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Two new species of *Macromotettixoides* (Orthoptera: Tetrigidae) from China, described with integrated morphological and mitogenomic evidence

Le LIU [1] & Weian DENG [2,*]

[1,2]Key Laboratory of Ecology of Rare and Endangered Species and Environmental Protection (Guangxi Normal University), Ministry of Education, Guilin, Guangxi 541006, China.
[1,2]Guangxi Key Laboratory of Rare and Endangered Animal Ecology, Guangxi Normal University, Guilin, Guangxi 541006, China.
[1,2]College of Life Sciences, Guangxi Normal University, Guilin, Guangxi 541006, China.

[*]Corresponding author: dengweian5899@163.com
[1]Email: liule11768@stu.gxnu.edu.cn

Abstract. The genus *Macromotettixoides* Zheng, Wei & Jiang, 2005 is an endemic, species-rich pygmy grasshopper group in China. Two new species, *Macromotettixoides emeiensis* sp. nov. from Sichuan and *Macromotettixoides yuanbaoshanensis* sp. nov. from Guangxi, are described and illustrated based on integrated morphological and molecular evidence. Their complete mitochondrial genomes were sequenced and phylogenetic analysis supports their placement within *Macromotettixoides*. Both new species are distinguished from congeners by a non-tectiform pronotum with carinate or tubercle-like elevations between the shoulders. *Macromotettixoides emeiensis* is characterized by a vertex width 2.3–2.4 times the compound eye width in females, and in lateral view, the anterior half of the pronotum is undulated with a lamellate, elevated median carina forming two hump-like projections, and the posterior half is straight. *Macromotettixoides yuanbaoshanensis* is characterized by a vertex width 1.5–1.6 times the compound eye width in females, and in lateral view, the upper margin of the pronotum is undulated. An updated identification key to species of *Macromotettixoides* is provided.

Keywords. Pygmy grasshopper, taxonomy, new species, morphology, key, phylogenetics, mitochondrial genome, China.

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Introduction

The pygmy grasshopper genus *Macromotettixoides* Zheng, Wei & Jiang, 2005 (Orthoptera: Tetrigidae: Metrodorinae) is endemic to China, with *Macromotettixoides jiuwanshanensis* Zheng, Wei & Jiang, 2005

designated as the type species. It is distinguished from *Macromotettix* Günther, 1939 by the presence of only a ventral sinus on the posterior margin of the pronotal lateral lobe, the absence of a tegminal sinus, and the presence of reduced or invisible tegmina and wings (Zheng *et al.* 2005). Since its establishment, the taxonomy of *Macromotettixoides* has been repeatedly revised and expanded, with numerous new species described (Zheng *et al.* 2006; Zha *et al.* 2017; Deng *et al.* 2020; Han *et al.* 2020; Wei & Deng 2023; Luo *et al.* 2024; Li *et al.* 2025). Currently, the genus comprises approximately 25 valid species (Cigliano *et al.* 2026), distributed mainly in mountainous areas of southern and southwestern China.

Species identification has traditionally relied on morphological characters, including the ratio of vertex width to compound eye width, the shape of the anterior margin and the median carina of the pronotum, the apex shape of the pronotal process, the shape of the ventral margins of the fore and middle femora, and the morphology of the ovipositor, among others. These characters are relatively stable at the species level with limited intraspecific variation. However, mitochondrial genome data provide valuable auxiliary evidence for species identification and generic placement. To date, complete mitochondrial genomes of four species of *Macromotettixoides* have been published (Luo *et al.* 2024; Li *et al.* 2025), providing reliable molecular evidence for determining the generic placement and phylogenetic position of new species.

During recent field investigations in Mount Emei, Sichuan Province and Mount Yuanbao, Guangxi Province, two distinct, undescribed species of *Macromotettixoides* were collected. In the present study, we formally describe *Macromotettixoides emeiensis* sp. nov. and *M. yuanbaoshanensis* sp. nov. based on integrated morphological and mitochondrial genomic evidence. The complete mitochondrial genomes of both new species were sequenced, annotated, and analyzed. Phylogenetic analyses were performed to confirm their generic placement and phylogenetic relationships. Additionally, an updated identification key to species of *Macromotettixoides* is provided. This study adds to the known species diversity of the genus and provides a foundation for further taxonomic and systematic research on Chinese Tetrigidae.

Material and methods

Sample collection and mitogenome sequencing

Macromotettixoides emeiensis sp. nov. was collected from Mount Emei, Sichuan Province, China (29°32′05″ N, 103°15′55″ E, elev. 1754 m) on 28 August 2024, and *M. yuanbaoshanensis* sp. nov. was collected from Mount Yuanbao, Guangxi Province, China (25°25′35″ N, 109°09′44″ E, elev. 1414 m) on 9 September 2021. Specimens were preserved in 100% ethanol and stored at -20°C. All material, including holotype and paratypes, is deposited in the College of Life Sciences, Guangxi Normal University, Guilin, China (CLSGNU).

Total genomic DNA was extracted from hind femur muscle using the TIANamp Genomic DNA Kit (TIANGEN). Paired-end libraries (350 bp insert size) were constructed and sequenced on the Illumina HiSeq X Ten platform (Berry Genomics, Beijing, China), yielding approximately 5 Gb of 150 bp reads per sample. Raw reads were filtered using fastp ver. 1.0.1 (Chen *et al.* 2025) to remove adapters and low-quality sequences. Clean reads were assembled de novo using GetOrganelle ver. 1.7.7 (Jin *et al.* 2020). The complete circular mitogenome was annotated using MITOS2 web server (Donath *et al.* 2019), with tRNA genes validated by tRNAscan-SE ver. 2.0.9 (Chan *et al.* 2021) and ARWEN ver. 1.2.3 (Laslett & Canbäck 2008), and refined in MEGA 12 (Kumar *et al.* 2024) and Geneious Prime ver. 2025.0.2 (Kearse *et al.* 2012). Mitogenome maps were generated using the Proksee web server (Grant *et al.* 2023). Nucleotide compositions of the mitogenome, protein-coding genes (PCGs), the three codon positions of PCGs, tRNA genes, rRNA genes, and the control region were calculated using PhyloSuite ver. 2 (Zhao *et al.* 2025), and AT and GC skews were computed using the formulas: AT skew = (A − T)/(A + T) and GC skew = (G − C)/(G + C) (Perna & Kocher 1995).

Table 1. Species included in the phylogenetic analyses and their NCBI accession numbers.

Subfamily	Species	Accession
Metrodorinae	*Macromotettixoides emeiensis* sp. nov.	PZ504138
	Macromotettixoides yuanbaoshanensis sp. nov.	PZ504139
	Macromotettixoides orthomargina Wei & Deng, 2023	OR030789
	Macromotettixoides yaana Deng, 2025	PQ826485
	Macromotettixoides brachycorna Luo, Zhang & Deng, 2024	OR003899
	Phaesticus moniliantennatus (Günther, 1940)	PQ767101
	Phaesticus moniliantennatus (Günther, 1940) (= *Flatocerus nankunshanensis* Liang & Zheng, 1984)	PQ767100
	Systolederus spicupennis Zheng & Jiang, 2003	MH791445
	Systolederus guangxiensis (Zheng, 1998) (= *Teredorus guangxiensis* Zheng, 1998)	OR260079
	Systolederus hainanensis (Zheng, 1993) (= *Teredorus hainanensis* Zheng, 1993)	MZ041207
Tetriginae	*Alulatettix yunnanensis* Liang, 1993	JQ272702
	Coptotettix cangshanensis Zheng, Nie & He, 2005	PZ259448
	Coptotettix longjiangensis Zheng & Wei, 2000	PZ259449
	Coptotettix longtanensis Zheng & Jiang, 2004	OK540319
	Ergatettix dorsifera (Walker, 1871)	MN083175
	Ergatettix serrifemora (Zheng & Shi, 2009)	MN938923
	Euparatettix bimaculatus Zheng, 1993	MN083177
	Euparatettix tridentatus Li, Deng, Zheng & Wei, 2014	OR260076
	Euparatettix variabilis (Bolívar, 1887)	MN083178
	Exothotettix guangxiensis Zheng & Jiang, 1993	OR260077
	Tetrix japonica (Bolívar, 1887)	JQ340002
Scelimeninae	*Gibbotettix parvipulvillus* Deng, Zheng & Wei, 2016	PQ869511
	Paragavialidium curvispinum Zheng, 1994	PQ524197
	Paragavialidium hainanense (Zheng & Liang, 1985)	OP650112
	Scelimena melli Günther, 1938	PQ783660
Batrachideinae	*Saussurella borneensis* Hancock, 1912	MZ169555
	Saussurella cornuta (Haan, 1843)	PQ835453
	Saussurella longiptera (Yin, 1984)	PQ835454
Outgroup	*Ellipes minuta* (Scudder, 1862)	GU945502
	Mirhipipteryx andensis Günther, 1969	KM657340

Phylogenetic analysis

Thirty taxa were selected for mitochondrial phylogenetic analysis, including two newly sequenced species and 28 mitogenomes retrieved from NCBI. *Mirhipipteryx andensis* Günther, 1969 (Ripipterygidae: Ripipteryginae) and *Ellipes minuta* (Scudder, 1862) (Tridactylidae: Tridactylinae) were selected as outgroups (Table 1).

The 13 protein-coding genes (PCGs) were extracted using PhyloSuite ver. 2, aligned with MAFFT ver. 7.505 (Katoh & Standley 2013), and refined with MACSE ver. 2.06 (Ranwez *et al.* 2018); ambiguously

aligned regions were removed using Gblocks ver. 0.91b (Talavera & Castresana 2007). ModelFinder ver. 3.0.1 (Kalyaanamoorthy *et al.* 2017) was used to select the best-fit partition model using BIC criterion. Maximum likelihood phylogenies were inferred using IQ-TREE ver. 3.0.1 (Nguyen *et al.* 2015) under the edge-linked partition model for 1000 standard bootstraps. Bayesian Inference phylogenies were inferred using MrBayes ver. 3.2.7a (Ronquist *et al.* 2012) under the partition model (2 parallel runs, 1 000 000 generations), in which the initial 25% of sampled data were discarded as burn-in. Convergence was assessed by ensuring the average standard deviation of split frequencies was <0.01. Genetic distances based on the 13 PCGs dataset were calculated using the Tajima-Nei model in MEGA 12 with 1000 bootstrap replications. Phylogenetic trees and distance matrices were visualized using Chiplo ver. 2.6.1 (Xie *et al.* 2023).

Morphological study

Specimens were examined and photographed using a stereo microscope (Olympus SZX7) and a digital microscope with 3D imaging (Keyence VHX-6000). All images were processed with Adobe Photoshop 2024. Distribution maps were generated using QGIS ver. 4.0.2 (QGIS Development Team 2026).

Morphological terminology and measurement landmarks follow Tumbrinck (2014), with pronotal projection abbreviations following Skejo & Bertner (2017) and Storozhenko & Pushkar (2017). Measurements are given in millimetres (mm). Taxonomy follows Cigliano *et al.* (2026).

Results

Mitochondrial genome organization and characteristics

The complete circular mitochondrial genomes of *Macromotettixoides emeiensis* sp. nov. and *M. yuanbaoshanensis* sp. nov. were 16 550 bp and 18 143 bp in length, respectively. Both mitogenomes contained 13 protein-coding genes (PCGs), 22 transfer RNA genes (tRNAs), two ribosomal RNA genes (rRNAs), and one control region (CR) (Fig. 1; Table 2). Nine PCGs (*cox1*, *cox2*, *cox3*, *cytb*, *nad2*, *nad3*, *nad6*, *atp6*, *atp8*) were J-strand encoded, and four (*nad1*, *nad4*, *nad4l*, *nad5*) were N-strand encoded; rRNAs were also on the N-strand.

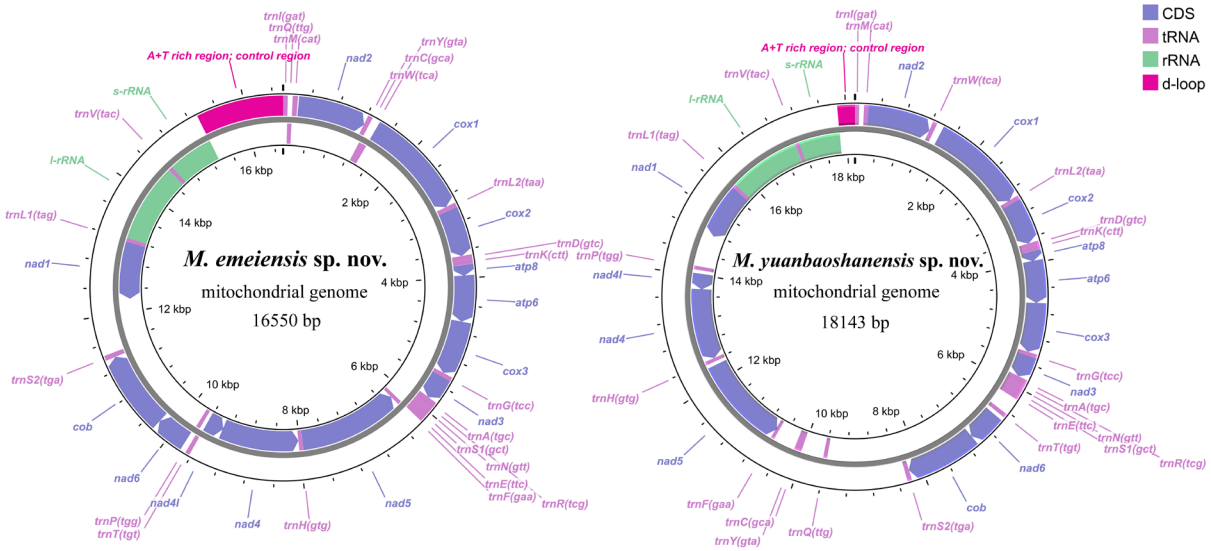


Fig. 1. Circular mitochondrial genome maps of *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

Table 2. Annotated mitochondrial genomes of *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

Gene	Position		Size	Codon		Strand	Identity
	Start	End		Start	Stop		
trnI	1/1	66/65	66/65	–	–	J/J	96.97
trnQ	67/9569	135/9638	69/70	–	–	N/N	82.86
trnM	135/139	206/206	72/68	–	–	J/J	84.72
nad2	222/208	1217/1218	996/1011	ATT/ATA	TAA/TAA	J/J	80.61
trnW	1216/1217	1283/1284	68/68	–	–	J/J	88.24
trnC	1276/10042	1339/10106	64/65	–	–	N/N	87.69
trnY	1340/10107	1402/10171	63/65	–	–	N/N	80
cox1	1400/1395	2933/2936	1534/1542	ATC/ATT	T/TAA	J/J	84.57
trnL2	2934/2932	2997/2995	64/64	–	–	J/J	92.19
cox2	2999/2997	3682/3680	684/684	ATG/ATG	TAA/TAA	J/J	83.77
trnD	3682/3680	3743/3742	62/63	–	–	J/J	96.83
trnK	3745/3744	3810/3810	66/67	–	–	J/J	91.04
atp8	3814/3814	3972/3972	159/159	ATG/ATG	TAA/TAA	J/J	79.87
atp6	3966/3966	4637/4637	672/672	ATG/ATG	TAA/TAA	J/J	80.95
cox3	4637/4637	5426/5426	790/790	ATG/ATG	T/T	J/J	81.27
trnG	5427/5427	5488/5489	62/63	–	–	J/J	95.24
nad3	5489/5490	5842/5843	354/354	ATT/ATT	TAG/TAG	J/J	82.2
trnA	5841/5842	5905/5905	65/64	–	–	J/J	96.92
trnR	5905/5905	5965/5966	61/62	–	–	J/J	87.1
trnN	5966/5968	6031/6034	66/67	–	–	J/J	85.07
trnS1	6032/6035	6098/6101	67/67	–	–	J/J	91.04
trnE	6099/6102	6162/6169	64/68	–	–	J/J	85.29
trnF	6161/10570	6222/10631	62/62	–	–	N/N	82.26
nad5	6223/10615	7945/12294	1723/1680	ATG/ATT	T/TAA	N/N	81.84
trnH	7949/12359	8013/12423	65/65	–	–	N/N	86.15
nad4	8013/12423	9338/13748	1326/1326	ATG/ATG	TAG/TAG	N/N	84.54
nad4L	9332/13742	9622/14032	291/291	ATT/ATT	TAA/TAA	N/N	86.6
trnT	9625/6438	9686/6500	62/63	–	–	J/J	98.41
trnP	9687/14097	9751/14162	65/66	–	–	N/N	83.33
nad6	9768/6560	10244/7063	477/504	ATA/ATA	TAA/TAA	J/J	78.57
cytb	10244/7063	11381/8202	1138/1140	ATG/ATG	T/TAA	J/J	82.72
trnS2	11382/8201	11449/8268	68/68	–	–	J/J	85.29
nad1	12220/14767	13158/15708	939/942	ATT/ATT	TAA/TAA	N/N	84.93
trnL1	13159/15709	13223/15773	65/65	–	–	N/N	92.42
rrnL	13225/15775	14509/17059	1285/1285	–	–	N/N	91.14
trnV	14513/17063	14579/17129	67/67	–	–	N/N	98.51
rrnS	14579/17129	15324/17872	746/744	–	–	N/N	89.42
CR	15325/17873	16550/18143	1226/271	–	–	J/J	12.79

Table 3. Nucleotide composition and skewness of different elements of the mitochondrial genomes of *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

Regions	Size (bp)	AT(%)	GC(%)	GT(%)	AT skew	GC skew
Full genome	16550/18143	71.4/74.4	28.6/25.6	39.8/40.9	0.179/0.143	-0.266/-0.295
PCGs	11079/11094	69.7/72	30.3/28	54.1/52.7	-0.13/-0.103	-0.029/-0.069
PCGs-1st	3693/3698	67.5/69.2	32.5/30.8	53.3/51.4	-0.011/0.021	0.183/0.138
PCGs-2nd	3693/3698	65.6/66.5	34.4/33.5	59.9/60.3	-0.379/-0.375	-0.145/-0.13
PCGs-3rd	3693/3698	75.8/80.3	24.1/19.7	48.9/46.5	-0.021/0.015	-0.152/-0.287
tRNAs	1433/1442	72.4/74	27.7/26	50.9/50.5	0.036/0.044	0.157/0.163
rRNAs	2031/2029	74.4/76.6	25.6/23.5	63.7/62.5	-0.259/-0.225	0.323/0.328
rrnL	1285/1285	75.5/77.1	24.5/22.9	64.2/62.9	-0.266/-0.232	0.34/0.342
rrnS	746/744	72.5/75.6	27.5/24.4	63/61.7	-0.246/-0.211	0.298/0.304
CR	1226/271	80.4/76	19.7/24	45.1/36.9	0.127/0.282	0.012/-0.2

The 13 PCGs totaled 11 079 bp in *Macromotettixoides emeiensis* sp. nov. and 11 094 bp in *M. yuanbaoshanensis* sp. nov. (Table 3). Start codons were primarily ATT, ATA, and ATG; stop codons were TAA, TAG, and T (incomplete). AT content was 69.7% and 72.0%, with AT-skew of -0.130 and -0.103, and GC-skew of -0.029 and -0.069, respectively. At the third codon position, A+T content reached 75.8% and 80.3%.

RSCU analysis revealed strong bias toward A/U-ending codons in both species (Fig. 2). UUA (Leu2) was the most frequently used codon, followed by UCU (Ser2) in *Macromotettixoides emeiensis* sp. nov.

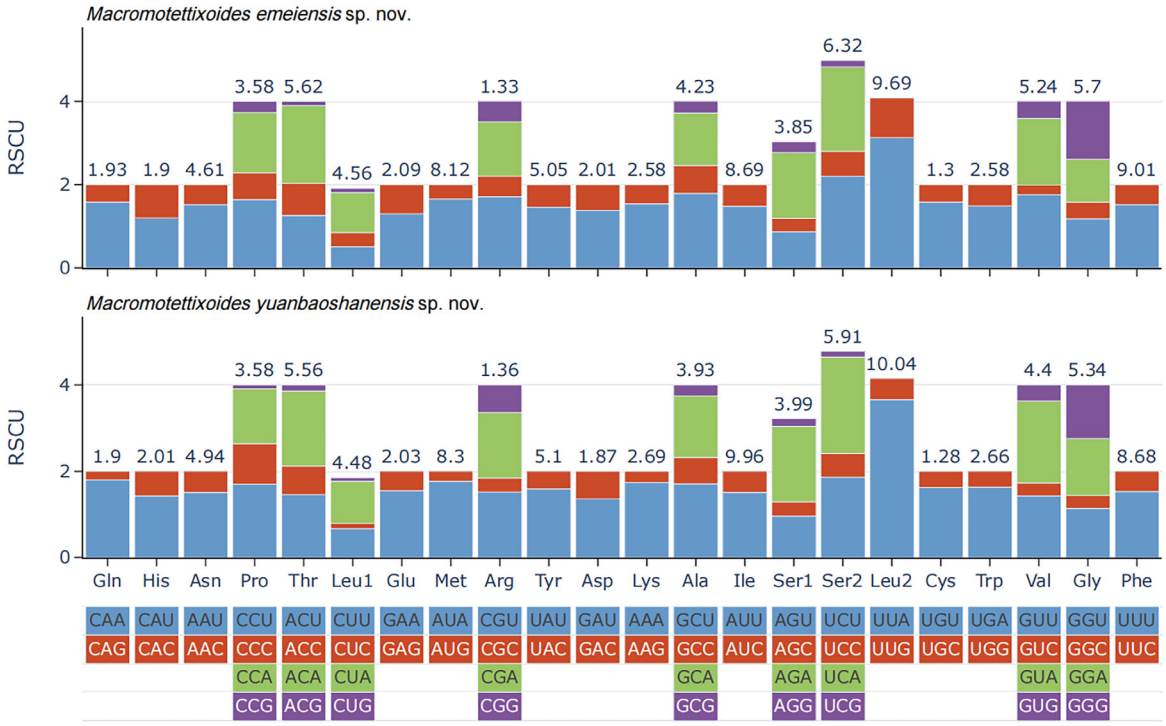


Fig. 2. Relative synonymous codon usage (RSCU) in the protein-coding genes of *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

and UCA (Ser2) in *M. yuanbaoshanensis* sp. nov. High-frequency codons included AUA (Met), ACA (Thr), GUA (Val), and GGA (Gly); low-frequency codons included UUG (Leu), UCG (Ser), ACG (Thr), and GCG (Ala).

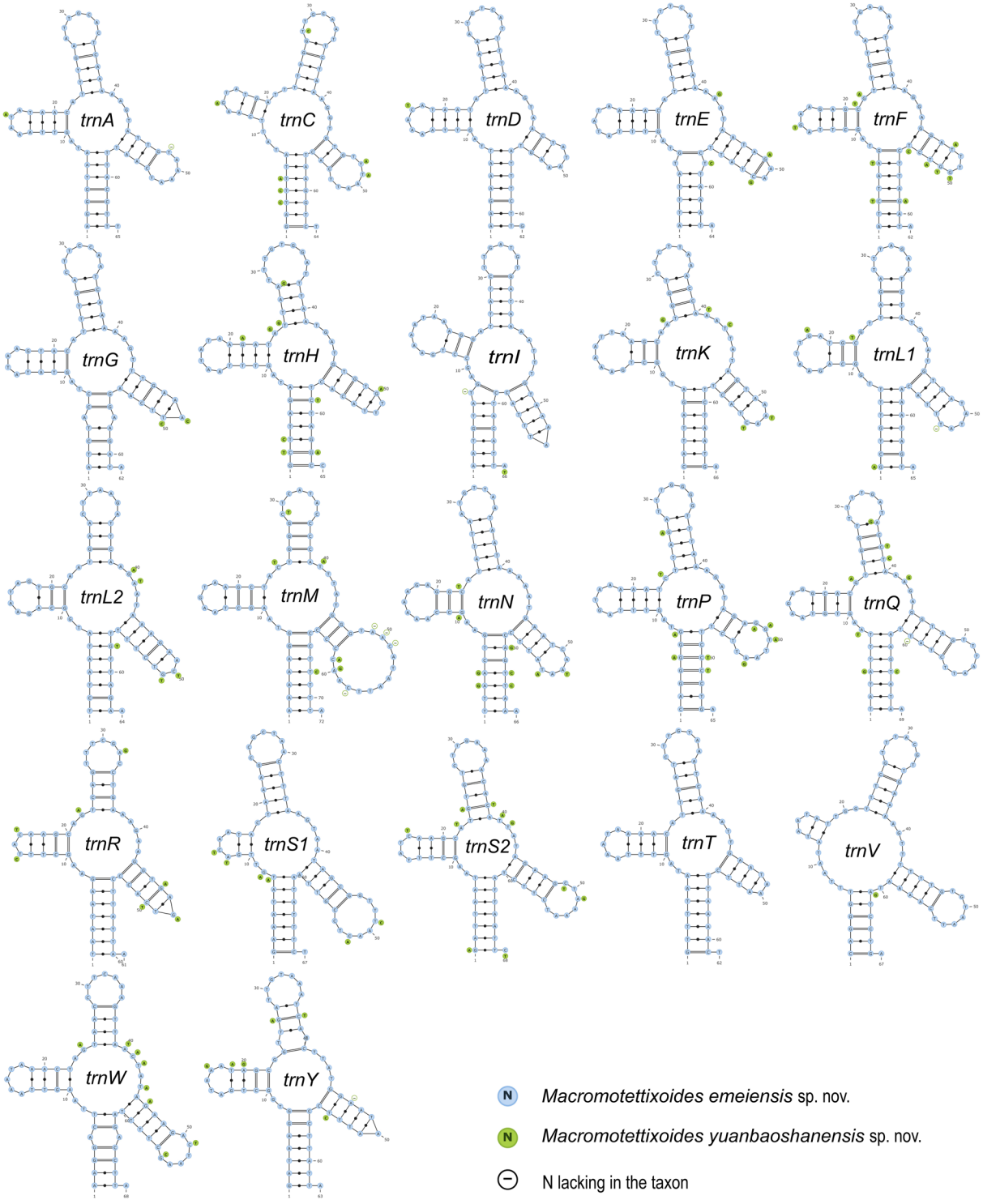


Fig. 3. Secondary structures of mitochondrial tRNAs in *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

All 22 tRNAs fold into typical cloverleaf structures, ranging from 61–72 bp (*Macromotettixoides emeiensis* sp. nov.) and 62–70 bp (*M. yuanbaoshanensis* sp. nov.) (Fig. 3). The rRNA genes (*rrnL* and *rrnS*) totaled 2031 bp and 2029 bp, with *rrnL* being 1285 bp in both species and *rrnS* being 746 bp and 744 bp, respectively. The control region was highly A+T rich (80.4% and 76.0%).

Phylogenetic analysis and genetic distance

Phylogenetic trees based on 13 concatenated PCGs showed congruent BI and ML topologies (Fig. 4). *Macromotettixoides* was recovered as monophyletic with strong support (posterior probability [PP] = 1.00; ultrafast bootstrap [UFBoot] = 100%), with *Macromotettixoides yuanbaoshanensis* sp. nov. as sister to *M. brachycorna* Luo, Zhang & Deng, 2024 and *M. emeiensis* sp. nov. grouped with *M. orthomargina* + *M. yaana*. At the suprageneric level, *Macromotettixoides* was sister to *Phaesticus* + *Systolederus* (*Teredorus*) (PP = 1.00; UFBoot = 92), with *Ellipes minuta* and *Mirhipipteryx andensis* as outgroups.

Genetic distances support the specific status of both new species. Interspecific distances to the nearest congeners (0.164–0.228) exceed the typical insect intraspecific threshold (<0.02) by an order of magnitude, yet remain below intergeneric distances (>0.36), confirming both as distinct species within *Macromotettixoides* (Supp. file 1: Table S1).

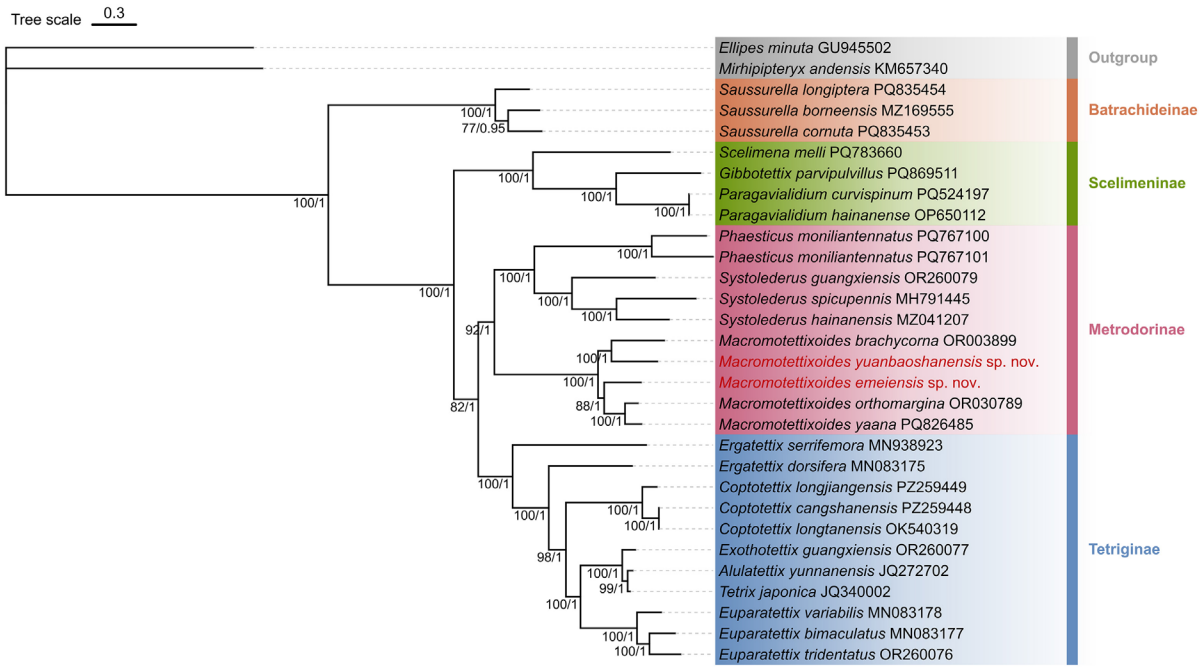


Fig. 4. Phylogenetic tree obtained from Maximum Likelihood (ML) and Bayesian Inference (BI) analyses based on the 13 protein-coding genes (PCGs). Bootstrap support values (ML) and posterior probabilities (BI) are indicated at the nodes.

Taxonomy

Class Insecta Linnaeus, 1758
Order Orthoptera Olivier, 1789
Family Tetrigidae Rambur, 1838
Subfamily Metrodorinae Bolívar, 1887
Genus *Macromotettixoides* Zheng, Wei & Jiang, 2005

Macromotettixoides emeiensis sp. nov.
urn:lsid:zoobank.org:act:53DC402B-C8B0-4846-88AF-DBDD31691E5A
Figs 5–7, 11

Diagnosis

The new species is distinguished from other known species in the genus by its pronotum in dorsal view not tectiform and with carinate elevations between the shoulders. It's similar to *Macromotettixoides yuanbaoshanensis* sp. nov., and the main differences are shown in the Table 4.

Etymology

The specific epithet is derived from the name of the type locality, Emei Mountain in Sichuan Province, China.

Type material

Holotype

CHINA – **Sichuan Province** • ♀; Leshan City, Emei Mountain; 29°32′05″ N, 103°15′55″ E; elev. 1754 m; 28 Aug. 2024; Le Liu leg.; CLSGNU.

Paratypes

CHINA – **Sichuan Province** • 1 ♂, 2 ♀♀; same collection data as for holotype; CLSGNU.

Description

Female

Body. Size small and stout, body surface coarse and uneven, covered with protuberances and short carinae.

Head. Head not exserted above pronotal surface. Fastigium of vertex wide; in dorsal view, width of vertex between eyes 2.3–2.4 times width of compound eye; anterior margin nearly truncate, slightly surpassing anterior margin of eye; median carina visible in anterior half but absent in posterior half; lateral carinae projected forwards and reaching level of anterior margin of eyes, vertex uneven with paired fossulae. In lateral view, face vertical, fastigium of vertex together with frontal costa rounded-angle and markedly exserted, frontal costa distinctly concave between eyes, protruded anteriorly and broadly rounded between antennal grooves. In frontal view, frontal costa diverges above the lateral ocelli, the bifurcation of the frontal costa is in the middle of the compound eye height; longitudinal furrow widely divergent between antennae, width of longitudinal furrow of frontal ridge distinctly narrower than antennal groove diameter. Antenna filiform, antennal grooves inserted slightly below inferior margins of compound eyes; superior margins of antennal grooves are situated at the level of inferior margins of compound eyes; 15-segmented, the 9th and 10th segments are the longest, about 3.5–4.0 times as long as wide. Eyes globose, the lateral ocelli at slightly below the middle of the anterior margin of eyes.

Thorax. Pronotum in dorsal view not tectiform and with coarse dorsum, with carinate elevations between the shoulders (the median carina distinctly elevated before and behind the shoulders; with 2–3 pairs of carinate elevations on either side of the median carina; with a pair of carinae posterior to humeral

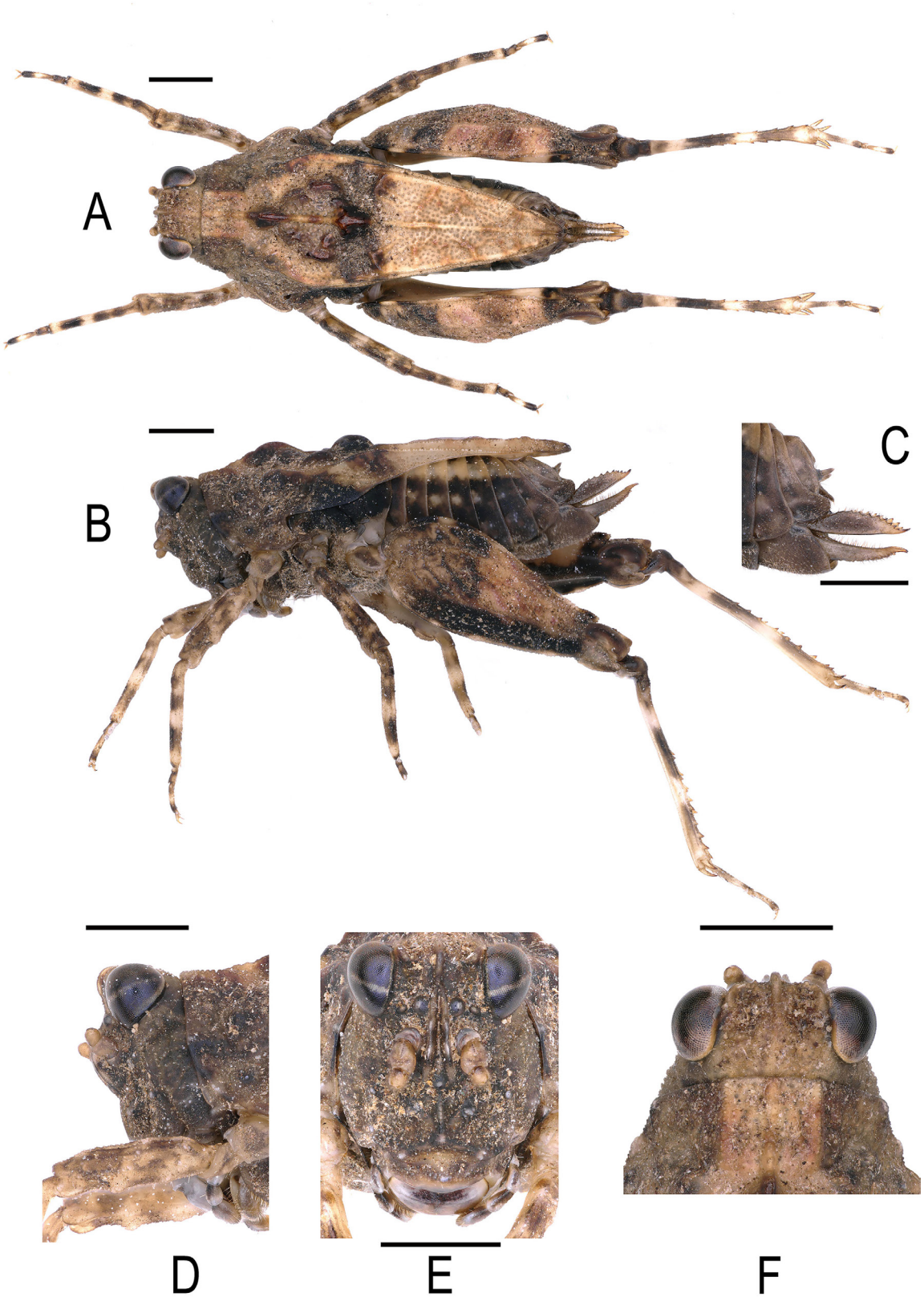


Fig. 5. *Macromotettixoides emeiensis* sp. nov., holotype, ♀, 8.05 mm (CLSGNU), Emei Mountain, Leshan, Sichuan Province, China. **A**. Dorsal view of body. **B**. Lateral view of body. **C**. Lateral view of genitalia. **D**. Lateral view of head. **E**. Frontal view of head. **F**. Dorsal view of head. Scale bars = 1 mm.

angles), the median carina of pronotum between the shoulders distinctly depressed, and the posterior half of pronotal disc with net-like carinae and notches. In lateral view, the anterior half of the upper margin undulated, the median carina lamellate and elevated and form two hump-shaped elevations; and the posterior half straight. Anterior margin of pronotum truncated, prozonal carinae parallel; humeral angle arched; hind pronotal process narrow and short, nearly reaching knee of hind femur and its apex narrowly rounded; external lateral carinae of metazona curved upwards, lower margins of hind process curved downward, width of infrascapular area is 1.1 mm. Posterior angle of lateral lobe of pronotum extending obliquely backwards and slightly outwards, apex slightly truncate; posterior margins of lateral lobes of pronotum only with ventral sinus. Tegmen and wing invisible.

Legs. Fore and middle femora slightly compressed, margins finely serrated and carinate and ventral margins with two projections and distinctly undulated. Hind femur stout, 2.5 times as long as wide, with carinated, margins finely serrated; antegenicular denticle triangular, distinctly high, apex nearly right-angled, genicular denticle extending backwards, apex obtuse. Outer side of hind tibia with 5–7 spines, inner side with 5–6 spines; length of first segment of hind tarsi 1.4 times as long as third, first and second pulvilli small and apices sharp, third pulvillus large and apex obtuse.

Abdomen. Upper valva of ovipositor about 4.4 times as long as wide, upper margin arcuate, outer margins of upper and lower valvae with saw-like teeth. Subgenital plate length nearly equal to width, median carina visible only in anterior half, middle of posterior margin broadly triangularly projected and slightly folded inwards.

Coloration. Body brown or yellowish brown. All tibiae with two to three yellowish brown rings each. Ovipositor brown.

Male

Similar to female, but smaller and narrower. Width of vertex between eyes 2.0 times width of compound eye. Subgenital plate short, cone-shaped, apex bifurcated.

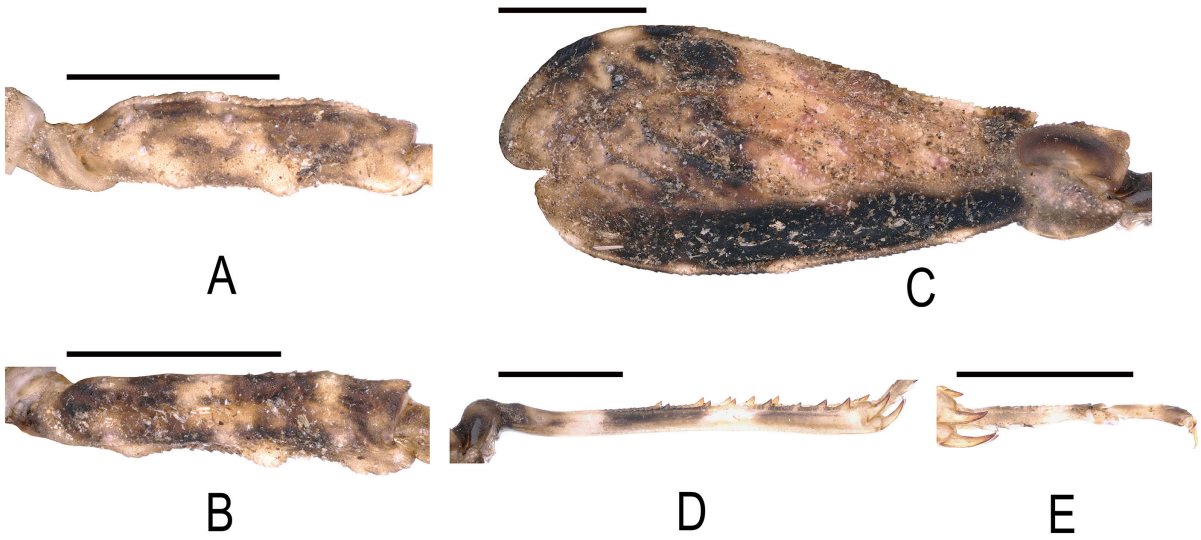


Fig. 6. *Macromotettixoides emeiensis* sp. nov., holotype, ♀, 8.05 mm (CLSGNU), Emei Mountain, Leshan, Sichuan Province, China. **A**. Left-lateral view of fore femur. **B**. Left-lateral view of middle femur. **C**. Left-lateral view of hind femur. **D**. Left-lateral view of hind tibia. **E**. Left-lateral view of hind tarsus. Scale bars = 1 mm.

Measurements

Length of body ♂ 6.2 mm, ♀ 7.5–8.3 mm; length of pronotum ♂ 5.5 mm, ♀ 6.1–6.4 mm; length of hind femur ♂ 4.2 mm, ♀ 4.5 mm.

Ecology and distribution

This species was collected from the high-altitude forest region of Emei Mountain (1754 m), where it inhabits leaf litter and moss-covered loose soil in shaded areas of bamboo forests. The habitat is characterized by dense vegetation, high humidity, and cool temperatures typical of subtropical montane forests.

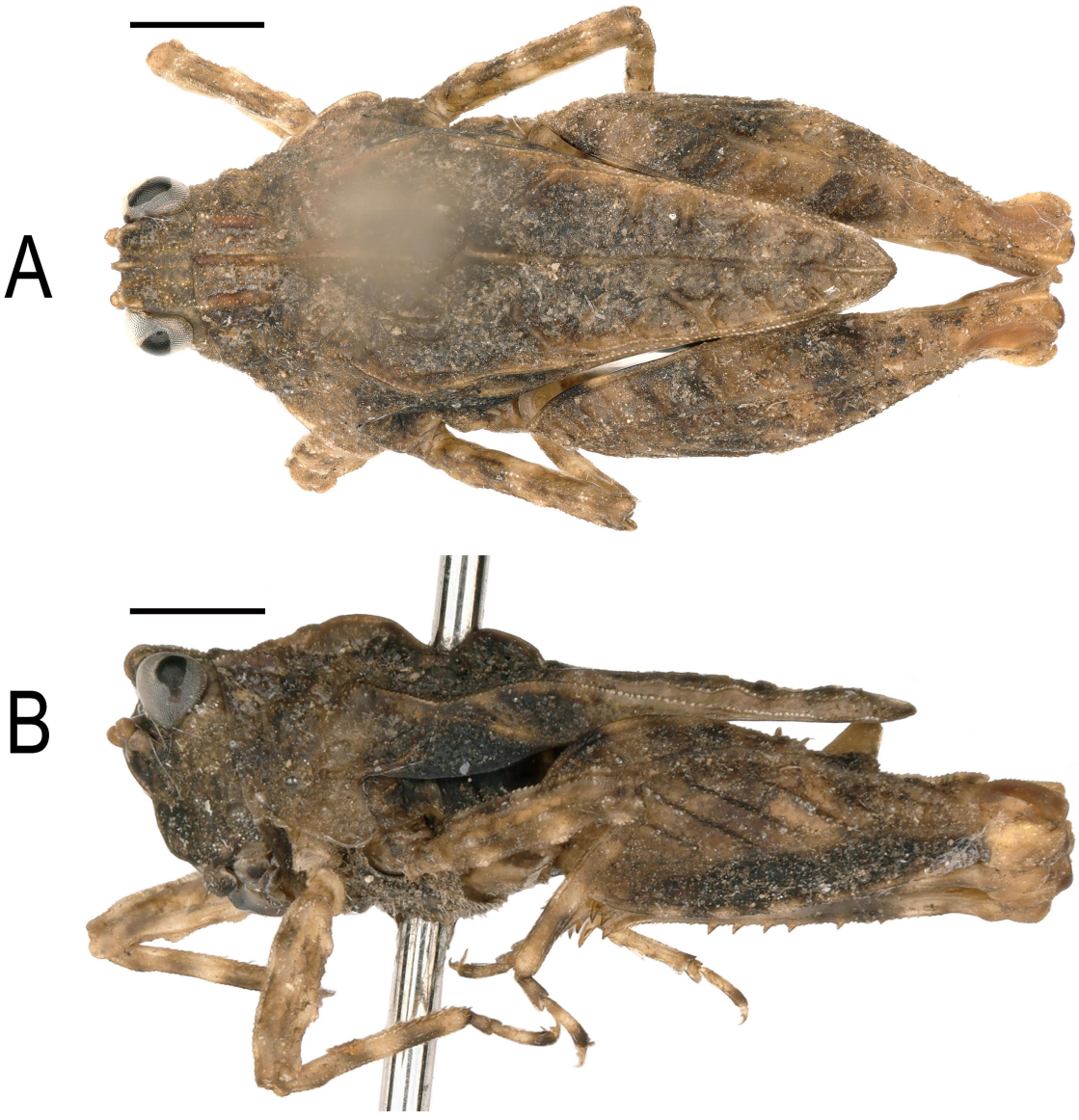


Fig. 7. *Macromotettixoides emeiensis* sp. nov., paratype, ♂, 6.15 mm (CLSGNU), Emei Mountain, Leshan, Sichuan Province, China. **A**. Dorsal view of body. **B**. Lateral view of body. Scale bars = 1 mm.

Table 4. Comparison of *Macromotettixoides emeiensis* sp. nov. and *Macromotettixoides yuanbaoshanensis* sp. nov.

Characters	***Macromotettixoides emeiensis*** sp. nov.	***Macromotettixoides yuanbaoshanensis*** sp. nov.
Vertex in female	width of vertex between eyes 2.3–2.4 times width of compound eye	width of vertex between eyes 1.5–1.6 times width of compound eye
Width of longitudinal furrow of frontal ridge	distinctly narrower than antennal groove diameter	distinctly wider than antennal groove diameter
Pronotum between the shoulders	with carinate elevations	distinctly tuberculately elevated
In lateral view, the upper margin of pronotum	the anterior half undulated, the median carina lamellate and elevated and form two hump-shaped elevations and the posterior half straight	undulated
Ventral margins of fore and middle femora	with two projections and distinctly undulated	slightly undulated

Macromotettixoides yuanbaoshanensis sp. nov.
urn:lsid:zoobank.org:act:9791A7FC-E49E-4C18-8EE0-6031923DF8E6
Figs 8–11

Diagnosis

The new species is distinguished from other known species in the genus by its pronotum in dorsal view not tectiform and distinctly tuberculately elevated between the humeral angles. It's similar to *Macromotettixoides emeiensis* sp. nov., and the main differences are shown in the Table 4.

Etymology

The specific epithet is derived from the name of the type locality, Yuanbaoshan Mountain in Guangxi, China.

Type material

Holotype

CHINA – **Guangxi Province** • ♀; Liuzhou City, Yuanbao Mountain; 25°25′35″ N, 109°09′44″ E; elev. 1414 m; 9 Sep. 2021; Chaomei Huang leg.; CLSGNU.

Paratypes

CHINA – **Guangxi Province** • 5 ♂♂, 4 ♀♀; same collection data as for holotype; CLSGNU.

Description

Female

Body. Size small and stout, body surface coarse and uneven, covered with protuberances and short carinae.

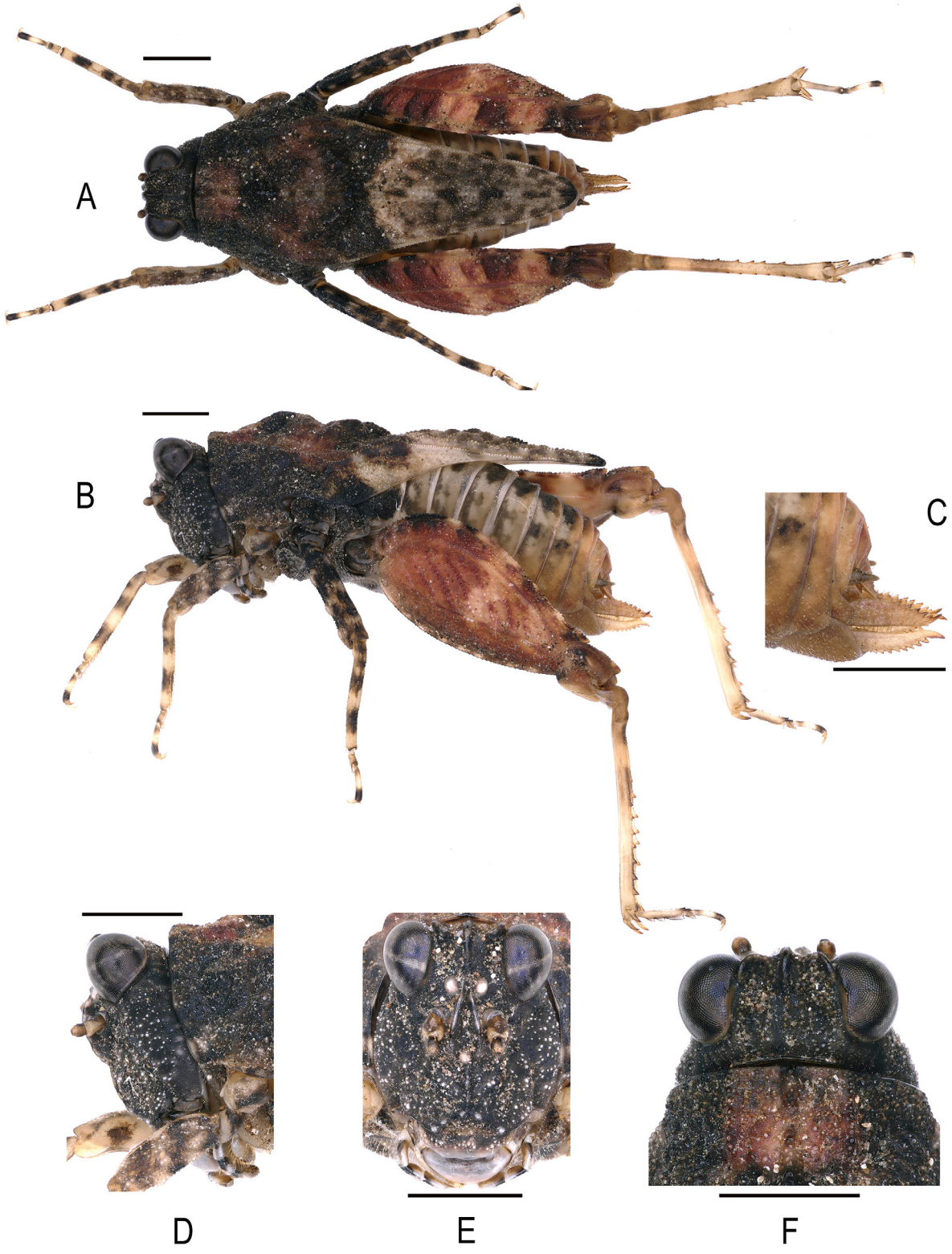


Fig. 8. *Macromotettixoides yuanbaoshanensis* sp. nov., holotype, ♀, 7.93 mm (CLSGNU), Yuanbao Mountain, Liuzhou, Guangxi Province, China. **A**. Dorsal view of body. **B**. Lateral view of body. **C**. Lateral view of genitalia. **D**. Lateral view of head. **E**. Frontal view of head. **F**. Dorsal view of head. Scale bars = 1 mm.

Head. Head not exserted above pronotal surface. Fastigium of vertex wide; in dorsal view, width of vertex between eyes 1.5–1.6 times as wide as compound eye; anterior margin of fastigium slightly concave on both sides of median carina and undulated, slightly surpassing anterior margin of eye; median carina visible anteriorly; lateral margins turned backward; vertex uneven with paired fossulae. In lateral view, face vertical, fastigium of vertex together with frontal costa rounded-angle and slightly exserted, frontal costa distinctly concave between eyes, protruded anteriorly and broadly rounded between antennal grooves. In frontal view, frontal costa bifurcated above lateral ocelli, longitudinal furrow widely divergent between antennae, width of longitudinal furrow of frontal ridge 1.5 times as wide as antennal groove diameter. Antenna filiform, antennal grooves inserted slightly below inferior margins of compound eyes; superior margins of antennal grooves are situated at the level of inferior margins of compound eyes. Eyes globose, lateral ocellus located lowest third of compound eye height.

Thorax. Pronotum in dorsal view not tectiform, distinctly tuberculately elevated between the humeral angles, with a median depression on the elevation; posterior half with reticulated keels and impressions. In lateral view, the upper margin undulated. Anterior margin of pronotum truncated, prozonal carinae parallel; humeral angle obtusely rounded; hind pronotal process narrow and short, nearly reaching knee of hind femur and its apex narrowly rounded; external lateral carinae of metazona curved upwards, lower margins of hind process curved downward, width of infrascapular area is 1.2 mm. Posterior angle of lateral lobe of pronotum extending obliquely backwards and slightly outwards, apex subtruncated; posterior margins of lateral lobes of pronotum only with ventral sinus. Tegmen and wing invisible.

Legs. Fore and middle femora slightly compressed, margins finely serrated and carinate and ventral margins slightly undulated. Hind femur stout, 2.4 times as long as wide, with carinated, margins finely serrated; antegenicular denticle and genicular denticle acute. Outer side of hind tibia with 7–8 spines, inner side with 5–6 spines; length of first segment of hind tarsi 1.2 times as long as third; three pulvilli of first segment of posterior tarsi are increased in turn, all apices acute.



Fig. 9. *Macromotettixoides yuanbaoshanensis* sp. nov., holotype, ♀, 7.93 mm (CLSGNU), Yuanbao Mountain, Liuzhou, Guangxi Province, China. **A**. Left-lateral view of fore femur. **B**. Left-lateral view of middle femur. **C**. Left-lateral view of hind femur. **D**. Left-lateral view of hind tibia. **E**. Left-lateral view of hind tarsus. Scale bars = 1 mm.

Abdomen. Ovipositor narrow and long, length of upper valvulae 3.2 times as long as wide, upper and lower valvulae with slender saw-like teeth. Length of subgenital plate nearly equal to its width, middle of posterior margin of subgenital plate triangular projecting.

Coloration. Body brown or reddish brown. Hind tibia dark brown, with two light rings in the middle.

Male

Similar to female, but smaller and narrower. Width of vertex between eyes 1.4–1.5 times as wide as compound eye. Subgenital plate short, cone-shaped, apex bifurcated.

Measurements

Length of body ♂ 6.5–7.4 mm, ♀ 7.4–8.4 mm; length of pronotum ♂ 5.3–5.8 mm, ♀ 6.0–6.7 mm; length of hind femur ♂ 3.9–4.1 mm, ♀ 4.1–4.9 mm.

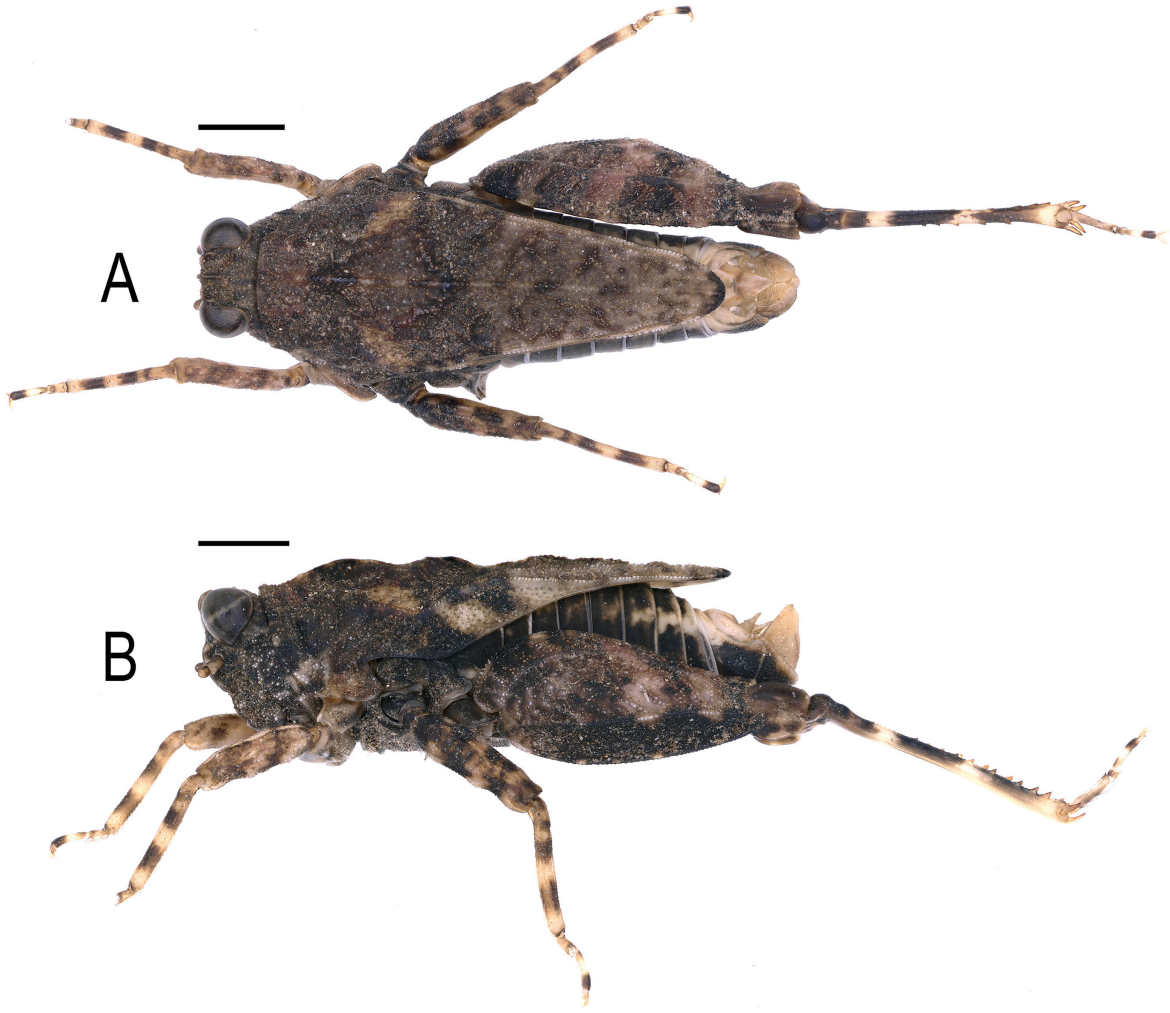


Fig. 10. *Macromotettixoides yuanbaoshanensis* sp. nov., paratype, ♂, 6.7 mm (CLSGNU), Yuanbao Mountain, Liuzhou, Guangxi Province, China. **A**. Dorsal view of body. **B**. Lateral view of body. Scale bars = 1 mm.

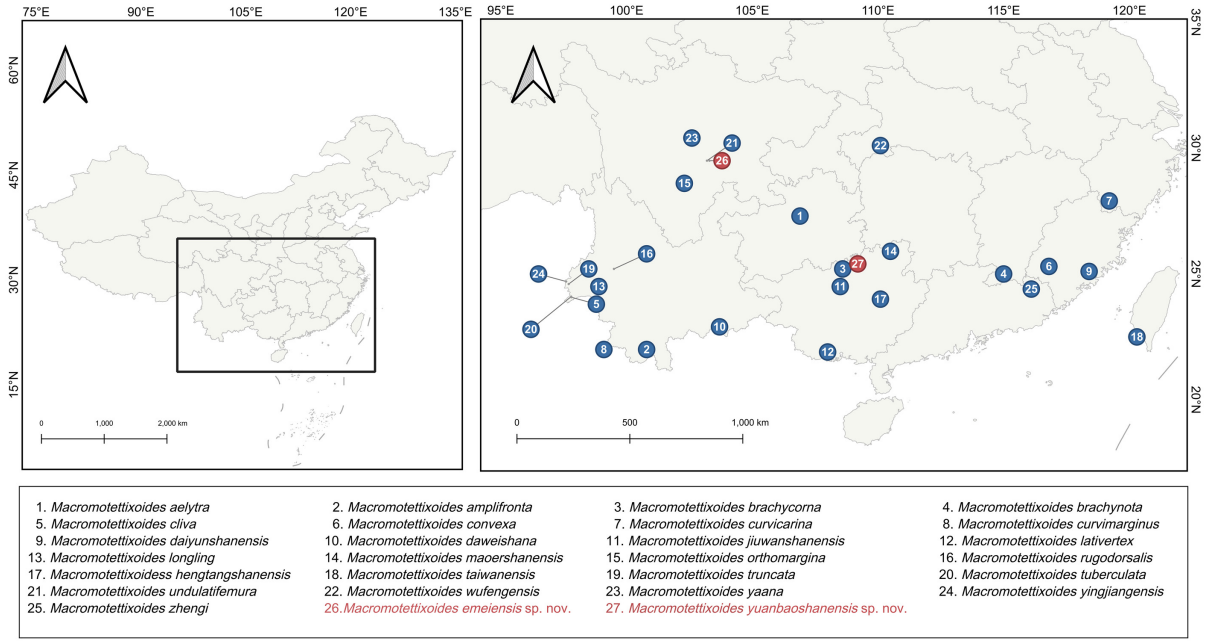


Fig. 11. Distribution map of 27 species of *Macromotettixoides* Zheng, Wei & Jiang, 2005 in China. Blue and red circles represent known and new species, respectively.

Ecology and distribution

This species was collected from the montane forest region of Yuanbao Mountain (1414 m) in Rongshui County, Guangxi Province. It inhabits leaf litter and moss-covered rocks in shaded areas of mixed deciduous and evergreen forests. The habitat is characterized by moderate humidity, diverse vegetation, and typical karst topography.

Key to species of Macromotettixoides Zheng, Wei & Jiang, 2005

The following identification key is based upon the keys of Wei & Deng (2023). *Macromotettixoides aelytra* (Zheng *et al.*, 2002) and *Macromotettixoides brachynota* Zheng & Shi, 2009 were described based on the larvae, these two species are excluded from the identification key.

1. Pronotum in dorsal view not tectiform, except for carinate elevations (or tubercle-like elevation) between the shoulders, the rest of it relatively flat 2
– Pronotum in dorsal view tectiform 3

2. Width of vertex between eyes 2.3–2.4 times as wide as compound eye in female; in lateral view, the upper margin of pronotum with the anterior half undulated, the median carina lamellate and elevated, forming two hump-shaped elevations and the posterior half straight .....***M. emeiensis*** sp. nov.
– Width of vertex between eyes 1.5–1.6 times as wide as compound eye in female; in lateral view, the upper margin of pronotum undulated ..... ***M. yuanbaoshanensis*** sp. nov.

3. Anterior margin of pronotum obtusely angular 4
– Anterior margin of pronotum truncate 6

4. Pronotal disc smooth and interspersed with dense granules; lower margin of hind pronotal process and external lateral carina of metazona straight ..... ***M. jiuwanshanensis*** Zheng, Wei & Jiang, 2005

– Pronotal disc with many net-like wrinkles and notchs, lower margin of hind pronotal process and external lateral carina of metazona curved 5

5. Width of vertex between eyes 1.7–1.8 times as wide as compound eye, antennal grooves inserted between inferior margin of compound eyes, middle of pronotal disc flat and without concavity; interhumeral carina present .....***M. lativertex*** Deng *et al.*, 2014
– Width of vertex between eyes 2.5–2.6 times as wide as compound eye; antennal grooves inserted slightly below inferior margin of compound eyes; interhumeral carina absent .... ***M. rugodorsalis*** Li & Mao, 2020

6. Hind pronotal process broad and apex concave or broadly rounded 7
– Hind pronotal process narrow and apex narrowly rounded 8

7. Apex of hind pronotal process concave ..... ***M. curvimarginus*** Zheng & Xu, 2010
– Apex of hind pronotal process broadly rounded ..... ***M. amplifronta*** Fan, Li & Mao, 2023

8. Median carina of pronotum strongly elevated and distinctly arch-like in profile or arch-like before shoulders 9
– Median carina of pronotum low and straight or undulated in profile 12

9. Median carina of pronotum distinctly arch-like in profile ..... ***M. curvicarina*** Deng, 2020
– Median carina of pronotum arch-like before shoulders in profile and straight or undulated behind shoulders 10

10. Pronotal surface without tuberculiform convex between shoulders; middle femora with straight ventral margins ..... ***M. wufengensis*** Zheng, Wei & Li, 2009
– Pronotal surface distinctly tuberculiform convex between shoulders; middle femora with undulated ventral margins 11

11. Width of vertex between eyes 2.0 times as wide as compound eye; pronotal disc interspersed with dense granules, median carina of pronotum straight behind shoulders; lower outer carina of hind femora without projection .....***M. cliva*** Zheng *et al.*, 2006
– Width of vertex between eyes 1.4–1.5 times as wide as compound eye; pronotal disc interspersed with dense protuberances of variable sizes and short carinae and notchs, median carina of pronotum undulated behind shoulders; postmedian of lower outer carina of hind femora with two projections .....***M. convexa*** Deng, 2020

12. Lower carinae of fore and middle femora with two to three teeth and distinctly wavy 13
– Lower carinae of fore and middle femora without tooth and straight or slightly undulated in general 19

13. Lower outer carina of hind femora smooth and without projection 14
– Postmedian of lower outer carinae of hind femora with two projections 18

14. Median carina of pronotum low and not lamellar in profile; hind pronotal apex broadly rounded .... ***M. daweishana*** Wei & Deng, 2023
– Median carina of pronotum high and lamellar in profile; hind pronotal apex narrowly rounded 15

15. Width of vertex between eyes 2.0 times as wide as compound eye; antennae 15-segmented 16
– Width of vertex between eyes 1.3–1.6 times as wide as compound eye; antennae 13-segmented or 14-segmented 17

16. Median carina of pronotum undulated in profile; apex of hind pronotal process slightly concave; lower margin of hind femora with five or six teeth and undulated ..... ***M. undulatifemura*** Deng, Zheng & Yang, 2012
– Median carina of pronotum slightly arc in profile; apex of hind pronotal process rounded; lower margin of hind femora serrated ..... ***M. maoershanensis*** Luo, Zhang & Deng, 2024

17. Pronotal surface interspersed with dense protuberances of variable sizes and notches; lower margin of hind process straight ..... ***M. yaana*** Deng, 2025
– Pronotal surface interspersed with dense granules; lower margin of hind process curved ..... ***M. brachycorna*** Luo, Zhang & Deng, 2024

18. Width of vertex between eyes 1.4–1.6 times as wide as compound eye in female; posterior half of pronotal disc interspersed with net-like carinae; lower margin of hind pronotal process curved; interhumeral carina present ..... ***M. shengtangshanensis*** Deng, 2020
– Width of vertex between eyes 2.0 times as wide as compound eye; pronotal surface interspersed with dense protuberances; lower margin of hind pronotal process straight; interhumeral carina absent ... ***M. orthomargina*** Wei & Deng, 2023

19. Pronotum coarse, disc with many net-like wrinkles and notches 20
– Pronotum smooth, disc covered with granules 22

20. Lateral carinae of prozona contracted backward; interhumeral carina absent ..... ***M. taiwanensis*** Liang, 2000
– Lateral carinae of prozona parallel; interhumeral carina present 21

21. The upper margin of antennal base segment just level with lower margin of eyes; in profile, median carina of pronotum distinctly elevated with swollen base before shoulder ..... ***M. tuberculata*** Mao, Li & Han, 2020
– Antennae inserted between lower margin of eyes; in profile, median carina of pronotum slightly elevated with swollen base before shoulder ..... ***M. yingjiangensis*** Fan, Li & Mao, 2023

22. Apex of hind process of pronotum truncated ..... ***M. truncata*** Mao, Li & Han, 2020
– Apex of hind process of pronotum acutely rounded 23

23. Mid femora undulated; the caudal pronotum suddenly becoming fine ..... ***M. daiyunshanensis*** Deng, 2020
– Mid femora straight; the caudal pronotum not suddenly becoming fine 24

24. Width of vertex between eyes 1.3 times width of compound eye; anterior margin of fastigium of vertex truncate; three pulvilli of first segment of posterior tarsi equal in length ..... ***M. zhengi*** Deng, 2011
– Width ofvertex between eyes 1.6–2.0 times width of compound eye; anterior margin of fastigium of vertex arcuate; three pulvilli of first segment of posterior tarsi increasing in length ..... ***M. longling*** Deng, 2016

Distribution

Based on known specimen records and literature data, species of *Macromotettixoides* are primarily distributed in southern and southwestern mountainous regions of China, including Guangxi (Zheng *et al.* 2005; Deng *et al.* 2014, 2020; Luo *et al.* 2024), Yunnan (Zheng *et al.* 2006; Han *et al.* 2020; Li *et al.* 2020; Fan *et al.* 2023; Wei & Deng 2023), Sichuan (Deng *et al.* 2012; Wei & Deng 2023; Li *et al.*

2025), Fujian (Deng *et al.* 2020), Guizhou (Zheng *et al.* 2006), Zhejiang (Deng *et al.* 2020), Jiangxi (Zheng & Shi 2009), Hubei (Zheng *et al.* 2009), Guangdong (Deng 2011), and Taiwan (Zheng *et al.* 2012) (Fig. 11). Among these, Yunnan, Guangxi, and Sichuan are regions with relatively concentrated distributions of known species. Of the two new species, *M. emeiensis* sp. nov. is distributed on Mount Emei in Sichuan, and *M. yuanbaoshanensis* sp. nov. is distributed on Mount Yuanbao in Guangxi, both occurring in montane forest habitats.

Discussion

The taxonomic status and systematic placement of the genus *Macromotettixoides* have long been controversial due to high morphological similarity among species and frequent homoplasy in traditionally employed diagnostic characters. Herein, the integrative taxonomic approach combining morphological examination and mitochondrial phylogenomics provides robust support for the establishment of two new species, *M. emeiensis* sp. nov. and *M. yuanbaoshanensis* sp. nov., and confirms their generic affiliation within *Macromotettixoides*.

The molecular phylogenetic analyses clearly placed both new species within the genus *Macromotettixoides*, revealing an intrageneric divergence pattern. *Macromotettixoides yuanbaoshanensis* sp. nov. is resolved as sister to *M. brachycorna*, whereas *M. emeiensis* sp. nov. clusters with the *M. orthomargina* + *M. yaana* clade, suggesting that speciation within this genus may be associated with geographic isolation. The genetic distance analysis based on 13 PCGs further confirms that the divergence levels between the two new species and their closest congeneric relatives (0.164–0.228) substantially exceed the intraspecific variation threshold of insect mitochondrial genomes, and conform to the general pattern of intrageneric divergence, providing strong molecular support for their specific status.

Morphologically, the two new species are distinguished from congeners by their pronotum in dorsal view being non-tectiform and with carinate elevations or tubercle-like elevation between the shoulders. In *Macromotettixoides emeiensis* sp. nov., the width of the vertex between the eyes is 2.3–2.4 times as wide as the compound eye in the female; in lateral view, the upper margin of the pronotum of the anterior half is undulated, the median carina is lamellate and elevated and forms two hump-shaped elevations whereas the posterior half is straight. In *M. yuanbaoshanensis* sp. nov., the width of the vertex between the eyes is 1.5–1.6 times as wide as the compound eye in the female; in lateral view, the upper margin of the pronotum is undulated. These morphological discontinuities justify their recognition as distinct evolutionary units.

With the description of *Macromotettixoides emeiensis* sp. nov. and *M. yuanbaoshanensis* sp. nov., the number of valid species of *Macromotettixoides* increases to 27, all endemic to montane habitats in southern and southwestern China. The discovery of these two new species highlights that the diversity of *Macromotettixoides* remains underestimated, particularly in poorly surveyed mountainous regions such as Sichuan and Guangxi provinces. Future systematic surveys in these areas are likely to reveal additional undescribed species.

The genus *Macromotettixoides* was originally placed in Metrodoridae (nowadays Metrodorinae). Due to limited taxon sampling, our molecular phylogenetic analyses recovered *Macromotettixoides* as sister to two genera of uncertain subfamilial assignment, *Phaesticus* Uvarov, 1940 and *Systolederus* Bolívar, 1887 (Fig. 4) (Zha *et al.* 2021; Skejo *et al.* 2025). Currently, we tentatively assign *Phaesticus* and *Systolederus* to Metrodorinae. However, their definitive subfamilial placement requires expanded taxon sampling integrating both molecular and morphological phylogenetic evidence. Morphologically, *Macromotettixoides* also exhibits strong similarities to species of *Paraguelus* Günther, 1939 (Metrodorinae, distributed in Indonesia and the Philippines) (Storozhenko & Tan 2026), as well as

apterous forms of *Hyboella* Hancock, 1915 from Pacific-island Criotettiginae Kevan, 1966 (Subedi *et al.* 2025). Whether these taxa are congeneric remains uncertain and requires further molecular data to resolve.

In conclusion, integrative taxonomic evidence firmly supports the validity of the two new species. This study enhances the phylogenetic framework and taxonomic foundation of *Macromotettixoides*, demonstrating the effectiveness of integrative taxonomy combining morphological and mitochondrial phylogenomic data for delimiting morphologically similar pygmy grasshopper species.

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Data availability

The complete mitochondrial genome sequences generated in this study have been deposited in the National Center for Biotechnology Information (NCBI) GenBank database under accession numbers PZ504138 (*Macromotettixoides emeiensis* sp. nov.) and PZ504139 (*M. yuanbaoshanensis* sp. nov.).

Author contributions

Le Liu: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft. Weian Deng: Investigation, Validation, Writing – review & editing. All authors read and approved the final manuscript.

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The members of the *EJT* consortium are: Muséum national d'Histoire naturelle, Paris, France; Royal Museum for Central Africa, Tervuren, Belgium; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Meise Botanic Garden, Meise, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands; Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; Leibniz Institute for the Analysis of Biodiversity Change, Bonn – Hamburg, Germany; National Museum of the Czech Republic, Prague, Czech Republic; The Steinhardt Museum of Natural History, Tel Aviv, Israel.

Supplementary file

Supp. file 1. Table S1. Pairwise genetic distances of mitochondrial DNA for 28 species of Tetrigidae Rambur, 1838 based on 13 protein-coding genes (PCGs).
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