), we prefer not to make any formal nomenclatural acts pending the next edition of the International Code of Zoological Nomenclature becomes available, which may hopefully provide clarity regarding this problem.

We show in this paper a high degree of variation in the form of the terminal maxillary palpus within *Cascomastigus* (Fig. 2E,2G) by discovering another *Cascomastigus* species from Burmese amber. Our finding throws new light on the morphological disparity of the genus (also on the supertribe Mastigitae), and also suggests a potentially high diversification of *Cascomastigus* during the late Mesozoic. We hope this find would stimulate further search and study on the Cretaceous Mastigitae, which are no doubt of great significance for understanding the early evolution of this supertribe, especially the relationships between the extinct lineages.

5. Conclusions

Our discovery of a second Cascomastigus species from Burmese amber further addresses the antiquity of Mastigini, and suggests that the group may be once widely distributed across the north Laurasia landmass during late Mesozoic. Members of the Mastigini has no doubt survived the Cretaceous–Paleogene boundary extinction event, and retained (for at least 54 myr) the long antennal bristles in their Eocene progenies (Jałoszyński, 2016). Likely, it was only recently has major shifts of feeding habits of these beetles occurred, and for some yet unknown reason, was their current disjunctive distribution shaped (Fig. 1).

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Supplementary notes

In the latest publication by Jałoszyński et al. (2018), the names *Cascomastigus* Yin & Cai (in Yin et al., 2017) and *Clidicostigus* Jałoszyński, Brunke & Bai (in Jałoszyński et al., 2017) were synonymized, with the latter being the senior synonym. The authors wrote (p. 19) "*†Cascomastigus does not differ in any characters from †Clidicostigus; their diagnostic features, including uniquely shaped maxillary palps with an asymmetrical palpomere 4, and elytral striae, are identical. Neither structural nor spatiotemporal arguments support a separate placement of these taxa, and †Cascomastigus is here placed as a junior synonym of †Clidicostigus (**the former name with the online publication date 2017.03.07; the latter 2017.01.03**)*." As already addressed in our paper (with which this sheet is attached), we agree that these two genera and their type species probably belong to a same taxon, and should be synonymized at some point in the future. However, it must be pointed out that "2017.01.03" was the date when the 'ACCEPTED MANUSCRIPT' of Jałoszyński et al. (2017)' work was put online, which was one of the early versions of the publication with unfixed content, followed by an online correction stage of the proof in a few days. In this regard, the synonymy proposed in Jałoszyński et al. (2018) must be considered invalid.

In fact, same 'publication date' problem similarly occurs in all Elsevier journals, but it becomes a major concern especially when a journal publishes many new date-sensitive names (like Cretaceous Research) in the sense of ICZN. By far there is no official way to acquire the exact publication date of the 'final e-version (without pagination)' of a work published in *CR*, and many would have to consider the time when the printed version (with pagination) comes out as the correct date (for *Clidicostigus*, it was Apr. 2017, as shown on the web: https://www.sciencedirect.com/science/article/pii/S0195667116302452).

Further, beyond the hasty new synonymies proposed in Jałoszyński et al. (2018), it seems that none of the authors care to provide new combinations for the species included in the two generic taxa they dealt with, which may cause further confusions. It was never our attention to 'scoop' a name that appeared online two months earlier than ours, and we do hope the next edition of ICZN would provide enough clarity regarding to the ongoing controversy of the aforementioned as well as other issues raised by e-publications.

Zi-Wei Yin
May 4, 2018

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