

Systematics of the Artiodactyla of China in the 21st century

Colin GROVES*

School of Archaeology & Anthropology, Australian National University, Canberra, ACT 2600, Australia

ABSTRACT

In this paper, I have introduced the concept of the Evolutionary Species, and shown how it affects the taxonomy of the Artiodactyla of China. The "traditional" taxonomy of the Artiodactyla, which has remained almost unchanged for 100 years, relies on ill-formulated notions of species and subspecies, only slightly modified by the population-thinking of the 1930s. Species are populations (or metapopulations) differentiated by the possession of fixed heritable differences from other such populations (or metapopulations). In the Artiodactyla, there are many more species than "traditionally" recognised; this is by no means a drawback, as it enables the units of biodiversity to be identified in a testable fashion, and brings the taxonomy of large mammals into line with that long practised for small mammals. Species are likely to differentiate where there are natural gaps in the distribution of a genus, such as mountain blocks (for example in the genus *Budorcas*) or otherwise dissected habitat (for example in the genus *Cervus*). Natural hybridisation between distinct species is not an uncommon phenomenon, again illustrated well in the genus *Cervus*, where hybridisation between the *elaphus* and *nippon* groups occurs today and evidently occurred in the past, as shown by the distribution of mtDNA.

Keywords: Artiodactyla; Taxonomy; China; Evolutionary species; Phylogenetic species concept

INTRODUCTION

Throughout the 20th century, the taxonomy of Artiodactyla which was in general use was based on Lydekker's *Catalogue of the Ungulate Mammals in the British Museum (Natural History)* (Lydekker, 1913-1916; Lydekker & Blaine, 1914). A few groups were revised during the 20th century, and a few changes were made, but always on the basis laid down in these volumes, so that Artiodactyla taxonomy became, as it were, "fossilised". It was only in 2011, with the publication of Groves & Grubb's

Ungulate Taxonomy, that a new approach was laid down, bringing into play the advances in taxonomic and evolutionary understanding that had been accumulating since the 1980s (Groves & Grubb, 2011).

In the main, these advances in understanding concern species theory. Lydekker was influenced by the work of Rothschild and others who introduced the concept of the subspecies (or, as they were often called, "races") into mammalian taxonomy, but took it to extraordinary lengths. He wrote: "To a great extent the principal of classifying nearly related kinds of animals to races of a single species, rather than as distinct species, has been followed" (Lydekker, 1913, 1: vi). He did not say precisely what he meant by "nearly related kinds", nor did he define what he meant by species at all; evidently, he regarded species simply as convenient pigeonholes, and subspecies as lesser pigeonholes within them, neither being more than convenience categories.

The 1930s saw considerable advances in evolutionary theory, and it became clear that taxonomy should be based on populations. Mayr (1963) most explicitly defined species as populations (or groups of populations) which do not interbreed with other such populations (or groups of populations) under natural conditions, and the species/subspecies views of authors such as Lydekker fitted easily into this concept. Increasingly, however, systematists and evolutionists in general became dissatisfied with this definition, and proposed other concepts of species. Mayden (1997) reviewed all the concepts of species that had been proposed, and he concluded that only one fit in the criterion of a primary species concept: the "evolutionary species" (a species is an evolutionary lineage), arguing that what had been called the Phylogenetic Species Concept (that species are diagnosable - consistently different) is a suitable criterion for recognising evolutionary species. De Queiroz (2007) maintained that "every lineage is a species", and criteria such as non-interbreeding may be expected to evolve, over time, between different species, but again argued that the

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*Corresponding author, E-mail: colin.groves@anu.edu.au

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criterion of consistent difference is the most suitable way of differentiating them.

Groves & Grubb (2011: 1) therefore defined a species as “the smallest population or aggregation of populations which has fixed heritable differences from other such populations or aggregations”. Such a definition means that species are units of taxonomy, and of biodiversity in general:

Species are populations (or groups of populations);

They have fixed differences between them (i.e., they differ 100%, consistently);

The differences between species are heritable (i.e., they relate at some level to the genome).

Species are thus testable, and any claim that two populations are diagnosable, i.e., different species, can be falsified if new evidence comes to hand. Morphological, genetic, and behavioural characters can all be used to diagnose species.

Many former subspecies, when closely examined, turn out to be fully diagnosable in this sense, and must therefore be regarded as distinct species. Those taxonomists who adhere to this view of species will thus recognise many more species than in the “traditional” view. Many of them do not recognise subspecies at all; others admit the subspecies as a taxonomic category, but agree that they are subjective, as they represent populations of a species which differ by the frequencies of certain characters, or by measurements which overlap. Whether subspecies are recognised or not, it is clear that they are not evolutionary units like species, and should therefore not be reified.

HIGHER CATEGORIES IN THE CLASSIFICATION OF ARTIODACTYLA

Since the 1990s, DNA-based phylogenetic research (see, for example, Waddell et al., 1999) has concluded that the old concept of Suiformes is inaccurate: of the three families formerly included in this group, the Suidae (pigs) and Tayassuidae (peccaries) are indeed evolutionary sister groups, but the Hippopotamidae (hippos) are more closely related to the ruminants, and their sister group is the Cetacea (whales and dolphins). This view of the hippopotamus as a sort of whale which remains partially terrestrial is revolutionary, but very solidly based.

The classification of the order Artiodactyla adopted by Groves & Grubb (2011) is as follows:

- Suborder Tylopoda
 - Family Camelidae
- Suborder Suina
 - Family Suidae
 - Family Tayassuidae
- Suborder Whippomorpha
 - Infraorder Cetacea
 - Infraorder Ancodonta
 - Family Hippopotamidae
- Suborder Ruminantia
 - Infraorder Tragulina
 - Family Tragulidae
 - Infraorder Pecora
 - Family Moschidae
 - Family Giraffidae

Family Antilocapridae

Family Cervidae

Family Bovidae

The order contains most of our domesticated mammals. The nomenclature of domestic species and their wild ancestors/relatives has, in the past, been very contorted, but 10 years ago the International Commission on Zoological Nomenclature decreed that the name given to a domesticate shall not take precedence over that given to a wild species, and this was discussed by Gentry et al. (2004).

Tylopoda

The sole living family, Camelidae, consists of the genera *Camelus* and *Lama*. *Camelus ferus*, the wild Bactrian camel, is the only species native to China.

Suina

The genus *Sus*, the only genus of the pig family in China, is extremely difficult to classify. Provisionally, Groves & Grubb (2011) recognised three species in China: *Sus moupinensis* Milne Edwards, 1871, from most of China, extending south into Burma and north into Korea; *Sus chirodontus* Heude, 1888, from the swamps south-west of Shanghai; and *Sus ussuricus* Heude, 1888, from Heilongjiang and northern Jilin, extending into the Russian Far East.

Sus chirodontus is larger on average in males, and lighter-coloured, than *Sus moupinensis*, with a narrower skull, but females are the same size (i.e., there is less sexual dimorphism in size). *Sus ussuricus* is of enormous size in both sexes.

Moschidae

This is another family which is difficult to classify. Groves & Grubb (2011) recognised seven species, of which six are known from China:

Moschus moschiferus Linnaeus, 1758, the Siberian musk-deer, which extends from northernmost China (eastern Liaoning, eastern Jilin, north-eastern Nei Mongol, and Heilongjiang, extending to Korea, Mongolia and Siberia). This has a softer, less quill-like pelage than other musk-deer, with a pair of whitish stripes running from the chin to the chest, and the coat is often spotted.

Moschus chrysogaster Hodgson, 1839, the Alpine musk-deer, from the Alpine zone of the Tibetan Plateau, a very large species with an ill-defined broad whitish band running down the throat, pale rump, yellow-tipped ears, and light-coloured legs.

Moschus anhuiensis Wang et al., 1982, the Anhui musk-deer, from the lowlands of south-western Anhui, small and spotted.

Moschus berezovskii Flerov, 1929, the forest musk-deer, from the eastern slopes of the plateau, south into northernmost Vietnam, with three wide white stripes down the throat and black rump. There is some possibility that populations from southeastern China and northern Vietnam, which are much smaller and paler than others, might actually be a distinct species.

Moschus leucogaster Hodgson, 1839, the Himalayan musk-deer, from the southern slopes of the Himalayas, and

provisionally recorded in China in the Zhangmu district of south-eastern Tibet (unless this population, together with one in the Khumjung district of Nepal, represents a different species).

Moschus fuscus Li, 1981, the black musk-deer. There is a possibility that this species in fact consists of melanistic individuals of other species, but very dark musk-deer from the southern slopes of the eastern Himalayas, and brown musk-deer from northern Burma, are probably distinct species.

Recently, Liu & Groves (2014) published further notes on musk-deer, bringing together the rather disparate existing data and striking some cautionary notes. Pan et al. (2015) worked out a phylogeny of the genus, recognising the above six Chinese species and separating them into two clades: *M. chrysogaster*, *fuscus* and *leucogaster* versus *M. moschiferus*, *berezovskii* and *anhuiensis*; it is unclear where samples of *M. fuscus* and *leucogaster* derive from. A great deal remains to be learned about musk-deer taxonomy.

Cervidae

The two subfamilies of Cervidae are Capreolinae and Cervinae. The Capreolinae include the Capreolini (*Capreolus* and *Hydropotes*), Alceini (*Alces*) and Rangiferini (*Rangifer* and the New World deer, *Odocoileus* and its relatives). The Cervinae include the Muntiacini (*Elaphodus* and *Muntiacus*) and Cervini (*Dama*, *Axis*, *Rucervus*, *Panolia*, *Elaphurus* and *Cervus*, of which the last three occur in China).

Two species of roe deer, *Capreolus*, are traditionally recognised (European *C. capreolus* and Asian *C. pygargus*), and Groves & Grubb (2011) had no evidence to affirm or query this, although there is some suggestion that *C. pygargus* may consist of two or three species. At present, it appears that the two species may overlap in the Caucasus, east of which *C. pygargus* extends as far as northern China, Korea and the Russian Far East; geographic populations of this presumed species differ in the number of B chromosomes, those from China (and other eastern areas) having more B chromosomes (up to 14) than those in Kazakhstan and western Russia.

The water-deer, *Hydropotes inermis*, is an antlerless deer which, according to molecular and behavioural datasets, is sister to roe deer. It is found in wetland areas of eastern China, mainly along the coast, especially Zhejiang, Jiangsu and the lower Yangtze, and in Korea. There is no evidence for more than one species, though this should be re-examined.

Alces americana is the moose (Elk) species found from central Siberia eastward through northern China and into North America, differing consistently from *Alces alces* of Europe and western Siberia. Populations from northern China and the Russian Far East appear distinctive, but it is unclear whether the differences are entirely genetic.

Reindeer, called caribou in North America, are traditionally ascribed to a single species, *Rangifer tarandus*, but some of the North American populations probably represent distinct evolutionary lineages, i.e., are distinct species. In the Old World, there are no distinctive Arctic island forms analogous to those in northern Canada, but the same tundra versus woodland division exists as in the New World. The relationships between

the “ecotypes” in Eurasia (including far northern China) and North America have not been worked out, and a great deal of work remains to be done on the taxonomy of the genus.

Muntiacini

Traditionally, a single species, *Elaphodus cephalopus*, of Tufted Deer, has been recognised, from central and southern China (north as far as Sichuan, Hubei and Zhejiang) and northern Burma, but the mountainous distribution is probably divided into different blocks, and further research may find that several different evolutionary lineages (phylogenetic species) are involved. So far, insufficient material has been studied, and DNA work remains to be done.

There are many more species of the genus *Muntiacus*, known as muntjaks, than have previously been acknowledged. China has two species of the *M. muntjak* (Red or Indian muntjak) group. The first of these is the black-legged *M. nigripes* from Hainan, northernmost Vietnam and the southern mainland Chinese borderlands. The second is the pale-coloured *M. vaginalis*, which extends from Nepal and eastern India to Burma, Thailand, Laos and most of Vietnam into southernmost Yunnan, but the eastern populations are somewhat different from those of the South Asian regions, and might represent a different species. A third taxon, from Guangdong, has been described as *Muntiacus muntjak guangdongensis*, and needs to be compared with the two so far known from China. A second species-group is represented by *M. crinifrons* of western Zhejiang, south-eastern Anhui and Fujian, and *M. gongshanensis* of the Gaoligong and Biluo mountains. A third species-group is represented by *M. reevesi* which appears to have a wide distribution south of the Yangtze, including Taiwan.

Muntjak have long been known for their wide range of chromosome numbers. *M. reevesi* has a diploid chromosome number of $2n=46$, the *M. crinifrons* group has eight in females and nine in males, and *M. vaginalis* has six in females and seven in males, the lowest number known in mammals.

Cervini

In most earlier publications, these typical Old World deer were generally referred to a single genus, *Cervus* (except for the distinctive *Dama*, *Axis* and *Elaphurus*), although sometimes the Sambar group have been set apart as a separate genus, *Rusa*, and the White lipped deer as genus *Przewalskium*. Work by Meijaard & Groves (2004) and by Pitra et al. (2004) has shown that relationships are different from those traditionally depicted: while *Elaphurus*, *Dama* (from western Eurasia) and *Axis* (from South and Southeast Asia) are indeed distinct, the only other distinct genera are *Panolia* and the mainly South Asian *Rucervus*.

One of the three species of *Panolia*, the Brow-antlered or Eld's deer, occurs in China. This is *P. siamensis*, a small spotted species which is rare in its mainland range (Thailand, Cambodia, Laos) but has been well-preserved on Hainan.

Père David's deer, *Elaphurus davidianus*, famously became extinct in the wild in historic times and preserved only in the Imperial Hunting grounds, whence a few specimens were

kidnapped in the 1890s and bred in large numbers in Britain. Many have now returned to China, where they are breeding freely in much the same area as they were known in the 19th century. Characters of this peculiar genus, both morphological, behavioural and molecular, indicate it is of ancient hybrid origin between *Cervus* and *Panolia*.

There are numerous species in the genus *Cervus*, the “true deer”, in China. *Cervus equinus*, the Southeast Asian sambar, has simple three-pointed antlers, a coarse, shaggy coat, and a long bushy tail. It occurs in Sumatra and Borneo, and mainland Southeast Asia north into southern China, including Taiwan.

Cervus albirostris, the White-lipped deer, is characteristic of the Tibetan Plateau.

Deer of the *C. elaphus* group – Red deer, wapiti, shou and sika – are widely distributed in China. In the far west, in the Tarim Basin in Xinjiang, occurs *C. yarkandensis*, characterised by a straight antler beam with only three tines. Both DNA and morphological data indicate that its affinities lie with deer related to *Cervus elaphus*, which are distributed in Europe and western Asia. In the Tianshan and Altai systems occurs the very different *C. canadensis*, identical (or nearly so) to the wapiti of North America, a very large deer with complex antlers and a very large rump patch; and a related species, *Cervus xanthopygus*, the Manchurian wapiti, occurs in north-eastern China and the Russian Far East. Three further species belong to the group known as the shou: *C. wallichii*, the Tibetan shou, in southern Tibet, along the Tsangpo River; *C. macneilli*, the Sichuan shou, on the wooded slopes of Sichuan and Gansu; and *C. alashanicus*, the Alashan stag, in Ninxia and the borders of Nei Mongol. These last three species have a characteristic antler form and small, dark-edged rump patches.

The last group of deer of the genus *Cervus* are related to *C. nippon*, the sika deer of Japan. They are much smaller than other species of the genus, and have very simple antlers. Different species of the group are known from the Japanese islands, while in China, *C. taiouanus* lives on Taiwan, *C. hortulorum* in northern China and the Russian Far East, *C. sichuanicus* in an isolated area of Sichuan, and *C. pseudaxis* in southeastern China and northern Vietnam. Unfortunately, throughout the Imperial period in China sika were kept on deer farms, and it seems likely that deer from different areas were mixed up, so that many surviving populations are of hybrid stock. There is still however scope to try to determine the affinities of deer from different captive facilities. There is a possibility that the full specific diversity of sika in China has not been documented; for example, it may be that the deer at present combined as *C. pseudaxis* from southern China and from northern Vietnam may actually represent two different species.

An interesting finding has been that the Chinese (and American) deer of the *C. elaphus* group, with the exception of *C. yarkandensis*, have mtDNA that aligns them with deer of the *C. nippon* group rather than with the European and West Asian representatives of the *C. elaphus* group. Groves & Grubb (2011) hypothesise that the *C. elaphus* group spread north-eastward from the southern Himalaya slopes, interbreeding with local sika populations as they spread, *elaphus*-group stags with *nippon*-group hinds, the pure stags

then backcrossing with hybrid hinds over many generations until the deer population were entirely phenotypically *elaphus*-like but with *nippon*-like mtDNA.

Bovidae

The family Bovidae, the Hollow-horned Ruminants, is the largest family in the Order Artiodactyla, containing well over 200 species. This number is double that recognised before the Groves & Grubb (2011) revision; this has caused a certain amount of angst in some quarters (Heller et al., 2013; Zachos et al., 2013), but there have been cogent rebuttals (Cotterill et al., 2014; Groves, 2013). To put it very simply, we cannot complain about revisions to a taxonomic scheme that had remained unaltered, untested, for 100 years.

There are two subfamilies of Bovidae: Bovinae (containing cattle and buffaloes, as well as some Indian and African “antelopes”), and Antilopinae (containing sheep and goats and their relatives, gazelles, and a variety of African “antelopes”). The bovids occurring in China belong both to Bovinae (genus *Bos*) and to Antilopinae (genera *Saiga*, *Gazella*, *Procapra*, *Pantholops*, *Budorcas*, *Hemitragus*, *Pseudois*, *Capra*, *Ovis*, *Nemorhaedus*, *Capricornis*).

There appear to be no taxonomic problems connected with the Bovini. Two wild species of the genus *Bos* occur in China: *Bos gaurus*, the gaur, occurs in southernmost Yunnan, and *Bos mutus*, the wild yak, occurs on the Tibetan Plateau. Both have given rise to domestic forms: the mithan, derived from the gaur, is in use in northern Burma, north-eastern India and Bhutan, and possibly in southern Yunnan, while the domestic yak is spread throughout the Plateau and bordering mountains, at lower altitudes being hybridised with ordinary domestic cattle.

Antilopini

The saiga antelope, *Saiga tartarica*, was formerly widespread in Kazakhstan, and occurred in northern Xinjiang, but is believed to be now extinct in Chinese territory. The second, smaller species, *Saiga mongolica*, lives in western Mongolia and is not known to have occurred in China.

A single species of gazelle, *Gazella yarkandensis*, occurs in Xinjiang and probably other northern desert provinces of China. It has generally been regarded as a subspecies of *Gazella subgutturosa*, but this latter now appears to be confined to Iran and neighbouring countries.

All three species of the genus *Procapra* (formerly, but incorrectly, thought to be a kind of gazelle) live in Chinese territory. *Procapra picticaudata*, known as the Tibetan gazelle, the smallest species, is widespread across the Tibetan Plateau, just extending beyond Chinese territory into the Indian territory of Ladakh. The largest species, the Mongolian gazelle *Procapra gutturosa*, occurs in Nei Mongol.

It is the third species, Przewalski's gazelle *Procapra przewalskii*, which is of most interest. Its historical range was the region of Qinghai Lake, in the north-east of the Tibetan Plateau (*Procapra przewalskii przewalskii*), and lower altitudes in Gansu (*P.p diversicornis*). According to Mardan et al. (2013), it is now restricted to the shores of Qinghai Lake and the Buha River which flows into it, but the present population corresponds

to the putative subspecies *diversicornis*, and this has been so since about 1990 or before. Hypothetically, recent climatic change has caused the Gansu population to shift its range to higher altitudes, where it has outcompeted the indigenous population. To increase the complexity of the situation further, it appears that one of the surviving populations, in the Wayu region south-west of the lake, differs rather strongly morphologically from the others, a situation which needs further investigation (Mardan et al., 2013).

Caprini

The Chiru, *Pantholops hodgsoni*, is another species widespread on the Tibetan Plateau, and so almost confined to Chinese territory (just extending into Ladakh).

The takins (genus *Budorcas*) have traditionally been ascribed to a single species, but it is unclear why, since on the available evidence the four named taxa appear to be consistently different from each other, and so represent unique evolutionary species (Groves & Grubb, 2011). All four occur in China, two of them being endemic. *Budorcas taxicolor*, extending from the Mishmi Hills of north-eastern India through northernmost Burma into Yunnan, is light brown developing with age an extensive black wash on the flanks, belly, legs, throat and head; males are much larger than females. *Budorcas whitei* occurs in south-eastern Tibet and in Bhutan; in skull, horns and pelage it resembles juveniles of *B. taxicolor*, but is much the same size (an apparent case of neoteny). *Budorcas thibetana*, from Sichuan, lacks the specific dark areas of *B. taxicolor* but develops overall darkening with age and a yellowish saddle on the back, and with a black nose. Finally the beautiful Golden takin, *Budorcas bedfordi*, from the Qinling Range, is more golden in tone, without darkening on the face, and is less sexually dimorphic than other species.

A genus that is distributed over discontinuous habitat, such as high altitude grasslands and forests, like *Budorcas*, is especially likely to undergo speciation. Most genera of the tribe Caprini, almost all of which are specialists of high altitude or hilly country, are divided into well marked divergent species in this manner.

The only species of true wild goat (*Capra*) in China is the so-called Siberian ibex, *Capra sibirica*, which is spread from Kashmir to the Altai and the Gobi ranges, and enters Chinese territory in Xinjiang, Gansu and Nei Mongol. Geographic variation in this species, or whether it is indeed a single species, remains to be worked out properly.

The genus *Ovis*, containing sheep (domestic and wild), is widespread from the Middle East across central and northern Asia into North America. The number of species has been much debated; most authors have divided the Old World wild sheep into urial (from the lower desert ranges of the Middle East), argali (from the high mountains of Central Asia), and snow sheep (from central and eastern Siberia), treating these as species, or sometimes subspecies-groups within a single species. In the analysis of Groves & Grubb (2011), each of these informal groups contains a number of species. Only argali are found in China. *Ovis hodgsoni*, the Tibetan argali, spread over the whole of the Tibetan Plateau, is a large, mainly uniformly brown species with a sharply set-off light belly and

rump and a long light-coloured "ruff" on the throat. In the Tianshan occurs the so-called Marco Polo sheep, *Ovis polii*, which is smaller but with very long, widely spreading horns; it is darker, with a much more spreading pale rump patch and a very small ruff present only in winter pelage. *Ovis darwini*, the Gobi argali, may extend into Chinese territory; the Shanxi argali, *Ovis jubata*, is endemic to China (Shanxi, Shaanxi, Hebei, Nei Mongol); it is small and dark fawn-grey in colour with a large rump patch, and a very long ruff.

The Gorals, genus *Nemorhaedus*, live on wooded slopes up to about 3 000 m., from the southern slopes of the Himalayas south-east to northern Thailand and north-east to the Russian Far East. The Chinese goral, *Nemorhaedus griseus*, is endemic to China, from Fujian west to Sichuan and north to Shanxi and (formerly) the vicinity of Beijing; it is grey in colour, light on underparts, with yellowish or white limbs below knees and hocks, and a golden-white throat; the tail is bushy but short. To the north-east (Heilongjiang, extending west to Mongolia and north to Korea and the Russian Far East) occurs the Long-tailed goral, *Nemorhaedus caudatus*, pale in colour, with no golden tone on the throat, and an extremely long tail-brush. To the south (Yunnan, extending to Burma and Thailand) occurs the Burmese goral, *Nemorhaedus evansi*, very light fawn in colour, and at least in summer very short-coated. Finally at higher altitudes in south-eastern Tibet, the Gongshan, and far northern Burma occurs the Red goral, *Nemorhaedus baileyi*, distinguished by its foxy-red colour with pale underparts and small size.

The final genus of Chinese Caprini is *Capricornis*, the serows, whose total range extends from Sumatra to Gansu and Shaanxi and west to the southern slopes of the Himalayas, in hilly country but mostly not excessively high altitudes. Endemic to China is the White maned serow, *Capricornis milneedwardsi*, which is black, with whitish and reddish lights, legs red below the knee and hock, and a long silvery-white mane. Just entering Chinese territory in the Chumvi Valley (Tibet, on the borders of India and Bhutan) is the Himalayan serow, *Capricornis thar*, with a mane that has less white in it, and the legs are white rather than reddish below the knees. The brindled-toned Indochinese serow, *Capricornis maritimus*, may just enter Chinese territory to the north of the Vietnam border.

OVERVIEW

The species of Artiodactyla occurring in China are listed in Table 1.

The realisation that a species is an evolutionary lineage makes explicit an undercurrent that has pervaded the taxonomy of small mammals for several decades. When applied to small mammals, such as rodents, insectivores and bats, it is relatively uncontroversial, but the idea that this is the essence of species also in large mammals has met with some resistance (see above in the introductory section). Looked at in this way, it can be seen that species (unlike genera, families and so on) have a real existence. They are defined not as having "enough difference" from their relatives to qualify as species, but as being objective units of biodiversity. If it means that there are twice as many species of Bovidae and other artiodactyls as we have thought, 10 years ago, this is a small price to pay for objectivity.

Table 1 List of species of living Artiodactyla occurring in China

Species	Common name	Notes
<i>Camelus ferus</i>	Wild Bactrian camel	
<i>Sus moupinensis</i>	Common Chinese wild pig	Needs further revision
<i>Sus chirodontus</i>	Chinese marshlands wild pig	
<i>Sus ussuricus</i>	Ussuri wild pig	
<i>Moschus moschiferus</i>	Siberian musk-deer	
<i>Moschus chrysogaster</i>	Alpine musk-deer	
<i>Moschus leucogaster</i>	Himalayan musk-deer	Possibly an undescribed species
<i>Moschus anhuiensis</i>	Anhui musk-deer	
<i>Moschus fuscus</i>	Black musk-deer	Status doubtful
<i>Moschus berezovskii</i>	Forest musk-deer	Possibly more than one species
<i>Capreolus pygargus</i>	Asian roe deer	Possibly more than one species
<i>Hydropotes inermis</i>	Chinese water deer	Taxonomic revision needed
<i>Alces americana</i>	Eastern moose	
<i>Rangifer tarandus</i>	Reindeer	Taxonomic revision needed
<i>Elaphodus cephalophus</i>	Tufted deer	Possibly more than one species
<i>Muntiacus nigripes</i>	Black-footed muntjak	
<i>Muntiacus vaginalis</i>	Indian Red muntjak	Taxonomic revision needed
<i>Muntiacus crinifrons</i>	Hairy-fronted muntjak	
<i>Muntiacus gongshanensis</i>	Gongshan muntjak	
<i>Muntiacus reevesi</i>	Chinese muntjak	
<i>Panolia siamensis</i>	Eastern Eld's deer	
<i>Elaphurus davidianus</i>	Père David's deer	
<i>Cervus equinus</i>	Sambar	Taxonomic revision needed
<i>Cervus albirostris</i>	White-lipped deer	
<i>Cervus yarkandensis</i>	Yarkand deer	
<i>Cervus canadensis</i>	Wapiti	
<i>Cervus xanthopygus</i>	Manchurian wapiti	
<i>Cervus wallichii</i>	Wallich's deer	
<i>Cervus macneilli</i>	McNeil's deer	Further research needed
<i>Cervus alashanicus</i>	Alashan deer	Further research needed
<i>Cervus hortulorum</i>	North Chinese sika	
<i>Cervus taioanus</i>	Formosan sika	
<i>Cervus sichuanicus</i>	Sichuan sika	
<i>Cervus pseudaxis</i>	Vietnam sika	Taxonomic revision needed
<i>Bos gaurus</i>	Gaur	
<i>Bos mutus</i>	Wild yak	
<i>Saiga tatarica</i>	Saiga	Probably extinct in China
<i>Gazella yarkandensis</i>	Yarkand gazelle	
<i>Procapra picticaudata</i>	Tibetan gazelle	
<i>Procapra przewalskii</i>	Przewalski's gazelle	Further research needed
<i>Procapra gutturosa</i>	Mongolian gazelle	
<i>Pantholops hodgsoni</i>	Chiru	

Species	Common name	Notes
<i>Budorcas taxicolor</i>	Mishmi takin	
<i>Budorcas whitei</i>	Bhutan takin	
<i>Budorcas thibetana</i>	Sichuan takin	
<i>Budorcas bedfordi</i>	Golden takin	
<i>Capra sibirica</i>	Siberian ibex	
<i>Ovis hodgsoni</i>	Tibetan argali	
<i>Ovis polii</i>	Marco Polo sheep	
<i>Ovis jubata</i>	Shanxi argali	
<i>Ovis darwini</i>	Gobi argali	Not certainly existing in China
<i>Nemorhaedus griseus</i>	Chinese grey goral	
<i>Nemorhaedus caudatus</i>	Longtailed goral	
<i>Nemorhaedus evansi</i>	Burmese goral	
<i>Nemorhaedus baileyi</i>	Red goral	
<i>Capricornis milneedwardsi</i>	White maned serow	
<i>Capricornis thar</i>	Himalayan serow	May occur in China
<i>Capricornis maritimus</i>	Indochinese serow	May occur in China

REFERENCES

- Cotterill FPD, Taylor PJ, Gippoliti S, Bishop JM, Groves CP. 2014. Why one century of phenetics is enough: response to 'Are there really twice as many Bovid species as we thought?'. *Systematic Biology*, **63**(5): 819-832, doi: 10.1093/sysbio/syu003.
- De Queiroz K. 2007. Species concepts and species delimitation. *Systematic Biology*, **56**(6): 879-886.
- Gentry A, Clutton-Brock J, Groves CP. 2004. The naming of wild animal species and their domestic derivatives. *Journal of Archaeological Science*, **31**(5): 645-651.
- Groves CP, Grubb P. 2011. *Ungulate Taxonomy*. Baltimore: Johns Hopkins University Press.
- Groves CP. 2013. The nature of species: A rejoinder to Zachos et al. *Mammalian Biology*, **78**(1): 7-9.
- Heller R, Frandsen P, Lorenzen ED, Siegmund HR. 2013. Are there really twice as many Bovid species as we thought?. *Systematic Biology*, **62**(3): 490-493.
- Liu ZX, Groves CP. 2014. Taxonomic diversity and colour diversity: rethinking the taxonomy of recent musk-deer (*Moschus*, Moschidae, Ruminantia). *Gazella*, **41**: 73-97.
- Lydekker R. 1913-1916. *Catalogue of the Ungulate Mammals in the British Museum (Natural History)*. London: British Museum (Natural History) Trustees.
- Lydekker R, Blaine G. 1914. *Catalogue of the Ungulate Mammals: In the British Museum (Natural History)*. London: British Museum (Natural History) Trustees.
- Mardan T, Jiang ZG, Groves CP, Yang J, Fang HX. 2013. Subspecies in Przewalski's gazelle *Procapra przewalskii* and its conservation implication. *Chinese Science Bulletin*, **58**(16): 1897-1905.
- Mayden RL. 1997. A hierarchy of species concepts: the denouement in the saga of the species problem. In: Claridge MF, Dawah HA, Wilson MR. *Species: The Units of Diversity*. London: Chapman and Hall, 381-423.
- Mayr E. 1963. *Animal Species and Evolution*. Harvard: Belknap Press.
- Meijaard E, Groves CP. 2004. Morphometrical relationships between South-east Asian deer (Cervidae, tribe Cervini): evolutionary and biogeographic implications. *Journal of Zoology*, **263**(2): 179-196.
- Pan T, Wang H, Hu CC, Sun ZL, Zhu XX, Meng T, Meng XX, Zhang BW. 2015. Species delimitation in the genus *Moschus* (Ruminantia: Moschidae) and its high-plateau origin. *PLoS One*, **10**(8): e0134183, doi: 10.1371/journal.pone.0134183.
- Pitra C, Fickel J, Meijaard E, Groves CP. 2004. Evolution and phylogeny of old world deer. *Molecular Phylogenetics and Evolution*, **33**(3): 880-895.
- Waddell PJ, Okada N, Hasegawa M. 1999. Towards resolving the interordinal relationships of placental mammals. *Systematic Biology*, **48**(1):1-5.
- Zachos FE, Apollonio M, Bärmann EV, Festa-Bianchet M, Göhlich U, Habel JC, Haring E, Kruckenhauser L, Lovari S, McDevitt AD, Pertoldi C, Rössner GE, Sánchez-Villagra MR, Scandura M, Suchentrunk F. 2013. Species inflation and taxonomic artefacts—a critical comment on recent trends in mammalian classification. *Mammalian Biology*, **78**(1): 1-6, doi: 10.1016/j.mambio.2012.07.083.