EAZA BEST PRACTICE GUIDELINES

TUFTED DEER

(ELAPHODUS CEPHALOPHUS)

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Image by Johanna Kok, taken in Rotterdam Zoo

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Preamble

The following preamble should be added to EAZA Best Practice Guidelines: Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country. Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Contributors

Our thanks go out to all contributors that helped out by sending in filled questionnaires, sending pictures and answering supplementary questions. Our thanks also go out to Johanna Kok, for providing different pictures of the animals in Rotterdam Zoo.

Summary

The tufted deer (*Elaphodus cephalophus*) is a small deer with three subspecies, which is near-endemic in south China. It is closely related to the muntjacs (*Muntiacus*). A tuft of hair, dark brown coat, white patterned ears and tail, and, for the males, enlarged canines and very small antlers, are the main characteristics for this species. The species occurs in forests, mainly on hillsides, and is a browsing herbivore. The species has a seasonal reproduction; mating takes place in autumn and fawns are born in spring and early summer. The conservation status is Near Threatened and this status is supposed to vary between subspecies. In European zoo collections, Michie's tufted deer (*Elaphodus cephalophus michianus*) are maintained. All photographs in this document show this subspecies, unless stated otherwise. The tufted deer needs a planted enclosure which provides shade and shelter. An interesting enclosure is enriching in itself. Year-round access to an indoor area is recommended. They can be kept individually, in a pair or in a trio, but always only one adult male per enclosure. The animals should be fed forage, browse, (leafy) vegetables and concentrate, enriched with vitamin E. Tufted deer are strong, and few medical conditions are reported. The species should not be housed with or near to sheep, since they are susceptible to infection with ovine herpesvirus 2.

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Section 1 - Biology & Field Data

Taxonomy

The taxonomy of the tufted deer, and deer in general, is certainly not fixed. Different sources have evaluated the overall taxonomy of the species and investigated the existence of one or more subspecies. An overview of the taxonomy of the tufted deer is presented in this section.

Taxonomic history

The genus *Elaphodus* was first described in 1872 by Milne-Edwards. *Elaphodus* is a composite of the Greek words *elaphus*, meaning deer, and *odous*, meaning teeth. Milne-Edwards placed his new discovery, a small deer collected in Baoxing, Sichuan, western China, in this genus and gave it the binomial name *Elaphodus cephalophus*. The name *cephalophus* is composed of the Greek words *kephale*, meaning head, and *lophos*, meaning crest or tuft of hair. The binomial name thus roughly translates to 'toothed deer with a crest on the head', which is a very fitting name for the tufted deer. The complete and correct name for the species is then ***Elaphodus cephalophus* Milne-Edwards, 1872** with the preferred common name **tufted deer**.

Species taxonomy

The taxonomy of the tufted deer as a species is debated among different sources. The order to which the tufted deer belongs is named *Cetartiodactyla* (Price *et al*., 2005). The genus *Elaphodus* is closely associated with the genus *Muntiacus*, and therefore often placed closely together with it. This is supported by mitochondrial DNA (Pang *et al*., 2008). The clade of *Elaphodus* and *Muntiacus* together have been placed in different taxonomic positions, such as the family *Muntiacidae* (Bubenik, 1990; Groves & Grubb, 1990), the subfamily *Muntiacinae* (within the family *Cervidae*) (Chaplin, 1977), the subfamily *Cervinae* within *Cervidae* (Groves, 1974; Grubb 2005) and the tribe *Muntiacini* (within the family *Cervidae* and subfamily *Cervinae*) (Groves and Grubb, 2011; Mattioli 2011a, 2011b). The most recent taxonomy is used in this document.

Class: *Mammalia* - Mammals
Order: *Cetartiodactyla* - Whales and Even-toed Ungulates
Suborder: *Ruminantia* - Ruminants
Infraorder: *Pecora* - Horn-bearers
Family: *Cervidae* - Deer, Elk, Moose and Caribou
Subfamily: *Cervinae* - Old World Deer
Tribe: *Muntiacini* - Muntjacs
Genus: *Elaphodus*
Species: *E. cephalophus* - tufted deer

Subspecies

The subspecies of *Elaphodus cephalophus* are debated in literature. Historically, four subspecies have been described:

- *Elaphodus c. cephalophus* - tufted deer. Milne-Edwards, 1872. Type locality: ''Moupin'' [=Baoxing], Sichuan, western China.
- *Elaphodus c. michianus* (originally described as *Lophotragus michianus*) - Michie's tufted deer. Swinhoe, 1874. Type locality: ''Ningpo'' [=Ningbo], Zhejiang Province, eastern China.
- *Elaphodus c. ichangensis* (originally described as *Elaphodus ichangensis*) - Ichang tufted deer. Lydekker, 1904. Type locality: ''Mountains near Ichang, Province of Hupei, central China.''.
- *Elaphodus c. fociensis* (originally described as *Elaphodus michianus fociensis*) - No common name. Lydekker, 1904. Type locality: ''Fing-ling, Fokien, lying considerably to the south of Ningpo;'' This has been adapted to ''Kowang near Ching Feng Ling, about 100 miles northwest of Foochow'' (Groves and Grubb, 1990).

Recent sources vary in opinions on the matter of tufted deer subspecies. Table 1 summarizes the most notable sources on this subject. Wang *et al*. (2007) provides scientific evidence for the splitting of three subspecies. Based on measurements of 32 different cranial traits, in a sample of 32 adult tufted deer from different regions of China the distinction between three subspecies was made. *E. c. cephalophus* and *E. c. michianus* differed on 19 traits, and *E. c. michianus* and *E. c. ichangensis* differed on 14 traits. Interestingly, *E. c. cephalophus* and *E. c. ichangensis* differed on only 2 traits.

Table 1: tufted deer subspecies assessed by different authors.

Source Subspecies	Allen (1940)	Groves and Grubb (1990)	Grubb (2005)	Wang *et al*. (2007)	Groves and Grubb (2011)	Mattioli (2011)
cephalophus	Recognized	Recognized	Recognized	Affirmed	Not recognized	Recognized
michianus	Recognized	Recognized	Recognized	Affirmed	Not recognized	Recognized
ichangensis	Recognized but questionable	Provisional	Recognized	Affirmed	Not recognized	Recognized
fociensis	Synonymous with *michianus*	Provisional	Recognized	Not assessed	Not recognized	Not recognized

Based on the findings of Wang *et al*. (2007) and the classification of Mattioli (2011a, 2011b), the same three subspecies are recognized in this document.

Common names

The preferred names are shown in **bold**.

English:	**Tufted deer**, Chinese tufted deer (ssp *cephalophus*): **Western tufted deer** (ssp *michianus*): **Michie's tufted deer** (ssp *ichangensis*): **Ichang tufted deer**
Dutch:	**Kuifhert**, Chinees kuifhert, dwergmuntjak
German:	**Schopfhirsch**, Schopfmuntjak
French:	**Élaphode**
Spanish:	**Élafodo**
Chinese:	**毛冠鹿**

Evolution

Often it is stated that the tufted deer is a primitive species, originating directly from an ancient lineage. Interestingly, recent research takes a different direction. Even though the tufted deer, as well as the muntjacs and Chinese water deer (*Hydropotes inermis*), resembles early deer, these species actually evolved from an antlered deer ancestor. Through selection pressures which favoured the 'slinker' lifestyle, these larger, more gregarious deer evolved into smaller deer with small to no antlers and elongated canines to replace the antlers as weapons (Cabrera & Stankowich, 2018). So, *E. cephalophus* as well as the *Muntiacus* species should be seen as secondary primitive, instead of 'primary' primitive (Geist, 1998).

Morphology

The tufted deer is a small cervid, built as a 'slinker'. The small body size, small antlers, elongated canines and white patterning are all adaptations to a secretive lifestyle in forests.

Body measurements

The tufted deer is a small cervid. In terms of general body size, there is no sexual dimorphism. The head-body length is 100-120 cm, the tail length 7-13 cm, the shoulder height 50-70 cm and the mass lies between 17-30 kg for adult specimens. Literature states that the sizes of the subspecies, or at least animals from different locations, are different. The western animals are larger than the eastern animals. This is confirmed by the study of Wang *et al*. (2007), which shows that *E. c. cephalophus* and *E. c. ichangensis* are both significantly larger than *E. c. michianus*, but the first two do resemble each other in size. Strangely, the type specimen of *Elaphodus michianus fociensis* is considerably large, which contradicts with the aforementioned observations, since it is seen as synonymous with the eastern subspecies *E. c. michianus*. This suggests that there might be substantial individual variation.

Figure 1: Male tufted deer portrait. The small antler and large canine are visible. Rotterdam Zoo, picture by J. Kok.

Figure 2: Female tufted deer portrait. Both sexes have the tuft of spiky hair on their head. Note the white patterning of the ears. Rotterdam Zoo, picture by J. Kok.

General description

The main colour of the tufted deer is dark chocolate brown, with dark brown to black legs. White patterning is present around the eyes, inside and on the tips of the ears and on the muzzle. The insides of the hind legs and the tail also shows white patterning. The fawns have the same base colour as the adults, but have white spots on both sides, which fade once they reach maturity. The species has winter and summer pelage. In winter, the coat is thicker and darker than in summer. In summer, the animals are more light brown, which is mostly visible on the head and neck. The tufted deer is named after its tuft of long, spiny hairs on top of the head in between the ears. Both sexes have this tuft, however it may be larger in the males. The tuft of hair mostly covers the males´ small (2.5-3.5 cm) antlers. These antlers are unbranched, stump and the pedicles do not continue onto the orbital bar, as they do in muntjacs (Geist, 1998). While both sexes have elongated canines, these are more strongly developed in the males. The canines are robust and protrude down, slightly outward. The entire dental formula is I 0/3, C 1/1, P 3/3, M 3/3. The tufted deer is known to have at least pre-orbital, metatarsal and (only on the hind legs) interdigital scent glands. The tufted deer has two pairs of mammary glands.

Antlers

The developmental pattern of the antlers remains largely unknown, but it is expected that the antlers are shed irregularly (Groves & Grubb, 1990; Geist, 1998). In Berlin Zoo, some observations were made on antler physiology. In April, one tufted deer male shed its antlers. In August of the same year, the velvet of the new antlers was shed. Then in December, the antlers were shed again. The growing of new antlers took some time, and in June of the next year the lengthwise growth of the antlers started. In the meanwhile, the pedicles had been covered with velvet. The velvet was then shed in late July and early August. The antlers were than cast in May of the following year. The antlers were different in size, one being 2.8 cm and the other being 3.5 cm in length (Pohle, 1989). These observations show an irregular pattern, but more observations are needed to confirm these findings.

Figure 3: A male tufted deer in early July, showing antler development. No 'bony' antler is visible. Rotterdam Zoo.

Digestive system

Like other deer, the tufted deer is a ruminant and a foregut fermenter. Tufted deer are classified as primarily browsers (concentrate selectors), consuming leaves, shoots, flowers, herbs, fruits and fungi (Ou et al., 1981; Sheng and Lu 1982; Flach, 2003; Zhang et al. 2004). In the only published record of a dissection of a male Michie's tufted deer, it was noted that its small intestine was 7.06m long, its large intestine was 2.94m long and its caecum was 0.23m long (Garrod, 1876). The characteristics of the digestive system of the tufted deer are comparable to those of muntjacs (Leslie *et al*., 2013).

Longevity

The tufted deer is suspected to live up to 10-12 years in the wild (Leslie *et al*., 2013). In the European studbook for *E. c. michianus*, the oldest recorded male lived to 21.6 years old, and the oldest female lived up to 16.3 years old. Based on the European studbook data, the mean longevity for males is 9,8 years and for females 9,2 years. 30 day mortality is 21%

Genetics

The tufted deer has varying chromosomal diploid numbers. For does, 2n=46-48 and for bucks 2n=47-48. The sex chromosomes are polymorphic, bucks have one X and one Y chromosome, and does have two X chromosomes (Leslie *et al*., 2013 and sources therein). The mitochondrial genome is about 16,000 base pairs (bp) long and its entire genome size is estimated to be 2.43×10^9 bp (Pang *et al*., 2008; Wang *et al*., 2008). It was recently found that the Yangtze river is an insignificant boundary for genetic flow between tufted deer populations, even though there is some genetic distinction between populations on different sides of the river, there are no different haplotypes (Sun *et al*., 2016).

Zoogeography and ecology

Distribution

The tufted deer is near-endemic in southern China. Historical records show that the range extended into northern Myanmar, but recent surveys failed to find it there (Harris & Jiang, 2015; Naing *et al*., 2015). The entire species range lies between latitudes 24-34°N and longitudes 98-122°E. The subspecies ranges are uncertain, but a rough estimation is available. In the western part of the range *E. c. cephalophus* is found, in the eastern part *E. c. michianus* and in between these two lies the range of *E. c. ichangensis* (Otashi and Gao, 1990). Different camera trap surveys have been carried out in China (figure 1; table 4). It should be noted that the sampling effort in western China is higher, due to the fact that the tufted deer shares habitat with species like the giant panda (*Ailuropoda melanoleuca*) and golden snub-nosed monkey (*Rhinopithecus roxellana*), which are subject to heavier conservation measures. In the east, a lesser number of surveys has been done and gaps in knowledge on the range of the tufted deer are present. The map contains 36 locations where a camera-trapping survey was carried out over 22 studies. Two of these lie out of the tufted deer's supposed range (32, 33), and on five locations no tufted deer were found (27, 31-34).

The species range was based on Harris & Jiang (2015), and the subspecies range was based on Ohtaishi & Gao (1990).

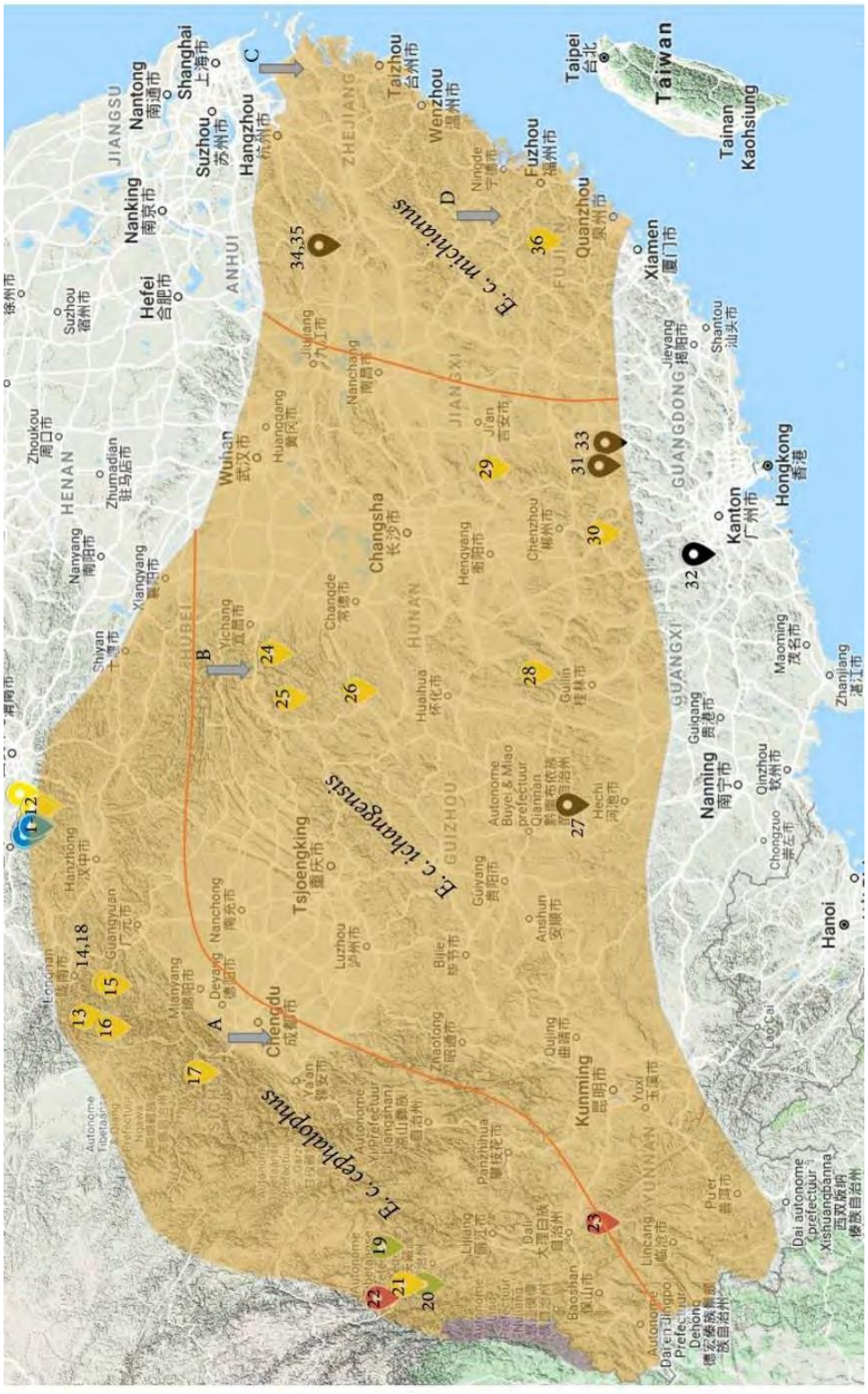

Figure 4: Range map of the tufted deer. Markers represent camera trapping surveys. Black markers represent locations where no tufted deer were found. For the key to the locations see Table 4.

Table 2: Key to figure 1. The numbers correspond to the numbers on the map. Letters correspond to the approximate collection locations of the type specimens. * denotes locations where no tufted deer were found.

	Location	Sampling time	Source
1	Qinling mountains	2010-2013	Wang *et al.*, 2017
2	Qinling mountains	2010-2013	Wang *et al.*, 2017
3	Qinling mountains	2010-2013	Wang *et al.*, 2017
4	Qinling mountains	2010-2013	Wang *et al.*, 2017
5	Qinling mountains	2010-2013	Wang *et al.*, 2017
6	Qinling mountains	2010-2013	Wang *et al.*, 2017
7	Qinling mountains	2010-2013	Wang *et al.*, 2017
8	Qinling mountains	2010-2013	Wang *et al.*, 2017
9	Lainfengya	2009-2012	Liu *et al.*, 2017
10	Xigou	2009-2012	Liu *et al.*, 2017
11	Guanyinshan	2009-2011	Wu *et al.*, 2012
12	Changqing	2008	Li *et al.*, 2012
13	Wanglang	2004-2005	Li *et al.*, 2012
14	Tangjiahe	2002-2004	Li *et al.*, 2012
15	Laohegou	2005-2007	Li *et al.*, 2012
16	Xuebaoding	2004-2007	Li *et al.*, 2012
17	Wolong	2005-2009	Li *et al.*, 2012
18	Tangjiahe	2002-2003	Dajun *et al.*, 2006
19	Langdu	2011-2014	Buzzard *et al.*, 2018
20	Gehuaqing	2011-2014	Buzzard *et al.*, 2018
21	Baima Xueshan	2011-2012	Li *et al.*, 2014
22	Baima Xueshan	2013-2014	Li *et al.*, 2018
23	Nanjiang Wuliang	2014-2015	Li *et al.*, 2018
24	Huping Shan	2002-2003	Dahmeri *et al.*, 2014
25	Ba Da Gong Shan	2012-2013	Xie *et al.*, 2014
26	Gao Wang Jie	2012-2013	Lui *et al.*, 2014
27	Maolan*	2016	Lui *et al.*, 2018
28	Mahoer Shan		
29	Jing Gang Shan		
30	Nan Ling	2012-2015	Cai *et al.*, 2016
31	Chebaling*	2014-2016	Shu *et al.*, 2018
32	Dinghu Shan*		Source in Shu *et al.*, 2018
33	Jiulianshan*		Source in Shu *et al.*, 2018
34	Gu Tian Shan*	2009-2011	Si & Ding, 2014
35	Gu Tian Shan	2014-2015	Chen *et al.*, 2016
36	Daiyun Shan	2017-2018	Lin *et al.*, 2018

	Type species	Year	Source
A	*Elaphodus cephalophus*	1872	Milne-Edwards, 1872
B	*Elaphodus ichangensis*	1904	Lydekker, 1904
C	*Lophotragus michianus*	1874	Swinhoe, 1874
D	*Elaphodus michianus fociensis*	1904	Lydekker, 1904

Habitat

The tufted deer prefers 'high, damp forests up to the tree line and close to water' (MacKinnon, 2008). It occurs at elevations of 300-4750 meters above sea level (Sheng & Lu, 1982; Ohtaishi & Gao, 1990). In Sichuan, it was found to occur in different mountainous areas, but not in subtropical forest (Seidensticker *et al.*, 1984). The tufted deer seems to use different habitats compared to the giant panda and red panda (*Ailurus fulgens*) in winter, in areas where the three species occur together. The tufted deer preferred low-elevation hillsides, with low bamboo density, high shrub density and high herbaceous plant cover, where both pandas preferred the upper hillsides and a higher bamboo density (Zhang *et al*., 2004). In Tangjiahe Nature Reserve, Sichuan, it was found that tufted deer abundance was higher in mixed broadleaf forest (Dajun *et al*., 2006). Data from Li *et al*. (2013) shows that tufted deer has a considerable habitat overlap with Chinese serow (*Capricornis milneedwardsii*) and that it avoided oak shrubs in the Baima Xueshan Nature Reserve, southwest China. During spring in the Fengtongzhai nature reserve, Sichuan, the tufted deer preferred broadleaved forest with sunny exposure and access to water, situated on low-elevation slopes with a 20-30° gradient (Liu & Hu, 2008). In the Guanyinshan Nature Reserve, Shaanxi, the animals were found in all assessed habitat types (open areas with gentle slope, low elevation areas with high bamboo coverage, high elevation areas with high canopy coverage, wildlife migration passages), but occurred mostly in the first habitat type (Liu *et al*., 2017). In Langdu, Yunnan, it was mostly found in mixed conifer forest (4000-4200m) and rhododendron/oak forest (4100-4300m). In Gehuaqing, Yunnan, it was mostly found in conifer/hardwood forest (3050-3350m) (Buzzard *et al*., 2018). The tufted deer distribution is affected by disturbance, and they tend to occur further from human settlements than other mammals. Thus, tufted deer occur in different types of forest, mostly caused by local variation in vegetation. (Dajun *et al*., 2006; Liu & Hu, 2008; Li *et al*., 2018).

Population and conservation status

The tufted deer is listed as Near Threatened (NT) on the IUCN red list of endangered species, and it is classified as Vulnerable A1acd, B1ab(i,ii,iii)+2ab(i,ii,iii) in the Chinese Red List, but it is not classified as a national protected species. In Hunan, Sichuan, Tibet, and Gansu it is listed as a provincially protected species (MacKinnon, 2008; Harris & Jiang, 2015). Currently, the population size is unknown. In early sources, it was estimated that the population of tufted deer would lie around 300,000-500,000 individuals (Sheng and Ohtaishi, 1993; Sheng *et al*., 1998). The current population is decreasing (Harris & Jiang, 2015). The harvest data give an impression of the distribution of these population numbers (Table 3). These numbers do not take hunting effort, percentage of usable habitat and other factors in account, so only a rough comparison between areas can be made.

Threats

The tufted deer was hunted extensively in the past, with an estimated harvest number of around 100.000 animals in 1978-1980 (Sheng and Lu, 1982). The origin of these animals is shown in table 3. Currently, it is suspected that harvesting still contributes to the decreasing trend of the species, but data on this subject is lacking. It is suspected that habitat destruction and fragmentation have a negative impact on the tufted deer population, and that this is a severe threat for *E. c. michianus* in eastern China.

Table 3: The estimated tufted deer harvest in different Chinese regions in 1978-1980. * Denotes estimated percentages. Estimations were made based on the extrapolation of %of tufted deer skins in skin samples to the total deer harvest. Based on data of Sheng & Lu (1982).

Area	# sampled skins	# tufted deer skins	% tufted deer	Total deer harvest	Estimated tufted deer harvest
Southern Gansu	350	24	6.86	3000	206
Southwestern Shaanxi	1900	127	6.68	40000	2674
Hubei	800	40	5.00	140000	7000
Sichuan	2300	910	39.57	90000	35609
Hunan	2700	667	24.70	110000	27174
Southern Anhui	3700	39	1.05	20000	211
Zhejiang	12760	743	5.82	16000	932
Jiangxi	2000	28	1.40	70000	980
Guizhou	1800	434	24.11	60000	14467
Northeastern Guanxi	1250	351	28.08	15000	4212
Other regions of Guanxi	500	0	0.00	35000	0
Northeastern Fujian	360	28	3.00*	16000	480
Guangdong			1.00*	30000	300
Yunnan			3.00*	220000	6600
Total	30420	3391		865000	100843

Conservation actions

The tufted deer is not listed in any CITES appendix (CITES, 2019). Some studies regarding tufted deer distribution were done (figure 1). It is a species which uses the slipstream of conservation effort of other species, like the giant panda. *Ex-situ* conservation is undertaken in an EAZA ESB for *E. c. michianus* and an AZA Studbook and SSP for *E. c. cephalophus*. In China, several studies have been done *ex-situ*. In contrary to management in Europe and North-America, where subspecies are managed separately, In China the subspecies are managed together, as stated in one of the publications of Chengdu Zoo. This paper states that individuals from different subspecies produced hybrid offspring (Wu *et al*., 2007). This needs to be taken into account when imports of tufted deer into the European or North-American population are considered.

Diet and feeding behaviour

Food preference

Tufted deer are classified as primarily browsers (concentrate selectors), consuming leaves, shoots, flowers, herbs, fruits and fungi (Ou et al., 1981; Sheng and Lu 1982; Flach, 2003; Zhang et al. 2004). Concentrate selectors are predominantly highly selective, small ruminants consuming a diet consisting of highly digestible (dicotyledon) forages and fruits (Hofmann, 1989). The diet of wild tufted deer contains about 10.9% fruits and seeds (Sheng and Lu, 1982). The composition of the diet is influenced by seasonal distribution, as the winter diet is composed mainly of evergreen shrubs, and identified plant species were species of Liliaceae, Ericaceae, Rosaceae and Saxifragaceae (Ou *et al*., 1981; Sheng and Lu, 1982).

Feeding behaviour

Being a ruminant, a part of the tufted deers feeding behaviour is ruminating. During the active hours (see *activity*), the animals forage and during the inactive hours they will ruminate on a sheltered spot.

Reproduction

Seasonality

The tufted deer is a seasonal (short day) breeder. Though the precise environmental effects on breeding are unknown, it is suspected that the animals react to changes in photoperiod, as with other seasonally breeding cervids. The animals retain this adaptation in European zoos, mating season or ‘rut’ lasts from September until early December (Sheng & Lu, 1982; Hayssen *et al*., 1993; Sheng & ohtaishi 1993). There are registered births from March to December, but the peak lies in the period April-July.

Reproduction in females

Female tufted deer reach sexual maturity around 0.8 years of age, with the 1st parturition at 1.5 years (Hayssen *et al*., 1993). Despite being seasonal breeders, it is unknown how often the oestrus cycle and ovulations occur. A good overview of general deer reproductive cycles is provided by Asher (2011); but for the tufted deer this field needs more research. The does are estimated to be fertile until 12 years of age, based on models ran on ESB data. The placentas of two captive *E. c. cephalophus* have been described. The general appearance of the foetal-maternal barrier of the tufted deer is comparable to that of other deer. An early-term placenta weighed 95g with two cotyledons, and a late-term placenta weighed 400g and had five flat, disk-shaped cotyledons with a maximum diameter of 11 cm. The umbilical cord of the latter was 20 by 2 cm, unspiraled and had four large blood vessels and a large allantoic duct. Both placentas had large allantoic sacs attached to the base of the umbilical cord (Benirschke, 2004).

Reproduction in males

The tufted deer bucks show high seasonality in their reproductive physiology. Mean neck girth, testicular length and the ratio between testicular length and width are highest in autumn. Besides these traits, ejaculate quality, in terms of sperm total motility, forward progressive motility, and the percentage of spermatozoa with an intact acrosome, is highest in autumn (Panyaboriban *et al*., 2016). It is expected that bucks are able to sire offspring from the moment they reach sexual maturity until their death.

Figure 5: female tufted deer on the day of birth, April 12th, 2019. Fawns hide themselves well on the first days. Rotterdam Zoo.

Gestation period and birth

Tufted deer give birth to one fawn per gestation, but twins are a rare exception. Gestation length lies between 180 and 210 days and the time of parturition obviously depends on when copulation occurred (Leslie *et al*., 2013). All registered births in the EAZA population are singletons. After parturition the placenta is consumed by the doe (Pohle, 1989). To escape predation tufted deer fawns exhibit what is called “hider” behaviour. At first the female’s spend a lot of time bonding with their fawns by licking and cleaning. But soon after birth, the female leaves the infant for long periods of time so the fawn can hide.

Behaviour

The tufted deer is a solitary species, except during the rut and when does are caring for fawns. Unfortunately, not much is known about their behaviour, in both the *in-situ* and *ex-situ* environment. This creates opportunities for research in zoological institutions. After baseline studies on the behaviour of these animals, more specific questions could be assessed.

Activity

In Guanyinshan Nature Reserve, Shaanxi, tufted deer were found to be more active during day than during night (65.07% vs 34.93%), and there were two peaks in activity, at 6:00–10:00h and 16:00–20:00h (Liu *et al*., 2017). In four sampling sites in Sichuan, comparable results were found. Tufted deer showed activity peaks between either 06:00-08:00h (Wanglang Nature Reserve, Siguniang mountain) or 08:00-10:00h (Gongga mountain, Yading nature reserve) and 18:00-20:00h (Wan *et al*., 2018). The tufted deer thus has a bimodal activity pattern, with peaks in the early morning and early evening.

Predation

The tufted deer is a prey species, and predation by leopard (*Panthera pardus*) and tiger (*Panthera tigris*) is confirmed (Johnson *et* al., 1993; Tilson *et al*., 2014). Other possible predators are dhole (*Cuon alpinus*), grey wolf (*Canis lupus*) and Asiatic black bear (*Ursus thibetanus*) (Liu & Jiang, 2003; Li *et al*., 2012; Kamler *et al*., 2012).

Sexual behaviour

The sexual behaviour is largely unknown. It is known that males in the zoo environment will take part in territorial fights which can result in injury and possibly even casualties (Leslie *et al*., 2013). Antlered deer will display and spar to, preferably, avoid fighting, which contrasts to the smaller cervines. It is suspected that tufted deer do not spar, but rather directly initiates fighting (Geist, 1998). These fights are followed by dominant and submissive behaviours, which include chasing and head-butting by the dominant male, and the adoption of submissive postures by the subordinate male (Leslie *et al*., 2013). In rutting season, bucks will chase after does while making high-pitched vocalizations. When not in rut, both sexes will maintain and defend territories, which are patrolled through regularly used trails, which can be visible in the landscape (Geist, 1998).

Social interaction

The tufted deer is a mainly solitary species, which mainly interacts through scent (Geist, 1998). Dung piles, latrines and scent-marked objects communicate presence. The deer scent-mark frequently and the pre-orbital glands are cleaned after scent-marking. Even though the animals are mostly solitary, allogrooming has been observed among zoo-housed individuals (Schwenn, 1988). No literature on maternal-offspring relations has been published, for male-female interaction see *sexual behaviour*. Besides scents, the tufted deer uses a range of vocalizations. These include ‘clicking’, ‘barking’, ‘whining’ and ‘whistling’. The use of the different vocalizations is context dependent. Barking is heard as an alarm and

during courtship. The high-pitched whining is a sound made by a subordinate animal in a stressful situation. Finally, the clicking noise is a regularly heard sound, used in social interactions, and new situations (Leslie *et al*., 2013).

Figure 6: Social interactions of tufted deer include sniffing, like here between a fawn and its mother. Rotterdam Zoo. Picture by J. Kok.

Figure 7: When fleeing, the tufted deer will make strong, cat-like jumps. Rotterdam Zoo. Picture by J. Kok.

Section 2 – Zoo management

Different *ex-situ* tufted deer populations are currently managed in zoological institutions. These populations are composed of supposedly pure subspecies, *E. c. michianus* in Europe and *E. c. cephalophus* in North America. A third population is managed in Asia, mainly in China.

Enclosure

Outside enclosure

Tufted deer naturally occur in forests, and thus a tufted deer enclosure is best located in an area where trees are present. It is essential that the enclosure provides shade and cover for this naturally shy species. The enclosure should be planted with (in any combination) bamboos, low to medium high shrubs and trees. It should be taken into account that the deer will forage on specific plants, which can lead to degradation of the foliage. The enclosure preferably has a natural ground cover, for example grass or forest floor. To promote healthy wear of the hooves, rocks or hard stand substrate can be used. The enclosure can further be optimized by adding features like logs and a pond or stream. These features promote natural behaviour like scent-marking and, with males, sparring. Enclosure size in the assessed collections ranges from 275 m^2 to 700 m^2. A minimum size of 250 m^2 is recommended for a pair. It is preferred that the deer have a covered area to retreat from visitor view. This can be realized by a small off-show paddock, but also by 'fencing off' a corner of the enclosure with bamboo or comparable foliage. This need can also be fulfilled by an indoor enclosure.

Figure 8: Outside enclosure for tufted deer. Note the grass floor, structural hidings and trees. Zoo Heidelberg.

Figure 9: A forested outside enclosure with different enclosure furnishings, like rocks, structural hiding places and smaller bushes. These kinds of enclosures provide both shade and cover. Zoo Halle.

Figure 10: The gradient in this enclosure is a nice feature. The mix of foliage and rocks looks natural and stimulates natural behaviour for tufted deer. Zoo Leipzig.

Figure 11: An enclosure planted with large trees and bamboos recreates the tufted deer's natural environment. Rotterdam Zoo.

Figure 12: The area on the right of this image is densely planted. Here, the deer can retreat from visitors, keepers and the sun. Rotterdam Zoo.

Off-display enclosure and indoor housing

The tufted deer should have access to an indoor enclosure where they can retreat or can be separated. For cleaning convenience, the floors should be concrete or a comparable material. This should be covered with an insulating substrate, like woodchips. In winter or when a fawn or sick animal is kept inside, hay or straw should be offered as extra bedding. Ideally, the indoor enclosure should be dividable into separate boxes which can be opened or closed from outside. For a pair, a minimum of three boxes, sized 2.5 × 2.5m is needed. The enclosure should be insulated, and temperatures should be comfortable year-round, meaning that they don't go below the freezing point in winter and don't get too high during summer, ideally between 10-15°C. If needed, the temperature can be regulated using a central heating unit or infrared panel. It is preferable that the inside enclosure is not visible for the public. It is, in general, not necessary to lock the animals in at night and it is recommended to provide access to the inside enclosure throughout the day. Inside enclosure size ranges from 8 m^2 to 45 m^2.

Figure 13: A Tufted deer inside box. Note the sliding door and cover of wood shavings. Zoo Halle.

Figure 14: An inside box for tufted deer. This box is one in a row of three, which are connected through sliding

doors. Each box has an exit to the outside enclosure. Rotterdam Zoo.

Figure 15: A tufted deer pair in the inside enclosure. Hay bedding increases the comfort of the inside enclosure. Note the broom, which can help enrich the animals. Zoo Heidelberg.

Barriers

The preferred barrier for tufted deer is fencing. Different types are used successfully, ranging from closed panels (concrete, metal plate, glass) to more 'open' fencing (metal and wooden fence), but the closed fences are preferred. Artificial rocks are also used, but the slope and height of these should be constructed in a way that these are unclimbable. Electric fencing can be used but is recommended to be only supplementary to the non-electric fence. The fencing should be at least 1.80m high, and this can be visually lowered by adding a dry moat on the enclosure side. This should be considered when the deer are planned to be housed in an existing Red panda (*Ailurus fulgens*) enclosure, which is often the case. The fencing for this species is generally lower. Besides fencing, stress should be taken into account. If the animals do not have any place to retreat, chances are they will try to escape during a stressful situation. In this case, a 1.20m 'open' metal fence proved to be too low for them. It can occur that the animals start pacing along the fencing. A solution for this is the placement of tree trunks and rocks near the barriers, forcing the deer more inward. This has been successfully implemented by Zoo Halle.

In the indoor enclosure, stable boxes can be created by using stable fencing, of which the lower half is closed. These boxes should be connected by upwards sliding doors, which can be controlled from outside the boxes in order to separate the animals. These sliding doors should measure 80 cm and 40 cm wide.

Figures 16-19: Different fencing options for tufted deer. Glass provides a nice viewing area for the visitors. Bamboo can be used for a decorative effect on closed walls. Closed walls and covered fencing are preferred over open fencing. Electric fencing should be only supplementary.
Fig. 16: Zoo Leipzig
Fig. 17: Parc Animalier d'Auvergne
Fig. 18, 19 & 20: Zoo Heidelberg


16
18


19


20

Diet and feeding

Water

The tufted deer should have *ad libitum* access to fresh water. When water is provided in a bowl, the bowl should be cleaned at least daily. Tufted deer will also drink from streams and ponds.

Basic diet composition

Since tufted deer are classified as primarily browsers, their captive diet should consist mostly of good quality browse or leafy roughage, which is fed ad libitum. Browse consumption can improves overall animal welfare by improving gastrointestinal and dental health, nutrient digestibility and stimulates natural behaviours. Preferred species of browse are: berry bushes, lilac, ash, elm, lime tree, Norway maple, rose, oak, willow and bamboo, but no sycamore. Ideally, fresh browse should be provided throughout the year. Browse has a different nutrient composition compared to grass, as browse contains more protein and plant cell content, and less fibre. As browsers, compared to grazing ruminants, digest fibre less effectively, alfalfa/lucerne hay is preferred instead of grass or hay.
In winter, browse provision is a big challenge for temperate climate zoos, in terms of harvesting, logistics and storage. Freezing vacuum sealed browse, drying browse or browse silage are suitable options that works when fresh browse is not available throughout the year. Forage/roughage quality should, ideally, be regular monitored through analysis in order to ensure appropriate quality and to determine what additional nutrients are needed in order to provide the animals with a balanced diet.

A browser pellet should be provided in order to compensate for specific nutrient deficiencies or inappropriate nutrient ratios in the browse or roughage. It is recommended that both pellets and roughage are weighed to ensure an adequate diet is fed. When energy and/or nutrient requirements increase (e.g. during growth or lactation) adjusting the roughage types and the roughage: pellet ratio should be sufficient.

In the wild, tufted deer consume leaves and twigs of plants and forbs, as well as seeds and wild fruits. It should be remembered that the composition of fruits consumed in the wild is very different from commercially available fruit. Commercially available fruits and vegetables, cultivated for human (sweet) taste, are relatively low in fibre and high in sugar (Oftedal, 1996). Therefore, fruits in general and most vegetables (except green vegetables) are high in sugar and/or starch and should not be included in captive diets of frugivorous browsers. In the past, captive wild ruminant species were often fed diets high in highly digestible feeds, such as commercial fruits and high starch pellets (Clauss et al. 2003), which can lead to gastrointestinal disorders such as ruminal acidosis (Clauss and Dierenfeld, 2008). In addition to roughage, green (leafy) vegetables can be offered as part of the daily diet of tufted deers.

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Figure 21: Browse should be available *ad libitum* where possible. Here it is provided on the floor, covered by large rocks. Rotterdam Zoo

Suggested Diet and nutrient recommendations

The diet presented in Table 4 has successfully maintained tufted deer in Rotterdam Zoo. The proposed diet meets published nutrient requirements of domestic and exotic animals (Table 5 and serves as a guideline for holders. Diets may need to be adjusted based on the nutrient composition of product, product availability and body condition score.

Table 4: Basic diet of tufted deer in Rotterdam Zoo (per animal per day)

Frequency	Product	Amount (g)	Variation
Daily	Leaf vegetables	200	endive, chicory, cabbage
Daily	Green vegetables	100	broccoli, kohlrabi, zucchini, celery, etc.
Daily	Browser pellet	100	
Daily	Alfalfa hay	ad lib	
	Rose	ad lib	
	Willow	ad lib	

Table 5: Dietary nutrient concentrations for captive ruminant concentrate selectors, based upon National Research Council requirements of domestic animals and research with wild/zoo animals (90% dry matter basis) (extracted from Lintzenich & Ward, 1997)

Nutrient	
Protein %	16-20
Vitamin A IU/g	1.0-3.5
Vitamin D IU/g	0.5-1.0
Vitamin E IU/g	200-350
Calcium %	0.15-0.74
Phosphorus %	0.10-0.44
Magnesium %	0.09-0.18
Potassium %	0.45-0.80
Sodium %	0.05-0.16
Iron mg/kg	27-45
Zinc mg/kg	10-30
Copper mg/kg	6-9
Manganese mg/kg	18-36
Selenium mg/kg	0.07-0.18
Iodine mg/kg	0.09-0.72

Feeding

Naturally, tufted deer forage on the floor and on the lower foliage layer. When feeding tufted deer, this behaviour should be simulated, by providing browse and forage on the floor or in a low-placed feeding rack. There should be a minimum of two feedings per day, and old food should be cleaned out at least daily.

Figure 22: Feeding in an inside enclosure. Fresh food provided in separate bowls. Note the salt lick. Zoo Heidelberg.

Social environment

Social grouping

The wild tufted deer is mostly a solitary animal, which has direct social interactions only during the rut and when there is a fawn. In zoos however, the animals are mostly housed in pairs throughout the year. It is possible to house one buck with several does, but it is not recommended to house adult bucks together, since territorial fighting may occur (Rose *et al*., 2007). An adult pair will tolerate the (female) offspring until at least 2 years of age. It should be considered however, that tufted deer does become sexually mature around 0.8 years and might mate with their sire. Naturally, this is to be avoided. It is suspected that older male offspring will induce in territorial fighting, and thus should be separated from the adult buck after a year.

Changing group structure

Introducing a new animal to a single animal is generally straightforward, but since the tufted deer is naturally a solitary animal, some considerations should be taken. When introducing a buck to a doe or vice versa, regular observations should be done to see whether any aggressive encounters occur. It is not recommended to introduce a buck to another buck. A controlled way of introducing a new animal to an existing enclosure is gradual habituation. This means that the current and new animals are housed next to each other, for example through adjacent yards or stables, where the animals can smell, hear and see each other. After a successful habituation period, the animals can be fully introduced.

Co-housed species and mixed exhibits

The tufted deer is a very tolerant species. Of the eight institutions that responded, five house tufted deer together with red pandas. This makes sense in an ecological and geographic context, since the species ranges and habitats overlap. The animals use different parts of the enclosure, the pandas occupy the trees, and the deer the ground. Non-hostile interactions between the animals occur, which enrich both species. One record of consumption of a deceased neonate of Reeves's muntjac (*Muntiacus reevesi*) by a red panda is known, but it is unknown whether the panda killed it, or if it was already deceased. Nevertheless, this is supposed to be a unique case (Svábik, 2019). Tufted deer can also be combined with other ungulates, like the golden takin. This is enriching for both species, and no aggressive encounters have been observed. Tufted deer are also combined with black-necked cranes (*Grus nigricollis*). The deer were introduced in the enclosure, and the cranes were visible in the enclosure next to it. The animals were observed after being introduced to each other, and some chasing of the deer by the cranes and vice versa occurred. No further problems were noted. Tufted deer should not be housed together with or near to sheep, since these can transfer ovine herpesvirus 2 (see *Known health problems*).

Figure 3: A mixed exhibit with Red panda and tufted deer. This particular image shows the different levels that both species use. This combination thus makes the exhibit more interesting for visitors and shows very well from an elevated pathway. Parc Animalier D'Auvergne.

Breeding

Mating

Generally, the tufted deer rut occurs in autumn (see *Seasonality*). During this period, the buck may chase the doe intensively. To reduce stress for the doe, a place to retreat should be provided. These places can be as simple as a visual barrier of dense foliage, for example bamboo, which can reduce the chasing. Only in extreme cases separation is recommended, since this could interfere with the mating.

Pregnancy and parturition

Tufted deer gestation lasts from 180 to 210 days, and (with very rare exceptions) one fawn is the norm. Most births occur between April and July. When expecting a fawn, it is advisable to prepare ahead by supplying extra bedding in the inside enclosure. In harsh weather conditions, the doe can be separated inside before parturition. Generally, there is no need to separate the buck and possible older offspring during the period around parturition.

Neonatal care

Lock mother and fawn inside or for the first days when possible. It is recommended to lock the fawn in during periods with temperatures lower than 10°C or during very harsh weather. When the deer are combined with Red pandas, cranes or other (partly) carnivorous species, it is advisable to separate the animals until the fawn is able to walk and run properly. In all cases where the fawn is locked in, the doe should be present too. When locking the fawn in, temperature regulation should be considered according to the ambient temperature. If all circumstances are favourable, the fawn can be let outside after approximately two weeks. In any case, extra bedding should be provided in the inside enclosure and hiding places should be available in the outside enclosure.

Hand rearing

Hand rearing is not recommended by the EEP. Questions regarding hand rearing can be directed to the EEP coordinator.

Contraception

Because of the small population size and need to increase the population there is no need for contraception. If contraception is necessary because of veterinary or management issues please contact the EEP coordinator. A contraceptive manual for Cervidae and Tragulidae can be found on the EAZA Reproductive Management Group (formerly EGZAG) website with the following link:
https://www.egzac.org/home/viewdocument?filename=Cervidae%20and%20tragulidae%20EGZAC%20taxon%20sheet%202017.pdf

Figure 23: A juvenile female tufted deer browsing on rose leaves. The animal is 79 days old. Rotterdam Zoo.

Identification methods

Because tufted deer are mainly kept in pairs and it is not difficult to distinguish individuals. The preferred method of identification is the use of a transponder.

Population management

Population history

The first Michie's tufted deer arrived in Europe (Rotterdam Zoo) in 1992. This followed by two animals (1.1) in 1995. These four animals originated from Shanghai Zoo. In 1997 Berlin Tierpark imported four animals (3.1) from the United States (Bronx Zoo and San Diego Zoo). The sire and dam of these animals also originated from Shanghai Zoo. Five of the imported animals mentioned above are founders of European population. In 1994 the first fawn was born in Rotterdam Zoo.
Noam Werner from Jerusalem Zoo and Chair of the Deer TAG started monitoring the species and compiled the first monitoring studbook in 2014. As per 26 August 2015 the EEP Committee approved the establishment of a Michie's tufted deer ESB. In 2020 the ESB changed to a new style EAZA Ex situ Programme (EEP) as proposed during the Deer Regional Collection Plan (2019).

Conservation roles

The tufted deer EEP population has direct and indirect conservations roles. The direct conservation roles are:

- Insurance; on species level the population is expected to be in significant decline and is close to qualifying for Vulnerable – this includes the subspecies. As there currently is no coordinated programme within the region where tufted deer occur naturally in the wild, the EAZA population of *Elaphodus cephalophus michianus* could be developed to function as an insurance population.
- Research; The *ex-situ* population can support taxonomy research in situ by providing sample material from the ex situ population and funding. Potentially EAZA facilitates uptake research by science community of the taxonomy research needed.

The indirect conservation role of the population is education. This (sub) species offers a good example to educate about Evolutionary Distinctiveness of this species and the topic of Evolutionary Distinctiveness.

Population goals

Increasing the population size is the main population goal. Besides increasing the population importing new founders to increase genetic variation is top priority.

Behavioural management

Training

The tufted deer can be trained through positive reinforcement. Crate training is very useful when a transport is planned, so that stress is minimal. Possible other training can be, for example, scale training and a voluntary blood draw.

Enrichment

An interesting enclosure, with variation in cover and features like rocks, logs and (running) water promote the natural behaviour of the animals. When further enrichment is considered, there are a few points to take into account. The tufted deer can be challenged, and the animals are known to stand on their hind legs to reach higher placed feed. The species is curious so food can be provided in an interesting way. Branches can be hung at varying heights instead of provided on the floor. Other food can be provided in a more challenging way, like a ball or another bowl. When the animals are given a new object, there might be an aversive reaction the first time, which can lead to leftover food. In this case, the animals should still be provided with the leftover food in the regular fashion. More trials might be needed to introduce a specific novel form of enrichment. A possible enrichment form for tufted deer is scent enrichment.

Handling and transport

Capture

For capture, crate training is recommended. When crate training is not possible the animals can be carefully driven into a crate. It is important to minimize stress in this situation.
Long acting tranquilizer is recommended during transport. Successful used tranquilizers are Cisordinol Depot 200mg/ml 0,1ml per 8kg or perphenazine 100mg/ml 0,1ml per 5-10kg. For best results the tranquilizer needs to be administered 3 days before the transport date.

Restraining

Manual/ non–chemical restraint is in most cases stressful. If truly needed, the animals should be locked into a smaller enclosure to make the catching easier. Tufted deer are known to keep on “fighting” during restraint.

Crate size

Crate sizes of 75×60×65 cm and 80×41×75 cm have successfully been used. The top inside of the crate should be covered with foam rubber or a comparable material, so that males do not damage their small antlers.

Health and veterinary

Veterinary management

Basic veterinary management for tufted deer should entail regular faeces checks and de-worming. Basic blood parameters are known from a Chinese study (table 6 Wu *et al*. (2007)).

Known health problems

Not many health problems have been described for tufted deer. Malignant catarrhal fever, caused by ovine herpesvirus 2 was found to be the cause of death for at least three tufted deer, one in the Fort Worth Zoo, Texas, and two in Zoo Halle (Lung *et al*. 1999). Ovine herpesvirus 2 is transferred by sheep. In the Fort Worth Zoo, these were mouflon (*Ovis aries*) and aoudad (*Ammotragus lervia*). In Zoo Halle, these were blue sheep (*Pseudois nayaur*), which were housed next to the tufted deer. Positive antibodies to bovid gammaherpesvirus, which is likely associated to ovine herpesvirus 2 was found in a captive *E. c. michianus* (Mensink *et al*. 1997). In Parc Animalier d’Auvergne, a female tufted deer died due to a *Yersinia pseudotuberculosis* infection. In Rotterdam Zoo, one animal developed chronic skin abscesses, caused by *Pseudomonas aeruginosa*. The origin of the wounds in the first place is unknown.

Table 6: Basic blood composition data for the tufted deer. Based on Wu *et al*. (2007)

Index	Group	# of samples	Mean ± SD	Minimum	Maximum
Haematocrit	Young	5	0.57 ± 0.04	0.53	0.62
	Sub-adult	2	0.61 ± 0.02	0.60	0.63
	Adult	7	0.56 ± 0.05	0.49	0.65
Red blood cells × 10^{12} cells/ml	Young	5	14.06 ± 1.21	13.15	15.98
	Sub-adult	2	14.17 ± 0.95	13.50	14.84
	Adult	7	12.77 ± 1.19	10.98	14.25
Hemoglobulin g/l	Young	5	174.20 ± 9.44	158	181
	Sub-adult	2	184.50 ± 9.19	178	191
	Adult	7	173.57 ± 17.31	140	197
Mean corpuscular volume	Young	5	40.48 ± 1.97	38.80	43.80
	Sub-adult	2	43.20 ± 1.27	42.30	44.10
	Adult	7	44.23 ± 2.93	41.10	48.90
White blood cells × 10^{9} cells/ml	Young	5	3.00 ± 2.35	1.20	7.00
	Sub-adult	2	1.65 ± 0.07	1.60	1.70
	Adult	7	2.01 ± 0.61	1.20	2.90

Table 7: Protein levels in tufted deer blood. Based on Wu *et al*. (2007)

Index	Group	# of samples	Mean ± SD	Minimum	Maximum
Total protein g/l	Young	5	55.88 ± 5.91	52.00	67.80
	Sub-adult	2	66.20 ± 4.80	62.80	69.60
	Adult	7	62.33 ± 5.19	51.00	65.40
Albumin g/l	Young	5	35.12 ± 3.28	29.80	38.80
	Sub-adult	2	40.05 ± 3.18	37.80	42.30
	Adult	7	37.61 ± 2.56	33.40	40.70
Globulin g/l	Young	5	23.76 ± 4.75	19.70	31.80
	Sub-adult	2	26.15 ± 1.63	25.00	27.30
	Adult	7	24.71 ± 3.25	17.60	26.90
Albumin/Globulin	Young	5	1.50 ± 0.31	1.10	1.80
	Sub-adult	2	1.50 ± 0.00	1.50	1.50
	Adult	7	1.53 ± 0.21	1.30	1.90

Anaesthesia

Used drugs combination for anaesthesia in tufted deer can be found in the table 8. The information from the table is imported from the Species360 System.

Disclaimer: The Species360 System provides this anaesthesia summary information on an "as is" basis. These summaries are derived from the anaesthesia event records entered by our global member community. This information should not be interpreted as a recommendation for any of the drug combinations or dosages shown and reported historical usage for a species does not imply safety in any individual animal. All anaesthesia events are associated with some risk of complications, including death. This summary information is provided to clinicians to aid in choosing drug combinations and dosages that will minimize risks and maximize safety. Responsibility lies with the clinician to exercise proper judgement and consider all relevant animal, staff and environmental factors when selecting drugs and dosages for an anaesthesia event.

Elaphodus cephalophus / Tufted deer													**Total Animal Count : 59**
#	**Drug Protocols**	**DOSAGE**				**COMPLICATIONS**			**Abnormal Recovery**	**Died in Recovery**	**Multiple Issues**	**Anaesthesia Events**	**Body Weight Range(kg)**
		Mean	**Median**	**Range**	**Units**	**Minor**	**Major**	**Fatal**					
1	Ketamine	4,50	4,79	1,50 - 8,33	mg/kg	11 (14,67%)	0 (0,00%)	0 (0,00%)	12 (16,00 %)	0 (0,00 %)	4 (5,33 %)	75 (42) Animals	6,50 - 36,30
	Medetomidine	0,10	0,10	0,028 - 0,17									
2	Butorphanol	0,31	0,29	0,06 - 0,58	mg/kg	2 (7,41 %)	0 (0,00%)	0 (0,00%)	2 (7,41 %)	0 (0,00 %)	0 (0,00 %)	27 (17) Animals	13,80 - 23,10
	Ketamine	3,35	3,47	0,98 - 5,85									
	Medetomidine	0,07	0,07	0,030 -0,12									
3	Carfentanil Citrate	0,013	0,005	0,003 -0,045	mg/kg	4 (26,67%)	0 (0,00%)	0 (0,00%)	2 (13,33 %)	0 (0,00 %)	1 (6,67 %)	15 (7) Animals	16,96 - 23,14
	Xylazine	0,36	0,30	0,09 - 0,66	mg/kg	4 (26,67%)	0 (0,00%)	0 (0,00%)	2 (13,33 %)	0 (0,00 %)	1 (6,67 %)	15 (7) Animals	16,96 - 23,14

Table8: Used combination in tufted deer (ZIMS 360 Feb, 2020)

Used antagonist for the drug combination Ketamin/Medetomidine (drug protocol #1 in table 3) is atipamezole (5x dosage medetomidine in mg). The drug combination Medetomidine/Ketamin/Butorphanol (drug protocol #2 in table 3) can be reversed with 0,1mg/kg antipamazole IM or IV to reverse alpha2-agonists

Recommended research

After reading this document, one hopefully realizes that there still are gaps in the knowledge of this interesting deer species. The entire community of tufted deer holders can help close these gaps by providing more information and data. It is highly recommended to document the process of pregnancy, parturition and neonatal care. Specific research can be conducted in physiology and behaviour of the animals. Interesting topics can be the monitoring of sex and stress hormones and enrichment research. Antler physiology is not that important to the conservation of the species, but still a very interesting subject, given the observed nature of antler growth and shedding in this species.

Section 3 – References

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