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GEOGRAPHICAL DISTRIBUTION OF TWO SPECIES OF *MESOBUTHUS* (SCORPIONES, BUTHIDAE) IN CHINA: INSIGHTS FROM SYSTEMATIC FIELD SURVEYS AND PREDICTIVE MODELS

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ABSTRACT. Although *Mesobuthus* scorpions in China have become endangered in recent years, they are largely underinvestigated. Even the baseline data on their distributions are lacking. Here the geographical distributions of two *Mesobuthus* scorpions in China are provided through a combined study of systematic field surveys and GIS-based ecological niche modeling using 227 surveyed point occurrence data across an area of ca. 2800 × 1700 km^2 and validated historical records. *Mesobuthus martensii* (Karsch 1879) appears to be restricted to latitude south of 43°N and the north side of the Yangtze River, bordered by the Helan Mountains and the Tengger and Mo Us sand desert in the west and limited by the sea in the east. *Mesobuthus eupeus* (C.L. Koch 1839) reaches the east side of the Helan Mountains and the west edge of the Loess Plateau, extending westward along the northern slope of the Qilian Mountains and ultimately penetrating to the northern part of the Junggar Basin. The former is mainly found in semi-humid and humid regions while the latter is an arid and semi-arid dweller. The two species show a parapatric distribution on the whole with a contact zone formed at the boundary of their ranges across the big turning of the Yellow River in the central-western part of Inner Mongolia, Ningxia and the middle part of the Gansu Province. This pattern of distribution is shaped both by the fundamental ecological niche constraint of the species and possibly by the biological interactions between the two species. Some diagnostic features for the two species are also provided for quick identification.

Keywords: *Mesobuthus martensii*, *Mesobuthus eupeus*, ecological niche modeling, contact zone

Formal description of the scorpion fauna of China began in 1840's (Gervais 1844). This was followed by occasional reports of new species, records, or amendments throughout the last two centuries mostly by non-Chinese scholars (Simon 1880; Karsch 1881; Pocock 1889; Kraepelin 1899, 1901; Birula 1898, 1904, 1911, 1917, 1925; Kishida 1939; Vachon 1952; see Shi & Zhang 2005 for review). Wu (1936) was the first Chinese scholar who studied the scorpion fauna of China; since then there have been few additional reports in this field. In fact, scorpion taxonomy and biogeography still remained a virgin field in China until very recently. This is rather surprising given that scorpions have long been used in traditional Chinese medicine (e.g., it was already well described in the medical code *Peaceful Holy Benevolent Prescriptions* compiled between 978–992 AD in the Song Dynasty).

Recently, Zhu et al. (2004) compiled a checklist of the scorpions in China, and Shi & Zhang (2005) reviewed scorpion systematics with special emphasis on the buthids in the region. The species diversity of Chinese scorpions seems to be rather low in comparison with scorpion faunas of other regions of the world. The nineteen species and subspecies reported in China as listed in Zhu et al. (2004) belong to 9 genera and 5 families. For comparison, 16 species belonging to 9 genera and 3 families were recorded from Israel and Sinai (Levy & Amitai 1980), and more than 60 species (11 genera and 4 families) in Baja California, Mexico and adjacent islands (Williams 1980). Considering the large size of

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China and the ecological diversity of its different regions, it is quite possible that the scorpion fauna in China has been largely underestimated (Lourenço et al. 2005a). This suspicion was justified by the recent discovery of more than 10 new species from Tibet, Yunnan, and Hainan Province (Qi et al. 2005; Lourenço et al. 2005a, 2005b). Therefore, additional new species can be expected, especially in the arid areas.

Among the 19 scorpion species and subspecies listed in Zhu et al. (2004), the *Mesobuthus* scorpions are the most well known species in China. The genus *Mesobuthus* Vachon 1950, with some 15 species reported so far (Fet & Lowe 2000; Gantenbein et al. 2000; Lourenço et al. 2005a), is widespread in the Palaearctic Region from Turkey to Korea. In fact, *Mesobuthus* species are the most common and abundant scorpions in a variety of arid habitats, from sand deserts to high mountains, with the centers of diversity in Central Asia and Iran (Fet et al. 2000; Gantenbein et al. 2003). Historically, three species had been reported in China, viz.: *M. martensii* (Karsch 1879) (Simon 1880; Karsch 1881; Pocock 1889; Birula 1911; Kishida 1939; Song et al. 1982; Qi et al. 2004), *M. eupeus* (C.L. Koch 1839) (Birula 1911, 1925; Schenkel 1936; Fet 1989, 1994), and *M. caucasicus* (Nordmann 1840) sensu Fet 1998 and Gantenbein et al. 2003 (Fet 1989, 1994). A fourth species, *M. songi* Lourenço et al. 2005 was just described from Tibet (Lourenço et al. 2005a). Of the aforementioned scorpions, *M. martensii*, commonly called the ''Chinese scorpion'', was the most studied and the most popularly used species in traditional Chinese medicine. Over the past decade, more than 70 different peptides, toxins, or homologues have been isolated from venom of this species (Goudet et al. 2002). Even so, its taxonomic status is still blurred due to dubious synonymization (Karsch 1881) and misleading discrimination where different type specimens were examined (Pocock 1889). Another species, the mottled scorpion, *M. eupeus* is widely distributed with a dozen or so subspecies being recognized mainly based on coloration and morphometric characteristics (Fet 1994). Two subspecies, *M. eupeus mongolicus* (Birula 1911) and *M. eupeus thersites* (C.L. Koch 1839), occur in northwest China (Birula 1911, 1925; Fet 1989, 1994; Zhu et al. 2004; Shi & Zhang 2005). This species has also been used in Chinese medicine in recent years (CMS & DXZ pers. obs.). Both species are now threatened by human overexploitation and habitat loss. Fortunately, *M. martensii* has now been listed in the China Species Red List and is considered vulnerable (Wang & Xie 2005), a timely action for protecting this species in China. However, the lack of some basic knowledge about these species greatly impairs conservation efforts. For example, distribution records of *M. martensii* often appear to be a broad-brush description such as ''from Inner Mongolia to Korean Peninsula.'' The same treatment was given to *M. eupeus* in China but with an even vaguer outline. Thus, up-to-date baseline data on the geographical distribution of these species, which are fundamental for conservation planning (Ferrier et al. 2002; Funk & Richardson 2002; Rushton et al. 2004; Elith et al. 2006), are critically needed.

During the last 6 years, we have conducted a systematic sample collection and an extensive field survey of the geographical distribution of two mesobuthid scorpions in China. This allows us to draw a detailed picture of the biogeographical distribution of these species and predict their potential distribution ranges using some ecological modeling methods, such as the Genetic Algorithm for Rule-set Prediction (GARP, Stockwell & Nobel 1992), in a geographic information system (GIS) environment. Here we report the results of our combined study with emphasis on the field survey data, which are unique in scale and density in the study of the two *Mesobuthus* species.

METHODS

Occurrence data and field survey.—The literature dealing with *M. martensii* and *M. eupeus* was consulted to extract distributional records, which served as the start point for our field survey. Extensive geographical surveys were carried out from May to September during 2001–2006, using the following strategies: first, the places with historical records were visited; then we extrapolated our survey outward from around the areas where scorpions were successively collected, according to the similarity of the topography and climatic parameters in 50–100 km intervals; finally, we explored the areas of different landscape adjacent to the outermost sample localities. The above survey was complemented by irregular collections from the putative distributional areas.

Scorpion collection was carried out either by a stone-rolling method in daytime or UV-light collection at night (Williams 1968). The sample localities were positioned using a GPS receiver (Garmin International), with their longitude, latitude, and elevation recorded. The animals obtained were either deposited in 99.7% ethanol or brought back to the laboratory alive. A subset of specimens was preserved in 75% alcohol for subsequent morphological analysis under a Nikon SMZ1500 stereomicroscope. All the materials are deposited at the Laboratory of Molecular Ecology and Evolution, Institute of Zoology (MEE-IOZ), Chinese Academy of Sciences, Beijing.

Modeling the species' potential distribution.—A species' presence in a place can often be assured when it was successfully sampled there, but its absence cannot be deduced simply from its not being collected in an area. Therefore, a field survey alone is not enough for delimiting a species' distribution range. Modern computational and GIS technologies provide opportunities to use species' presence-only locality data to predict their potential distributions. All the point occurrence data collected by field surveys and literature reviews were geo-referenced to the nearest 0.1° of latitude and longitude and used for ecological niche modeling. Ecological niche models use known occurrence point locations for a species and values for environmental variables (i.e., temperature and precipitation) at those point locations to generate an approximation of the fundamental ecological niche for that species. This ecological niche can then be projected onto a map of the study area in order to predict where that species might occur. Based on ecological niche models, species' distributions were modeled using the Genetic Algorithm for Rule-set Prediction (GARP) (Stockwell & Noble 1992). The occurrence points are divided evenly into training and test data sets. GARP models based on presence-only data, and absences are included in the modeling exercise via sampling of pseudo-absence points from the set of pixels where the species has not been detected. A method is chosen from a set of possibilities (e.g., logistic regression, bioclimatic rules) and then applied to the training data to develop or evolve a rule through an iterative process of rule selection, evaluation, testing, and incorporation or rejection (Peterson et al. 2006). Predictive accuracy is evaluated based on the testing data. The change in predictive accuracy between iterations was used as the criterion to evaluate whether particular rules should be incorporated into the model. The algorithm runs 1000 iterations or until convergence.

GARP modeling was carried out on Desktop-GARP (http//www.lifemapper.org/desktopgarp), which offers much improved flexibility in choice of predictive environmental data layers. The 14 environmental data layers, in the form of raster grids with 0.1° resolutions, were obtained from the website http//www.lifemapper.org/desktopgarp. An environmental layer jackknifing procedure is performed to determine what environmental factors are more significant or important than others for our species (Peterson & Cohoon 1999). Based on the evaluation of commission and omission errors as well as accuracy values, the environmental layers are incorporated or discarded in subsequent modeling.

To optimize model performance, we developed 100 replicate models of ecological niche for each species. The 10 best models were selected from the replicate models according to the procedure developed by Anderson et al. (2003) using "Best Subset Selection Parameters" option with the "extrinsic" omission limit set to 10%. Model quality was tested via the testing data. Chi-squared tests were employed to determine whether test points fall into regions of predicted occurrence more often than expected by chance (Peterson 2001; Anderson et al. 2002a, b). Finally, these 10 models were imported into ARCVIEW GIS 3.2 (Environmental Systems Research Institute, Inc. 1999) and overlaid to create one consensus predictive range map. Grid cells that were predicted as present by at least 9 of these models were extracted to give an optimal model for *M. martensii* and *M. eupeus*, respectively. Sympatric zone was obtained by superimposing the optimal models of the two species in ARCVIEW GIS 3.2 with spatial analyst extension.

RESULTS

The scorpions.—The adults of the two species, *M. martensii* and *M. eupeus*, can be easily recognized based on size and coloration, and the contrasts are especially obvious when they are observed together (for example, when they occurred at the same locale or were in the same collecting jars). Generally, *M. martensii* is larger, with carapace and mesosomal tergites yellowish-brown to blackish-brown. Metasomal segments I–IV are yellowish, while metasomal segment V has conspicuous darkish-brown to blackish spots, especially on the ventral and lateral surfaces. *Mesobuthus eupeus* is smaller, with the whole body yellow to yellowish-brown and with the coloration relatively uniform on the carapace, mesosomal tergites, and metasomal segments. Metasomal V has only slightly brownish pigmentation. Mesosomal tergites often have irregular longitudinal blackish-brown stripes.

In the laboratory, the two species can be easily distinguished by the following characters: in *M. martensii*, the ventromedian carinae of the metasomal segment II and III are crenulate and the granules are evenly developed; the ventrolateral carinae of the metasomal segment V are serratocrenulate and the granules are evenly developed or slightly increasing in size posteriorly; the pedipalp chela is slender with Cl/Cw = 4.45 ± 0.23 (Cl = chela length, Cw = chela width, mean ± SD, n = 65) for the female and 3.71 ± 0.24 (n = 43) for the male, and both the fixed finger and the movable finger having 12–13 rows of oblique granules. In *M. eupeus*, the ventromedian carinae of the metasomal segment II and III are serratocrenulate with the granules increasing in size posteriorly; the ventrolateral carinae of the metasomal segment V are crenulate, and the granules are irregularly increasing posteriorly with 1–3 of them significantly enlarged and lobate; the pedipalp chela is strong with Cl/Cw = 3.47 ± 0.25 (n = 52) for the female and 3.23 ± 0.27 (n = 26) for the male, the fixed finger and the movable finger having 10 and 11 rows of oblique granules, respectively.

Occurrence and distribution.—Our survey covers 16 provincial administrative regions and we succeeded in collecting scorpions from 211 sites belonging to 174 counties across an area of ca. 2800 × 1700 km^2. Information about the voucher specimens' exact localities is available from authors on request for scientific purposes only. We reserve the right not to release these data for public review for conservation consideration. These two species have been overexploited for commercial purposes and these activities have become rampant in recent years (CMS & DXZ pers. obs.). Releasing our data will make the situation even worse. However, below we present broad information about the two species' ranges.

Mesobuthus martensii (Karsch 1879)*:* historical records of the distribution of *M. martensii* are rather cursory. Many literature sources gave some very broad descriptions, such as Northwest and/or North of China or just provincial names. We were only able to specify 12 localities to recognizable administrative regions (Table 1), which are shown by triangles in Fig. 1.

We have collected *M. martensii* from 175 sites belonging to 15 provincial regions: Anhui (2 sites), Beijing (3), Gansu (16), Hebei (17), Henan (16), Hubei (2), Inner Mongolia (4), Jiangsu (1), Liaoning (10), Ningxia (9), Qinghai (1), Shandong (46), Shaanxi (27), Shanxi (20), and Tianjin (1) (squares in Fig. 1). The northernmost locality where we have collected this scorpion is Beipiao (41.83°N, 120.61°E), Liaoning Province, and the westernmost sample site is Guide (36.01°N, 101.40°E), Qinghai Province. We successively collected specimens on eight islands of Miaodao Archipelago and from Wafangdian (39.37°N, 121.50°E) of Liaodong Peninsula. The elevations of the sample sites range from < 10 m (Shandong and Liaodong Peninsula) to more than 2300 m (Qinghai Province) above sea level. Almost all the sites lie in the mountain areas, great or small. Thus this species is a typical "mountaineer," and shows strong lithophilism in the plain regions. On the Loess Plateau the species may be found in the crevices and some burrows of other invertebrates or small mammals and reptiles. On three occasions we found this species in human dwellings.

Mesobuthus eupeus (C.L. Koch 1839)*:* documented localities of this species in China are very few (Table 1). Two subspecies had been recorded. The subspecies *M. eupeus mongolicus* was described from Gansu, Gobi-Altai and Alashan regions by Birula in 1911, and later reported from Tianshan (Tien-shan) Mountains near Urumchi (Schenkel 1936), Xinjiang Uygur Autonomous Region. Birula (1911, 1925) had recorded that this subspecies was found in Lanzhou, Gansu Province, but

Table 1.—Historical occurrences of *Mesobuthus martensii* and *M. eupeus* in China.

Species	Locality	Lat. °N	Long. °E	References
M. martensii	Beijing (Pekin)	39.9	116.4	Simon 1880, Karsch 1881, Pocock 1889
	Yantai (Tchefou) Shandong	37.5	121.4	Simon 1880, Pocock 1889, Wu 1936
	Tianjin (Tientsin)	39.1	117.2	Karsch 1881
	Alashan, Inner Mongolia	38.8	105.7	Birula 1911
	Wulingshan, Hebei	40.6	117.4	Kishida 1939
	Chaoyang, Liaoning	41.5	120.4	Kishida 1939
	Lingyuan, Liaoning	41.2	119.3	Kishida 1939
	Chengde, Hebei	40.7	118.1	Kishida 1939
	Kaifeng, Henan	34.7	114.4	Wu 1936
	Xuanhua, Hebei	40.6	115.0	Wu 1936
	Donghai, Jiangsu	34.5	118.7	Wu 1936
	Changshandao, Shandong	37.9	120.7	Wu 1936
M. eupeus	Gobi-altai, Mongolia	42.5	104.0	Birula 1911
	Alashan, Inner Mongolia	40.5	103.0	Birula 1911
	Lanzhou, Gansu (Lantsho-fu, Kan-su)	36.0	103.7	Birula 1911, 1925
	Tianshan, Xinjiang (Tien-shan Urimchi)	43.8	87.6	Schenkel 1934

we failed to find this species there or in adjacent areas whereas *M. martensii* were found instead (Lanzhou: 36.12°N, 103.72°E; Yuzhong: 36.35°N, 104.28°E; and Gaolan: 36.33°N, 103.90°E). Another subspecies, *M. eupeus thersites*, was also observed in northwest China (Fet 1989, 1994). Here we just identified specimens to species, with no effort to further identify them to subspecies.

We collected *M. eupeus* from 36 sites (circles in Fig. 2), spanning Gansu (12 sites), Ningxia (12), Xinjiang (1) and Inner Mongolia (11). The southernmost site is Jingyuan (36.50°N, 104.60°E; Gansu), and the easternmost one is Urad Qianqi (40.67°N, 108.73°E; Inner Mongolia). The majority of sites lie in the Gobi desert and bald mountains. There are three exceptions: one site is in a deserted human dwelling, one site lies in the interdunal zone of sand desert, and the third is in a degraded pasture.

Contact Zone*:* In 8 localities (bisected circles in Figs. 1–3) we collected *M. martensii* and *M. eupeus* at the same site: Jingyuan (36.5°N, 104.6°E) and Jingtai (37.2°N, 104.3°E) of Gansu province; Qingtongxia (37.7°N, 106.0°E), Siyanjing (37.7°N, 105.7°E) and Shikong (37.7°N, 105.5°E) of Ningxia Autonomous Region; and Alashan Zuoqi (37.8°N, 105.5°E), Urad Qianqi (40.7°N, 108.7°E) and Urad Zhongqi (41.3°N, 108.6°E) of Inner Mongolia. All these sites are near or on the litho-mountains.

Prediction of potential distribution and sympatric zone.—In total, 227 occurrence points, 187 for *M. martensii* and 40 for *M. eupeus*, were used for modeling the potential distributions. Of the 14 environmental layers six were excluded from modeling because of their high omission and commission errors and low predictive accuracy. The eight environmental layers used in the predictive modeling are annual means of frost days, solar radiation, precipitation, minimum temperature, mean temperature, maximum temperature, water vapor pressure and wet days. The chi-square test yielded significant results for all the models produced ($P < 10^{-34}$ for *M. martensii* and $P < 10^{-5}$ for *M. eupeus*).

Projections of models onto maps permit visualization of the ecologically potential distribution ranges of the two species. Thus, *M. martensii* appears restricted to the latitude south of 43°N and to the north side of the Yangtze River, bordered by the Helan Mountains in the west and limited by the Yellow Sea and the East China Sea in the east (Fig. 1); an area covering the North China Plain in the east, the Loess Plateau in the west, and the Liaohe Plain in the north.

The occurrence points for *M. eupeus* are concentrated in a relatively small sub-area of

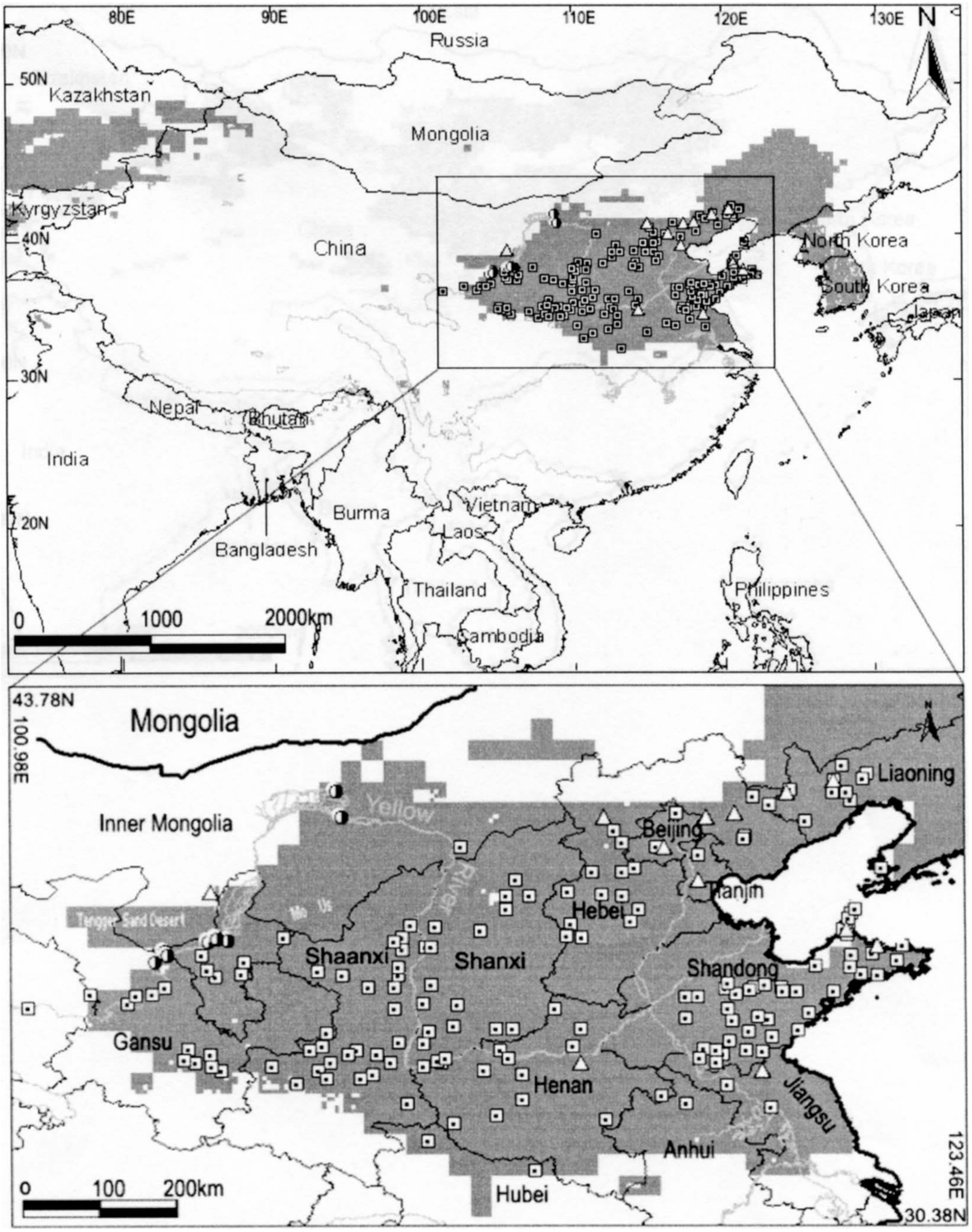

Figure 1.—Ecological niche-based prediction of potential distribution of *M. martensii*. Squares, present data; triangles, historical records. Bisected circles show the sites where *M. martensii* and *M. eupeus* co-occurred.

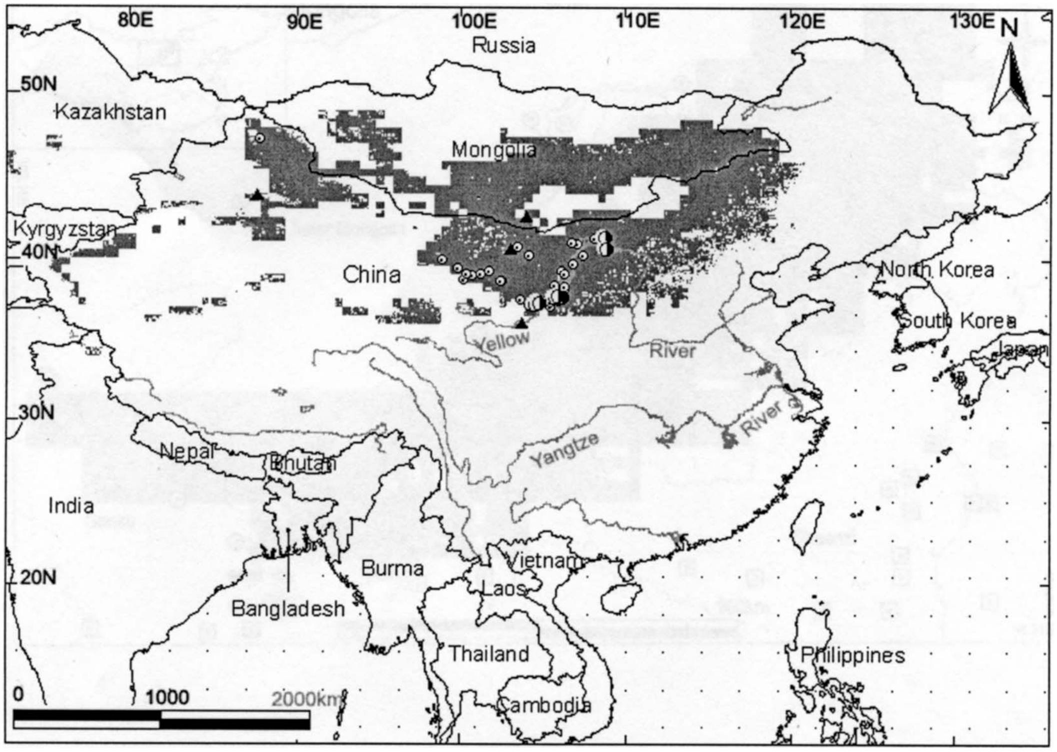

Figure 2.—Ecological niche-based prediction of potential distribution of *M. eupeus*. Circles, present data; triangles, historical records. Bisected circles show the sites where *M. eupeus* and *M. martensii* co-occurred.

its range, being less optimal for ecological niche modeling. A circular potential distribution in the region 36–48°N and 94–120°E (Fig. 2) was predicted, plus some patchy appearance in Xinjiang, west Mongolia, and Kazakhstan and Kyrgyzstan. This is in accordance with historical records of this species there. Outside China, this species ranges from central Anatolia through Caucasus and Turkey to Mongolia and has been found in Afghanistan, Armenia, Azerbaijhan, Georgia, Iran, Iraq, Kazakhstan, Kyrgyzstan, Pakistan, Russia (Astrakhan region), Tajikistan, Turkmenistan, and Uzbekistan (Fet 1989, 1994; Karatas & Karatas 2001, 2003).

Superimposition of the two species models reveal limited areas of potential sympatry (Fig. 3). The potential sympatric zone lies across the big turning of the Yellow River in central-western Inner Mongolia, Ningxia and the middle part of the Gansu Province. Altogether, 24 sites lie in the potential sympatric zone. Ten of those represent collections of *M. eupeus* and six of those *M. martensii*. The remaining eight sites where two species co-occurred fell exactly into the predicted sympatric zone.

DISCUSSION

Our data indicate that *M. martensii* and *M. eupeus* show a parapatric distribution with a contact zone formed at the boundary of their ranges. *Mesobuthus martensii* mainly occurs in the humid and semi-humid regions where the mean annual rainfall exceeds 300 mm. Its range spans the so-called second and third geographical cascades of mainland China, with the average altitude descending eastward from more than 2500 m to less than 10 m above sea level, and includes the littoral zone (Remy & Leroy 1933; Millot & Vachon 1949) and some islands of Bohai Sea. The northern limit of the Chinese scorpion might not exceed 43°N. This is in accordance with Kishida (1939), who recorded that there was no scorpion in Ongniud Qi (42.9°N, 119.0°E). The

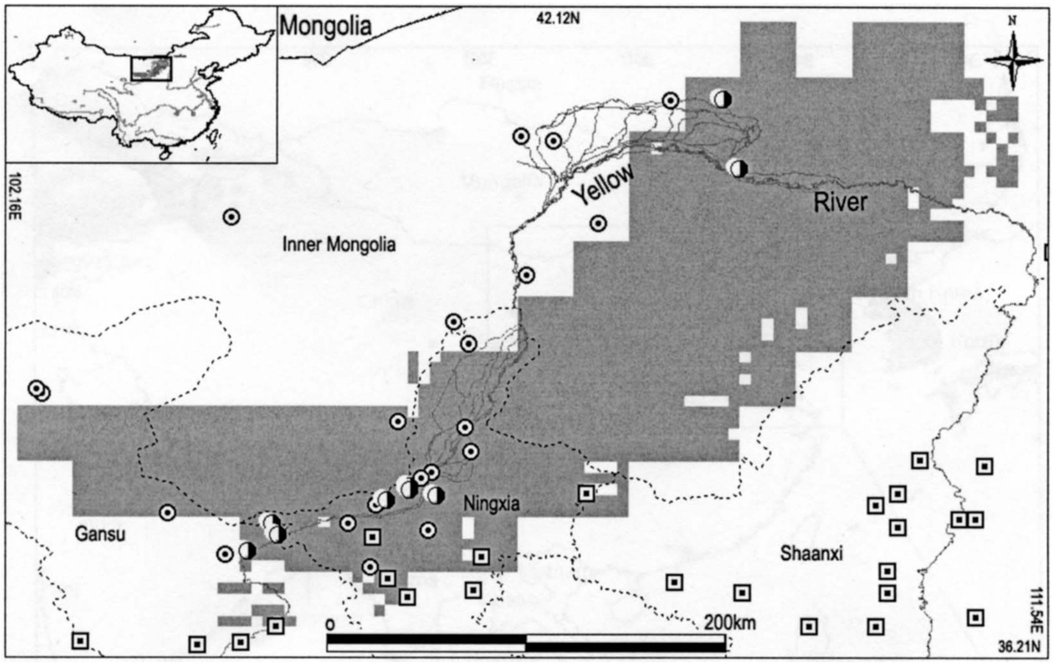

Figure 3.—Ecological niche-based prediction of potential range of the contact zone between *M. martensii* and *M. eupeus*. Squares, *M. martensii*; circles, *M. eupeus*. Bisected circles show the sympatric sites.

Tengger and Mo Us sand desert constitute the northwestern distributional boundary for *M. martensii*.

In contrast, *M. eupeus* is an arid dweller living in the arid and semi-arid environment, as recorded in the literature. All our sampling sites are in or near the desert regions, ranging from the central western area of Inner Mongolia to western Gansu Province, and proceeding further west- and northward to the Altai region, Xinjiang. Although our data about *M. eupeus* are relatively restricted, our models indicated the potential distribution of *M. eupeus*, especially in China, ranges from the east side of the Helan Mountains, expanding westward along the northern slope of the Qilian Mountains, ultimately penetrating to the northern part of the Junggar Basin. We think the sample sites presented here largely cover the whole range of its distribution in China. This species is abundant in the central-western part of Inner Mongolia and Gansu and the west part of Ningxia where the average rainfall is less than 300 mm or even less than 100 mm in some areas.

Distribution patterns of species are shaped by a number of factors, including barriers to dispersal, physical and biological factors that make particular regions of habitat unsuitable for viability and/or reproduction, etc. (Burton 1998). Potential distribution predicted by GARP ecological niche modeling relied on the fundamental niche (Soberón & Peterson 2005). The actual geographic distribution is a modification of the fundamental niche because it is defined by the complex interaction of the realized environment (as well as some biological and historical realities) and the fundamental niche (Brown et al. 1996; Patterson 1999; Peterson et al. 1999; Anderson et al. 2002a, b; Anderson & Martínez-Meyer 2004). This may be why some regions in Central Asia are predicted to be suitable for *M. martensii*, but it is unlikely that this species could have occurred there in reality. There is no report of *M. martensii* from this region and it cannot escape the attention of the scorpiologists' investigation given that it is a ''hotspot'' region of *Mesobuthus*. Other explanations also exist for its absence: 1) the populations there have gone locally extinct and 2) *M. martensii* has failed to disperse to this region because the existence of *M. eupeus* acts as an effective biological barrier preventing *M. martensii* from dispersing further west.

Biological interaction as a constraint for species distribution is possible in the case of *M. eupeus*. Ecological models predict that *M. eupeus* can survive further south and east in the middle part of Inner Mongolia, but this species is restricted to the northwest possibly due to the existence of *M. martensii*. We suggest that in the central western region of Inner Mongolia, Ningxia and the middle part of Gansu the two species mutually limit the range expansion of their counterparts, probably due to the competition for food and other resources (such as shelters).

The absence of *M. martensii* in the area north of mid-Liaoning may be the result of population extinction due to some undefined reasons in relatively recent time. This is in accordance with our field survey at Tieling (42.3°N, 123.8°E) where we failed to spot a scorpion. However, several elderly residents ascertained the occurrence of the scorpion there when they knocked down old houses before the 1970's, but they have not seen any since the 1980's. The abuse of insecticides and other poisonous chemicals may be an explanation for its disappearance to some extent, but it cannot account for all. Scorpions are nocturnal obligatory predators but with poor optical sensitivity, detecting their prey through substrate vibration using the tarsal sensilla (Brownell 1977; Brownell & Farley 1979a, b, c; Brownell & Hemmen 2001; Foelix & Schabronath 1983) and/or via air borne vibrations by the trichobothria on the pedipalps (Hjelle 1990). These biological features effectively reduced their exposure to poison because the scorpions will not prey on the poisoned dead creatures that produce no vibration. Actually, *M. martensii* is abundant under the fence stones of farmland in Haiyang (36.83°N, 121.03°E), Shandong Province. Some other anthropogenic activities, such as house rebuilding and large-scale soil cultivating, which cause habitat loss and recent exceptional climate change may serve as alternative explanations for the absence of this species in Tieling. This deserves further investigation.

The two *Mesobuthus* scorpions were found on either side of the Yellow River. The majority of sympatric sites (7 of 8) lie on the outer (western and northern) bank of the river (Fig. 3). This observation suggests that the Yellow River does not constitute an effective barrier for the two species and the present patterns of distribution are the results of historical processes, an interesting topic meriting further investigation by phylogeographical approaches.

Our results cast further doubt about the identity of *M. martensii* (Kishida 1939; Qi et al. 2004). The type specimens upon which *M. confucius* was described by Simon (1880) were collected from Yantai (Tchefou) and Beijing (Pékin). With no convincing evidence, *M. confucius* was then synonymized with *M. martensii* by Karsch (1881) when he examined specimens collected from Beijing and Tianjin. The holotype locality of *M. martensii* is presumably Singapore (Karsch 1879). However, none of our predicting models showed that Singapore is a suitable area for the survival of *M. martensii*. There are two possible interpretations: 1) the type specimen of Karsch (1879) represents a different taxon from that found in Singapore but the name (then *Buthus martensii*) was wrongly given to the Chinese scorpion, i.e., *M. martensii* and *M. confucius* are two different species; 2) the type specimen of Karsch (1879) is of Chinese origin. Karsch (1879) recorded ''Exemplum singulum typicum in Mus Berol. asservatum a Prof. de Martens in Singapore collectum''; there was the possibility that the specimen was initially transported by Chinese immigrants from China to Singapore possibly for medical use. It is a pity that neither Qi et al. (2004) nor we could have examined that specimen; thus this issue remains to be clarified in the future.

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