



侏罗纪道虎沟生物群瘦魔蜂属(*Leptephialtites* Rasnitsyn, 1975)一新种(昆虫纲: 膜翅目: 魔蜂科)*

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提要 瘦魔蜂属(*Leptephialtites* Rasnitsyn, 1975)是哈萨克斯坦晚侏罗世卡拉套生物群中魔蜂科魔蜂亚科的一个分异度比较高的类群, 也曾报道于我国内蒙古宁城地区中-晚侏罗世道虎沟生物群, 但没有描述和图示。本文对产自宁城道虎沟村中-上侏罗统道虎沟化石层的一块雌蜂标本进行了描述, 将其归入瘦魔蜂属并建立了一新种: 张氏瘦魔蜂(*Leptephialtites zhangii* Ding and Zhang, sp. nov.)。该新种区别于卡拉套生物群中瘦魔蜂属的所有种: 前翅1-Rs脉长为其与翅痣基部距离之半(后者1-Rs脉不长于其与翅痣基部的距离), 横脉1r-rs完整(后者1r-rs残存或完全消失); 腹部纺锤状, 最宽处在其中部(后者腹部最宽处位于其端半部)。本文还提供了瘦魔蜂属所有已知种的检索表。另外, 瘦魔蜂属仅存在于卡拉套生物群和道虎沟生物群, 证实了这两个生物群具有密切的关系。

关键词 魔蜂亚科 张氏瘦魔蜂(新种) 中-晚侏罗世 道虎沟生物群 卡拉套生物群

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A new species of *Leptephialtites* Rasnitsyn, 1975 (Insecta: Hymenoptera: Ephialtitidae) from the Jurassic Daohugou beds of NE China

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Abstract *Leptephialtites* Rasnitsyn, 1975 is a diverse wasp genus of the subfamily Ephialtitinae (Ephialtitidae) in the Late Jurassic Karatau Biota from Karatau, southern Kazakhstan. It was also reported from the Middle-Late Jurassic Daohugou Biota in Ningcheng, Northeast China but with no descriptions and figures provided. Herein, a new species, *Leptephialtites zhangii* Ding and Zhang, sp. nov., is established based on a female wasp specimen from the Middle-Upper Jurassic Daohugou beds near Daohugou Village, Wuhua Town, Ningcheng County, Chifeng City, Inner Mongolia, China. The new species shows some differences from the Karatau species in having a forewing with 1-Rs

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about half length of its distance to the pterostigma (vs. at most as long as its distance to the pterostigma) and complete 1r-rs (vs. rudimentary or completely absent), and a spindle-like metasoma that is widest at the middle (vs. widest in the rear half). Furthermore, a key to the species of *Leptephialtites* is provided. Occurrences of the genus *Leptephialtites* in both the Karatau and Daohugou biotas confirm the close relationship between the two biotas.

Key words Ephialtitinae, *Leptephialtites zhang* sp. nov., Middle-Late Jurassic, Daohugou Biota, Karatau Biota

1 INTRODUCTION

The family Ephialtitidae is an Early Jurassic–Early Cretaceous group of wasps, with 29 genera known from Kazakhstan, China, Mongolia, Democratic People's Republic of Korea, Russia, Spain, Germany and Brazil (Meunier, 1903; Rasnitsyn, 1975, 1977, 1990, 1999, 2008a, b; Zessin, 1981, 1985; Zhang, 1986; Darling and Sharkey, 1990; Rasnitsyn and Ansoerge, 2000; Rasnitsyn and Martínez-Delclòs, 2000; Zhang *et al.*, 2002, 2010, 2014; Rasnitsyn *et al.*, 2003; Rasnitsyn and Zhang, 2004, 2010; Ding *et al.*, 2013, 2016; Li *et al.*, 2013, 2015; Li and Shih, 2015; Zhang, 2020; Won and So, 2022). Flourishing in the Middle–Late Jurassic, this family is considered to be the most basal group of the hymenopteran suborder Apocrita (Rasnitsyn and Zhang, 2010).

The family is divided into two subfamilies: Ephialtitinae Handlirsch, 1906 and Symphytopterinae Rasnitsyn, 1980. The Ephialtitinae differs from the Symphytopterinae in having a long ovipositor and an interstitial (or nearly so) cu-a crossvein in the forewing (Handlirsch, 1906–1908; Rasnitsyn, 1980; Zhang *et al.*, 2002; Rasnitsyn *et al.*, 2003; Rasnitsyn and Zhang, 2010). So far, 21 genera have been assigned to the Ephialtitinae and eight genera have been assigned to the Symphytopterinae (Li *et al.*, 2015; Zhang, 2020).

Here a new species assigned to the ephialtine genus *Leptephialtites* Rasnitsyn 1975 is established and illustrated based on a female wasp from the Middle-Late Jurassic Daohugou beds of Northeast China. The new record adds to the diversity of both the subfamily Ephialtitinae and the family Ephialtitidae, and further confirms the close relationship between the Daohugou and the Karatau biotas.

2 MATERIAL AND METHODS

The new taxon established herein is based on a

specimen from the Daohugou beds near Daohugou Village, Ningcheng County, Chifeng City, Inner Mongolia, China. The Daohugou beds were previously considered to be Bathonian to Callovian (Middle Jurassic) in age and to belong to the Jiulongshan Formation (e.g., Li *et al.*, 2013). However, recent biostratigraphic and radiometric dating results suggest that they are of Callovian to Oxfordian age (latest Middle–earliest Late Jurassic; e.g., Liu *et al.*, 2006; Liu *et al.*, 2012; Wang *et al.*, 2013; Huang, 2016; Wang *et al.*, 2018).

The specimen was prepared with PaleoTools Micro-Jack 3, observed dry and in ethanol using a light microscope (NIKON SMZ1000), and photographed with a digital camera (DXM1200) connected to the microscope at the State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing. Line drawings were made using CorelDRAW X8 software. Wing-venation terminology of Rasnitsyn (1969) and Rasnitsyn and Zhang (2010) is adopted herein with the addition of vein abscissa numbers.

The specimen is housed at the Nanjing Institute of Geology and Palaeontology (NIGP), Chinese Academy of Sciences.

3 SYSTEMATIC PALAEONTOLOGY

Order Hymenoptera Linnaeus, 1758

Suborder Apocrita Gerstaecker, 1867

Family Ephialtitidae Handlirsch, 1906

Subfamily Ephialtitinae Handlirsch, 1906

Genus *Leptephialtites* Rasnitsyn, 1975

Type species *Leptephialtites caudatus* Rasnitsyn, 1975

Composition Eleven species including *L. angustus* Rasnitsyn, 1975, *L. caudatus* Rasnitsyn, 1975, *L. euryarthrus* Rasnitsyn, 1975, *L. gigas* Rasnitsyn, 1975, *L. linearis* Rasnitsyn, 1975, *L. minor* Rasnitsyn, 1975, *L. pallidus* Rasnitsyn, 1975, *L. picturatus* Rasnitsyn, 1975, *L. stephanocephalus* Ras-

nitsyn, 1975 and *L. tenuicornis* Rasnitsyn, 1975 from the Upper Jurassic Karabastau Formation of Karatau–Mikhailovka, southern Kazakhstan, and the new species *L. zhangi* sp. nov. from the Middle–Upper Jurassic Daohugou beds of Ningcheng, Northeast China.

Revised diagnosis Head behind eyes often enlarged; antenna with 16–30 segments. Forewing venation complete with 1a-2a absent, 1r-rs sometimes absent, and A2 usually absent; 1-Rs strongly directed posterobasally, not angular with 1-M; 2rm basally not basal of pterostigmal base; cell 3rm shorter than 2mcu; cu-a interstitial or nearly interstitial. Hindwing with r closed; r-m shorter than 1-Rs; cu-a antefurcal, occasionally slightly postfurcal. Metasoma usually widened apically (widest in rear half), rarely spindle-like (widest at middle part) or nearly parallel-sided (in males); first segment smoothly transitional to second. Ovipositor not shorter than metasoma, often much longer than body (in such a case, ovipositor curved downwards).

Age and distribution Middle–Late Jurassic; Kazakhstan and China.

Species *Leptepialtites zhangi* Ding and Zhang, sp. nov.

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Etymology Species name is dedicated to the late Prof. Zhang Junfeng, a well-known Chinese palaeoentomologist.

Holotype NIGP201447, a female wasp specimen in dorsal view, with antennae, legs and wings more or less damaged (Figs. 1–2).

Diagnosis Head behind eyes enlarged. Mesosoma stout, about as long as wide; pronotum short. Forewing with 1-Rs about half length of its distance to pterostigma; 1r-rs complete; 2rm basally at the same level of pterostigmal base; 2A present at least in distal half. Hindwing with 1-Rs greatly longer than r-m; cu-a distinctly antefurcal. Metasoma spindle-like, widest at middle part. Ovipositor about as long as metasoma and bent distally.

Horizon and locality Daohugou beds, Middle–Upper Jurassic; Daohugou Village, Wuhua Town, Ningcheng County, Chifeng City, Inner Mon-

golia, China.

Description Head large; eyes large, occupying almost both sides of head; ocelli small, with posterior two much more distant to each other than to anterior one. Right antenna with basal 14 segments preserved and left antenna with basal 2 segments preserved; scape distally enlarged, slightly longer than wide; pedicel short, greatly narrower than scape; flagellum with basal 12 flagellomeres recognized although flagellomeres 7–10 badly preserved; flagellomeres 1 and 2 distinctly narrower than pedicel distally, slightly gradually becoming enlarged distally, and 3 times as long as wide; flagellomeres 3 and 4 cylindrical, thick as flagellomere 2 distally and 3 times as long as wide; remaining flagellomeres as thick as flagellomere 4 and about twice as long as wide.

Mesosoma stout, as long as wide, and about 1.5 times as wide as head; pronotum short, mostly covered with head; mesonotum with scutum shorter than scutellum, notauli V-shaped and reaching trans-scutal suture; metanotum short; propodeum nearly twice as long as metanotum. Fore and mid legs badly preserved; hind leg with coxa stout and distinctly larger than mid one, femur clavate, tibia slightly longer than femur with an apical spur, tarsus thin with basitarsomere about one-third of tibial length, second about one-third length of basitarsomere, third slightly shorter than second, fourth badly preserved. Forewing with 1-Rs distinctly directed posterobasally, about half length of its distance to pterostigma; 1-M in line with and as long as 1-Rs; pterostigma narrow, elongate and acuminate, with 2r-rs issuing slightly basal of its mid-length, ending on fore side of 2rm at its basal two-thirds length (3-Rs about twice as long as 4-Rs), and about twice as long as pterostigmal maximal width; 1r-rs complete, slightly curved, and as long as 2r-rs; 1r slightly longer than 2r; 3r long and acute apically, about 1.4 times as long as 1+2r; 2r-m slightly sigmoid, as long as 2r-rs; 3r-m subvertical; 3rm slightly longer than 2rm; 1m-cu subparallel to 1-M, and meeting M slightly beyond fork of Rs+M at the level of pterostigmal base; 2m-cu slightly curved, meeting M at about basal one-fourth of posterior margin of 3rm (4-M about 1/3rd length of 5-M); 1mcu about 2.6 times as long as wide; 2mcu



Fig. 1 *Leptephialtites zhangi* Ding and Zhang, sp. nov.

Holotype, NIGP201447, images of the wasp specimen in dorsal view. **A.** Habitus. **B.** Apical metasoma and ovipositor in ethanol. **C.** Left forewing and hindwing, and left hind leg. **D.** Head, mesosoma, basal metasoma and right forewing and hindwing. Scale bars = 2 mm.

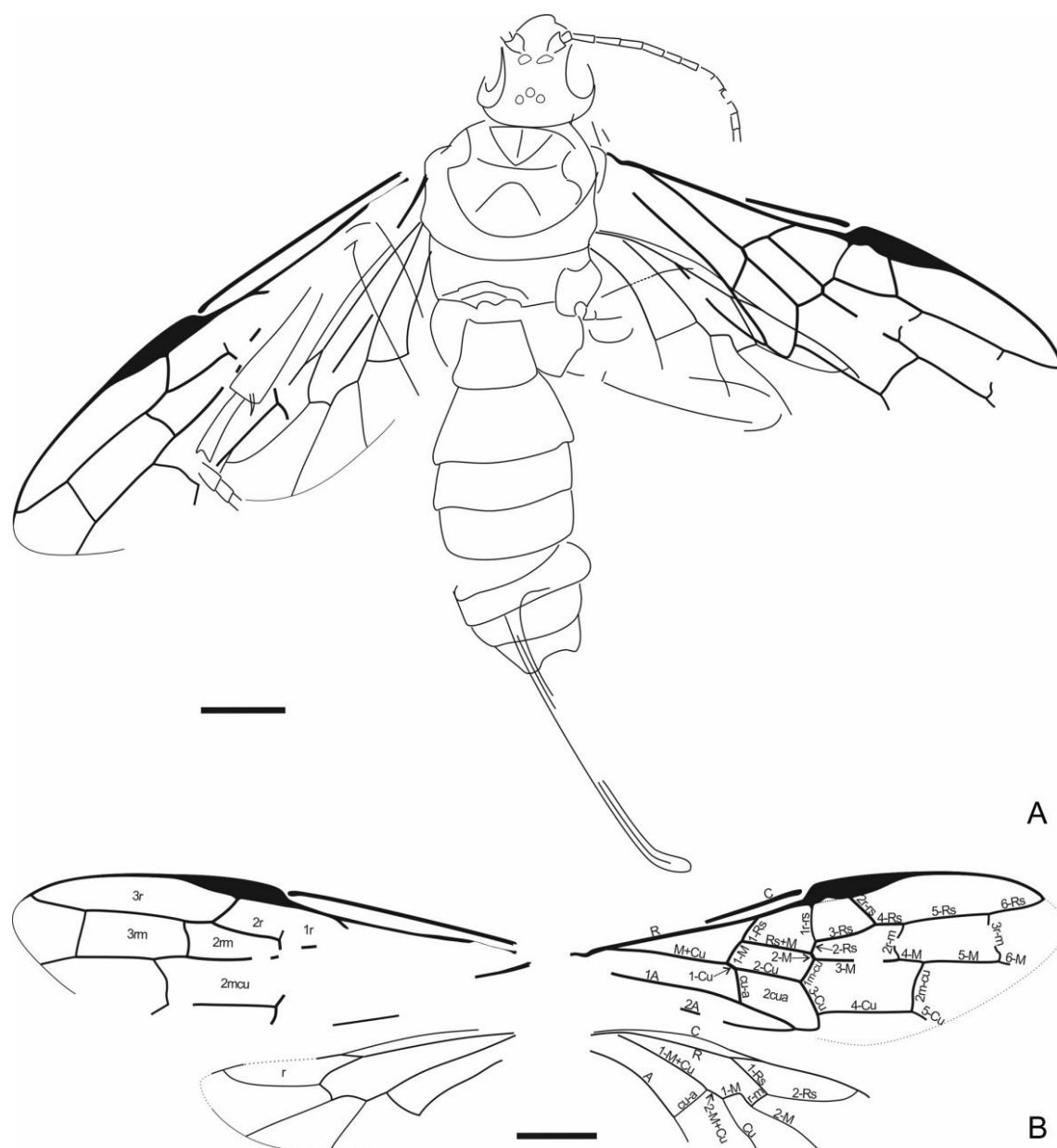


Fig. 2 *Leptephialtites zhangii* Ding and Zhang, sp. nov.

Line drawings of the holotype specimen. A. Habitus. B. Forewings and hindwings with venational explanations. Scale bars = 2 mm.

about 1.5 times as long and twice as wide as 1mcu, and slightly longer than 3rm; cu-a slightly postfurcal, about 3.5 times as long as its distance to M+Cu fork; 2cua about as long and 1.7 times as wide as 1mcu; 2A present at least in its distal half; 1a-2a absent. Hindwing with Rs originating slightly basal of M+Cu fork; 1-Rs nearly 3 times as long as r-m; r closed; r-m slightly curved, and directed posterobasally; 1-M distinctly curved, and slightly shorter than 1-Rs; cu-a distinctly basal of M+Cu fork, and about 2.5 times as

long as 2-M+Cu.

Metasoma spindle-like, widest at middle part (third and fourth segments) widest; first segment frustum-like, length slightly shorter than its width distally; second trapezoid, slightly longer than first, and about twice as wide distally as long; third and fourth as wide as second distally, and about two-thirds of length of second; remaining segments much shorter. Ovipositor about as long as metasoma and distinctly distally bent, with sheaths about

three-fourths of metasomal length.

Head granular; mesosoma granular and coarsely rugose; mid and hind coxae, and first metasomal segment coarsely rugose.

Measurements (in mm): head length 2.6, width 2.7; mesosomal length 4.1, width 4.0; forewing length 12.8, width (estimated) 4.2; hindwing length 8.0, width 2.5; metasomal length 7.9; ovipositor length 7.8, sheath length 6.0.

4 DISCUSSION

The new species is placed in the genus *Leptephialtites* Rasnitsyn, 1975 based on the following characters: its enlarged head behind eyes; forewing venation complete with 1-Rs strongly directed posterobasally, not angular with 1-M, 2rm basally not basal of pterostigmal base, cell 3rm shorter than 2mcu, cu-a slightly postfurcal, and 1a-2a absent; hindwing with r closed, r-m shorter than 1-Rs, and cu-a antefurcal; first metasomal segment smoothly transitional to second; and ovipositor not short (as long as metasoma). It differs from its congeners in having a forewing with 1-Rs about half length of its distance to pterostigma (vs. at most as long as its distance to pterostigma), and 1r-rs complete (vs. rudimentary or completely absent); and metasoma spindle-like and widest at its middle part (vs. widest in rear half). It further differs from all other *Leptephialtites* species known from female specimens in having a forewing with 2rm basally at the same level of pterostigmal base (vs. distal of pterostigmal base), and an ovipositor as long as metasoma (vs. at least longer than metasoma). Additionally, a key to the species of *Leptephialtites*, modified from Rasnitsyn (1975), is provided here.

Key to species of *Leptephialtites* Rasnitsyn, 1975

- 1 Metasoma thick, evenly thickened apically or medially. Female 2
- Metasoma thin in basal half (segments 1–3 not swollen or almost so) but swollen apically. Male 9
- 2 Metasoma spindle-like, widest medially; ovipositor about as long as metasoma
- L. zhangii* Ding and Zhang, sp. nov.
- Metasoma thin in basal half, widest in distal half; ovipositor longer than metasoma

- ma 3
- 3 Forewing with 1r-rs absent; first metasomal segment greatly wider than long 4
- Forewing with 1r-rs present; first metasomal segment longer than wide 5
- 4 Forewing with A2 present; body pale
- L. tenuicornis* Rasnitsyn, 1975
- Forewing with A2 absent; mesosoma dark
- L. euryarthrus* Rasnitsyn, 1975
- 5 Forewing with 3rm clearly longer than 2rm; metasoma pale with abundant dark patterns
- L. picturatus* Rasnitsyn, 1975
- Forewing with 3rm not longer than 2rm; coloration different 6
- 6 Head not swollen; antenna 16-segmented; ovipositor shorter than body
- L. pallidus* Rasnitsyn, 1975
- Head swollen; antenna over 16-segmented; ovipositor longer than body 7
- 7 Forewing with A2 present, hindwing with 3r-m present; body 20 mm long
- L. gigas* Rasnitsyn, 1975
- Forewing with A2 absent; hindwing with 3r-m absent; body shorter than 20 mm 8
- 8 Hindwing with cu-a postfurcal; first metasomal segment almost cylindrical; body pale
- L. caudatus* Rasnitsyn, 1975
- Hindwing with cu-a antefurcal; first metasomal segment conical; body dark
- L. stephanocephalus* Rasnitsyn, 1975
- 9 Temples swollen; metasoma becoming thickened from fourth segment 10
- Temples not swollen; fourth and fifth metasomal segments not thickened
- L. linearis* Rasnitsyn, 1975
- 10 Metasoma thinnest before its middle
- L. angustus* Rasnitsyn, 1975
- Metasoma not becoming thin before its middle
- L. minor* Rasnitsyn, 1975

So far, the genus *Leptephialtites* is only known from the Upper Jurassic Karabastau Formation of Karatau, southern Kazakhstan and the Middle–Upper Jurassic Daohugou beds of Ningcheng, Northeast China (Rasnitsyn, 1975; Rasnitsyn and Zhang, 2004; this study), confirming the close relationship between the Daohugou and the Karatau biotas.

5 CONCLUSIONS

Based on a female wasp specimen from the Middle–Upper Jurassic Daohugou beds near Daohugou

Village, Wuhua Town, Ningcheng County, Chifeng City, Inner Mongolia, China, a new species, *Leptephialtites zhangi* sp. nov., is established and described. The new species is unique in the genus in having forewings with 1-Rs about half length of its distance to pterostigma and complete 1r-rs, and a spindle-like metasoma that is widest at its middle part. The genus *Leptephialtites* is so far only known from the Late Jurassic Karatau Biota in Karatau, southern Kazakhstan and the Middle–Late Jurassic Daohugou Biota in Ningcheng, Northeast China, confirming that the two biotas are closely related.

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参考文献 (References)

- Darling D C, Sharkey M J, 1990. Order Hymenoptera. In: *Insects from the Santana Formation, Lower Cretaceous, of Brazil*. Bulletin of the American Museum of Natural History, 195: 123–153.
- Ding Ming, Zhang Qi, Wang He, Zhang Qing-qing, Lei Xiao-jie, Zhang Hai-chun, 2016. New material of Ephialtitidae (Insecta: Hymenoptera: Stephanoidea) from the Middle–Upper Jurassic of Inner Mongolia, China. *Acta Palaeontologica Sinica*, 55: 87–97 (in Chinese with English summary).
- Ding Ming, Zheng Da-ran, Zhang Qi, Zhang Hai-chun, 2013. A new species of Ephialtitidae (Insecta: Hymenoptera: Stephanoidea) from the Middle Jurassic of Inner Mongolia, China. *Acta Palaeontologica Sinica*, 52: 51–56 (in Chinese with English summary).
- Gerstaecker A, 1867. Ueber die Gattung Oxybelus Latr. und die bei Berlin vorkommenden Arten derselben. *Zeitschrift für die Gesamten Naturwissenschaft*, Bd., 30: 1–96.
- Handlirsch A, 1906–1908. *Die fossilen Insekten und die Phylogenie der Rezenten Formen; ein handbuch für paläontologen und zoologen*. Leipzig: W. Engelmann. 1430. DOI: 10.5962/bhl.title.5636
- Huang Di-ying, 2016. *The Daohugou Biota*. Shanghai: Shanghai Scientific & Technical Publishers. 332 (in Chinese).
- Linnaeus C, 1758. *Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Editio decima, reformata. Volume 1. L. Holmiae [= Stockholm]: Laurentii Salvii. 824. DOI: 10.5962/bhl.title.542
- Li Long-feng, Shih Chung-kun, Rasnitsyn A P, Ren Dong, 2015. New fossil ephialtitids elucidating the origin and transformation of the propodeal-metasomal articulation in Apocrita (Hymenoptera). *BMC Evolutionary Biology*, 15: 45. DOI: 10.1186/s12862-015-0317-1
- Li Long-feng, Shih Chung-kun, Ren Dong, 2013. Two new wasps (Hymenoptera: Stephanoidea: Ephialtitidae) from the Middle Jurassic of China. *Acta Geologica Sinica - English Edition*, 87: 1486–1494. DOI: 10.1111/1755-6724.12152
- Li Long-feng, Shih Chung-kun, 2015. Two new fossil wasps (Insecta: Hymenoptera: Apocrita) from northeastern China. *Journal of Natural History*, 49: 829–840. DOI: 10.1080/00222933.2014.953223
- Liu Yong-qing, Kuang Hong-wei, Jiang Xiao-jun, Peng Nan, Xu Huan, Sun Hui-yi, 2012. Timing of the earliest known feathered dinosaurs and transitional pterosaurs older than the Jehol Biota. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 323–325: 1–12. DOI: 10.1016/j.palaeo.2012.01.017
- Liu Yan-xue, Liu Yong-qing, Zhang Hong, 2006. LA-ICPMS zircon U-Pb dating in the Jurassic Daohugou Beds and correlative strata in Ningcheng of Inner Mongolia. *Acta Geologica Sinica- English Edition*, 80: 733–742. DOI: 10.1111/j.1755-6724.2006.tb00296.x
- Meunier F, 1903. Nuevas contribuciones á la fauna de los himenópteros fósiles. *Memorias de la Real Academia de Ciencias y Artes de Barcelona*, 4: 461–465.
- Rasnitsyn A P, 1969. Origin and evolution of the lower Hymenoptera. *Transactions of the Paleontological Institute, Academy of Sciences of the USSR*, 123: 1–196 (in Russian).
- Rasnitsyn A P, 1975. Hymenoptera Apocrita of the Mesozoic. *Transactions of the Paleontological Institute, Academy of Sciences of the USSR*, 147: 1–134 (in Russian).
- Rasnitsyn A P, 1977. New Hymenoptera from the Jurassic and Cretaceous of Asia. *Paleontologicheskii Zhurnal*, 3: 98–108 (in Russian).
- Rasnitsyn A P, 1980. Origin and evolution of the Hymenoptera. *Transactions of the Paleontological Institute, Academy of Sciences of the USSR*, 174: 1–192 (in Russian).
- Rasnitsyn A P, 1990. Hymenoptera. In: *Late Mesozoic insects of Eastern Transbaikalia*. *Transactions of the Paleontological Institute, Academy of Sciences of the USSR*, 239: 177–205 (in Russian).
- Rasnitsyn A P, 1999. *Cratephialtites* gen. nov. (Vespida = Hymenoptera: Ephialtitidae), a new genus for *Karatau koiurus* Sharkey, 1990, from the Lower Cretaceous of Brazil. *Russian Entomological Journal*, 8: 135–136.
- Rasnitsyn A P, 2008a. New hymenopteran insects (Insecta: Vespida) from the Lower or Middle Jurassic of India. *Paleontological Journal*, 42: 81–85. DOI: 10.1007/s11492-008-1013-z
- Rasnitsyn A P, 2008b. Hymenopterous insects (Insecta: Vespida) in the Upper Jurassic deposits of Shar Teg, SW Mongolia. *Russian Entomological Journal*, 17: 299–310.
- Rasnitsyn A P, Ansoerge J, 2000. Two new Lower Cretaceous hymenopterous insects (Insecta: Hymenoptera) from Sierra del Montsec, Spain. *Acta Geológica Hispánica*, 35: 59–64.
- Rasnitsyn A P, Ansoerge J, Zessin W, 2003. New hymenopterous insects (Insecta: Hymenoptera) from the Lower Toarcian (Lower Jurassic) of Germany. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 227: 321–342. DOI: 10.1127/njgpa/227/2003/321

- Rasnitsyn A P, Martínez-Delclòs X, 2000. Wasps (Insecta: Vespida = Hymenoptera) from the Early Cretaceous of Spain. *Acta Geológica Hispánica*, 35: 65–95.
- Rasnitsyn A P, Zhang Hai-chun, 2004. Composition and age of the Daohugou hymenopteran (Insecta, Hymenoptera = Vespida) assemblage from Inner Mongolia, China. *Palaeontology*, 47: 1507–1517. DOI: 10.1111/j.0031-0239.2004.00416.x
- Rasnitsyn A P, Zhang Hai-chun, 2010. Early evolution of Apocrita (Insecta, Hymenoptera) as indicated by new findings in the Middle Jurassic of Daohugou, Northeast China. *Acta Geologica Sinica – English Edition*, 84: 834–873. DOI: 10.1111/j.1755-6724.2010.00254.x
- Wang He, Fang Yan, Wang Bo, Zhang Hai-chun, 2018. The Jurassic orthopteran *Allaboilus gigantis* Ren and Meng, 2006 (Prophalangopsidae) from Beipiao, Northeast China and its biostratigraphical significance. *Proceedings of the Geologists' Association*, 129: 629–634. DOI: 10.1016/j.pgeola.2018.04.006
- Won Chol-Guk, So Kwang-Sik, 2022. Two new wasps (Insecta: Hymenoptera) from the Lower Cretaceous Sinuiju Formation of Ryonsang-dong, North Phyongan Province, Democratic People's Republic of Korea. *Cretaceous Research*, 131: 105086. DOI: 10.1016/j.cretres.2021.105086
- Wang Liang-liang, Hu Dong-yu, Zhang Li-jun, Zheng Shao-lin, He Huai-yu, Deng Cheng-long, Wang Xiao-lin, Zhou Zhong-he, Zhu Ri-xiang, 2013. SIMS U-Pb zircon age of Jurassic sediments in Linglongta, Jianchang, western Liaoning: Constraint on the age of oldest feathered dinosaurs. *Chinese Science Bulletin*, 58: 1346–1353. DOI: 10.1360/972012-535
- Zessin W, 1981. Ein Hymenopterenflügel aus dem oberen Lias bei Dobbetin, Bezirk Schwerin. *Zeitschrift für Geologische Wissenschaften*, 9: 713–717.
- Zessin W, 1985. Neue oberliassische Apocrita und die Phylogenie der Hymenoptera (Insecta, Hymenoptera). *Deutsche Entomologische Zeitschrift*, 32: 129–142. DOI: 10.1002/mmnd.19850320118
- Zhang Hai-chun, 2020. *Proapocritus lini* sp. nov., a new ephialtitid wasp (Hymenoptera: Apocrita) from the Middle-Upper Jurassic of Daohugou, NE China. *Palaeoentomology*, 3: 54–58. DOI: 10.11646/palaeoentomology.3.1.8
- Zhang Hai-chun, Rasnitsyn A P, Zhang Jun-feng, 2002. Two ephialtitid wasps (Insecta, Hymenoptera, Ephialtitoidea) from the Yixian Formation of western Liaoning, China. *Cretaceous Research*, 23: 401–407. DOI: 10.1006/cres.2002.1004
- Zhang Hai-chun, Wang Bo, Fang Yan, 2010. Evolution of insect diversity in the Jehol Biota. *Science China Earth Sciences*, 53: 1908–1917. DOI: 10.1007/s11430-010-4098-5
- Zhang Jun-feng, 1986. A new Middle Jurassic insect genus *Sinephialtites* of Ephialtitidae discovered in China. *Acta Palaeontologica Sinica*, 25: 585–590 (in Chinese).
- Zhang Qi, Zhang Hai-chun, Rasnitsyn A P, Wang He, Ding Ming, 2014. New Ephialtitidae (Insecta: Hymenoptera) from the Jurassic Daohugou beds of Inner Mongolia, China. *Palaeoworld*, 23: 276–284. DOI: 10.1016/j.palwor.2014.11.001

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