PNAS

Supplementary Information for
High acoustic diversity and behavioral complexity of katydids in the Mesozoic soundscape

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This PDF file includes:

- Figures S1 to S10
- Tables S1 to S2
- Legends for Datasets S1 to S4
- SI References

Other supplementary materials for this manuscript include the following:

- Datasets S1 to S4

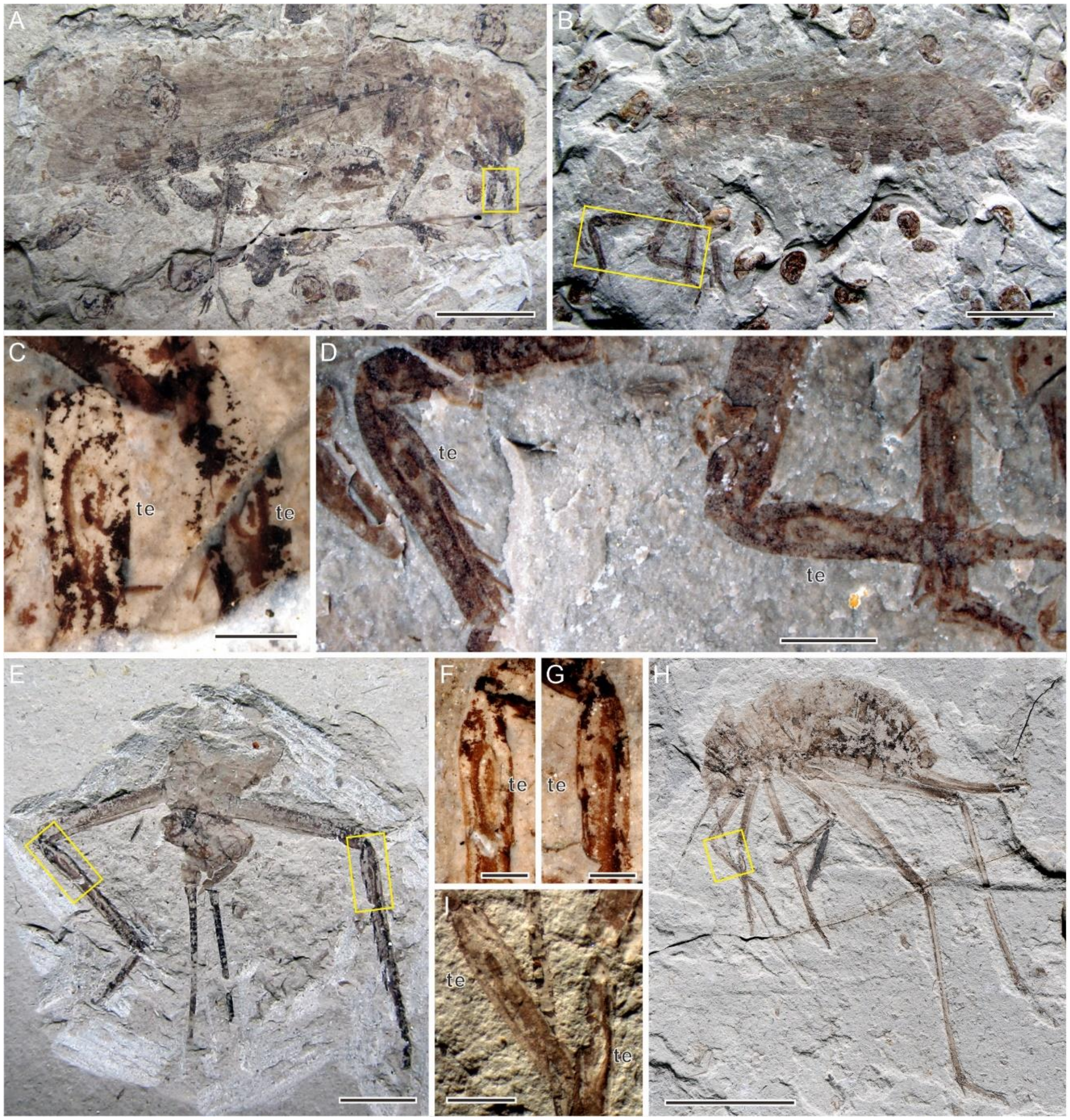

Fig. S1. Tympanal ears on Prophalangopsidae from the Middle Jurassic Daohugou Konservat-Lagerstätte. (*A*) *Sigmaboilus sinensis*, NND04334, female, with tympanal ears (*C*). (*B*) *Sigmaboilus sinensis*, NND12z088, female, with tympanal ears (*D*). (*E*) unknown taxon, NND08z049, with tympanal ears (*F* and *G*). (*H*) *Sigmaboilus* sp., STMN48-1599, female, with tympanal ears (*I*). te, tympanal ear. Scale bars, 10 mm (*A*, *B*, *E*, and *H*), 2 mm (*D*, *I*), and 1 mm (*C*, *F*, and *G*).

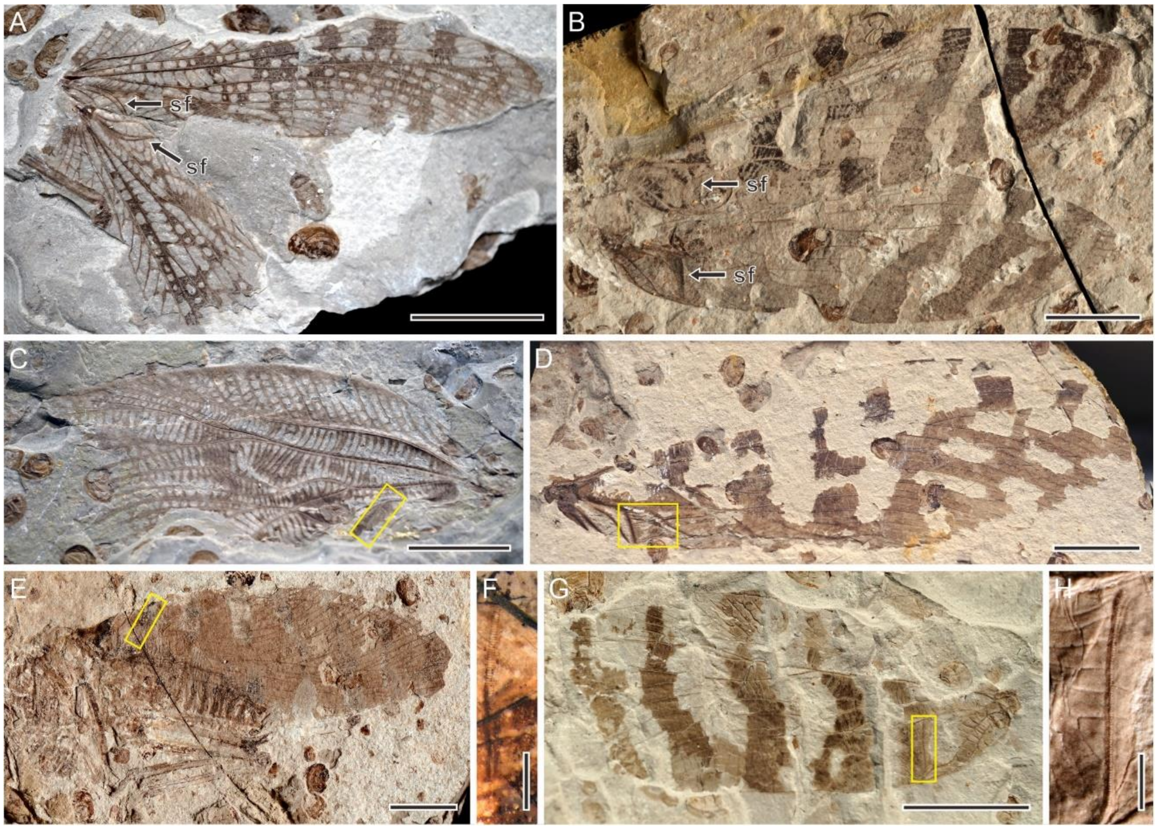

Fig. S2. Stridulatory files on Prophalangopsidae and Haglidae from the Middle Jurassic Daohugou Konservat-Lagerstätte. (*A*) *Sigmaboilus sinensis,* NND12z001, a pair of male forewings. (*B*) *Sunoprophalangopsis* sp., NND04340, a pair of male forewings. (*C*) *Liassophyllum caii*, NND12z186, male forewing, stridulatory file. (*D*) *Allaboilus gigantus*, NND12z171, male forewing, stridulatory file and harp. (*E*) *Allaboilus* sp., STMN48-1074, male forewing, stridulatory file (*F*). (*G*) *Sunoprophalangopsis* sp., NND12z025, male forewing, stridulatory file (*H*). sf, stridulatory file. Scale bars, 10 mm (*A*–*E*, and *G*), and 1 mm (*F* and *H*)**.**

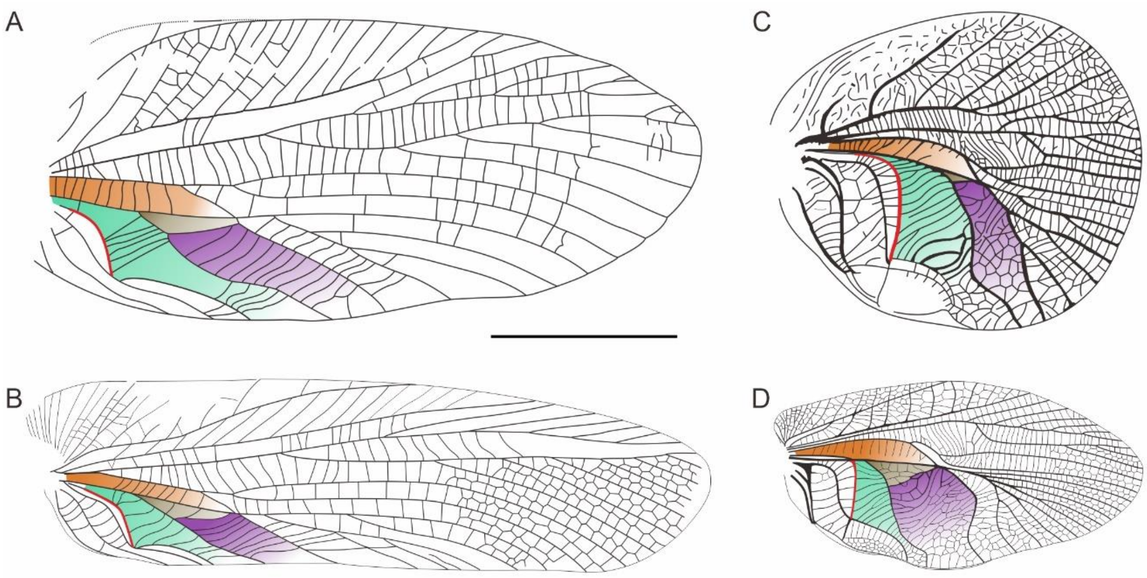

Fig. S3. Comparisons of forewings of fossil and extant Prophalangopsidae. (*A*) *Aboilus chinensis* (Prophalangopsidae; China; Middle Jurassic). (*B*) *Sigmaboilus sinensis* (Prophalangopsidae; China; Middle Jurassic). (*C*) *Tarragoilus diuturnus* (Prophalangopsidae; extant). (*D*) *Prophalangopsis obscura* (Prophalangopsidae; extant). Stridulatory file, red; harp, green; neck, orange; pre-mirror, grey; mirror, purple. Scale bar 10 mm. All to scale.

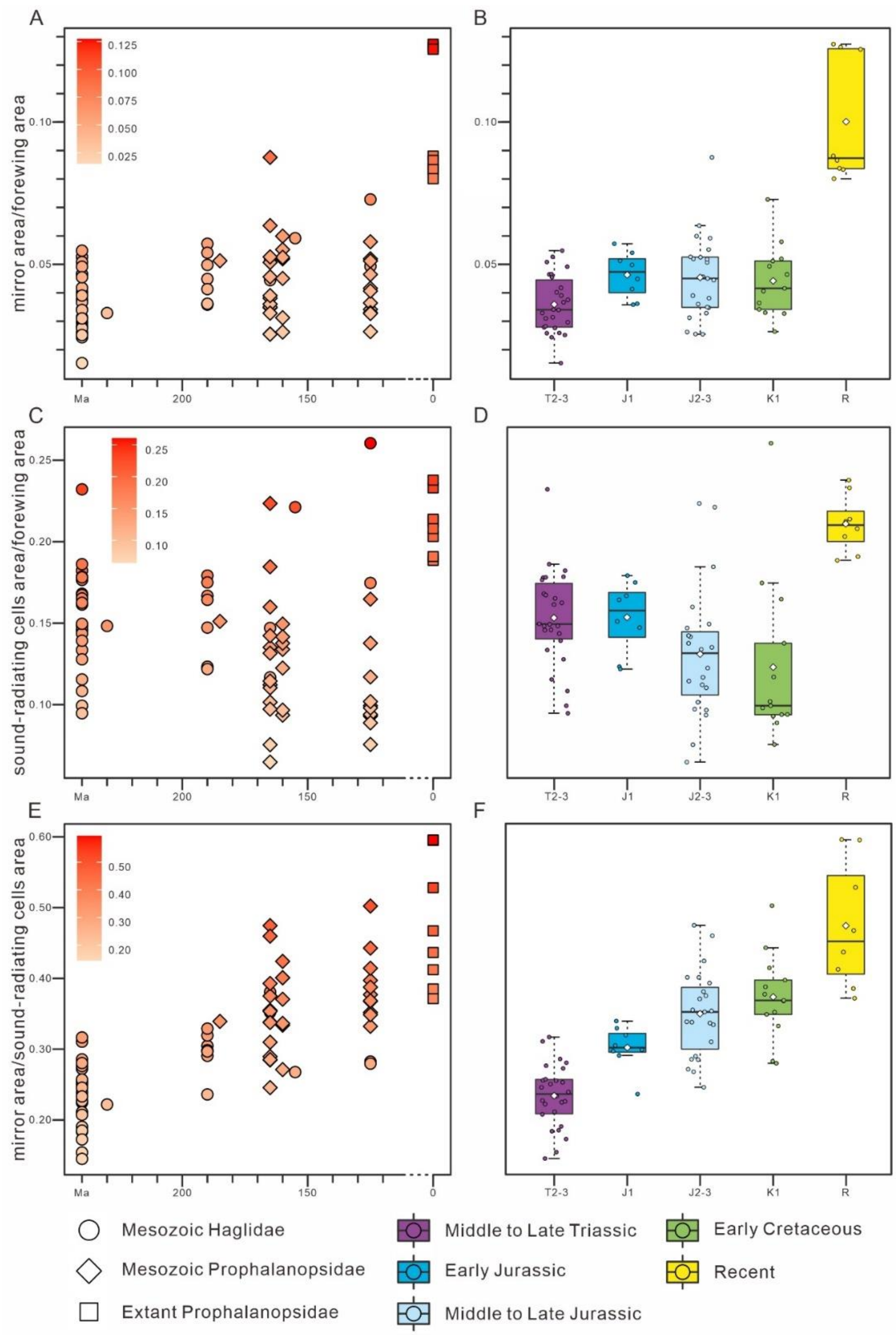

Fig. S4. Sound-radiating cells through time. (*A–B*) Mirror area/forewing area are shown plotted against time. (*C–D*) Radiating cells area/forewing area are shown plotted against time. (*E–F*) Mirror area/radiating cell area are shown plotted against time. Points are colored by the values of morphological traits. Abbreviations: T2–3, Middle and Late Triassic; J1, Early Jurassic; J2–3, Middle and Late Jurassic; K1, Early Cretaceous; R, Recent.

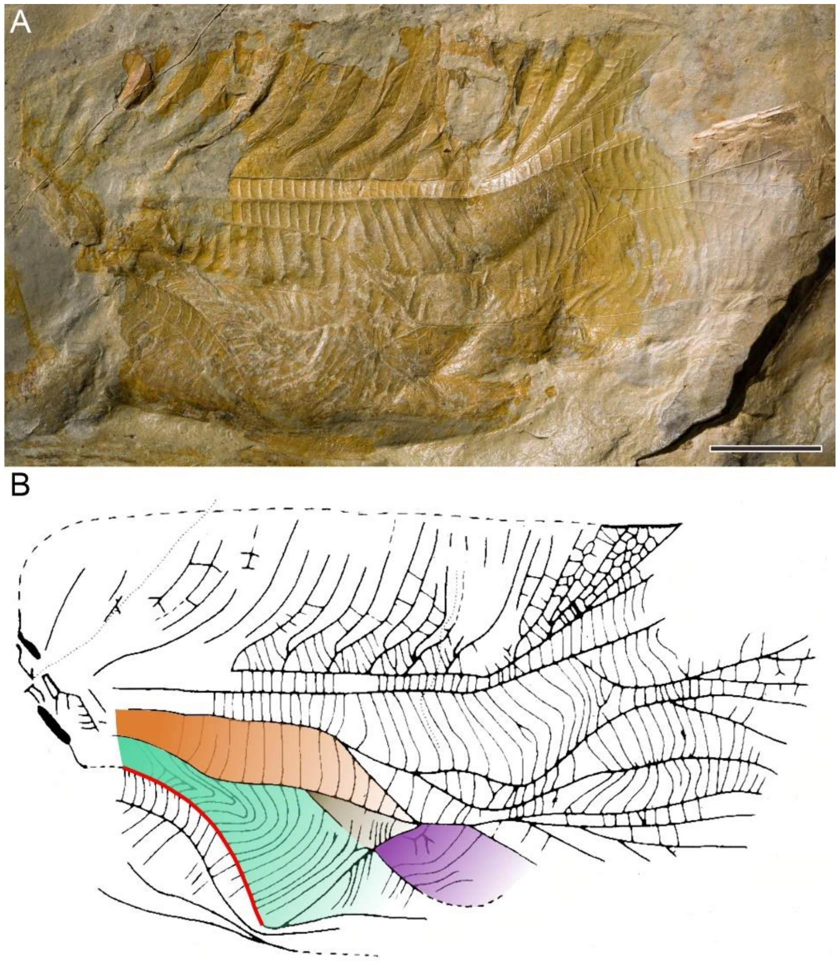

Fig. S5. *Afrohagla contorta* from the Late Triassic Molteno Formation of South Africa. Photograph (*A*) and line drawing (*B*) of the holotype, BP/2/20996, forewing. Putative stridulatory file, red; harp, green; neck, orange; pre-mirror, grey; mirror, purple. Scale bar 5 mm.

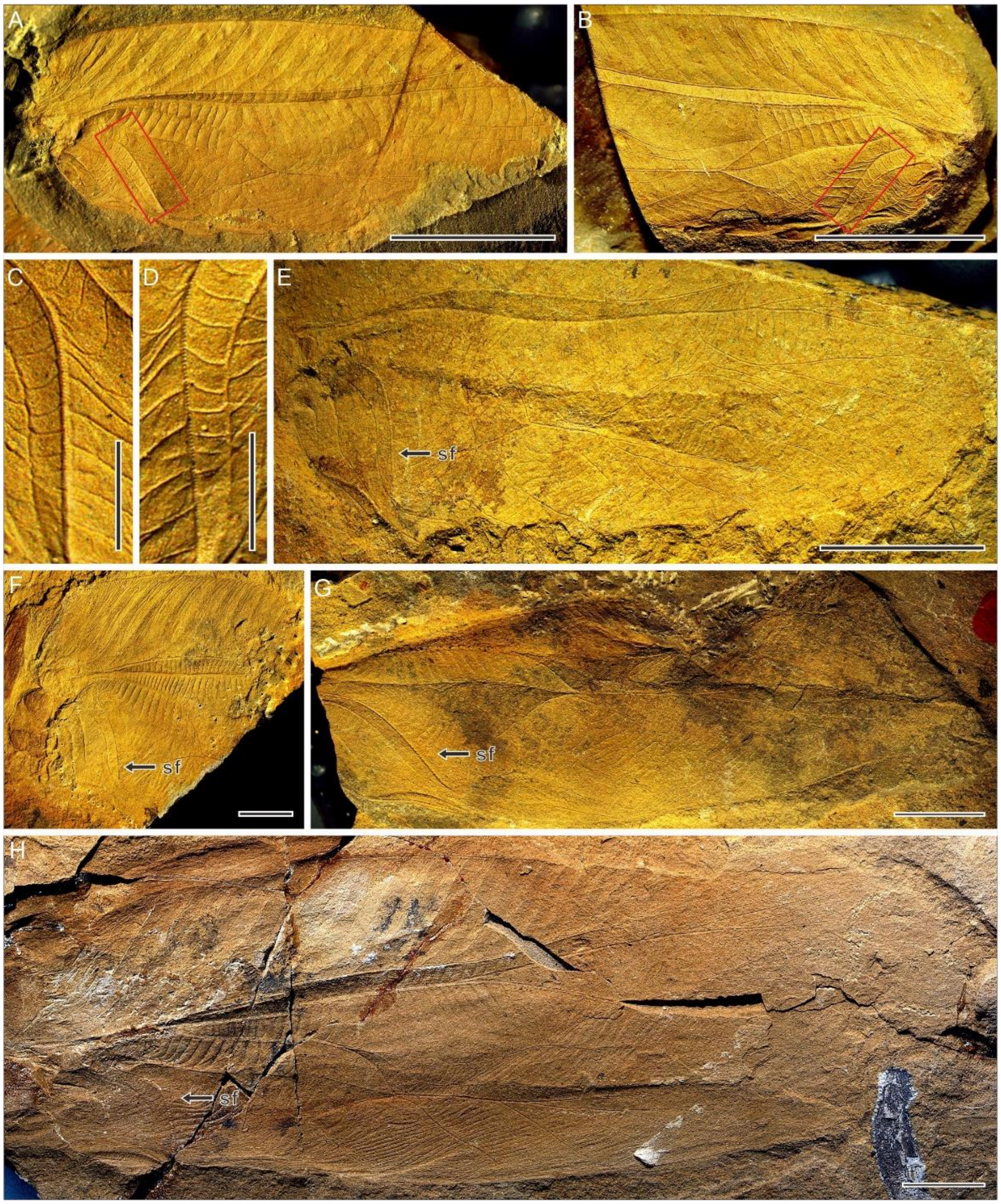

Fig. S6. Haglidae from the Middle/Late Triassic Madygen Formation of Kyrgyzstan. (*A–B*) *Euhagla saurensis,* PIN 2496/32, part and counterpart of male forewing, stridulatory file (*C–D*). (*E*) *Dulcihagla mistshenkoi*, PIN 2785/1961, male forewing. (*F*) *Macrovoliopus declivis*, PIN 2785/1856, male forewing, stridulatory file. (*G*) *Voliopellus latus*, PIN 2785/1861, male forewing, stridulatory file and harp. (*H*) *Zeunerophlebia gigas*, PIN 2240/4065, male forewing. sf, stridulatory file. Scale bars, 5 mm (*A*, *B*, *E* and *F*), 1 mm (*C* and *D*), and 10 mm (*G* and *H*).

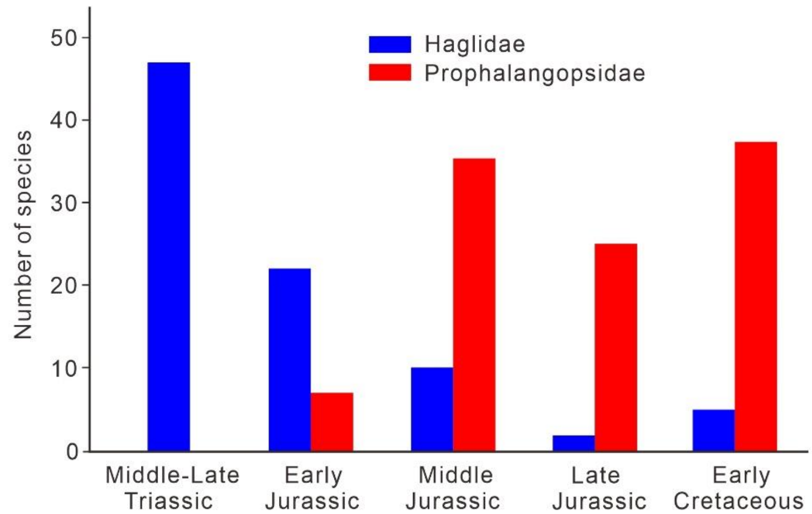

Fig. S7. The diversity of Mesozoic Haglidae and Prophalangopsidae.

Fig. S8. Ecological restoration of singing katydids from the Middle Jurassic Daohugou Konservat-Lagerstätte of China.

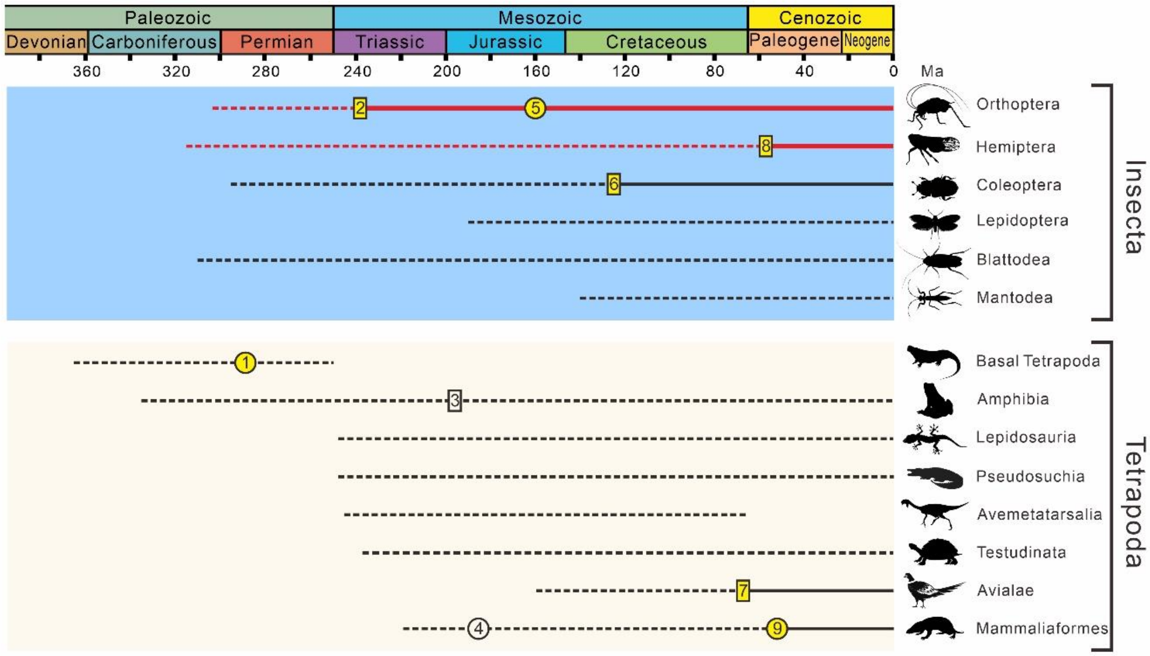

Fig. S9. Geological range of acoustic behavior in Insecta (airborne acoustic communication) and Tetrapoda in terrestrial paleoecosystems. Dashed lines indicate the earliest known stem groups; solid lines indicate the concluded origination of acoustic behavior; yellow quadrates and spots indicate the earliest known record of acoustic organs (sound-producing and sound-receiving organs) respectively; transparent quadrates and spots indicate the concluded origination of acoustic organs or behavior, respectively. 1, the earliest tetrapod tympanic membrane of the ear comes from the Early Permian (approximately 290–272 Ma; 296–268 Ma) (1, 2). 2, the earliest known orthopteran stridulatory apparatus comes from the Middle Triassic (approximately 242–237 Ma) (3). 3, the earliest known crown anuran comes from the Early Jurassic (approximately 199–183 Ma) (4), probably indicating the origin of vocal sacs. 4, the earliest high frequency hearing ability of mammals probably originated in the Early Jurassic. 5, the earliest orthopteran tympanum comes from the Middle Jurassic (approximately 160 Ma). 6, the earliest stridulatory structure of Coleoptera comes from the Early Cretaceous (approximately 125 Ma) (5). 7, the earliest bird vocal organ syrinx comes from the latest Cretaceous (approximately 68–66 Ma) (6). 8, the earliest definite cicada comes from the Paleocene (approximately 59–56 Ma when tymbals with sacs probably originated) (7, 8). 9, the earliest known echolocation of bats originates from the early Eocene (approximately 52 Ma) (9, 10).

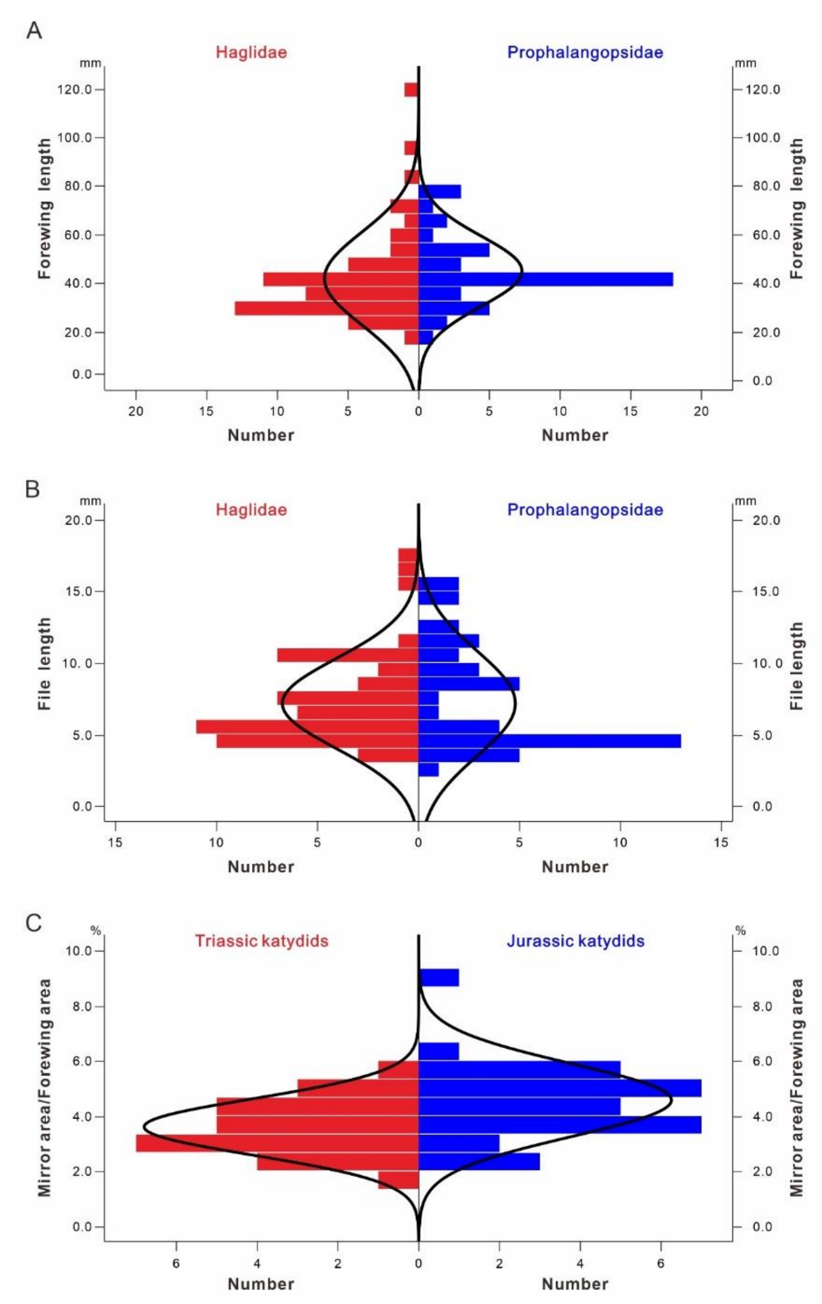

Fig. S10. Distributions of the data used for nonparametric tests. (*A*) Forewing length distribution of Mesozoic Haglidae (53 species) and Prophalangopsidae (44 species). (*B*) File length distribution of Mesozoic Haglidae (53 species) and Prophalangopsidae (44 species). (*C*) Distribution of mirror area/forewing area ratio of Triassic (26 species) and Jurassic (31 species) katydids. Numbers on the X-axis indicate the species number of participants; red histograms indicate Mesozoic Haglidae in (*A*–*B*) and Triassic katydids in (*C*); blue histograms indicate Mesozoic Prophalangopsidae in (*A*–*B*) and Jurassic katydids in (*C*); dark lines indicate the normal curve.

Table S1. Tympana measurements of Daohugou Prophalangopsidae.

Species	Gender	Number	length	width
Sigmaboilus sinensis	Male	NND04329*	1.5	0.7
Sigmaboilus sinensis	Male	NND04345	1.3	0.5
Sunoprophalangopsis elegantis	Male	NND04500	1.4	0.7
Sunoprophalangopsis elegantis	Male	NND12Z041	1.5	0.5
Ashangopsis daohugouensis	Female	NIGP143691	2.1	0.5
Sigmaboilus sinensis	Female	NND12Z088*	1.5	0.5
Sigmaboilus sinensis	Female	NND04334*	1.5	0.6
Sigmaboilus sp.	Female	NND12Z069	1.5	0.5
Sigmaboilus sp.	Female	NND04410	1.5	0.4
Sigmaboilus sp.	Female	NND12Z121*	1.5	0.6
Sigmaboilus sp.	Female	STMN48-1068*	1.3	0.5
Sunoprophalangopsis sp.	Female	NND12Z075	1.7	0.8
Sunoprophalangopsis sp.	Female	NND08Z056	1.4	0.6
Sunoprophalangopsis sp.	Female	NND12Z128	1.4	0.4
Sunoprophalangopsis sp.	Female	NND12Z009	1.3	0.5
Sunoprophalangopsis sp.	Female	NND12Z061*	1.5	0.6
Sunoprophalangopsis sp.	Female	NND12Z036	1.4	0.5
Sunoprophalangopsis sp.	Female	NND04337	1.0	0.4
Sunoprophalangopsis sp.	Female	NND04509	1.7	0.5
Sunoprophalangopsis sp.	Female	STMN48-1599*	1.6	0.7
Sunoprophalangopsis sp.	Female	NND04328	2.1	0.5
Sunoprophalangopsis sp.	Female	NND04501	1.1	0.5
Sunoprophalangopsis sp.	Female	NND12Z011	1.7	0.6
unknown	unknown	NND08Z049*	2.1	0.8

All measurements are in mm.

“*” represents fossils with two identical tympanal ears on left and right legs.

Table S2. Forewing measurements of selected specimens from Daohugou.

Species	Number	Forewing length	Forewing width	File length
Sigmaboilus sinensis	NND12Z001	37.0	9.7	4.4
Sigmaboilus sp.	NND12Z033	39.3	9.1	4.3
Sunoprophalangopsis sp.	NND04340	53.4	16.5	4.8
Sunoprophalangopsis sp.	NND12Z025	~52	16.4	4.4
Sunoprophalangopsis sp.	NND04390	~54	16.5	4.5
Sunoprophalangopsis sp.	STMN48-1447	51.4	15.7	4.5
Sunoprophalangopsis sp.	STMN48-1637	55.8	18.8	5.2
Allaboilus gigantus	NND12Z014	83.8	34.6	13.0
Allaboilus gigantus	NND12Z172	73.5	25.3	9.8
Allaboilus sp.	NND12z171	65.9	19.5	~7
Allaboilus sp.	NND12Z080	58.8	20.9	9.6
Allaboilus sp.	STMN48-1074	57.4	~21	~10
Allaboilus sp.	NND12Z157	~62	~22	11.0
Liassophyllum caii	NND12Z186	~50	~20	~10
Liassophyllum caii	NND04397	52.7	22.9	~10
Liassophyllum caii	NND04322	53.1	22.1	10.3

All measurements are in mm.

"~" represents the estimated length and width.

Dataset S1 (separate file). Measurements of Mesozoic katydids and Recent Prophalangopsidae with sound-radiating cells.

Dataset S2 (separate file). Diversity database of Mesozoic Haglidae and Prophalangopsidae.

Dataset S3 (separate file). Measurements of Mesozoic Haglidae with stridulatory files.

Dataset S4 (separate file). Measurements of Mesozoic Prophalangopsidae with stridulatory files.

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