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Is the northern chevrotain, *Tragulus williamsoni* Kloss, 1916, a synonym or one of the least-documented mammal species in Asia?

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Abstract. The northern chevrotain, *Tragulus williamsoni* Kloss, 1916, was described, and for nearly a century remained known, from only one specimen. This had been collected from Meh Lem in northern Thailand in 1916. Following a taxonomic revision of the genus *Tragulus,* its taxonomic status was regarded as uncertain. New information from a *Tragulus* specimen from Xishuangbanna, Yunnan province, China, stored in the Kunming Institute of Zoology, corroborates the status of *T. williamsoni* as a distinct taxon based on skull measurements. The conservation implications of this finding include the urgent need to determine conclusively the taxonomic status of *T. williamsoni*, and its distribution and conservation status.

Key words. mouse-deer, conservation, distribution, Williamson's chevrotain, Tragulidae, Artiodactyla

INTRODUCTION

Chevrotains (Tragulidae) are ungulates of Asia and Africa, often referred to as 'mouse-deer', indicating their small size and delicate features, although they have no particularly closer evolutionary relationship to deer than to other ruminants. They are somewhat of an evolutionary relic and were apparently much more species-rich during the Miocene. For example, 11.5 million years ago at least five different tragulid species co-occurred in one location in what is now northern Pakistan (Barry et al., 1991). Dozens of other Miocene species have been described from Africa and Europe (e.g., Bouvrain & de Bonis, 2007; Pickford, 2001). Until recently, however, only four extant species were generally recognised until taxonomic revision proposed five additional ones (Meijaard & Groves, 2004; Groves & Meijaard, 2005). The taxonomic status of one of these, the northern chevrotain, *Tragulus williamsoni* Kloss, 1916, remained uncertain (Meijaard & Groves, 2004).

Tragulus williamsoni was described from a skull and skin (BMNH 47.1510), which originated from 'Meh Lem' (modern name untraced) (Phrae Province) in northern Thailand (18°25′N, 100°23′E) (Kloss, 1916). It was named as a subspecies of the lesser chevrotain, *T. kanchil* (Raffles, 1821), a species occurring widely in mainland and island Southeast Asia. There are no junior synonyms of the taxon, which was for most of the 20th century referred to as *T. javanicus williamsoni,* having been named originally as *T. kanchil williamsoni* owing to taxonomic confusion between *T. javanicus* and *T. kanchil* (Meijaard & Groves, 2004). The initial taxonomic classification of the two taxa into one species reflected similarities in pelage. This remained the only skin or skull specimen, notwithstanding a karyological analysis of two specimens identified as this species from Mengla, Yunnan, China by Shi & Chen (1989). However, those authors neither reported the preservation or lodging of morphological vouchers in accessible collections, nor confirmed explicitly the similarity of the studied specimens to the type specimen of *T. williamsoni.* Pending further specimens, Meijaard & Groves (2004) considered it difficult to determine whether the Meh Lem specimen was simply an aberrantly large individual of *T. kanchil* or a distinct taxon, but provisionally referred to it as *T. williamsoni*.

This note presents new information from a *Tragulus* specimen held in the Kunming Institute of Zoology collection (KIZ 6401), originating from Mengla, Xishuangbanna, in southern Yunnan province, China (21°28′N, 101°35′E). This location is about 360 km north-northeast of the type locality of *T. williamsoni* in northern Thailand (Fig. 1).

MATERIAL & METHODS

Materials examined. Specimens examined are deposited in the Natural History Museum, London, UK (BMNH); the Field Museum, Chicago, USA (FMNH); Kunming Institute of Zoology, Kunming, China (KIZ); and Zoological Reference Collection of the Lee Kong Chian Natural History Museum (formerly the Raffles Museum of Biodiversity Research), National University of Singapore (ZRC) (Table 1).

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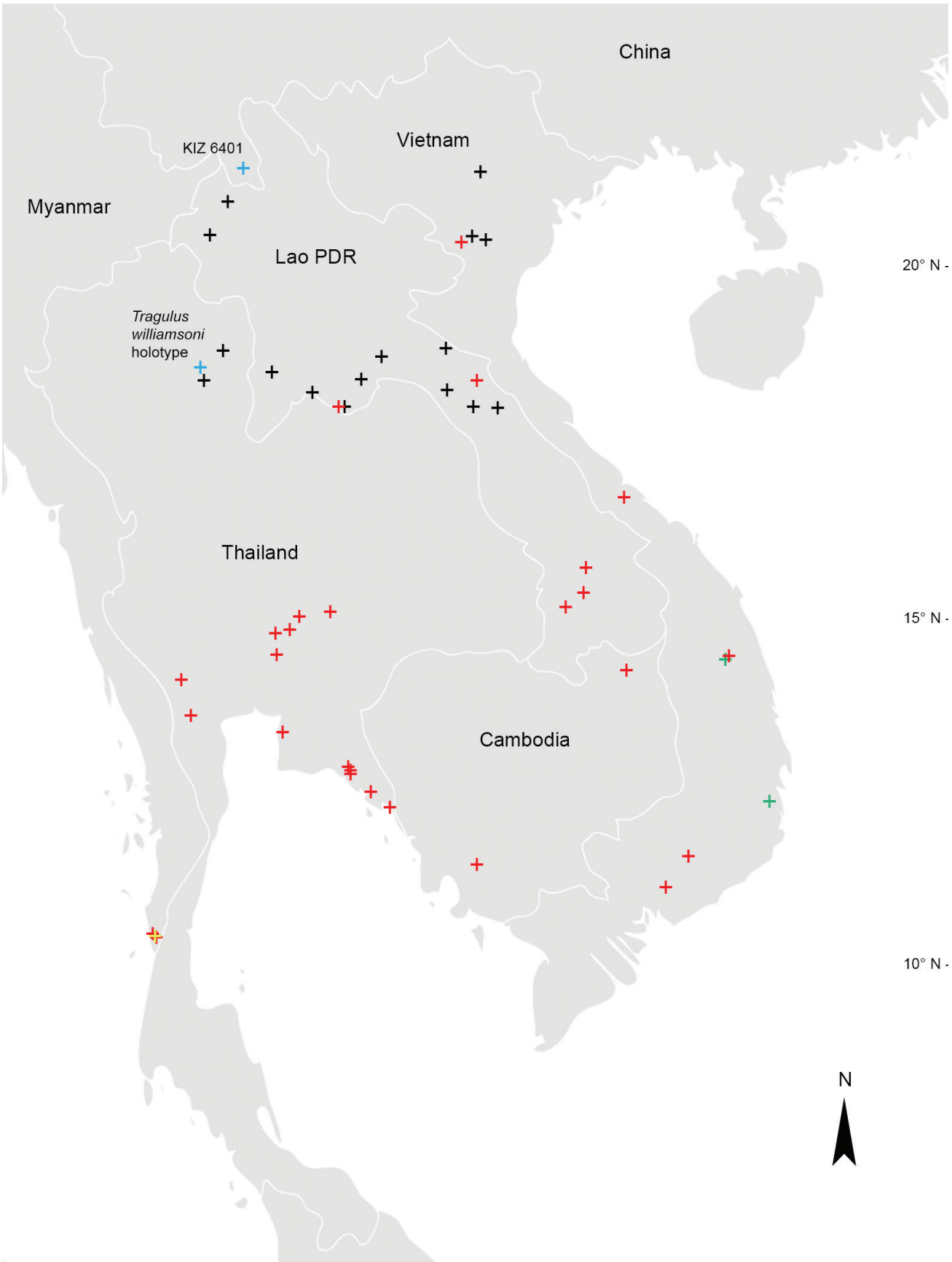

Fig. 1. Map of mainland Southeast Asia, showing records of *Tragulus* museum specimens identified as *T. kanchil* (red), *T. williamsoni* (blue), *T. versicolor* (green), and *T. napu* (yellow; at southern tip of Myanmar). Data from Meijaard & Groves (2004). Only locations north of 10°N are shown. Indicative and non-exhaustive locations where specimens or surveys have determined the presence of *Tragulus* but not to the species level between 17–22°N are marked with black crosses. The gap in west Lao PDR around 19–20°N may simply be an artefact of the lack of appropriate surveys there. In contrast, multiple appropriate surveys have failed to find *Tragulus* in the country's east, north of 19°N.

Table 1. Specimens examined in this study. BMNH: Natural History Museum, London, UK; FMNH: Field Museum, Chicago, USA; KIZ: Kunming Institute of Zoology, Kumning, China; ZRC: Zoological Reference Collection of the Lee Kong Chian Natural History Museum (formerly the Raffles Museum of Biodiversity Research), National University of Singapore.

Species	Locality	Sex	Catalogue No./Identifier
Tragulus kanchil	Krabi, Thailand	Female	BNHM 55.3228
	Maprit (Pathiu), Thailand	Female	BNHM 20.7.3.56
	Ban Dohn, Nakhon Si Thammarat, Thailand	Female	BNHM 55.3232
	Pachebore (Phetchabun), Thailand	Male	BNHM 61.4.12.20
	Thua-Thien, Thua-Thien Hue, Viet Nam	Female	BNHM 33.4.1.499
	No precise locality, Lao PDR	Female	BNHM 28.7.1.150
	Thaget, Tenasserim, Myanmar	Female	BNHM 14.12.8.237
	Hue, Vietnam	Male	BNHM 33.4.1.498
	Bien Hoa, Viet Nam	Male	BNHM 78.6.17.18
	Bankachon, Tenasserim, Myanmar	Male	BNHM 55.3225
	Muar, Johor, Malaysia	Male	FMNH 90446
	Janda Baik, Bentong, Pahang, Malaysia	Male	FMNH 98652
	Janda Baik, Bentong, Pahang, Malaysia	Female	FMNH 98653
	Ban Thangon, Vientiane, Lao PDR	Male	FMNH 36725
	Salavan, Lao PDR	Male	FMNH 38022
	Pak Chong, Nakhon Ratchasima, Thailand	Female	ZRC 4.4795
	Trang Bom (Bien Hoa), Viet Nam	Female	ZRC 4.4796
	Trang Bom (Bien Hoa), Viet Nam	Male	ZRC 4.4798
	Kompong Sun, Cambodia	Female	ZRC 4.4800
	Muak, Lek, Saraburi, Thailand	Male	ZRC 4.4801
	Pak Chong, Nakhon Ratchasima, Thailand	Male	ZRC 4.4803
	Kuala Pembeling, Pahang, Malaysia	Male	ZRC 4.4804
	Bukit Lunchu, Johor, Malaysia	Male	ZRC 4.4813
	Bukit Lunchu, Johor, Malaysia	Female	ZRC 4.4814
	Gurun, Kedah, Malaysia	Male	ZRC 4.4828
	Bang Nara, Pattani, Thailand	Female	ZRC.4.4850
	Bang Nara, Pattani, Thailand	Male	ZRC.4.4851
	Batu Kurau, Perak, Malaysia	Male	ZRC 4.4853
	Parit, Perak, Malaysia	Female	ZRC 4.4853
	Bukit Gantang, Perak, Malaysia	Female	ZRC 4.4861
	Rawang, Selangor, Malaysia	Male	ZRC 4.4862
	Parit, Perak, Malaysia	Male	ZRC 4.4863
	Teriang, Pahang, Malaysia	Male	ZRC 4.4866
	Padang Sireh, Perlis, Malaysia	Male	ZRC 4.4876
	Pelarit, Perlis, Malaysia	Male	ZRC 4.4879
	Lam Phura, Trang, Thailand	Male	ZRC 4.4881
	Nyalas, Malacca, Malaysia	Female	ZRC 4.4883
	Jelok Pah, Pasir Panjang, Negri Sembilan, Malaysia	Male	ZRC 4.4915
	Gurun, Kedah, Malaysia	Female	ZRC 4.4946
	Pongdok, Grahi, Thailand	Male	ZRC 4.4955
	Koh Lala, Rajburi (Ratchaburi), Thailand	Female	ZRC 4.4959
	Bankachon, Tenasserim, Myanmar	Male	ZRC 4.4964
Tragulus napu	Padang Tuan, Segamat, Johor, Malaysia	Female	BNHM 55.3214
	Bankachon, Tenasserim, Myanmar	Male	BNHM 66.4012
	Bankachon, Tenasserim, Myanmar	Male	BNHM 66.4015
	Bankachon, Tenasserim, Myanmar	Female	FMNH 83107
	Bankachon, Tenasserim, Myanmar	Male	FMNH 83108
	Kuala Lumpur, Selangor, Malaysia	Female	ZRC 4.4729
	Bukit Jong, Terengganu, Malaysia	Female	ZRC 4.4730
	Kuala Kampar, Kangsai, Perak, Malaysia	Female	ZRC 4.4733
	Ban Dohn, Nakhon Si Thammarat, Thailand	Male	ZRC 4.4753
	Bankachon, Tenasserim, Myanmar	Female	ZRC 4.4889
	Bankachon, Tenasserim, Myanmar	Male	ZRC 4.4891
	Bankachon, Tenasserim, Myanmar	Female	ZRC 4.4892

Species	Locality	Sex	Catalogue No./Identifier
Tragulus napu	Kuala Lumpur, Selangor, Malaysia	Female	ZRC 4.4893
Tragulus versicolor	Nha Trang, Viet Nam	Male	BNHM 6.11.6.33
	Nha Trang, Viet Nam	Male	BNHM 6.11.6.38
	Nha Trang, Viet Nam	Male	BNHM 6.11.6.39
Tragulus williamsoni	Meh Lem, Phrae, Thailand	Female	BNHM 47.1510
Tragulus sp.	Mengla, Xishuangbanna,Yunnan, China	–	KIZ 6401
	Mengla, Xishuangbanna,Yunnan, China	–	KIZ 6402

Fig. 2. Dorsal and ventral view of skulls and mandibles of KIZ 6401 (left) and KIZ 6402 (right) from the Kunming Institute of Zoology collection. The bottom panel shows the left mandible of KIZ 6401, and the right mandible of KIZ 6402. Photos by Li Song.

Morphological analysis and comparisons. We examined the only two *Tragulus* specimens held in the Kunming Institute of Zoology collection (KIZ 6401, 6402), undated and originating from Mengla, Xishuangbanna, in southern Yunnan province, China (21°28′N, 101°35′E) (Fig. 2). One of the specimens (KIZ 6402) was badly damaged, and could not be used for diagnosis; the other (KIZ 6401) was nearly complete and skull measurements were taken following protocols in Meijaard & Groves (2004). A principal components analysis was performed for 9 skull measurements (mandible length, zygomatic width, condylar width, occipital height from basion, least width across maxilla, braincase width, auditory bullae width, auditory bullae length, and interbullae distance; defined as in Meijaard & Groves, 2004) of KIZ 6401 and other mainland Asian *Tragulus* skull specimens as listed by Meijaard & Groves (2004) (Table 1; *T. napu* [Cuvier, 1822] [n = 13], *T. kanchil* [n = 42], *T. williamsoni* [n = 1], and *T. versicolor* Thomas, 1910 [n = 3]). All measurements were transformed to natural logarithms for the analysis. Statistical analyses were conducted in R version 3.2.2 (Team RDC, 2015) using the prcomp operation by singular value decomposition. The skulls of KIZ 6401, and *T. kanchil* and

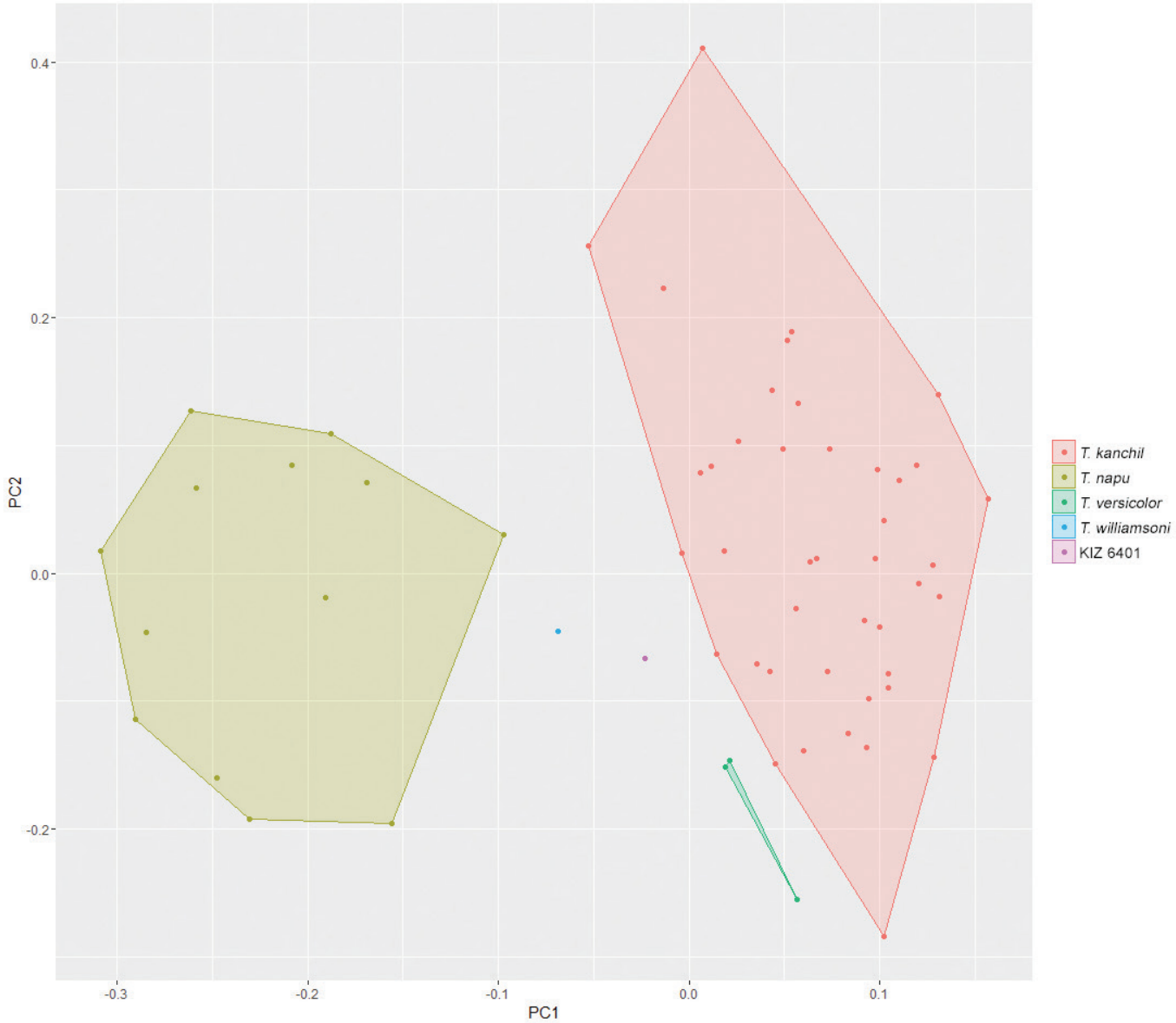

Fig. 3. Principal Component Analysis of nine measurements on 60 *Tragulus* skulls from mainland Asia. Brown dots = *T. napu* (n = 13); red dots = *T. kanchil* (n = 42); green dots = *T. versicolor* (n = 3), blue dot = *T. williamsoni* (n = 1); magenta dot = Yunnan specimen KIZ 6401.

Table 2. Skull measurements of *Tragulus* specimens used in the study in millimetres (mm).

	Tragulus williamsoni **(holotype)**	**KIZ 6401**	***Tragulus kanchil*** **(n=42)**	***Tragulus napu*** **(n=13)**	***Tragulus versicolor*** **(n=3)**
Mandible length	77.4	79.9	71.1 ± 2.58	85.4 ± 5.85	75.7 ± 1.29
Zygomatic width	45.2	43.2	40.6 ± 1.07	48.7 ± 2.56	42.9 ± 0.794
Condylar width	20.9	21.1	19.6 ± 0.765	23.2. ± 1.00	21.2 ± 0.265
Least width across maxilla	12.9	12.6	11.9 ± 0.513	15.0 ± 0.898	12.4 ± 0.208
Occipital height from basion	28.7	28.0	26.5 ± 0.880	29.8 ± 1.17	27.2 ± 0.416
Width of braincase	33.3	32.9	31.0 ± 1.01	34.9 ± 1.32	33.7 ± 0.153
Width of auditory bullae	9.1	9.0	8.56 ± 0.468	9.68 ± 0.613	9.10
Length of auditory bullae	19.8	18.1	17.5 ± 1.04	21.0 ± 1.12	17.9 ± 0.1
Interbullae distance	5.7	5.3	4.97 ± 0.530	7.01 ± 0.608	4.63 ± 0.289

Table 3. Component matrix from principal components analysis of 60 *Tragulus* skulls from mainland Asia.

	Component	
	1	**2**
Mandible length	–0.296	–0.303
Zygomatic width	–0.298	–0.167
Condylar width	–0.280	–0.138
Occipital height from basion	–0.201	–0.0343
Least width across maxilla	–0.382	–0.0423
Width of braincase	–0.196	–0.177
Width of auditory bullae	–0.186	–0.480
Length of auditory bullae	–0.309	–0.343
Interbullae distance	–0.624	–0.691
Standard deviation	0.113	0.0385
Total variance explained	0.807	0.0941

T. napu from the ZRC used for the PCA were examined for qualitative differences. Specimens of *T. versicolor* and the holotype of *T. williamsoni* were not available for these latter comparisons.

RESULTS

A principal components analysis of skull measurements (Table 2) revealed that the Yunnan specimen grouped with the *T. williamsoni* holotype from Meh Lem, and that these two were separated distinctly from the three other chevrotain species in mainland Southeast Asia (*T. kanchil*, *T. napu*, and *T. versicolor*) (Fig. 3). The separation between the taxa examined was chiefly based on overall size and interbullae distance. For *T. williamsoni*, both the holotype and KIZ 6401 differed from the similar-sized *T. versicolor* by the small interbullae distance and mandible size of the latter species. Components 1 and 2 account for 90.1% of the total variance explained (Table 3).

Observable differences in qualitative traits were present between the skulls of *T. kanchil*, *T. napu*, and KIZ 6401. These differences include the shapes of the palatine foramen, palatine bone, the pterygoid plates, and foramen magnum (Fig. 4). The palatine foramina open forwards into an anteriorly broadening trough in *T. napu*, whereas there is little or no trough in *T. kanchil* and in KIZ 6401. The anterior fork of the palatine bone diverges at a relatively shallow angle in KIZ 6401 compared with these bones in *T. kanchil* and *T. napu,* which are both canted outward sharply. The pterygoid plates in both *T. napu* and *T. kanchil* flare laterally at just about the level of the anterior end of the bulla, whereas in KIZ 6401 they flare well anterior to this point. The shape of the foramen magnum is anterio-posteriorly compressed in KIZ 6401 and *T. napu*, while it is laterally compressed in *T. kanchil.* Finally, the rostrum in KIZ 6401 looks to be flaring more laterally than in *T. napu* and *T. kanchil*, although it is difficult to be sure because the premaxillae are missing.

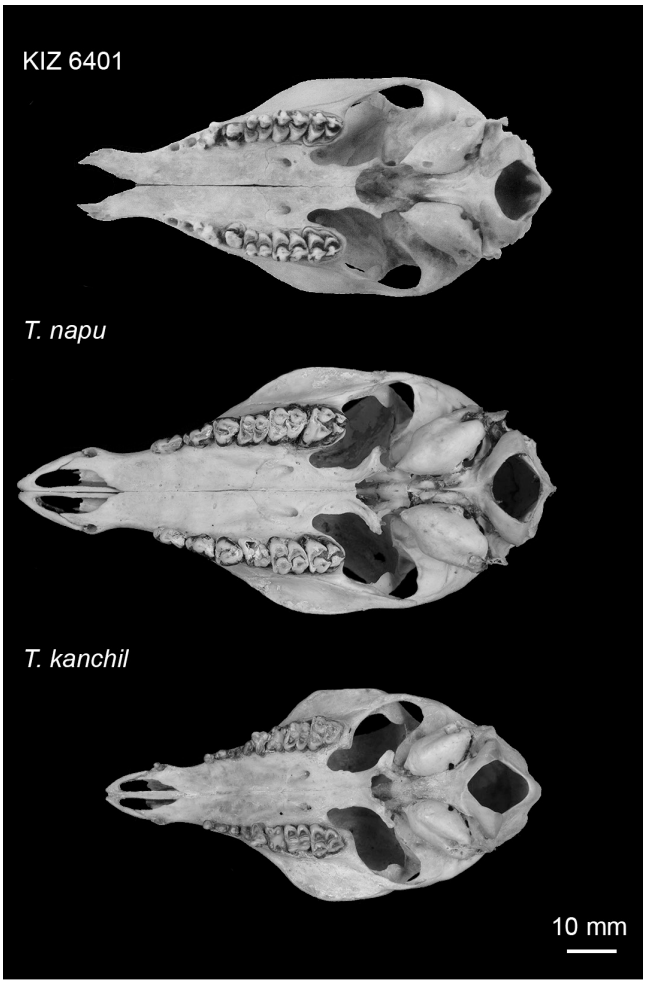

Fig. 4. Skulls of adult *Tragulus* spp. (ventral view). Top to bottom: KIZ 6401, *T. napu* (ZRC 4.4753, Nakhon Si Thammarat, Thailand), *T. kanchil* (ZRC 4.4800, Kompong Sun, Cambodia). Scale bar = 10 mm.

DISCUSSION

Taxonomic implications. A sample size of two is small, but the skull from Yunnan corroborates earlier suggestions that the holotype of *T. williamsoni* is not simply an aberrantly large individual of *T. kanchil* nor a specimen of *T. versicolor*. It suggests that *T. williamsoni* is a morphologically distinct valid taxon. The differences in skull size reflect those in body size, with the total length of the female *T. williamsoni* holotype measuring 599 mm, which is considerably larger than *T. kanchil* on the Asian mainland (range = 370–531 mm; mean = 427 mm; n = 23) (Meijaard, unpublished data). Further, large *T. kanchil* skulls do not have linear skull measurements and shape (including qualitative traits such as palatine bone and foramen magnum morphology) similar to those of *T. williamsoni*. The specimens of *T. kanchil* used in the analysis come from a wide latitudinal range, and there is no suggestion of a clinal increase in size with rising latitude (Meijaard, unpublished data) even though the most northerly *T. kanchil* is from only less than one degree in latitude and 240 km southeast of the *T. williamsoni* holotype. Two specimens identified based on unknown criteria as *T. williamsoni* from southern Yunnan also differ from *T. kanchil* (specimens from Malaysia) in the size of the Y-chromosome (Shi & Chen, 1989). These pieces of evidence support the full species status of this northern taxon of chevrotain. Its minimal known area of occurrence includes northern Thailand and far southern Yunnan, but further surveys might reveal its occurrence in other areas, potentially in sympatry with other chevrotain species (*T. kanchil* and possibly, given how poorly collected is the area between their known ranges, also *T. versicolor*).

Other than the differences in the skull morphometrics of *T. williamsoni*, *T. versicolor*, and *T. kanchil*, the three species appear to be diagnosable by other characters. *Tragulus versicolor*, known from two locations in Vietnam (Kuznetsov & Borissenko, 2004; Meijaard et al., 2004), has distinct silvery upperparts (Meijaard et al., 2004) not found in any other *Tragulus* species. *Tragulus williamsoni* is "ochraceous-buff to tawny" above and lighter on the sides (Kloss, 1916), while *T. kanchil* from Central Thailand (~12°N) is darker, and with wider throat markings (Kloss, 1919). *Tragulus napu*, on the other hand, is clearly larger than the other three species. In addition, it has not been recorded north of 10°08′N (Meijaard, 2011), although it is possible that the presence of the species further north might have been overlooked given the patchiness of survey and specimen collection effort. Geographically, it might be that both *T. williamsoni* and *T. versicolor* have relatively small distribution ranges compared with the more widespread *T. kanchil* and *T. napu*, but further surveys are needed to confirm this.

Although this study includes data from *Tragulus* specimens in many major natural history collections that have collections from the northern range of the genus, it was found that specimens of *Tragulus* from this area are rather poorly represented and geographically scattered. Improved taxon sampling and further work on zoological collections from these areas will increase both taxonomic knowledge, and understanding of the natural history (e.g., geographic distribution) of the species.

Conservation implications. *Tragulus williamsoni,* if truly a valid species, a hypothesis that needs further testing, might be one of the least-known mammal species in the world, but it cannot be assumed to be rare or highly restricted in range simply because known specimens are so few. The rarity of positive records for *T. williamsoni* might reflect the paucity of collecting in recent decades. Meijaard & Groves (2004) examined many collections in western institutions, but none in China, Thailand, Lao PDR or Vietnam, and additional specimens might well yet lie unrecognised. Surveyors in the region have paid little heed to the taxon's existence, and have rarely looked critically at chevrotains in the field or markets, mostly assuming that only one species inhabits northern Southeast Asia and adjacent China. Indeed, the same applies to the other recently revalidated chevrotain of Southeast Asia, *T. versicolor*, also known from few specimens (Kuznetsov & Borissenko, 2004; Meijaard & Groves, 2004).

The true distribution of *T. williamsoni* cannot be determined yet. The type locality is west of the Mekong River, a range barrier for some mammal species (Meijaard & Groves, 2006), but the new specimen is from east of this river. The genus *Tragulus* has an odd distribution within northern Southeast Asia. It is recorded from Myanmar only in the far south (Tun Yin, 1967), although Shan State, close to parts of Lao PDR and Thailand holding the genus, has not been well investigated. *Tragulus* is widespread in the west but apparently absent from the east of Lao PDR's northern highlands, and the intervening part remains to be investigated (Bergmans, 1995; Duckworth et al., 1999b: 269; Johnson et al., 2003; Timmins & Duckworth, 2013); the sign-based record of *Tragulus* from Phou Dendin National Protected Area (in far north-east of Lao PDR) in Evans et al. (2000) was by a relatively inexperienced observer, and upon later re-examination of his original notes, he retracted the record, since confusion with a muntjac *Muntiacus* fawn was possible. More telling, during interviews by the same observer in the same area in 2004–2005, villagers commonly reported that while they knew what a chevrotain ("kai" or "fan kai") is, most said it is essentially absent from the area, and always has been (W. G. Robichaud *in litt*. 2008). The apparent absence from the east of Lao PDR's northern highlands suggests that chevrotains may not occur in the contiguous Vietnamese northern highlands and indeed, while *Tragulus* inhabits northern Vietnam (Dang et al., 1994), the actual localities are few and in or near lowlands. The genus penetrates China only in Xishuangbanna prefecture of Yunnan Province (Luo et al., 1999; Cao et al., 2010).

The two records here assigned to *T. williamsoni* seem to be the only *Tragulus* records critically identified from the entire world range of the genus north of 18°10′N and west of Vietnam (Fig. 1). Three more specimens belong potentially, on grounds of locality, to this species, all in the United States National Museum but were not examined. Specimen USNM 355337, a skin from Ban Pha Hang, Nan Province, Thailand is from 18°48′N, 100°47′E, a location slightly north of the

Fig. 5. Camera trap photograph of a chevrotain taken at Xishuangbanna forest dynamics plot, Mengla County, Yunnan, China likely to be *Tragulus williamsoni*. Photo by Cao Lin from Zhang et al. (2016) reproduced with permission.

confirmed Meh Lem specimen of *T. williamsoni*. A second specimen (USNM 355338, also skin only) is from Pa Dong Lan, Amphoe Chum Phae, Khon Kaen, Thailand (16°25′N, 102°49′E). The third specimen (USNM 267202), from Huai Oi, Thailand (18°08′N, 100°38′E) is a female with a preserved skin and skull, of undetermined maturity. The northernmost confirmed *T. kanchil* from Thailand is from Pak Chong, East Thailand (14°42′N, 101°25′E). Further east, in Lao PDR, *T. kanchil* is known north to about 18°N, almost as far north as Meh Lem. The many locality records of *Tragulus* not identified to species level present close to the known latitudinal origin of the two known *T. williamsoni* specimens warrant further investigation (Fig. 1; black crosses).

Current population status and habitat requirements for *T. williamsoni* are unknown. In Yunnan, *Tragulus* inhabits the middle and lower slopes of low-altitude river valleys (Cao et al., 2010). There it feeds primarily on fruits of *Baccaurea ramiflora*, *Alpinia kwangsiensis*, *Phrynium capitatum*, and the syconia of *Ficus hirta*, all of which are species found along river banks (Luo et al., 1999; Cao et al., 2010). These animals presumably include *T. williamsoni* but with only one specimen from Yunnan (and none from directly adjacent Lao PDR) critically examined, the genus there could comprise a mix of *T. williamsoni* and *T. kanchil*. The 'relative abundance index' (apparently based on the photographic encounter rate, rather than on abundance per se) of *Tragulus*, assumed to be wholly or in part *T. williamsoni*, in the Xishuangbanna Forest Dynamics Plot, Yunnan, at about 750 m asl was estimated through camera trapping at 0.09 (Fig. 5), compared with other ungulate species red muntjac, *Muntiacus muntjak* (0.8), sambar, *Rusa unicolor* (0.02), and Eurasian wild pig, *Sus scrofa* (3.22) (Zhang et al., 2014). Chevrotains (which may or may not comprise or include *T. williamsoni*) are clearly common in and around Nam Kan and Nam Ha National Protected Areas, Lao PDR, at about 20–21°N (similar in latitude to the KIZ specimen), in the latter of which they are among the most commonly hunted, eaten, and traded wildlife (Johnson et al., 2003; Timmins & Duckworth 2013). This region of Lao PDR, Thailand and China is seeing unprecedented levels of conversion of remaining forest land to tree plantations, particularly rubber, reflecting rapidly rising demand by China (Li et al., 2007). General mammal hunting levels are extremely high, at least in relevant parts of Thailand and Lao PDR (Duckworth et al., 1999a; Tungittiplakorn & Dearden 2002; Johnson et al., 2003), and wild meat remains of pivotal dietary significance for many subsistence-level people (Krahn & Johnson, 2007). Therefore, this widespread conversion will be having three related negative effects on ground-dwelling forest mammals: direct loss of habitat; decline and destabilisation of the forest resource-base (including wild-meat sources) for subsistence-level communities, leading to higher hunting levels in remaining wildlife areas; and shrinkage of the size of natural habitat blocks, and thus higher chances of local extirpations. Because this is an emerging pattern, and because the ecology of *T. williamsoni* is unknown, it is not possible to determine the severity of the risk of extinction.

Conclusion and recommendations. The new evidence presented here supports the stance that *T. williamsoni* is a distinct species. Too little is known about its distribution and population trends to assess its conservation status. Considering the generally high hunting pressure in its range, a conservation status assessment is urgently needed, ideally with the following steps. First, review museum specimens of *Tragulus* in zoological collections in Thailand, China, Lao PDR, Vietnam and Myanmar to determine if any hold *T. williamsoni* specimens, and the northern limits of *T. kanchil*. Second, review camera trap photographs and survey reports from the region, particularly southern China, northern Thailand and northern Lao PDR, and interview survey teams and local hunters to determine where the genus *Tragulus* occurs. Third, collect specimens for critical identification and clarification of the taxonomy of *T. williamsoni*, starting with localities close to known *T. williamsoni* localities, or where other information suggests the species might occur. Fourth, whereas *T. williamsoni* is not yet known to differ in its external shape and pattern, and has only slight differences in colouration from *T. kanchil*—both show uniformly coloured light brown upperparts, with a barely visible darker nape streak (Meijaard, 2011)—it is worth checking additional museum skins carefully to look for as yet unknown consistent differences between the species. In addition to morphology, DNA analysis could be a valuable tool for *Tragulus* taxonomy, and understanding the inter- and intra-specific variation across its geographic range. Fifth, once the distribution range is better understood, if appropriate (for example, it turns out to be allopatric from *T. kanchil*) conduct interview surveys to determine species strongholds, threats, and perceived population trends, to determine the species's conservation status.

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