



Best Practice Guideline Dhole (*C. alpinus*) (1. Edition)



Canid and Hyaenid Taxon Advisory Group
February 18th, 2017



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ISBN:

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Preamble

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.

Summary

The first section gives a short overview about the general biology of the species with a closer look at topics of dholes in the wild: Conservation, feeding and hunting behaviour as well as reproduction and general behaviour. Section two deals with all aspects of dholes in captivity: Enclosure design, feeding and pack management as well as reproduction in zoos. One chapter informs about enrichment ideas. The last part is reserved for handling/transport issues and veterinary care. A list of literature helps to find more information about all aspects of the life of dholes in the wild and in captivity.

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Section 1: Biology and field data

Biology

Dholes *Cuon alpinus* are the only living members of the genus *Cuon*. They have rarely been studied genetically. Dholes have $2n = 78$ karyotypes (Graphodatsky et al. 2007). The mitochondrial genome sequence has a total length of 16,672 base pairs. It is the shortest among the Canidae (Zhang and Cheng 2010).

1.1. Taxonomy

Order: Carnivora
Family: Canidae
Genus: *Cuon*
Species: *C. alpinus* (Pallas, 1811)
Subspecies:

First, two species of *Cuon*, the southern dhole *C. javanicus* and the northern dhole *C. alpinus* were distinguished. This separation into two species was based on body size and the second upper and lower molars (Mivart 1890 in Durbin et al. 2009). Ellerman and Morrison-Scott (1951) first published ten subspecies. In 1966 they reduced this to nine subspecies (Ellerman and Morrison-Scott 1966). According to Ginsberg and MacDonald (1990) there are eleven subspecies recognized. These subspecies are listed below as given by them, but it is not genetically proven that these are distinct subspecies:

- *C. a. alpinus* (East of Eastern Sazans, East Russia): Thick tawny red coat, greyish neck and ochre muzzle.
- *C. a. lepturus* (South of Yangze River, China): Uniform red coat with thick under fur
- *C. a. dukhunensis* (South of the Ganges, India): Reddish coat, short hair on the paws and black whiskers.
- *C. a. adustus* (North Myanmar and North-east India): Reddish brown coat.
- *C. a. primaevus* (Himalayan Nepal, Sikkim and Bhutan): Longer redder coat than *C. a. Dukhunensis*, Long hair on paws.
- *C. a. laniger* (Kashimir and Southern Tibet): Full yellowish-grey coat, tail not black but same colour as body.
- *C. a. hesperius* (East Russia and China): Long yellow-tinted coat, white underside and pale whiskers.
- *C. a. fumosus* (West Szechuan, China and Mongolia): Luxuriant yellowish-red coat, dark back and grey neck.
- *C. a. infuscus* (South Myanmar, Malaysia, Thailand, Laos, Cambodia and Vietnam): Relatively uniform brown coat.
- *C. a. sumatrensis* (Sumatra, Indonesia): Short red coat and dark whiskers.
- *C. a. javanicus* (Java, Indonesia): Short, bright red coat.

Currently a genetic research on dhole subspecies is done by Qufu Normal University, China in co-operation with the EEP. Wild and captive dholes are being sampled.

Common names:

List of common names is found in the appendix, in table 8.

There have been considerations to include dholes into the genus *Canis*, according to genetic studies using mitochondrial DNA (Wayne et al. 1997 in Vilà, Maldano and Wayne 1999). The split between the genera *Canis* and *Cuon* occurred about 5.2 – 7.6 million years ago (Zhang and Cheng 2010).

One genetic study about subspecies comprised wild and captive dholes. Two big phylogeographic clades were found. Subspecies could not be distinguished clearly (Iyengar et al. 2005).

1.2. Morphology

The dhole is a large canid with a weight of twelve – 20 kilogram (Durbin et al. 2009).

There is no marked sexual dimorphism. Males tend to be slightly bigger and heavier.

Zoo animals even reach 22 – 23 kilogram (Maisch own observation).

The average shoulder height of a dhole is 50 centimetre and the average length is 130 centimetre (including the 40 – 45 cm long tail) (Venkataraman and Johnsingh, 2004). Most dholes have a reddish or brown coat. The tail is bushy and darker black tinged. Sometimes a white tip occurs. There are no quantitative anatomical differences known between the sexes. The ears are about half the length of the face. Their general form is triangular. The tips are rounded. The pinnae are mostly reddish-brown on the outside. The inside is mainly white. The white can also be cream-like or light brown. Sometimes the hairs at the base of the ears form bigger white tufts. The muzzle is relatively short and strongly built. It is reddish-brown. The silhouette is slightly convex. The eyes are amber or brown. The nose is black. Neck, back and the sides of the body are red – brown. Throat, chest and belly-side and inner sides of legs are often white, whitish or cream coloured. When dholes get older, creamy areas seem to become white. The white areas enlarge.

The southern dhole has a shorter fur and is rusty-red coloured. The fur of the northern dhole or those in colder areas is generally longer, brownish-red or yellowish-brown of colour (Pocock 1936, Cohen 1978). In Alpine regions the legs are notably shorter and the coat is a yellowish-grey colour in Himalayan regions. In Thailand, the coat is said to be more uniform brown. The animals might lack the lighter areas at throat and chest. The coat can be a bit greyish of colour. The toes are red, brown and/or white. In Europe, dholes moult from April to May or even until June (Sosnovskii 1967, Maisch own observation).

The dholes have unique dentition within the Canidae having one fewer lower molar (3/3-1/1-4/4-2/2) with the top of the lower carnassial M1 crested and with a single cusp (other Canid's within the range of *Cuon* have two cusps). The rostrum is relatively shorter than in other species of the canis family (Cohen 1978). *Cuon* and *canis lupus* bones can be distinguished by several prominent features (for details: Pérez Ripoll et al. 2010).

There are usually six or seven pairs of mammae, rather than the five pairs typical for *Canis*. (Sillero – Zubiri et al. 2004).

1.3. Physiology

Physiology of dholes seems to be like that of wolves and domestic dogs.

Body temperature might rise to 40 °C under anaesthesia (Boer, pers. comm., Muliya et al. 2016). Common domestic dog vaccines, contraception and anti-parasite treatments are used successfully.

1.4. Vocal repertoire

The vocal repertoire of dholes is large and shows a high, unusual variety. It includes whines, mews, yaps, squeaks and screams, among others. They whistle when moving in thick undergrowth. With those acoustic calls they keep in contact when the pack members are close by but cannot be seen in the undergrowth. This is the reason why they were called “whistling hunters” by M. W. Fox in his book. Whistle calls travel well at ground level due to their frequency and structure and allow easy location of the source. (Sillero – Zubiri et al. 2004). To humans it does not sound like a dog but rather resembles the piping of birds. Growls, growl-barks, chattering calls and screams are also used as close-ranging communication. There is also a long distance “hoo-hoo” call.

The sound is emitted with head lowered to the ground – like it can be seen in African painted dogs (Maisch own observation, Ludwig pers. comm.).

During bouts of excitement, like at hunts, or while play-chasing mates, they produce a loud “yip-yap” call. When fighting for food among dholes occurs – rarely seen – they sometimes use chattering calls (Maisch own observation).

Dholes are able to produce biphonic calls. Biphonic calls are two sounds produced at the same time with a high and low frequency. Lowest frequency observed was 0,52 kHz, the highest 10,77 kHz (Volodin et al. 2002). They also use low tonal, high tonal and pulsed components to form their individual calls (Volodin et al. 2001).

These biphonic calls might be used for recognition of other dholes, when they are not visible, for example during a hunt (Volodin et al. 2006). The whistle call differs among the individuals and might be a way for the dholes to differ between the pack mates (Durbin 1998).

1.5. Longevity

Dholes can live up to at least 16 years in captivity. Most animals in captivity will not get older than ten to twelve years. In the wild, Venkataraman (1998) observed that older dholes often “disappeared” from packs when they were seven to eight years old.

Field data

1.6. Conservation status/Zoogeography/Ecology

1.6.1. Distribution

In Plio-Pleistocene times, the genus *Cuon* was distributed in Europe, Northern America and Asia with several species. In Northeast Asia *Cuon* was found in Early, Middle and Late Pleistocene as well as during the Holocen period (Norton et al. 2010).

After the mass extinction in late Pleistocen, the genus *Cuon* became restricted to Asia (Iyengar et al. 2005). Today, the recent *Cuon alpinus* is only found in fragmented areas in Asia. He was once widely distributed in Central, East and Southeast Asia. The distribution ranged from the Altai Mountains in the north down to Java in the South. Siberia, China, India, Mongolia, Tibet, Nepal, Bhutan, Thailand, Cambodia, Laos, Vietnam, Java, Sumatra, Kazakhstan, Kyrgyzstan and Pakistan where among the countries in which to find dholes (Durbin et al. 2009).

In many parts where they were common, they have disappeared now.

Dholes have not been seen recently in Russia, Mongolia, Kazakhstan, Kyrgyzstan (found formerly in the Tian-Shan area) or Tajikistan (found formerly in the eastern Pamir area) (Durbin et al. 2009). In areas of western China in the Tian-Shan Range dholes did occur formerly. The current status in this area is unclear. Same is true for Korea and Bangladesh.

In the past the species has been in the Terai region of the Indo-gangetic plain, including the Royal Chitwan National park in Nepal. There have been few recent reports from Nepal. Dholes were present at Valkimi Tiger Reserve (which is bordering Chitwan National park) in 2005. Dholes were Camera trapped in Kangchenjunga Conservation Area in the north east part of Nepal in 2010 (Khatiwada et al. 2011). Dholes were captured by camera traps in Chitwan National park in 2011 (Thapa et al. 2013). In 2012 dholes were seen in the Dhorpatan Hunting Reserve.

The dhole is still living in Tibet, mostly in areas bordering the Ladakh region of India. Dholes reportedly still live in the Ladakh area of Kashmir, which is next to the Tibetan highlands in China.

They seem to be extinct in Pakistan. Although they might migrate through the alpine steppes of Ladakh, Kashmir, and India that extend into the region termed Pakistan-occupied Kashmir by India (Durbin et al. 2009).

Dholes are still living in parts of India. One main distribution is south of the river Ganges. They can be found mostly in the Central Indian Highlands and the Western and Eastern Ghats of the southern states. They are also found throughout northeast India. In the Himalaya and in north-western India, the status of dholes seems more critical due to the highly fragmented distribution.

In Bhutan in the 1970s the government implemented an extinguishing program for dholes by poisoning. Now the dholes seem to be back in the country. Dholes have been sighted in the Jigme Singye Wangchuck National park (Wang and Macdonald 2006). In some regions, dhole predation on wild boar *Sus scrofa* may be seen in a positive light by local people.

In the Virachey National park in Cambodia dholes have been sighted in 2007.

In Vietnam reports from the Quang Tri Providence showed the reappearance of the species in formerly non-inhabitant areas (Huy 2006).

In Thailand, dholes have been reported in Khao Ang Rue Nai Wildlife Sanctuary (Jenks et al. 2012). Jenks et al. (2012) recorded dholes in Khao Yai National park, Huai Kha Kaeng Wildlife Sanctuary, Kaeng Krachan National park, Kuiburi National park and Phu Khieo Wildlife Sanctuary.

In Myanmar, dholes were recorded by camera traps in 2003. They were the cause of death for four radio-collared Eld's deer *Cervus eldi* in a study in central Myanmar (McShea 2003). Dholes are still present in northern Laos PDR (Kamler et al. 2011).

On Java, dholes appear to live in protected areas at the eastern and western ends of the island. Stable populations are said to occur at Baluran National park and Blambangan Sanctuary in East-Java. The numbers at Halimun Sanctuary seem to decline (source: ZGAP news, 2).

In Malaysia camera traps recorded dholes in northern and central parts. In Taman Negara, dholes were photographed in 1999 – 2001 (Kawanishi and Sunquist 2008).

On Sumatra dholes are known to occur in major protected areas in the southern, central, and northern parts of the island (from camera trapping.).

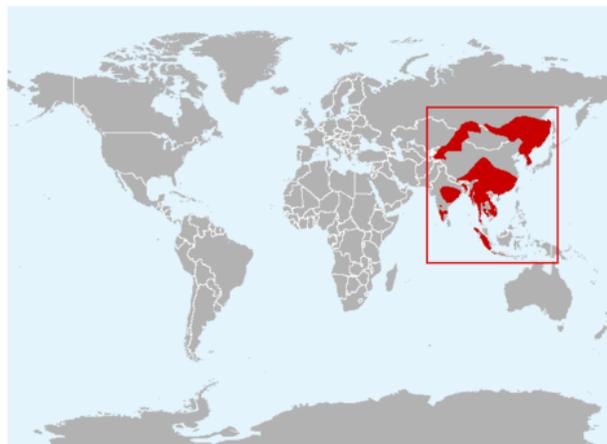


Figure 1: Distribution of dholes (IUCN Red list, 2010).

In China dholes were observed hunting blue sheep in Qilian Shan, Gansu (Harris 2006).

Dhole samples of wild animals were recently obtained in Jiangxi Province 2013 (Zhang pers. comm.). There is new evidence that dholes still survive in the Qinghai-Tibetan plateau (Gansu Providence) and in the Karakoram/Pamir region in the border area to Pakistan, Afghanistan and Tajikistan (Riordan et al. 2015). Camera traps also revealed dhole presents in the Altun Mountains in West China (Xue et al. 2015).

1.6.2. Habitat

The dhole occurs in different vegetation types. Grasslands with bushes and patches, with less undergrowth are accepted. Bare alpine steppes are also used. In the Himalaya, dogs were camera trapped at 3,759 metre in Sammewa Darauli (Khatiwada et al. 2011) and are said to be even found at 4,350 metre above sea level in that area.

Dholes inhabit forested areas as well. They live in primary, secondary and degraded forms of tropical dry and moist deciduous forest. They are even seen in tea-plantations. Evergreen and semi-evergreen forests are also used. They have not been seen in desert regions. Optimal habitats in India are tropical dry and moist deciduous forest.

Habitat selection might be influenced by the availability of sufficient ungulate prey and access to water. Also the presence of other large carnivore species, human population, densities and availability of suitable den sites (proximity to water, presence of suitable boulder structures and sufficient prey) are perhaps of influence (Durbin et al. 2009).

1.6.3. Population

The population is estimated on fewer than 2,500 mature individuals in the wild. The declining population trend is expected to continue. The Red list category & criteria is Endangered or C2a (i) and was passed in 2008 by the IUCN SSC Canid Specialist Group - Dhole Working Group and evaluated by the Canid Red list authority (Durbin et al. 2009).

Packs can comprise groups of four to 30 animals. As they often split up for hunting the actual size of a pack is not always clear.

1.6.4. Threats

There are four main factors influencing the survival of dhole population: Number and species of prey, persecution, habitat and competition with other species. Another minor one is diseases.

Prey issues:

Due to their size, a single killing bite in the neck or throat is nearly impossible with big prey (Maisch 2006). 96 % of dhole kills showed no single bite responsible for the death. Animals seem to have died of blood loss and shock (Karanth and Sunquist 2000).

The method of tearing their prey literally apart and to start feeding while the victim is not even dead has given dholes a very negative image among people.

In the colonies, mainly European hunters named the wild dog “pest species” or “vermin”. This “brute beast” harmed the stags, does, calves of the game the hunters wanted for themselves. They also angered hunters in killing the baited buffaloes, calves and goats meant to attract tigers (to shoot them). The spoiled hunters were equally indignant that wild dogs spoiled their leopard or tiger hunt (Caton Jones 1908). When the per head payment for dholes was withdrawn by the Madras government in 1927 British hunters and settlers were advised to destroy any wild dog they could, regardless of the lacking bounty. It was also advised to privately pay a bounty to locals to get on with extermination of the “red devils”, by paying them for dhole puppies. In the article it is clearly stated that the natives like

dholes, as they share kills and that they are reluctant to destroy dholes (editors in Morris 1927).

Till today, the attitude towards or against dholes is closely linked with the perception of dholes as direct threat for people and livestock (Jenks et al. 2014).

If the prey species is already rare due to human impacts, the predators have no long term chance. Hunting for bush meat and poaching depletes dholes of the possibilities to make prey. If they turn to livestock as a result, then public retaliation results.

Livestock predation

In general, dholes are still seen as pest species as they kill livestock like goat, sheep and cattle. In general, dholes prefer wild animals to domestic livestock (Venkataraman et al. 1995).

In north-eastern Nepal dholes are responsible for nearly 80 % of the kills of livestock. Herders in the area are very poor so that the loss of a single goat or cow threatens the whole family. Herders retaliate by shooting or poisoning (Khatiwada 2011). In Bhutan, families lost more than one domestic animal per year to dholes, tigers and leopards. This adds up to two thirds of their yearly cash income (Wang and Macdonald 2006).

There are hints that when natural prey becomes scarce (by direct or indirect human impact), dholes turn to readily available domestic animals (Venkataraman et al. 1995).

In Arunachal Pradesh, India, where dholes kill Mithun (Gaur domestic cow hybrids) which are very important religiously, as well as for giving as bride price etc. for a local tribe, shooting, poisoning and trapping is readily used to kill dholes.

Thus, dholes often get killed as retribution to take livestock. This human-predator-livestock conflict is the biggest threat for dhole conservation apart from habitat destruction. Guarded domestic animals are less likely to fall prey to dholes (Johnsingh et al. 2007, Thinley et al. 2011). Protecting livestock from dhole attacks is one of the most promising approaches to improve cohabitation of dholes and men.

Diminishing prey numbers

Some people believe that a dhole pack in the area means no food for other predators because they chase ungulates away. This belief was stated in the early 20th century mainly by colonial hunters in India, Java etc. It was even believed by native and British hunters that dholes would mark trees with their urine and that prey would not pass such markings. Allegedly, dholes could thus confine ungulates and kill them off one by one.

Scientific approaches could show that none of this is true.

Johnsingh (1980) has observed that even if dholes make a kill, ungulates might flee the scene first but will return later. Several sources mention dhole not paying attention to prey species if they are fed or feeding. Johnsingh (1978) even mentions a pack of dholes sharing their kill with a wild boar.

In some areas dholes seem to exploit the prey in one area and then move on just to reappear again after months and years. This may have led to the mystic belief that where dholes are the prey species disappear. If the number of prey is high enough to be sustainable then packs seem to become resident.

In modern times, when there are few suitable habitats left for roaming around (the pack is then forced to stay) and/or the prey is also an endangered species, dholes can have a

significant impact on prey levels. On Java dholes have distinctly decimated banteng numbers. Banteng became endangered due to habitat loss and persecution by humans. But then – if numbers are already critically low – predation on calves can push the species over the brink. After reducing dhole numbers banteng reproduction increased rapidly (Pudyatmoko and Sabarno 2007).

Habitat:

Habitat loss and fragmentation leads to the extinction of many dhole packs. It occurs all over the range. Deforestation of tropical forests, degradation of woodlands to agricultural areas depletes the dholes of areas to live, hunt and reproduce.

Only few areas big enough to hold large numbers of prey species are left. Road kills occur when many roads cross the sanctuaries as well as when dholes move between habitat fragments.

Competition with other species:

In many parts of Indochina, free living domestic dogs have been seen and/or camera trapped. The main competitor for prey species in Indochina is people. In Indonesia, in many parts of their range, dholes live in the same area as tigers and leopards and so the potential for significant interspecific competition for prey exist. Problems occur, if the prey population numbers are reduced as a result of hunting by people (Sillero – Zubiri et al. 2004, Durbin et al. 2009).

Minor threats for the dhole are direct encounters with leopards and tigers. Both species have reportedly killed dholes – and they kill leopards, tigers and bears when the pack is large enough. In the trans-Himalayan region dholes and snow leopards compete for prey.

Stealing of kills from dholes is also a problem. Due to the sounds made by dholes while hunting, humans can locate dhole kills and take the prey from them as dholes will not defend their kill against humans.

Disease and pathogens:

Diseases of feral and/or domestic dogs are a threat to dholes. Infected dholes can present a human health risk. The significance of disease is unclear in Indochina, but diseases are a significant threat in South Asia and probably in parts of Indonesia (Durbin et al. 2009).

Dholes have also been known to suffer from rabies, canine distemper, mange, trypanosomiasis, canine parvovirus and endoparasites such as cestodes and roundworms. In the 1940s, a rabies epidemic in Billigirangan Hills, India, resulted in villagers, cattle and domestic dogs being bitten by rabid dholes (Morris 1942). Dholes and pariah dogs have been observed to hunt together and to use the same kill. Infections and disease transfers are likely to occur.

1.6.5. Conservation actions

The dhole is included in CITES - Appendix II (2003). It is listed as endangered.

Current legal protection is given as by Durbin et al. 2009:

“In Cambodia, the dhole is protected from all hunting. A new forestry law is under preparation, and a proposal to list the species as a fully protected species is under

discussion. In India, the dhole is protected under Schedule two of the Wildlife Act of 1972 (permission is required to kill any individual unless in self-defence or if an individual is a man killer). The creation of Project Tiger Reserves in India has also provided some protection for the dhole. In the Russian Federation, dholes received the status of "protected animal" in 1974, however grey wolves are being poisoned and this may have an indirect effect on any remaining dhole populations. In Viet Nam, the dhole is protected by Decree 18/HDBT (17/01/1992) and the amendment Decree 48/2002/ND-DP (22/04/2002) under category IIB, which limits extraction and utilization. However, there are no limits set to the level of extraction or utilization. Dholes are listed as a category II protected species under the Chinese wildlife protection act of 1988."

In Europe dholes are listed in appendix B, EG-Directive 1158/2012 [EG].

Dhole conservation projects are rare. Mostly, dholes are protected by co-habitation in tiger reserves. Latest projects have been a dissertation by Kate Jenks who focused on dhole conservation in Thailand 2012. A new project is done by Jan Kamler, WildCru Oxford University. It aims at the ecology of dholes in Cambodia. Another one is planned by Kyran Kunkel of the University of Montana in Nepal.

1.7. Diet and feeding behaviour

1.7.1. Food

Because of the great range of dholes, prey species vary a lot. It also depends on sympatric living predators like tigers, leopards and striped hyenas. Most studies on prey species have been done by faecal analysis, carcass and killing observations.

Beetles, rodents, reptiles, birds and other rather small items have been recorded among dhole prey. Among small mammalian prey hares like blacknapped hares *Lepus nicricollis* or common hares may take up the biggest proportion (Barnett et al. 1980, Cohen 1978). Langur kills have not been directly observed but hairs do occur in scat samples. Maybe dholes forage on leopard kills. In one study, Langurs *Semnopithecus entellus* made up for 1.7 % of prey biomass (Selvan et al. 2013).

Dholes hunt mainly vertebrate prey. They show a preference for medium-sized ungulates. Second in prey preference are large prey types.

Studies of prey selection by sympatric carnivores in Nagarahole, in Southern India, showed that dholes prefer medium-sized prey between 31 and 175 kilogram in weight (Karanth and Sunquist 1995). The average weight of a prey killed by dholes was 43 kilogram. In Mudumalai Sanctuary, India, Venkataraman et al. (1995) reported the occurrence of prey remains in scats for two packs: chital *Axis axis* remains comprised 70 % and 41 %, sambar *Cervus unicolor* 22 % and 23 %, cattle 4 % and 15 %, and lagomorphs 3 % and 20 %, for the two packs observed, respectively.

In Banipur Tiger Reserve India, 73 % of the prey was chital (*Axis axis*) (Andheria et al. 2007). In Kalakad-Mundanthurai main prey species was sambar, followed by domestic cattle. One third of the prey biomass came from cattle (Selvan et al. 2013).

In the Himalayan region ibexes are also on the dholes prey list (Fox et al. 1992).

In eastern Laos, giant muntjac *Megamuntiacus vuquangensis* are hunted by dholes (Schaller and Vrba 1996). Black muntjacs *Muntiacus crinifrons* were discovered in dhole stomachs in China (Ho-Gee and He-Lin 1984). The supposed preying of dholes on rare animals like Takin *Budorcas taxicolor* and Giant Panda *Ailuropus melanoleuca* has led to severe hunting in China in the 1970s and later. Thien (1981) mentioned that groups of hunters were brought into Wanglang Sanctuary to kill dholes to save the Giant pandas.

In some areas of Russia, they feed on wild sheep *Ovis spp.*, reindeer *Rangifer rangifer* and wild goats *Capra spp.* Killing badgers *Meles meles* is also named (Sosnovskii 1967).

On Java they feed on banteng *Bos javanicus* as well as on red muntjac *Muntiacus muntjac* and Javan rusa *Cervus timorensis* (Hedges and Tyson 1996 in Durbin et al. 2009).

At Phu Khieo Wildlife Sanctuary in Thailand dholes preferred muntjak (42.6 % of scats) over sambar (31.5 %), and wild pigs (23.6 %) over hog deer (14.2 %) (Grassman et al. 2005).

In Bhutan, where leopard and tiger were also present, dholes showed a strong preference for sambar and avoided wild pig although the latter was the most common prey species in the area (Wang and Macdonald 2009).

In Taman Negara Nationalpark, Malaysia, dholes co-exist with Asiatic golden cats *Catopuma temminckii*. There, dholes mainly hunted mouse deer *Tragulus spp.* (Kawanishi and Sunquist 2008).

A recent study comparing prey preferences of dholes throughout their ranged showed that they mostly depend on sambar deer, Axis deer and wild pigs for survival (Hayward et al. 2014).

A wild dhole needs an estimate of 340 kilogram food per year (Karanth 1988).

Dholes and vegetarian items:

Dholes will sometimes eat vegetation and invertebrate prey. Grass is ingested, but may serve an anti-parasites function rather than a nutritional one. The amount of vegetarian food compounds is discussed controversially. Grass and other vegetation might be ingested by partially eating stomachs and guts of prey species. Sometimes scats comprise only grass and no prey item. Grass and leaves may stick to freshly killed prey and rather get swallowed with it than being eaten on purpose.

A food consumption study done by Barnett et al. (1980) showed 47 % of droppings had grasses and vegetation in them, and 6 % contained insects. Fruits were represented in only one percent of the scats. They were all Ziziphus fruits *Zizyphus jujuba*. The same fruits were also found in a study done by Fox and Johnsingh (1975).

Hunting wild versus domestic prey:

Dholes generally prefer to kill wild prey species (Sillero – Zubiri et al. 2004). Barnett et al. (1980) had only one faecal sample out of 151 with domestic animal parts in it. But if natural prey is scarce and domestic animals are left for grazing in the jungle without protection, they readily prey on them (Jongsingh et al. 2004). In an area with relatively low natural prey species, dholes took domestic yak and sheep in Bhutan (Wang and Macdonald 2009). Those domestic animals were not fenced in or in any way herded or protected so they were easily available.

In areas with high numbers of wild prey, dholes rarely used domestic animals to feed on (Kumaraguru et al. 2011).

1.7.2. Killing and Feeding Behaviour

Dholes hunt in packs, forming packs of over 30 animals. More often hunting groups consist of fewer than ten animals. Bigger packs split into smaller hunting units and are united again later. They split into groups prior of a prey encounter.

Dholes may also hunt alone or in pairs, taking smaller prey such as infant deer or hares. The dhole primarily forages at dawn or dusk but can hunt at any time of the day. It is said to be mostly a diurnal hunter (Venkataraman et al. 1995). They rarely hunt at night but observations have been made (Carlisle 1932). Time of activity can be influenced by the presence of other larger predators (e. g. tigers hunting at night) or by the activity pattern of the main prey species.

Dholes rarely give chase over a prolonged course. Mostly they use an ambush technique or give the hunt up within a couple of hundred meters. Hunting strategies vary with the openness of the area or if thick undergrowth or high grass is available for stalking.

A hunting area of a pack can comprise 40 km² but will be reduced in size till eleven square kilometres when puppies have been born (Macdonald 2001). In Bandipur, India, Johnsingh (1992) reports a home range of 40 km² and Venkataraman et al. (1995) found ranges of 54 and 83 km² in Mudumalai. Durbin et al. (2009) radio-tracked an adult male within a breeding pack (12 adults:12 puppies) in Kanha, India, and during the three-month tracking period, when adults were tending puppies at den sites, the pack used a range of 55 km². In a more recent study in Thailand, three adult male dholes were captured, radio-collared, and tracked for one to ten months in Phu Khieo Wildlife Sanctuary, Thailand, between March 2000 and June 2002. A total of 101 radiolocations were recorded for two animals and used to calculate home range sizes. The overall home range sizes of two of the males were twelve and 49.5 km² respectively (Grassman et al. 2005).

During hunts, some dholes may lie in ambush while others drive prey towards them. Kills are often made in or around water in India. Some postulate that, driving prey in the water is not the aim but that in hilly areas ungulates tend to flee downwards and end up in the stream – which often is at the bottom of the mountains. But kills in the water are too well-organised to be just an accidental by-product. Dholes often drive deer into water. Other pack members cross the river and stop the prey from escaping to the opposite river bank. They keep the animal at bay in the water. That way they effectively stop dangerous prey from kicking them or using antlers. If prey is driven into a river, the current and the swimming exhaust the prey species. Dholes let weakened animals back on the shore and kill it there. Killing by drowning in lakes and rivers has also been observed. As Peacock (1928) remarked, when domestic or pariah dogs hunt deer in the same area, the ungulates do not readily enter the water, so it seemed to him that dholes actually drive their prey in the streams. He did not find a single kill by domestic dogs done in water whereas he observed dozens of kills by dholes in the same area all made in the water.

Certain individuals take particular roles in the hunt, such as leading the chase or taking the first grab at the prey. Communication during the hunt is done by whistles and yelps. The pack members cooperate in bringing down and killing the prey. They also call pack members when they encounter a fresh kill (Morris 1934).

They will eat the parts like eyes, heart, liver, hind quarters, and other intestines first (Macdonald 2001). Some dholes readily attack the eyes, ears and tails of the prey during the chase. All extremities which are good to grab (like ears, scrotum and tail) are used to hold an animal at bay.

Biting out the eyes was often reported in folk lore as one of the tricks that dholes used to overcome much larger prey. Although eye wounds are seen (but only rarely) in escaped prey, most carcasses show missing eyes. It seems likely that eyes of dead animals were consumed rather than trying to get them while the prey still runs. But human observers focussed on those missing eyes – and this “cruel behaviour” was used to coin the negative image of dholes. In Thailand every single sambar carcass missed its eyes whereas muntjak and hog deer carcasses were intact (Grasmann and Tewes 2005). So it is either not necessary to blind such small animals to overcome them or the value concerning nutrition in those small mammals is too small to spend time on eating the eyes.

Usually one or more dholes keep guard when feeding on large prey. Tigers, leopards and humans are known to steal carcasses from dholes and even killing dholes to get the prey (Karanth and Sunquist 2000).

Dholes prefer to kill their own prey, but sometimes steal the kills of other species (tigers, leopards) or scavenge from old kills. Sometimes they come back for the kill the next day (Burton 1925).

Dholes are sometimes killed by panthers and tigers in disputes for prey or when they encounter each other. There have been several sightings of panthers and tigers that had been killed by dholes as well (Burton 1925, Morris 1925, Morris 1934, Schaller 1967, Connell 1944, Davidar 1969, Johnsingh 1978).

But peaceful encounters between these predators have been witnessed as well (Singh Deo, 1939). Domestic or stray dogs can get into fights with dholes. These fights might have a deadly outcome (Williams 1935). There are also observations on dholes hunting together with domestic dogs (Davidar 1965) and of dholes chasing domestic dogs away from the carcass but slowing down to let domestic puppies escape (Johnsingh 1982).

Dholes have only a single crested cusp (two in other canids) on the lower carnassial M1. The sheering capacity of the teeth might be improved by this (Durbin et al. 2009). This could influence the speed at which they can consume a prey. This may improve the dhole’s ability to compete with other animals, stealing their prey. They eat quickly (approximately one kilogram per dog in four minutes), with relatively little aggression (Maisch 2006, Durbin et al. 2009). Even a puppy weighing only four kilogram can stomach one kilogram of pure meat within minutes (Maisch 2006).

Dholes can hold several kilos of meat in their stomachs. They transport meat back to the dens and feed puppies and other pack members by regurgitation (Sillero – Zubiri et al. 2004). Depending on the size of the prey, the mother monopolizes small kills for herself and the puppies. At larger prey, puppies and adults feed simultaneously (Johnsingh 1982).

In captivity dholes cache food. They first dug the hole, regurgitated without outer stimulation or dropped meat chunks that they had carried in the muzzle and closed the cache (Maisch 2006).

Dholes do not fight during feeding on big carcasses. When a conflict situation occurs they rather give away their food or whine. In Perm, a fight between two dholes about a piece of food was seen once. But the dholes solved this by taking the food, pulling it and tearing it apart in two chunks (Volodina et al. 2004). This was also observed in other zoos and in the wild. Even puppies show this behaviour, e.g. tugging at rabbit carcasses to rip them apart communally (Maisch pers. observation).



Figure 2: Female dhole on the right defends her meat portion submissively.

1.8. Reproduction

Data about reproduction from the wild are not easy to get. There is nothing to suggest that oestrus length, gestation length or copulation ties differ between wild and captive situations.

1.8.1. Age of sexual maturity

In zoos, dholes may start reproducing with one and a half years. Female dholes in the wild tend to breed later. The first breeding in the wild was recorded at the age of three (Venkataraman 1998).

1.8.2. Seasonality of cycling

Mating occurs between November and April (dry season) in the wild in India, with a peak during December and January. In Indian zoos mating has been observed in September (Pandey 2013) and in November and December (Paulraj et al. 1992). In east Java, dholes are thought to mate mainly during January and May (i.e., end of the wet season).

Mating was once observed by Davidar (1973): The female took first a crouching position while being mounted. During the copulation tie they lay flat on their sides. The pack was attracted by the whimpering sounds of the female and started a greeting ceremony. Then they left the pair.

1.8.3. Dens

Dholes may use dens dug by others animals. But they also enlarge them or dig more access tunnels (Inverarity 1900, Davidar 1974). The dens can have a single or multiple entrances. Sometimes several dens are connected (Fox 1984).

Inverarity (1900) mentions the entrance angle to a burrow being 45 degrees. There might be several underground dens connected by tunnels. Packs will move the whole litter to another den when disturbed (Johnsingh 1982). Dholes also tend to hunt in areas adjoining the denning area.

1.8.4. Litter size in the wild

Six puppies were dug out of a den in India (Hood 1897).

Burton (1931) reports a female dhole which had seven embryos inside and he had observed a female with seven puppies. Inverarity (1900) found 3.2 puppies in a den after he had killed their mother. Johnsingh (1982) reports packs with eight and nine puppies and a lone bitch with five puppies - of which three did not survive.

Johnsingh (1979b) has observed lone females breeding outside the group with little or no success in rearing their litters. By contrast, three females have been seen suckling within a single group (Davidar 1974). Whether this represents plural breeding or "wet nursing" is uncertain.

1.8.5. Pup development

Due to their shy nature there are only few records about pup development in the wild.

Puppies at the age of about one week had not opened their eyes yet (Inverarity 1900).

For the first two months one mother stayed mostly with her puppies (Johnsingh 1982).

Davidar (1974) also observed that the dhole left behind in the den was the mother of the puppies. He found five week old puppies wandering around while no other dhole was present and took one. It fed readily on meat at that age.

First proof of meat consumption by faecal matters was seen with puppies less than four weeks old (Johnsingh 1982). Adult pack members regurgitate food for the mother and the puppies. When they are three months old, the puppies accompany the adult during hunts. However, the full pack might not be hunting together until about eight months (Sillero – Zubiri et al. 2004). The juveniles are fully grown when they reach the age of nine to ten months (Shilo et al. 2007). The mother – pup attachment is strong and lasts about a year (Davidar 1975). Guards can be observed at the den or near it (Johnsingh 1982).

Davidar (1974) observed two lactating females visiting a denning area - accompanied by a heavily pregnant female and to female yearlings. He also observed that there were many more females than breeding ones.

1.9. Behaviour

1.9.1. Activity

In the wild the dhole is most active in the evening and morning. Activity patterns follow that of their prey species (grazing, approaching water sources, etc.).

In India, dholes can be more active and hunt at any time of the day in the cooler rain season. During hot temperatures they tend to move their activities to the early morning hours and the evenings. Occasionally they hunt during moonlit nights (Sheldon 1992).

1.9.2. Locomotion

The dhole can walk, trot and gallop. The tail is, normally carried, hanging down. While galloping or cantering and in plays the tail is held higher, sometimes forming an upside-down U-shape. While walking and trotting the ears are raised but while galloping at full speed the ears are put in the neck, flattened with the ear opening towards the side. Trotting is one of the most used gaits for longer distances.

In high grass or thick but low undergrowth's they stand on hind legs or jump above vegetation level to orient themselves.

1.9.3. Social behaviour

Dholes mostly live in packs of five to ten individuals, but groups of as many as 18 (Alas Purwo, Java, Indonesia), 24 (Kanha, India) and 25 have been recorded on a regular basis. Pack sizes with 40 and more have been reported to European hunters at the beginning of the 20th century by natives. Packs with 100 animals are named in folk lore. These numbers included juvenile animals.

Group size and composition may vary under different environmental conditions. Most of the data comes from India. Packs studied by Johnsingh (1982 a and b), Venkataraman et al. (1995) and L. Durbin (1998), contained significantly more males than females, perhaps a reflection of female-biased dispersal (Sillero – Zubiri et al. 2004). There have been sightings of even bigger sized packs, which are probably several smaller packs together. These large groups, called clans, might migrate together but will disperse into smaller packs again when mating season approaches (Johnsingh 1982).

Dholes might live in a fusion-fission system. Clans would hold several packs and packs would know each other. These packs could fuse to larger groups and they split up again later. The size of the hunting party influences the size of the prey. Or rather maybe hunting groups form in accordance for the prey species and size in the vicinity.

1.9.4. Marking behaviour

Marking behaviour has scarcely been reported from the wild. Most observations are from captive situations.

The whole pack uses common latrines within the group's range. Latrines can serve as intra-group communicative functions (e.g. relaying information about the hierarchical or sexual status) as well as territorial ones. The ranges (or at least core areas) of neighbouring packs are often quite separate, though interactions between groups can be either friendly or hostile.

1.9.5. Play behaviour

Play behaviour of adults was only observed after feeding on prey, before the pack started again to hunt, after an unsuccessful hunt and with puppies at the den (Johnsingh 1982).

Section 2: Management in Zoos

In this section information and guidelines are given about the husbandry of the dhole. This information is based on earlier research and on questionnaires. These questionnaires were sent out to holders, to get information about enclosures, nutrition, breeding and medical treatment of dholes in zoos.

The first recorded, captive breeding took place in Wroclaw zoo in 1909 (Gewalt 1978).

2.1. Enclosure

In the text below guidelines are given for a dhole enclosure. Examples of different zoos are described. Also information from earlier research is given as a directive.

This does not mean that the following information is mandatory standard and the only suitable option.

2.1.1. Boundary

Dholes jump high from a standing position about two meters. They jump even higher if they are first able to jump against a tree, wall etc., or if they have been running before jumping.

To ensure that dholes do not escape most zoos either have fences with an overhanging part, electric wire on top of the fence or both. This is very important in corners or next to solid obstacles like walls, trees etc. The dogs jump either on top of or against solid structures or "sail" straight over a fence if they need to flee. By jumping from corner to concrete wall and back they can easily reach 3,5 m (Sanchez pes. comm.). Bumpy artificial rock structures help dholes to get up high on that boundary! They jump easily and need only tiny ledges for their paws. Dholes live and hunt on Himalayan steep hills – an artificial rock wall is an easy way out!

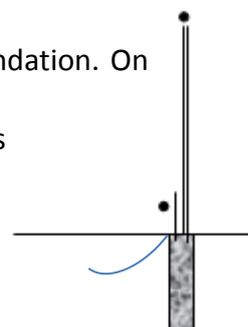
Dholes have very strong jaws. They can easily gnaw through deer fence or normal mesh wire. Electric fences are used to hinder dholes from direct contact with that kind of fencing material. Some zoos build wire mesh fences that are not tightened. So if dogs start to climb the whole construction starts to swing and wobble – making it impossible to climb the fence till the top. Although dholes do jump, climb over or bite through fences they are also prone to dig to get out of the enclosure. Fencing in the ground which is connected to the enclosure fence keeps dholes from digging themselves out. It is unnecessary and even impossible to have the whole enclosure fenced in the ground. But the perimeter area next to the erect fence should be secured by netting/fence in the ground about 30 cm below surface or installed at an angle. Budapest zoo uses a bent fence 60-80 cm deep in the ground and curved with about 50 cm inward length (Molnár pers. comm.)

A: Straight fence without overhang

Ground: Vertical concrete band, reaching 1 m deep into the ground as foundation. On top: a strong metal fence, 2.25 m high.

Additionally: electric fence at 50 cm height and on the top. The fence consists of two layers of metal bars. Additionally to that, just above the ground, casanett is used to hinder the puppies from slipping through the fence.

**Figure 3: Straight fence without overhang put into concrete.
Additionally: anti-digging fence in the ground**



B: Straight fences with overhang

The following straight fences are in use with success:

- a) 2.40 m high, the upper part is 60 cm leaning inward (about 45°) with six electric wires on top. Lower part of the vertical fence (0 – 60 cm) comprises of wire mesh: 5 cm x 20 cm, above (60 – 240 cm): wider wire mesh (10 cm x 20 cm). Two lines of electric fence at 50 cm and 70 cm from ground (about nose height) act as anti-gnawing device.
- b) Mesh wire, 2.5 m high, small grid, overhang leaning inward, total height: 2.8 m.

C: Bent fences

Fence posts have a 0.5 m long straight part (which is inserted in the ground in concrete) and an upper part which is bent. The top of the fence is 2.2 m high.

The radius of the bent part is 5 m. The curve hinders the dogs from climbing the fence. Therefore, no extra overhanging part is necessary.

Electric wire at about 20 – 30 cm and 50 cm high hinders the dogs from gnawing the fence.

Fence: deer fence with tighter mesh grit below than above.

Horizontal fence dug into the ground (0.3 cm deep, about 1 m from fence towards the enclosure centre) to stop dholes digging them out under the main fence.

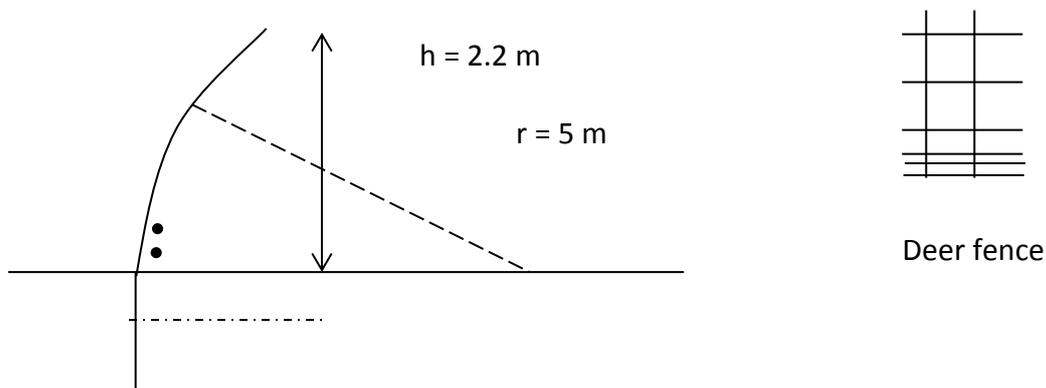


Figure 4: Bent fence posts creating an overhang at Schwerin Zoo.

2.1.2. Substrate

It is better to use natural material like sand or dirt than concrete. This is better for the animals and the overall impression of the enclosure. Concrete does not warm up in the sun, which causes rheumatism. This is visible with the older animals (Volodina et al. 2004). Natural soil with grass or wood chips is also fine. Dholes hide surplus food, so make sure there is soft soil or sand where they could dig their caches.

2.1.3. Furnishings and Maintenance

Dens:

Dens should allow the female to lie down with limbs extended. The height should be about the size of the dog. Not too high or too big as it is harder for the dholes to heat a big den with their body. As puppies are born in northern Europe at about March to May, temperatures at night can be low. No artificial heating is necessary. Inexperienced mothers tend to lie down somewhere in the den and not around their litter. So if the box is too big puppies might not realise in their first days of life that an adult is present – or they might be too weak to reach the female. (Experienced females circle around their puppies and then lie down during the first two weeks, so the puppies automatically are positioned at her belly. When the puppies are older they crawl/walk to the teats. Unexperienced bitches just lie down; the puppies might not make it if they have to crawl a meter or more towards her).

A den about 1 x 1 m² is big enough for three adult dholes to huddle together and sleep. Often dholes use the den as sleeping box during winter, if there are only a few dogs in the pack. Always offer more than one den as the litter will be transferred a couple of times to another den. If there is nothing suitable, the pack will spend hours carrying the puppies around. Whole litters have died due to that.

Dens are used all year around to rest and often as a retreat for subordinate pack members (Maisch own observation, Pandey 2013). Make sure there are enough dens/boxes in the outdoor enclosure to give all dholes a chance to retreat from bad weather, visitors and pack members. Other hiding places like bushes, rocks and hollow trees are needed too. Without these hiding places, dholes will panic and will go in their indoor enclosure if they have one. Or they tend to run up and down for hours.

If dholes get big dens, smaller ones should be provided as well. These smaller ones enable dholes to retreat or fend off other pack members.

The ground in the den could be concrete covered with a wooden plank and then hay or straw or wood chips as insulation. Something covering the ground like a wooden pallet would suffice (Grisham et al. 1999).

Dens are used all-year round. Sometimes as shelter for the night, sometimes low-ranking members retreat into the dens and defend the entrance. Those dens are important hiding places for them.

In times of high aggression, subordinates might not be allowed to leave the den for hours or, are chased back inside. Therefore, it is necessary to have several hiding places in the enclosure.

a) Box 100 cm x 80 cm total, with entrance 30 cm wide, leaving 70 cm for the den.

Front can be opened. Metal: stainless steel.

Walls: construction with planks (21 mm thick).

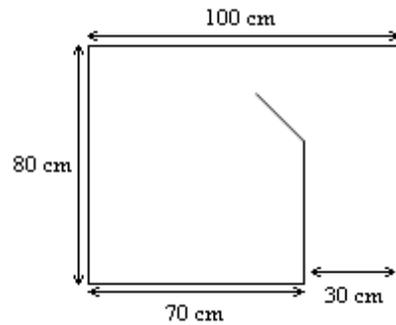


Figure 5: Measurements of a single den.

b) Den: inner area about 90 cm x 1 m, 80 cm to 90 cm high. Below the roof there is about 10 cm space for a miniature camera directly inside the den. Next to the den is a small room for electricity for the camera. Dholes love to lie on top of the den.

Two front doors, a small one for checking of the litter, a big one that opens the whole den and the small electricity space (the small door is part of the bigger one).

Left of the den: small entrance (about 40 cm width), next to that a bigger room for the rest of the pack. Floor: concrete, above that wooden floor, that can be taken out for cleaning.

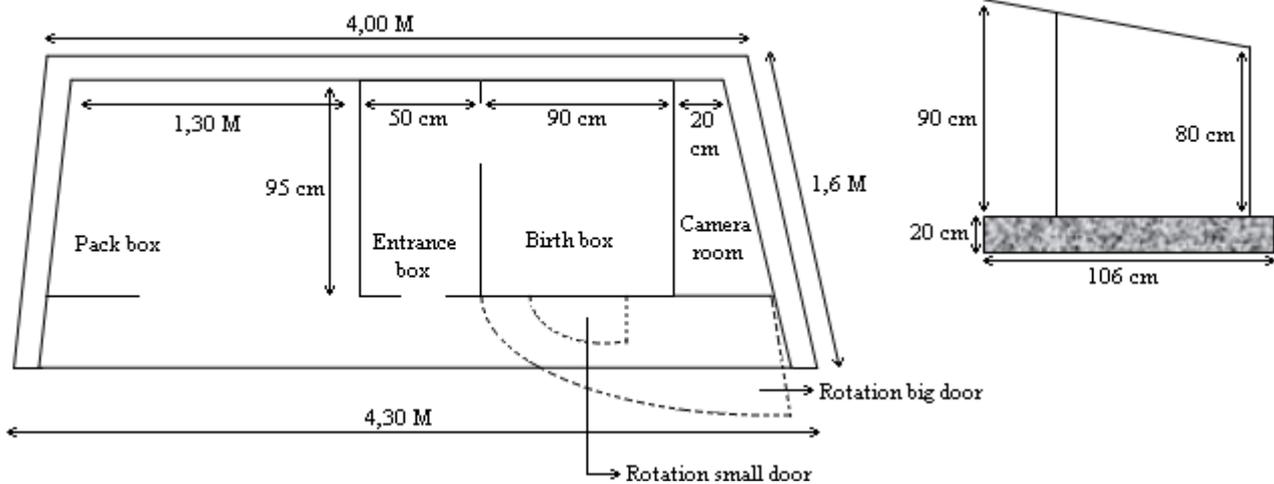


Figure 6: Measurements of a denning area with adjacent room for the pack.

c) Den inside a house:

Den size: 130 cm x 80 cm x 50 cm, simple entrance. The entrance is wide enough to give a person access to check on the litter through the entrance. There are several smaller rooms additionally (5 x 8.4 m²) inside the house, to separate dholes.

Ponds:

Dholes love to swim, dive and play in water. If they have access to it, they enter the water nearly daily, even in winter. Sometimes pregnant females like to stand in the water – which they might do because it eases the weight. After heavy meals (huge carcasses) the whole pack ambles to the water and drinks and rests – in the wild as well as in the zoos. Puppies play a lot in the water. Ponds should have shallow areas to enable puppies to get out of the water. They might not be able to turn around when confronted with a steep wall to find the shallow exit. Drowning of puppies has been reported in such cases.

Having dholes playing in water is a very attractive sight for visitors. Dholes are among the few canids (like tigers among the cat family) that clearly are very fond of water and swimming (Maisch own observation, Pandey 2013). A pond is really a must in a new exhibit. The pond should have a deeper part to allow swimming. Most parts should enable the dog to stand on the ground and be about two thirds submerged. As dholes also like to lie down in water, there should be areas where dholes can lie on banks and have their neck and head easily above the surface.



Figure 7: Dhole taking a bath.

Look-out posts:

Dholes use sentinels to keep an eye on their surroundings. Those watch-dogs like to sit or lie on an elevated structure to observe keepers and visitors. Big rocks, tree trunks etc. where the dogs can stand on, sit or lay down are perfect. That way, visitors easily see a dhole when approaching the enclosure.



Figure 8: Adult dhole using a stem to watch the surroundings.

2.1.4. Environment

In Russia zoo, dholes were kept without heating with temperatures of -25 °C till -28 °C without any trouble. The dholes retreated into their dens and huddled together (Sosnovskii 1967). In West Siberia climate with temperatures fluctuations from -49 °C to +36 °C do not cause any trouble (Shilo et al. 2007). In San Diego zoo the dholes have to live under freezing temperatures as well as in hot temperatures up to 38 °C (Mehrdadfar et al. 2003).

Most zoos have heating systems or infrared light bulbs as back up but healthy dholes do not need it. Dholes who come from a warmer or colder part of Europe should be given time to adjust to the new climate. Dens or houses are needed so they have some shelter against heavy – mostly wet - weather. Although they grow thick fur to stand dry, cold weather, becoming wet and cold should be avoided over long periods. They need several shelters so the dominant animals will not take over the shelter. Dholes do not need special lighting when indoors.

2.1.5. Dimensions

Sizes of indoor and outdoor exhibits vary greatly within EAZA zoos. Modern, newly built enclosures start with 800 to several thousand m². Old cage-type enclosures are phased out. In small enclosures, dholes tend to show stereotypies. They run up and down, in figure eight slopes or in circles. They also tend not to reproduce.

Maisch (2005) found out that in small enclosures, (smaller than 500 m², flat, barren, the dholes are unable to retreat to off-exhibit areas like thickets, behind hills etc.) reproduction failed eleven times where only five packs failed in a complex enclosure (500 m² or more, including thickets, pits, dens, and/or are fitted with hiding or look-out facilities) (Figure 9).

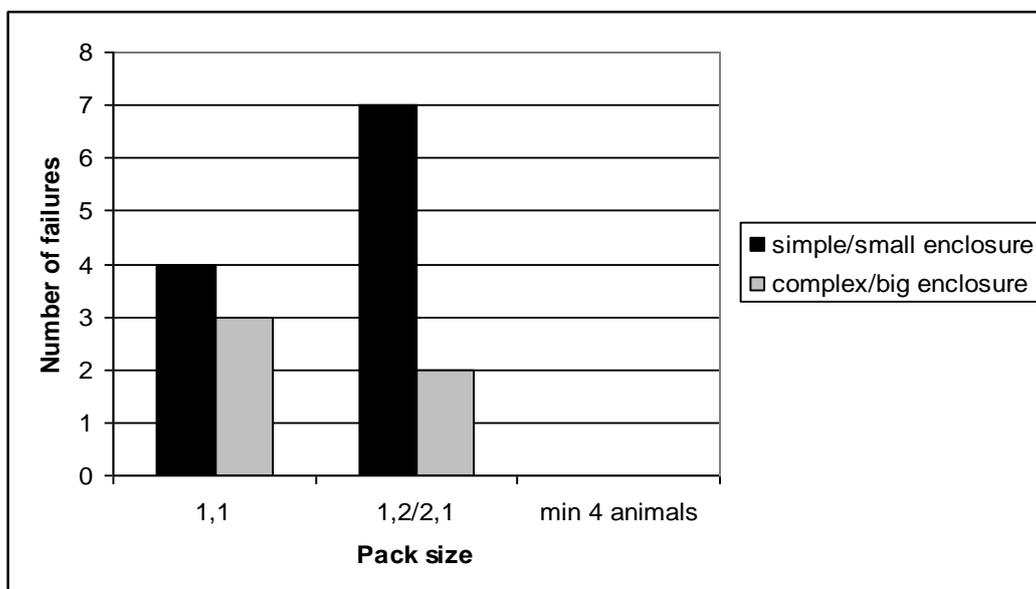


Figure 9: Reproductive failure in relation to enclosure parameters. The data about reproductive success were gathered in German zoos and one zoo in the Netherlands. Each year was counted as a possibility to breed, so packs may contribute several times to the data set (Maisch 2005).

Minimum sizes:

As general recommendation, new outdoor enclosure sizes starting from 500 m² onwards are the minimum for two non-reproducing animals. Keeping dholes just as infertile pair is not advisable but is acceptable for old dholes which are left over from a pack.

For additional dholes 100m² per individual are recommended, leading to a minimum size of 1000m² for seven non-reproducing dholes.

For the start of a breeding pack with n = four dholes 1,000m² is minimum. An adjacent second enclosure with minimum size of 500m² is necessary.

Keep in mind that – after one successful breeding season – additionally six to ten young ones are in the pack during the next breeding season. So space availability is crucial.

If dholes need to be introduced or separated, an adjacent area is needed. It is not always possible to find new holders for dholes which have been expelled from a pack. Adequate housing over months has to be ensured for those as well.

Bigger enclosures with 2000m² and more are highly recommended. They should be structured in a way that dholes cannot see the whole area. Then the pack moves around as a group, as not all parts and pack members can be seen from one point (Maisch own observations, Pandey 2013).

In an enclosure of that size, subordinate animals can retreat in times of higher aggression and periods with high stress levels (mating season). It also offers the dholes in times when they are easily disturbed (breeding season, rising of puppies) to retreat and feel save. This is crucial for the breeding success. Being able to retreat for the first weeks when puppies start exploring, is a short time compared to the months when visitors then can see the young ones – because there was a successful rising of the offspring.

2.2 Feeding

2.1.6. Basic Diet

In most zoos they feed meat with bones or even give the whole carcass. The amount that is fed is between 500 grams and three kilograms. In general, it can be said that, the more food the dholes get, the more fasting days they have. The amount of food needed for a 17 – 24 kilogram dog is about one to one and a half kilogram depending on the meat provided, according to the food amount of domestic dogs.

Dholes hide food in caches.

Feeding takes place once per day in the morning or afternoon or twice a day.

Table 1: Dhole nutrition in responding zoos (Questionnaires) –for a single animal if not said otherwise.

Type of meat	Structure	Amount
Beef	Meat with/without bones, carcass	500 grams – 3.1 kg
Chicken	Carcass, meat with bones	2 – 4 animals
Deer	Carcass	
Dove	Carcass, meat with bones	
Goat	Carcass	
Guinea pig	Carcass	

Hen	Meat with bones	1.5 kg
Herring	Carcass	
Horse	Meat without/without bones	700 gram 1.13 kg. Nebraska Brand Canned Diet (crude horsemeat)
Rabbit	Carcass	1 – 2 animals
Rat	Carcass	1 – 4 animals
Sheep	Carcass	
Veal	Meat with bones	

It varies per zoo if they give the dholes minerals or vitamins. Some zoos use one or more of the following products:

- Afarom (one time per day)
- Carmix
- Cod-liver oil (once a week)
- SDS Mazuri Carnivore Supplement (on every food)
- Ursovit (one time per day)
- Osteocal vet and Polybion

None of the zoos feed their dholes fruits or vegetables (in nutritional terms but as enrichment it appears on the list).

In one American zoo, dholes are fed dry dog food (Natural Balance Carnivore diet 5 % fat) five times a week, 900 – 1,350 grams per animal. The two remaining days they are fed rabbit or meat with bones. They are fed twice a day. For training and medical examinations, they use ox heart, sheep meat, marrow bone and dog feed with 15 % fat.

In many zoos, dholes are fed with different types of food (whenever available) like cow meat, birds (chicken with or without feathers, fowl, geese and turkey), freshly slaughtered rats, guinea pigs, rabbits, goats and sheep with hides. Dholes convert easily to different food. (Volodina et al. 2004).

In the wild, dholes seem to be digesting fur to protect their intestines from sharp bone fragments which are swallowed (Fox 1984, Fox and Johnsingh 1975). In a captive situation small whole carcasses should be fed with the skin to recreate this.

2.1.7. Special Dietary Requirements

In one of the zoos, an elder dhole is given extra calcium because he cannot eat bones. In most zoos the portion of food is doubled or raised when the female is pregnant or lactating. One zoo gives an extra feeding in the afternoon. Other zoos give more depending on if the pregnant female needs it and a lactating female gets more according to litter size and age of the puppies. Some zoos feed pregnant dholes extra and when the puppies are born the dholes are fed daily instead of any other day. Two zoos feed extra food in form of milk, eggs and curds (Questionnaires). At Indira Gandhi Zoological Park, the diet of the pregnant female is supplemented daily per animal with Proviboos (10cc), Osteocal vet and Polybion (each 10cc). Additionally one tablet of VitaFin is given daily (Ramalingam and

Murthy 2014). They increase the supplements after birth to 10ml of Syr Mimeral and 20ml Osteocal vet per day.

If the dholes will not get enough food when they have puppies, they will regurgitate all the food they eat for the puppies and do not have enough for themselves.

If the puppies are fed milk replacers caution is needed. They should contain low levels of lactose to prevent eye problems (Grisham et al. 1999).

2.1.8. Method of Feeding

Few zoos have a highly variable time of feeding. Most have rather fixed feeding times. Some feed in the afternoon. Others feed in the morning. Some zoos have two feeding times, one for checking the animals in the morning and the big feeding for visitors in the afternoon. Other zoos feed every other day but then increase the food ratio so that all pack members get enough food.

There may also be a small feeding for training and then the main food ratio in the afternoon.

Keepers can be present while dholes feed. So far they did not defend meat or carcasses against keepers. Keep in mind that dholes are wild dogs. Normal precaution should be applied in the enclosure all times.

Dholes can also be trained to enter a smaller enclosure for feeding. That way the dholes can be brought into an area where medical treatment/tele immobilisation is possible.

In one zoo, the male is conditioned to come into a small feeding cage and can be locked in during feeding, to ensure he gets its ratio and medication.

Pills should be inserted in meat pockets. Those meat pieces must be so small that the dhole can swallow it whole. Otherwise either another dhole gets the piece or if the dog finds the tablet because of chewing a larger piece then the tablet might get sorted out (Williscroft 2014). Deworming can be trained that way, throwing tiny meat pieces to each dhole.

As dholes tend to lie down and sleep with a full belly many zoos feed them in the afternoon. That way, dholes are on the lookout during the morning, expecting the keepers and might be more active.



Figure 10: Carcass feeding.

2.1.9. Water

Dholes like to drink during a meal when water is near. Dholes will eat snow as well. Water should always be accessible. Having a pond adds to an attractive view for visitors.

2.2. Social structure

The packs in captivity are mostly active by day. They show an activity rhythm with two main activity moments in the morning and in the later afternoon/evening. In these moments most activities and social contact can be seen.

During the breeding season more socio positive and agonistic interaction takes place during the evening. In bright nights, activity can continue till midnight. Normally they are found resting at night.

2.2.1. Basic Social Structure

As mentioned in the social behaviour paragraph, dholes mostly live in packs of five to ten individuals, but bigger groups up to 40 have been recorded. To successfully breed it is important for the dhole to have helpers. A research in Indira Gandhi Zoological Park showed that the presence of sub-ordinate female members in the pack is vital for survival of the dhole puppies to maturity in captive conditions (Pandey 2013). Larger packs tend to have more surviving offspring (average of 6.3 puppies) than packs with only two or three adults (average of 5.3 and 5.4). The maximum number of surviving puppies was eight for a breeding pair and eleven for a pack with more than four adults (Maisch own observation).

During active time spans, dholes are more willing to flee, warn or defend, then in the middle of the day. In the middle of the day the dholes spend most of their time with napping, lying down comfortably, hiding food and observing the enclosure. Most importantly at this time is, to rest without losing their view on the surrounding. This high level of attention is especially directed on the zoo personnel moving around between 7:30 and 16:00 outside of the enclosure. After 16:00 it is directed inwards to the social happenings in the group (Ludwig 2005).

In captivity, in a very large enclosure, they even move around as a group instead of as single animals. If they lose eye contact in undergrowth or hilly areas they keep contact by using whistles and whines (Maisch 2006). This behaviour is interesting for visitors to observe and explains why dholes were named "whistling hunters" (Fox 1984).

After resting, the whole group comes together in a "meet and greet" ceremony. They wag their tails low, show submissive grins, roll over on their back and show puppy behaviour. Within seconds the whole pack comes together into one heap with frenzied activities. Then they move on to feeding, playing or – in the wild – hunting. It seems that with this behaviour the pack arouses and coordinates itself for further co-operative action.

Pack members play together, even as adults. They also engage in mock-fights, rolling and social grooming. Social ranks are established by pushing and holding, but rarely by aggressive biting. The group has a strong hierarchical structure, with a dominant male and female who are the main, or only, breeders. Hierarchies are formed even in the first year of life (Ludwig

and Maisch pers. observation). There is a separate hierarchy in the males and females (Ludwig 2004).

2.2.2. Changing Group Structure

In the wild sex ratio is 2:1. Females emigrate at an earlier age than males.

Starting a new pack or introducing new pack members should be done with some caution but this mostly does not give problems. Dholes are very social and are not very aggressive. But there are individual differences. First contact should be with wired mesh between them but if there is no aggression or threatening sounds coming from both sides, they can be put together. It is mostly the alpha-female who shows the most aggression because competition between females is fiercer (Volodina et al. 2004).

When dholes are kept for several years in same-sex groups (e. g. full brothers) then introduction to the other sex can be difficult or even impossible due to aggression.

When the alpha-female or -male gets weak, the subordinate dholes will take over. This process can be very aggressive and can end in the death of the alpha-male or -female. To prevent this from happening it might be better to remove the alpha-male or -female from the pack. Reintroduction of this animal to the pack will not work (Ginman pers. comm., Maisch own observation).

In the wild, a part of the young, mostly females, will move away from the pack when they are fully-grown. They will form new packs with other young dholes or merge with other packs. In captive situation they are not able to do that. This can lead to inbreeding. Especially in situations where the alpha-male or -female is no longer able to fulfil his/her role as dominant animal and one of their young takes over leading to daughter-dad or son-mother pairings.

There are several zoos with a single sex group that until now have not observed any problems.

Keeping a dhole alone will result in apathy, depressive behaviour, lying down for very long times and stereotype behaviour, like pacing. Dholes should not be kept alone. The only exception might be very old animals of which all other pack members already died. Keeping them in their enclosure might be better than to transfer them in their old age.

Dholes who were kept alone and are showing stereotype behaviour can be put together again with other dholes. Eventually the stereotype behaviour will lessen or even disappear completely (Volodina pers. comm.).

There should be a distance between different dhole enclosures because otherwise they could hurt each other through the mesh, hurt themselves while trying to get to the other animal or the females will get an abortion because of the stress. There is no fixed distance recommended between dhole groups. This depends on the group sizes and how they behave towards each other.

2.2.3. Sharing Enclosure with other Species: mixed-exhibit

Not recommended at all. Dholes hunt even big prey very efficiently.

2.3. Reproduction

2.3.1. Sexual maturity

Dholes in zoos reach sexual maturity when they are one and a half to two years old (Sillero – Zubiri et al. 2004, Shilo et al. 2007). At Arignar Anna Zoo, first mating occurred with a 21-month old female (Paulraj et al. 1992). Bitches are still able to reproduce successfully at the age of ten (Madhavan 2013).

When they are eleven to twelve years old they stop reproducing (Anonymous 2003).

2.3.2. Mating season and Reproductive suppression

In Europe oestrus season mostly ranges from End of December to February (Maisch 2006). Dholes seem to be mono-oestrus but prolonged mating seasons have been observed. Maybe they are poly-oestrus and come into heat immediately again if the first mating did not result in a pregnancy (Ludwig pers. comm., Maisch own observations).

All adult females of the pack come into oestrus. Mostly, there is a reproductive suppression by the alpha-female. Alpha-males also hinder same sex animals from access to the alpha-female. In zoos and in the wild, several litters in one pack do occur.

Like other canids, dholes have a copulation tie. This tie can last several minutes (Paulraj et al. 1992). During the tie dholes may stand parallel, back to back or even lay down (Shilo et al. 2007). Afterwards both animals lick their genitalia. Mating can occur again after several minutes or there may be intervals of several hours.

As mating often takes place during the evening/night, observations are scarce.

The mating period lasts one to five days (Shilo et al. 2007). Subordinate males occasionally show sexual interest in the alpha-female and may contribute to the paternity of the litter (Sillero – Zubiri et al. 2004). In most situations the dominant male will stop other males from copulating with the dominant female (Maisch 2003).

Mostly, only the dominant alpha-female and -male reproduce. There are some exceptions to this but in most packs only the alpha-pair gets puppies. The alpha-pair can be recognized by their behaviour towards other pack members. The hierarchy can be seen clearly in pre-oestrus, oestrus and during the pregnancy phase (Maisch 2006, Ludwig 2005). During the rest of the year there are no clear dominance orders to be seen.

Alpha dholes will walk with a bouncy step. Their legs are stretched and their tail is held high. They raise their forelegs at the same moment in a kind of jump to intimidate others. The hind legs stay on the ground. They also stare at the submissive animals. Submissive animals will stay low when approaching the dominant animals and their tail will be held low and sometimes even between their legs. Submissive animals will even roll onto their back to show their stomach to the dominant animals. Another submissive behaviour is lying down

next to the alpha-male or -female and licking the alpha animal's lips. They often show a submissive grin and turn the pinnae backwards.



Figure 11: Animal on the left shows submissive grin, pawing like a puppy and ears are on their way to the back. Alpha-female on the right stares and has the tail raised high.

Submissive animals will whine while performing these behaviours (Volodina et al. 2004). Dens or boxes may be used by subordinate dholes to flee to and hide in. Sometimes the dominant female hinders the subordinate from leaving those retreats over several hours or days (Maisch own observation, Ludwig pers. comm., Pandey 2013). In most dhole packs the alpha-pair is not clearly recognizable all year around. It can be clearly seen only before and during the mating season.

Alpha-pairs over-mark each other's faeces and urine at the onset and during the mating season (Maisch 2006). Other pack members sniff at those markings but do not mark over it themselves.

In Schwerin zoo the forming of a new pack was observed. When forming the new pack, the highest ranking animals of both sexes became the alpha-pair on the first day the pack was put together. First communication between the dholes was to bond with each other. The alpha-pair mostly showed dominance displays and pair bonding behaviour. The alpha-pair marked from the beginning. The securing of their dominant position was already in September, instead of in the pre-oestrus period in November/December. In the pre-oestrus period the pair bonding behaviour increased. In this period the alpha-female became intolerant against her sister and the subordinate females become more interested in the alpha-male.

The alpha-pair shows its high status by increased marking behaviour from September till well into the breeding season. During oestrus there was a peak of this behaviour. Only alpha animals show marking behaviour. They only mark urine and faeces of their partner and their own samples. This marking by urine and faeces has no territorial meaning. It is important for the pair bond and could be serving as an indicator of "possession" for other pack members.

Dholes are able to recognize other pack members by faecal samples or urine. Females' secretions give information about their reproductive status (Maisch 2005).

A questionnaire about reproduction was sent out and eight zoos replied. In most zoos only the alpha-female openly showed signs of heat. In some zoos the females come in heat simultaneously. Frequent sniffing or licking of vulva by the alpha-male is seen the most. In some cases, other males, the female herself and even other females were observed doing this behaviour. Only one zoo observed a swollen vulva and one observed the alpha-female lying down in front of the alpha-male. The female in oestrus stays close to the alpha-female in most zoos. In only two of seven packs, the alpha-male hinders alpha-female on heat from contact with other males. In most packs more marking behaviour of both the alpha-male and -female was seen. In some packs there was even more marking behaviour of the other dholes. In two packs the female initiated mounting behaviour by keeping their tail sideways and their hind legs lowered. In one zoo the male follows the female into the night den. They often vomit hairballs because of the increase in social grooming (Questionnaires).

The alpha-female hindered other subordinate females from copulating in Schwerin zoo. Although there was enough food and several fertile females were present, only one female gave birth to puppies every year (Maisch 2005).

In five of the packs from the questionnaires, the alpha-male is the only one who copulates and in one of the zoos he even hinders the other males to copulate. In two zoos other males copulate as well. In these two zoos other females get mounted as well. There were two zoos where copulations were seen with the alpha-female, several times during five and 16 days. The copulations seen with the beta female were several times during two days and the other female several times during four days in a pack in Japan. Copulation ties were seen in five packs. In five zoos the female initiated contact (Questionnaires).

2.3.3. Gestation period

Dholes give birth once a year and have a gestation period of about nine weeks, on average 63 to 72 days (Sosnovskii 1967, Shilo 1994, Maisch 2006). At Arignar Anna Zoo, India, mean gestation period was 62.7 days (n = 3) (Paulraj et al. 1992).

In Schwerin zoo the whole pack became calm and friendly during the alpha-female's pregnancy (Maisch 2005). This was in stark contrast with the oestrus season right before, when the alpha-female heavily suppressed her sister. The alpha-pair did not separate itself from the rest of the pack anymore by marking and threat displays during the pregnancy. There was more socio positive behaviour, like greeting, playing or playful close contacts.

While being pregnant the alpha-female used the infantile „begging for food“-behaviour to get food, and less often in its ritualised meaning as greeting behaviour. The alpha-female also made sure she got first access to food in several different ways, like during feeding hours but also by caching food, finding other pack members cached food and defending it. The gestation period is approximately 62 days long (Maisch 2005).

2.3.4. Birthing

Dholes give birth in dens. Dholes dig into soil. They also use rocks or tree stems and root areas under which they make their den. They also like to have bushes or other material close to the entrance so that the opening is not easy to be seen.

In zoos they accept boxes, hollow tree trunks and even small huts as dens. They also dig their own burrow if possible.

On the first day after birth has taken place, the female does not leave her nest but on the second day she comes out for food and water (Sosnovskii I. P. 1967). Sometimes the bitch does not leave the den the day the whelping will occur (Kenji et al. 2006).

The female starts to pull out hair on her belly around the nipples around five to seven days before giving birth. The nipples can be seen even earlier when the mammal start to swell. Inspections of suitable dens can have already taken place or the female is seen quite often now entering dens and sometimes staying in them for a night.

The alpha-male and other group members become more aggressive in protecting the female. Often, group members stay near the den when the puppies have been born and guard the den from outside. Sometimes pack members dig pits close to the den in which they lay down and hide. Only the head can be seen over the rim (Maisch pers. observation). In Novobirsk zoo, dholes are mostly born in March to April, with air temperatures as low as -25°C (Shilo et al. 2007). In central Europe most births occur between March and May (studbook data). In Indian zoos whelping takes place in November and December (Paulraj et al. 1992, Pandey 2013).



Figure 12: Alpha-male and Beta-female guard the den with bitch and puppies inside.

Packs use several dens for breeding and will change holes with the puppies every ten to 15 days. This is probably for hygienic reasons. In the old hole there will be parasites and old bones with little parts of meat on it, which could threaten the health of the puppies.

Some alpha-males even take care of the stillborn or other dead puppies. The alpha-male will pick up the puppies and then shake them. If the pup will make sounds it is left in the den. Dead puppies will make no sound and will be taken out of the den and will be eaten (Maisch 2006).

Cleaning enclosures after birth: It depends on the pack, size of the pack and the enclosure size if they accept keepers in the enclosure.

Allo-suckling:

There are two zoos where several females had been giving birth. One of these packs had two litters of six and three puppies. In three of the four breeding situations both females suckled all the puppies. The two zoos with a pack with several females who gave birth mentioned that all the puppies were raised successfully (Questionnaires). It is up to the alpha-female if the second or third litter survives. Best chances are, if the second litter is mixed with the puppies of the alpha-female. There have been reports that the alpha-female actually killed a second litter or that she hindered the female and other pack members from nursing/feeding those puppies.

2.3.5. Litter size zoo

Litter sizes can be very different, even within the same pack in different years (e.g., up to eight, and five to ten, for two packs in Mudumalai). The largest litter size recorded is 13 (ARKS data).

It is not known if the litter size depends on the age of the bitch. First litters have often just four to six puppies. Some females seem prone to produce huge litter sizes and bring nine to 13 puppies each year (studbook data).

The number of puppies born and the number of puppies that are present when the den is controlled are different. Camera observations in dens showed that stillborn or weak puppies in the litter are eaten during the first day(s) (Maisch own observation, Kenji et al. 2006).

2.3.6. Pup development

Puppies are born with their eyes and ears closed. Their colour is dark brown and they have no teeth (Maisch 2006, Shilo et al. 2007). The eyes are open between the 10th and 19th day (Sosnovskii 1967, Paulraj et al. 1992, Maisch 2006).

At birth the coat of the pup is a dark, brownish-grey with a dark tail, sometimes with a white or black end. The hair is mostly thick and fluffy. The guard hairs are noticeably longer than the undercoat. The guard hairs are comparatively sparse and deep brown with black ends. At three weeks of age the puppies look rather light brown than grey (Paulraj et al. 1992). When they are three months old they start to become red (Shilo et al. 2007, Maisch own observations).

Most young dholes remain a dull red and will not get the colouring typical of adult dholes, the white colouring of lower parts of paws, belly, chest and neck, until they are at least a year old. Some have white or creamy parts when they are yearlings. The older they get, the bigger the white areas on feet and legs seem to become.

In captivity, new born puppies can weigh 200 to 350 gram, but by the age of ten days their body weight can double. Minimum weight given was 80 gram in a five puppies litter (Madhavan 2013). New-borns are small with body length of 25 to 27 centimetres from nose to tail tip (Paulraj et al. 1992). They grow fast. Hashikawa (unpub.) showed that dhole puppies in Yokohama Zoo reach a weight over four and a half kilogram at the age of twelve weeks, starting with 245 and 320 gram respectively.

When puppies are about ten days old they start to receive regurgitated meat from other pack members. In the beginning they just suck on it, lick it and carry it around but within a day or two they already start eat it inside the den. Feeding of small pieces of meat was observed at the age of six weeks at Indira Gandhi Zoo (Pandey 2013). Data about first eating regurgitated meat and solid food vary – depending on the time of observation. With CCTV inside the den, the food intake can be seen earlier than when observations have to be made out of the den. Variation of "first sighting" that vary for 14 days can be explained by that.



Figure 13: Brown puppy showing the first red hairs.

A pregnant bitch uses calls to get pack members near her to share food. This call is later used to call the puppies. At Schwerin zoo the bitch called pack members several times to her, while standing in front of the den. After parturition she used this to attract pack members to bring her food to the den (Maisch own observation). Sires have also been heard to use these specific calls to call puppies out of the den (Pandey 2013).

Puppies survive early weaning. But normally they are suckled for more than eight weeks. Weaning start from week six to ten onwards (Maisch own observation, Pandey 2013). Weaning might correlate to the onset of taking solid food which also varies from six to ten weeks of age. Puppies have been observed to suckle for a period of over six months of age if the bitch allows it. There is no teat order and puppies often change while suckling at the mother.

There is a period of several weeks when puppies still take milk but also start on solid food. First the mother lies down during suckling. Later she remains standing while the puppies suckle in a sitting or standing position. Sometimes they are already big enough to lie down while the bitch stands.

The puppies get their first teeth at ten to 16 days. The first teeth are the incisors of the upper jaw. Those of the lower jaw follow them. On days 20 – 21 the canines appear. Molars erupt around 21 – 25 days. The premolars are last. They appear around 28 days (Shilo 1994) or 30 – 35 days after birth (Sosnovskii 1967).

In the beginning the puppies tend to walk and crawl in circles. That way they always form a “living heap” and keep themselves warm. They paw at each other, but no real play is to be seen. Within the first days they get control over their legs and are able to go straight for some steps. Sometimes they still fall over, skip with the hind legs into a sitting position. They can also sleep with hind legs extended behind the rear.

When they are 20 – 30 days old they start to appear outside. This depends on the length of the tunnel to the entrance. Adults inside the den often grab a puppy and hinder it from leaving the den too soon (Maisch own observation, Pandey 2013). They also bring them back inside by carrying them. Puppies are willing to leave the den before pack members allow them to go out or stay outside. Sometimes pack members will also take a puppy out and let it crawl in front of the den (under surveillance) while the mother still tries to keep all puppies inside. Quite often it is the father taking them out (Ludwig pers. observation, Maisch own observation, Pandey 2013).

2.3.7. Care of Young: Helpers at the den

The role of the mother is suckling the young. The alpha-male and other group members take turns in cleaning, caressing and guarding the offspring. The female's energetic costs for gestation and lactation for up to 14 puppies are presumably very high for this medium-sized wild dog.

Even in captivity, where enough food is provisioned, this takes a lot of effort from the breeding female. Therefore, the help of the other pack members is needed for successfully raising of puppies. So do not separate the male or the pack from the female before birth!

All adults take turns in guarding, feeding, grooming and playing with the puppies (Maisch 2006, Ludwig 2005). Non-breeding pack members play an important role in pup caring (Pandey 2013). Depending on the mother she may allow the sire inside the den during birth, after the first day or even not at all during the first week. The second female in ranking might be allowed to care for the puppies early after parturition (Maisch own observation) or the bitch might express the most aggression towards "female number two" (Pandey 2013) during the first days and weeks. This could be a personal issue between both females. There might also be a tendency that with following litters, the bitch gets more and more relaxed and allows pack members an earlier access than before. Yearlings are closely guarded by adults when dealing with puppies (Maisch own observation, Ludwig pers. observation, Pandey 2013). Dholes seem to get more relaxed in each rearing season.

With a small pack of 1.1 dholes raising puppies will consume most of the energy from the parents.

With the presence of additional helpers, the task of caring for puppies is spread more evenly within the pack. All pack members have different tasks, which depend on the sex and their age. The mother will suckle her puppies and sometimes allo-suckling (suckling by other females than their mother) can be seen.

Helpers, which are relatives of the offspring, gain indirect fitness by helping to raise kin. But pup-raising behaviour must be learned and is only partly inherited. Pack mates who have helped with raising puppies have an increased chance of later successfully raising their own offspring when they have left the pack (Maisch 2003).

The alpha-male provides food for the puppies and lactating female(s). The females and yearlings also bring food to the puppies or regurgitate. In the reproduction questionnaire, in three of four zoos, all the dholes provided meat for the puppies. In one zoo it was done only by the males. In one zoo the alpha-male was seen providing meat to the lactating female. The females in one zoo guarded the puppies. In another zoo one of the females threatened the visitors while the keepers were threatened by the alpha-female and another female.



Figure 14: A rather tired-looking alpha-male guarding a playful puppy which is pawing at his head and licking at his muzzle.

Regurgitation:

In many zoos it is mainly the alpha-male or the father of the puppies that provides most often meat by regurgitation (Maisch own observation, Pandey 2013). If there are several litters in different dens, then most often the father of the second litter is the one providing food to that den.

As dholes feed for themselves and then regurgitate for the mother and later for the puppies' mineral supplements on meat might not reach the last dhole in the chain.

If there is not enough food, adults tend to bring all food to the puppies and stay hungry. Adequate food rations for packs with huge litters are necessary.

2.3.8. Hand-Rearing

Hand rearing does not differ from hand rearing of domestic dog puppies concerning the milk formula.

In Australia, one of the female dholes had a difficult birth ending with a caesarean. The female and her puppies were returned to their enclosure but the puppies did not suckle and appeared weak. Their mother did care for the puppies, grooming and toileting them, once she recovered from the anaesthetic. Eventually puppies were moved out of the enclosure for hand rearing on the day of their birth. When the puppies were six days old, they were returned to the dhole exhibit, to allow the three adults (parents and one-year-old female) to have contact through mesh. Puppies were put back in the enclosure when they were six weeks old. This took five days with full contact reintroductions. First, the mother was put in with them. Then the puppies were put in with the father on the second day and then the mother and father were put in with them. On the 4th day the daughter was put in as well. And eventually the whole family was together again and things went very well (Ginman pers. comm.).

In 1974, a hand-raised, injured puppy started to take minced meat in its first week and it refused the bottle from the second week on. Then it was fed only meat powdered with a

multivitamin. It was friendly towards the keepers' pet badger hound, but was aggressive or fearful towards humans. It was reintroduced to the family group after an absence of nine months. This went smoothly.

Hand-rearing of litters was done in Germany with commercial puppy milk and meat without any problems. Reintroduction to the parents was not possible in one case. They attacked and injured the puppies (like before when they had to be taken out due to injuries inflicted by parents) immediately after reintroduction.

Domestic dog as foster mother:

It is mentioned once from India in 1897. One bitch refused to accept the dhole puppies, the other one raised them. They were really quarrelsome and the domestic puppies were taken away "to save them from harm".

The dholes would only eat raw meat (preferred monkey). They were dangerous to approach when feeding, but could be handled quite well at any other time. The dholes did not attack men but would attack any or every other animal they might see (Hood 1897).

2.3.9. Contraception

Separation of the sexes during oestrus severely disrupts the whole social behaviour of the pack. It is not recommended. Apart from castration, hormonal contraception is used.

In general, female canids under hormonal contraception tend to have a higher percentage of pyometra, endometrial hyperplasia and cancer. If possible, the males should be treated hormonally to avoid the problems of uterine diseases which develop in females with prolonged hormonal contraception (Wingold pers. comm.).

Dholes have not been contracepted regularly, so data about success or failure are still sparse. Please submit data to EGZAC and the EEP, so that the knowledge is shared.

So far the following products have been used:

Megestrolacetat:

Implant 500 mg has been effectively used in female dholes.

Side effects are higher percentage of pyometra, endometrial hyperplasia and cancer in canids compared to those without hormonal contraception and compared to those with Deslorelin.

Deslorelin:

Suprelorin[®] (Virbac) Implants with 4.7 mg

Females: During the first two to three weeks, Deslorelin pushes hormonal levels towards ovulation, only later the levels get regulated down. So using it might actually be leading to ovulation or pseudo pregnancy. Separation of animals is not always possible so Deslorelin is not one hundred percent safe as contraception when used singly. The onset of the increasing hormonal level should be counteracted. This has been done with Megestrolacetat tablets, 1 mg/kg per day are given seven days prior and seven days after implantation of Deslorelin. No ovulation, pregnancies or behavioural changes have been observed in a zoo using this method since 2008. It not sure if the female will ever cycle again.

In one zoo the implanted female showed more aggression than before (Ginman pers. comm.).

Application of Suprelorin without Megestrol led to a litter of healthy puppies.

Males: theoretically induces a reversible infertility. It did not work in one zoo where the male was able to sire offspring after implantation.

2.3.10. Population management

Target population size is 200 animals. As mostly only the breeding pair reproduces, the “genetically active” proportion of 200 animals is quite low.

Single sex packs are needed to have enough dholes in the population, but to keep reproduction rates at a manageable level.

Dhole packs with different sexes are most stable when puppies are born and cared for.

Helpers are very important to raise puppies – and to learn how to care for their own offspring when brought into a breeding situation.

Whenever possible no yearlings are to be transferred. At least one sex of a newly formed pack should be experienced as helper to improve the first breeding success.

“Breed and cull” is accepted as management tool. “Culling” is meant in its original meaning: to sort. There will be dholes that are kept for breeding. Surplus animals can either be neutered or non-permanent contraception can be used. Due to negative health effects of hormonal contraception euthanizing of surplus dholes is also applicable – if not contrary to countries’ laws. Packs can then reproduce and if the offspring can be placed, they will be transferred. If not, they will be euthanized rather than be kept suffering under sub-standard conditions. Euthanizing dholes is a case to case decision where all aspects from legal, ethical as well as population and health concerns are discussed in accordance to the EAZA Culling Statement (2015):

<http://eaza.net/assets/Uploads/position-statements/EAZA-Culling-statement.pdf>

If dholes are euthanized for management purposes they should at least be used to enlarge the knowledge about the species. So blood samples, taking of body temperature and measures including weight and sizes and a post mortem report should be standard procedure. Send FTA Cards or blood also to the EEP coordinator for future use.

2.4. Behavioural enrichment

2.4.1. General information about enrichment

These are some general guidelines for enrichment, which can be applied to the dholes as well. Enrichment should:

- Bring opportunities for appropriate social interaction: A structure of a dhole group in captivity should be as close as possible to the structure of a group in the wild.
- Provide conditions in which the animal’s exploration is rewarded with new and useful information, allowing it to make choices about its activities and some control of its environment: Adding different substrates, concealing food and using smells will make a dhole show more exploratory behaviour. It stimulates its mental capacity and increases its activity level. That way it is also more active to be seen by visitors.

- If an enclosure has more landscape and barriers (buildings, hills, moats, trees or rocks) the dholes will have more space to retreat.
- Provide escape routes and improve social interactions. A structure might also provide shade, temperature gradients and possibilities to hide from pack members and visitors. The dhole can choose what kind of activities it would like to do and has a certain control of its environment.
- Decrease undesirable behaviour such as stereotypes, aggressiveness, coprophagy, etc.
- Improve overall well-being of the animal by allowing it to use its intelligence and physical abilities.
- Improve the educational experience for the public as the public observes species typical behaviours, such as foraging, social bonding, playing, etc.

2.4.2. Enrichment for dholes

Dholes like to play, even when they are fully grown. They play with pack mates but also with objects. Even in a barren enclosure they will always find objects to play with, like a water bowl or a stick or a broom.

As dholes are very social animals they like to play together with an object. So the size of a bone, stick etc. should enable several youngsters or adults to hang on.

They love to tear at something, a behaviour which could also be used. Dholes have been observed to jump up to grab a branch and then drag it down just to be catapulted above the ground by the branch again - swinging up and down for minutes!

A food lift is also easy to make. Two pieces of meat hang on a rope. The rope hangs down on both ends of a wooden T without touching the ground. As soon as one dhole grabs the meat on one end and tears it to the ground the second part is lifted higher in the air. If another dhole jumps to get the dangling treat, the first dhole has to keep hold on its piece as it is lifted in the air. Both end up in a tug-of-war to secure their piece.

They are very curious, so keepers should have an eye on their brooms, buckets and other material they take into the enclosure for cleaning.

Some zoos use whole carcass feeding as enrichment for the whole pack. Freezing tiny pieces of meat in a bucket of water makes a good object to spend time with. Apples and other floating fruits can be thrown in the pond so that dholes can “hunt” them.

Dholes are interested in smells. Faecal samples or wool of all kinds of zoo animals are very interesting. Marking the enclosure with scents of other species, perfume, spices is also a good option. In one zoo, keepers put aromatic oil on their boot soles before walking and cleaning in the enclosure. The dholes follow the scent trail. Some dholes like cinnamon and roll themselves in it.

Giving of big bones (leftovers from tiger or lion feeding) is also a welcomed enrichment object. Dholes crack the bones of cows and horses with delight and consume the bone marrow.

Zoos also scatter commercial dog pellet food in enclosures or scatter feed with small pieces of meat.

Feeding Enrichment (Questionnaires):

In some zoos a whole carcass is fed as a form of enrichment. Other forms of food enrichment used are:

- Food is offered on trees so dholes must climb to reach it
- Whole skin from horse when available
- Meat in bags made of sisal and paper
- Leftover bones from the feeding of the tiger
- Beef and bison meat/bones
- Scatter feed dog food and meat
- Pig ears
- White tail deer legs/hide
- Cow ribs
- Corn rolls, pumpkin, apples in water
- Sprinkling of blood (chicken, beef, horse, goat, sheep) on logs, sticks and other objects to induce object and prey play.



Figure 15: A puppy playing with a twig made "tasty" by certain odours.

2.4.3. Dangers of enrichment

All forms of enrichment should be tested before presenting them to animals. Dholes have very strong jaws. Objects save for snow leopards or tigers might crack under some dholes' grip. Make sure not to transmit parasites or other pathogens. Items should not be sharp and if ropes are used they should be hanged in such a way that the animals will not be able to entangle themselves.

2.5. Handling

Dholes do not respond well to being handled. Direct restraint and handling should only be done if results cannot be obtained any other way.

2.5.1. Individual Identification and Sexing

As dholes show no marked sexual dimorphism it is not easy on the first sight to distinguish them from a distance. Colours (like pig marker) do not adhere well on the coats. Notching ears is a way to identify an animal from a distance but it is not recommended as the pinnae are important messengers for communication. In some countries it is forbidden as it is a painful and invasive treatment. For example in Germany, it is illegal to destroy healthy tissue without medical necessity.

Most dholes look alike. Only scars/injuries on tails, skin or ears can help with individual identification.

Dholes should be transpondered as puppies to be able to register them as individuals.

Sexing can be done by handling them as puppies or by watching adults urinate. Females and males both use squat urination. While raised-leg urinating, the bitches simply raise the leg alongside the body vertically. Males lift the hind-leg sideways. Only alpha-females may use a handstand position.

2.5.2. General Handling

In many zoos, keepers can enter the dhole enclosure without frightening the dhole or causing aggression. In breeding periods, this might be different, because the dholes become more protective of the puppies and their mother. Some packs even allow certain keepers' access to puppies from the first day on. Other zoos avoid going near the denning area in that time just as precaution.

It is very important that the same keepers care for the animals. They get used to them quite fast. Unknown keepers or several persons approaching can lead to nervous behaviour, pacing or even jumping in flight in fences, on walls etc. in small enclosures.

They learn quickly that every time two or more persons appear, something apart from the routine will happen. So approaching enclosures by several people without any negative incidents should be trained.

When the dholes first arrived in San Diego Zoo, they were very nervous when keepers were present and would run up and down the fence line and even jumping off the fence. To calm them, three zookeepers started taking care of them exclusively. Now the dholes are sometimes playful towards the keepers, but never aggressive. The dholes are hand fed so it is easy to administer medicines. The dholes are trained ten to 15 minutes, four to five days per week (Mehrdadfar et al. 2003).

2.5.3. Catching/Restraining and training

Dholes are very sensitive and nervous when cornered. Therefore, catching causes a lot of stress. Dholes have died while being caught or died in the transport crate. So to do this, sedation might be needed (Volodina et al. 2004). While some zoos do use nets or scoops to capture dholes, most zoos use sedation and/or tele immobilisation.

In San Diego zoo dholes have been successfully conditioned to go in a special made squeeze crate, which makes it easy to do a health check without sedation and to administer medicine like flea and tick prevention (Mehrdadfar et al. 2003).

At Twycross Zoo, they trained an old dhole via positive reinforcement to take portions of meat from a stick. Thereby they could administer medicine directly to the individual without separating it from the pack.

2.5.4. Transportation

To exchange animals is a mandatory necessity to have a population with as much genetic variability as possible. It is very stressful for dholes and maximum care has to be taken that the travel is safe for dogs as well as the handlers. Several dholes have died so far during transfer. The risk increases after stressful chasing to catch them.

Material:

Due to the strong jaws of dholes' crates must be built very solid. Boxes must also be safe to handle with the wild dog inside. Covering ventilation holes with tight wire netting prevents handlers accidentally putting fingers inside the crate while manipulating it.

Bars along the sides should provide safe grip for hands. Spacer bars on the underside make it easy to lift the crate with a forklift.

Strong wood plates outside and metal plates inside are a good option for long-distance transfers.

Front and back parts should be constructed as sliding doors. They can be either constructed as solid doors with openings for air and light or double doors with the inner doors consisting of vertical metal bars. Make sure the doors can be locked, so that dholes cannot open them by pushing and that the latch does not open accidentally when the crate is pushed.

Ventilation areas on the doors as well as on the sides are necessary for good ventilation. Bigger net wire areas allow the handlers to check on the animal inside the crate. Dholes should not be able to bite into parts of the crate. Dholes have been known to break off teeth in unsuitable mesh wire. So make sure the wire netting is strong and tightly knit.

Material on the floor should be used to absorb urine and faeces. Straw pellets, wood chafing's etc. do the job nicely. Water bottles or metal dishes for long journeys must be secured properly.

A normal plastic dog kennel is no safe means of transportation!

Size:

They should be able to lie down comfortably and turn around. Standing with extended head must also be possible. Crates should be big enough that standing is possible but not standing on hind legs and falling over backwards. Maximum height in the crate should be about ten centimetres higher than the ear tips.

Suitable dimensions for adult dholes are:

Length: 1.20 m Width: 0.60 m Height: 0.80 m

Detailed transportation legislation can be obtained from the 2000, IATA "Live Animal Regulations" 27th Ed.

2.5.5. Safety

Dholes normally pose no threat to people. The only attacks stated were of a dhole with rabies and of a dhole in the wild defending its den from humans who wanted to dig out puppies. Both incidents happened in the wild.

But as it is a medium sized animal with a strong grip and powerful jaws precaution should be taken to avoid getting bitten. They tend to flee and might only attack as last resort when there is no other way to escape. Depending on the safety protocol of the zoo, some zoos shoot dholes when they escape from their enclosure. There might also be no decision making by the zoo itself if the police takes over in emergency cases. Best is, to talk to local decision makers before an escape happens.

Keepers entering a dhole enclosure should always wear a broom, rake or anything else to keep dholes at a safe distance. Even a playful nip in the heels is painful.

2.6. Veterinary: Considerations for Health and Welfare

In General dholes resemble domestic dogs in sedation, vaccination and surgery.

2.6.1. Routine sampling and controls

Blood sampling should be done when the animal is under anaesthesia anyway.

Taking measurements of weight, size and body temperature should be standard.

Checking of teeth and other body conditions is mandatory.

Faeces should be checked for parasite infection.

Parasite treatment:

Puppies are easily infected by parasites and should also be screened. Routine deworming with a broad-spectrum antihelmintic at six and eight weeks of ages is highly recommendable. In areas where heartworm is present, preventative medication should be given and occult heartworm test performed annually.

Deworming has been done with domestic dog products like Ivermectin. Equine panacure (1/3 sachet (10.1 g) per day for their consecutive days) has also been used as well as Flubenol (5 %, five grams each day). 20 days old puppies at Arignar Anna Zoo showed *Ancylostoma caninum* eggs in their faecal samples. They were successfully treated with pyrantel pamouate (5 mg/kg body weight) (Devaki et al. 2006).

Stronghold has been used against external parasites. In India, Sol Butax is used daily (2-2,5ml per animal) against ticks (Ramalingam and Murthy 2014).

Vaccination:

Dholes are susceptible for canine distemper. Whole packs have died when they got in contact with contaminated foxes and/or their faeces.

Normal domestic dog vaccines are used successfully.

Vanguard[®] has been used as well as Eurican DHPPI in combination with Eurican L.

The level of antibodies necessary to protect a vaccinated dhole against the infection is unknown. Normally the titre of domestic dogs is used as comparison.

There has been a case in which a whole pack was vaccinated against Parvovirus. One dhole did not have enough IgG and IgM to be immune while the rest of the vaccinated dholes had

titres ranging from 640 – 1,280 IgG (80 or more are seen as positive results of a vaccination). So, checking blood titres whenever possible is very important!

Antibiotics:

Amoxicillin (Clamoxyl LA) 15 mg /kg (300 mg)

Synulox 250: two times a day one tablet for five days (in combination with Apetitoso/comp 250 mg).

Baytril 5 % can be injected in food and given orally. Marbocyl has also been applied.

Enrofloxacin and amikacin sulphate has been used successfully in a severe E. coli infection of adults and puppies (Murthy et al. 2008).

Anti-inflammatory:

Carprofen (Rimadyl) 4 mg/kg BW

Blood parameters:

Blood pressure syst. 183+ 20 mmHg, diast. 207+ 20 mmHg (Böer et al. 2002). Blood can be taken at the same spot as with domestic dogs. The various blood parameters of puppies are given below in table 3. For size and diameter of dhole blood cells see: Salakij et al. (2009).

Table 2: Blood parameters of dholes as given in Murthy et al. 2008.

Parameter	Wild dog - female	Wild dog - male
Haemoglobin {HB %}	10.5 gm/dl	14.0 gm/dl
T W B C	8,700 cells/cu. mm	9,200 cells /cu. mm
DC: Polymorphs	65 %	47 %
Lymphocytes	33 %	52 %
Eosinophils	2 %	1 %
Monocytes	0 %	0 %
Basophils	Nil	Nil
E S R	20 mm/1st hour	16 mm /1st hour
P V C	32 %	42 %
Serum Creatinine	20 mg/dl	2.1 mg/dl
Blood Urea	135 mg/dl	150 mg/dl
SGOT (AST)	85 U/L	171 U/L
SGPT (ALT)	120 U/L	125 U/L
Alk. Phosphatase	250 U/L	265 U/L
Serum Electrolytes		
Sodium	138 mmol/L	141 mmol/L
Potassium	3.9 mmol/L	3.7 mmol/L
Chloride	102 mmol/L	104 mmol/L

2.6.2. Sedation/Anaesthesia

As most zoos use distance immobilisation, the products should be applicable in small quantities, should have a huge range of tolerance before being overdosed and should not cause tissue damage. Needles most commonly used are 20 – 25 millimetres long.

Antisedan and Atipamezol are used for reversal. Many zoos use combinations (see table 4).

Table 3: Blood parameters of captive dholes.

Haematology	Result	Unit	Val. Ref.
<u>red series</u>			
red blood cells	7.13	$\times 10^6/\mu\text{L}$	4.4 – 5.8
Haemoglobin	10.3	g/dL	13.1 – 17.3
Vol. MCV	42.9	fL	79.7 – 96.7
haematocrit	30.6	%	38.9 – 51.4
MCH	14.4	pg	26.2 – 33
MCHC	33.7	g/dL	31.2 – 36
Indice de anisocytosis	20.6	fL	8 – 18
NRBC	0	$\times 10^3/\mu\text{L}$	
NR/W	0	%	0 – 0
<u>white series</u>			
total leucocytes	11.7	$\times 10^3/\mu\text{L}$	3.7 – 11.6
neutrophils %	93.4	%	41 – 74
lymphocytes %	6.39	%	17.8 – 48
monocytes %	0.154	%	3.5 – 11.6
eosinophils %	0.031	%	0.5 – 8.8
basophils %	0.046	%	0 – 3.1
neutrophils	10.9	$\times 10^3/\mu\text{L}$	1.8 – 8.1
lymphocytes	0.746	$\times 10^3/\mu\text{L}$	1 – 4.8
monocytes	0.018	$\times 10^3/\mu\text{L}$	0.1 – 1
eosinophils	0.004	$\times 10^3/\mu\text{L}$	0 – 0.6
basophils	0.005	$\times 10^3/\mu\text{L}$	0 – 0.2
<u>Platelet series</u>			
platelets	485	$\times 10^3/\mu\text{L}$	130 – 400
Vol. Mean platelet	11.2	fL	7.6 – 12
<u>Biochemistry</u>			
Glucose	186	mg/dL	70 – 109
Urea	54	mg/dL	15 – 55
creatinine	0.61	mg/dL	0.6 – 1.3
<u>Lipidic Metabolism</u>			
Cholesterol	118	mg/dL	110 – 200
triglycerides	44	mg/dL	0 – 150
<u>Enzymes</u>			
GPT	89	UI/L	0.1 – 55
Alkaline phosphatase	61	UI/L	40 – 150
Serum cholinesterase (butyrylcholinesterase)	1,938	UI/L	3,930 – 11,900
<u>Mineral Metabolism</u>			
Phosphorus	3.98	mg/dL	2.3 – 4.7
Calcium	10.1	mg/dL	8.1 – 10.4

Protein Metabolism			
Albumin	3.52	g/dL	3.98 – 5.51
Total proteins	6	g/dL	5.9 – 8.3
Immunological study			
Acetylcholine receptor antibodies	0.21	nmoles/L	
IgA	87	mg/dL	70 – 400
IgM	36	mg/dL	40-230
IgG	126	mg/dL	700 – 1,600

Ketamine is a drug used in many zoos for sedation of dholes. The influence of the drug was tested on 16 dholes in Germany in 2002. 16 individuals of a pack of 21 dholes were routinely examined clinically (age: 8 – 82 months, BW 21 ± 3 kg). A combination of ketamine (4.3 ± 0.8 mg/kg BW) and medetomidine (32.0 ± 5.6 μ g/kg BW) was used. Body reflexes, pain reaction and muscle tone were examined. Cardiopulmonary and metabolic parameters were also recorded. No changes in those were observed during anaesthesia. It took eleven – 43 minutes to induct anaesthesia. There were no problems.

After 40 to 50 minutes one group (n=7) received atipamezole (186 ± 40 μ g/kg BW). Those dholes recovered within three to 23 minutes. Recovery without atipamezole (n=5) took 0.2 to 39 minutes. In two dholes only sedation could be achieved, two further specimens showed no signs of sedation or anaesthesia at all (Böer et al. 2002).

In a research in Thailand, where wild dholes were captured and radio collared, they used three different drugs: Intra-muscular injection of Zoletil® (Virbac, Ltd., Carros, France), (tiletamine hydrochloride) at ten milligram per kilogram, Calypso® (Gideon Richter, Ltd., Budapest, Hungary) (ketamine hydrochloride) at ten milligram per kilogram and Tranquivid® (Ben Venue Laboratory, Inc., Bedford, Ohio) (xylazine hydrochloride) at two milligram per kilogram. Drugs were administered via a pole syringe injection in the hindquarters (Grassman et al. 2005).

In India four dholes were immobilised with a Ketamine-Xylazine combination. 8mg Ketamine/kg bodyweight and 1mg Xylazine/kg were used. Anaesthesia was rapid and smooth. Three dholes showed a body temperature higher than 39°C. Ethanol sprayed on foot pads, groin area and abdomen was used as well as i. v. injections of lactated ringers' solution to bring the body temperature down (Muliya et al. 2016).

Body temperature might get as low as 37.3 °C during anaesthesia. But under medetomidine-ketamine anaesthesia temperatures of around 40 °C could be measured with no negative aftereffect (Böer et al. 2002). Arousal before capture might be a reason for high body temperature during anaesthesia (Muliya et al. 2016).

A medetomidine-ketamine anaesthesia slightly lowers the respiratory frequency. Normal frequency is about 23 to 25 breaths per minute.

Please send protocol of anaesthesia, blood results etc. to the dhole vet advisor Torsten Moller (mail to: Torsten.Moller@kolmarden.com). Collect hair with roots (~ 50) and blood (EDTA or use FTA cards) of individuals for future use and send it to the EEP coordinator.

Table 4: Overview of drugs that is being used for Sedation (ARKS reports, unpublished).

Drugs	Dosis
Dormitor + Ketaject + Albipen	0.8 cc + 0.4 cc + 5.0 cc
Ketamine + Xylazine	200 mg + 5 mg (for checking of wound)
Ketamine + Xylazine	200 mg or 250 mg per animal 4 or 4 mg (for crating)
Ketamine Medetomidine	5 mg/kg (100 mg per animal) 50 mg/kg (1 g per animal)
Medetomidine+ Ketamine+ Valium	1 mg 20 mg (10 mg for 1 bigger dhole extra) + 3 mg
Ketamine + Medetomidine + Atipamezole	5 mg/kg + 50 mg/kg 250 mg/kg (as reversal)
Domitor + Ketaset Antisedan	0.5 or 0.6 ml 1.1 ml (for 50 min. of immobilisation) 0.5 ml (as reversal)

Table 5: Drugs used for reversal.

Atipamezole	250 mg/kg
Antisedan	0.5 ml
Antisedan	1 ml
Atipamezole Doxapram	1.55 cc 1 cc

Diazepam can be used (10-30 mg per animal and day) to lower excitement during pack formation (T. Moller/Th. Lind personal communication)

2.7. Specific problems

So far no dhole specific medical problems arose in zoos.

Parasite related problems:

In the wild, Indian dholes seem to spread *Sarcocystis* sporocysts. *Sarcocystis axicuonis* is found in chital Axis where it mainly infects the heart and skeletal muscles. Dholes ingest the coccidian with the meat. The sexual part of the two-host cycle is done in the mucus membranes of the dhole intestines. Dholes then shed sporocysts in the faeces.

It is unknown if infected chital are easier prey for dholes or not. But it is a clear example of a specific prey-predator-parasite system (Jog et al. 2005).

One zoo lost a juvenile that had shown symptoms of epileptic seizures, disorientation and cramps before being found dead. Post mortem analysis showed parasite induced lesions in the kidney, liver and brain. Parts of *Larva migrans* were found.

Bacterial infections:

A whole pack with puppies was affected by an E. coli infection. Diarrhoea with blood, cramps and kidney failure were symptoms observed. They could be cured with Amikacin sulphate injections (500 mg) and Erofloxacin injection (10 % solution) over a five days' period. Fluids were given intravenous (Ringer lactate solution) as well as injections of sodium chloride and dextrose for the weak puppies. Additionally, five millilitre of potassium chloride was given orally. All dholes recovered over a five days' period (Murthy et al. 2008).

Dholes have also been tested positive for Ywersinai enterocolitica but showed no symptoms.

Organ related problems:

There is one case in which only one testis was found in a nine-year-old dhole. The second could not be found.

One dhole showed poor breathing and lameness at the age of 14.5 years. Post-mortem report revealed an aortic body tumour.

2.8. Recommended research

Since there has not been done a large amount of research on the dhole, in the wild as well in captivity, there are some subjects where little or no information is available. The following topics need more research:

- Subspecies: The existence of subspecies of dholes still awaits genetic proof.
- Physiology: There is no information available on the body temperature, heart rate and respiratory rate. It is assumed that it is like in other dog species.
- Pair bonding: How does it work? Are there individual choices? Is it always the highest ranking male or female of a same sex sibling group that becomes alpha?
- Starting a new pack: What sex-ratios and age classes are best?

Since ex situ and in-situ projects are undergoing permanent change: if you are interested in current scientific work, please contact the EEP coordinator. You will get an up to date list and descriptions of dhole projects. To keep this document a working document: please add your projects to the EAZA conservation database, contact Simon Marsh (mail to: s.marsh@yorkshirewildlifepark.com) or the EEP coordinator and let them know about it!

Section 3

Tables

Table 6: Dhole body measurements.

	Head Body length	Tail	(shoulder) Height	Weight male	Weight female	Birth weight
Cohen 1978	880 – 1,130 mm	410 – 500 mm		15 – 20 kg	10 – 13 kg	
Phu Khieo Wildlife Sanctuary , Thailand L. Grassman unpubl. (Sillero,2004)	male:970 mm (880 – 1,050) n=3	male:340 mm (320 – 360) n=3		16.0 kg (15.0 – 17.0) n=3		
Kanha , India L.Durbin unpubl. (Sillero,2004)	1,355 mm n=1	421 mm n=1		15.5 kg, n=1		
Taronga zoo (Ginman,pers comm)			Female is 40 – 42 cm Male is 45 – 48 cm	<i>Cuon alpinus infuscus</i> male 14 – 16 kg	<i>Cuon alpinus infuscus</i> female 11 – 13 kg	<i>C.a. infuscus</i> 260 – 280 g
Taronga zoo Old Chinese dhole (Ginman)	head to rump length Male 91,5 cm Female 92 cm			16 kg	13.6 – 16 kg	
Dholes (Maisch,2006)	88 – 120 cm	40 – 50 cm		10 – 25 kg	10 – 25 kg	
Sosnovskii (1967)						200 – 350 g
Brehms (1990) 1. <i>Cuon Alpinus</i> 2. <i>Cuon Alpinus Dukhunensis</i> 3. <i>Cuon Alpinus Alpinus</i>	1. 85 – 110 cm 2. up to 1.25 m 3. up to 1.3 m	1. 40 – 48 cm 2. 40 cm 3. 40 cm	1. 40 – 50 cm 2. 45 cm 3. 45 cm	15 – 20 kg	15 – 20 kg	
Senglaub (1981) <i>Cuon Alpinus Alpinus</i>	100 – 110 cm	45 – 50 cm	50 cm			
Macdonald (2001)	90 cm	40 – 45 cm	50 cm	± 17 kg		
Wilson (2009)	88 – 135.5 cm	32 – 50 cm		15 – 20 kg	10 – 13 kg	200 – 350 g

Table 7: Common Names of dholes reflecting their wide distribution.

Language/Subspecies	<i>Cuon alpinus</i>
English	Asiatic wild dog, dhole, Indian wild dog, Red dog
French	Chien sauvage d'Asie, Cuon D'asie, Le dhole
German	Rothund, historically: Rotwolf
Spanish	Perro Salvaje Asiatico
Indigenous names:	
Assamese	Kuang-kukur, Rang kukur
Bahasa Indonesia	Adjag or ajag Anjing hutan
Bahasa Malaysia	Srigala
Bengali	Ban-kutta, Ban-kukur, Ram kutta
Bhutanese	Phara, Phou
Burmese	Tan-kwe, Tokway
Buryat	Zurbi
Canaresich	Ken-nai, Chennai
Chenchu	Reis kukul
Chinese	Cai, Nyar, Tsai-lang
Gujarati	Earam-naiko, Kol kutta, Kutra
Gurkhali	Ban-kukur
Himalaya region	Bhaosa, Bhoonsa, Buansa
Hindi	Adivi-kuta(r), Ban-kuta, Bheriya, Hundar, Jungli kuta, Rasa-kuta, Son(a) kuta
Indo- und Sundanesisch	Serigala
Javanese	Ajag, Asu alas
Kachin	Kyi-kwa-lam
Kannada	Bun-seeta, Kadu nai, Korku
Kasmmiri	Ban-kuta, Bhansa, Jungli-kuta, Ramhun, Ramkun
Kazakh	Chue
Kirgizian	Chue, Nyar
Khmer	Chkai, Prey (wild dog)
Korku	Bun-secta
Ladakh	Farra
Lao	Ma nai (big dog)
Lepcha	Sa(-)tun
Malayisch	Arjing, Kutar, Sirgala,
Malayalam/Tamil	Chen nai, Cennuay, Hahmasai-kuta, Kattu, Kolsa, Kotshun
Mandarin	Chái
Manipuri	Huithou
Marathi	Kolsun, Jungali kukur
Mongolian	Dhsergul
Nepali	Ban kukur, Bwaso
Oriya	Balia Kukura
Russian	Chikalka, Krasnyi volk (Red wolf), Krasni Vock, Dikaya Sobaka (Wild dog)
Sunda	Ajag
Telegu	Resu kukka, Vanna kooka
Thailand	Maa paa
Tibetan	Farra, Khi-Chaang, Sidda ki
Tungus	Dzergil
Vietnamese	Cho soi lua

References

This list contains only literature used in these guidelines. A full list of dhole literature can be obtained from the EEP coordinator.

Anonymous, Rothund Cuon Alpinus (Palas 1811), <http://www.jww.de/445,611/>

Barnett, B.D., Cohen, J.A., Johnsingh, A.J.T., Fox, M.W., 1980, Food Habits of the Indian Wild dog (Cuon Alpinus): a preliminary analysis. *Journal of the Bombay Natural History society* 77(2), Pp. 313-316.

Böer, M., Schöne, J., Schneider, M.A. and Hackenbroich, CH., 2002, Zur Medetomidin-Ketamin-Distanzanästhesie de Asiatischen Wildhundes (Cuon alpinus Hodgson 1838) und ihrer Wirkung auf kardiopulmonale und metabolische Parameter, *Schattauer GmbH Tierärzt Prax* 30 (K): Pp. 57-63.

Burton, R. W., 1925, Panthers and wild dogs, *Journal of the Bombay Natural History Society* 30 (4), Pp. 910-911.

Burton, R.W., 1931, The number of puppies in a wild dog's litter, *Journal of the Bombay Natural History Society* 35 (2), Pp. 442.

Carlisle, T. H., 1932, Wild dogs killing by night, *Journal of the Bombay Natural History society* 36 (1), 239.

Caton Jones, F.W., 1908, Some notes on wild dogs and panthers, *Journal of the Bombay, Natural History society* 41(4), Pp. 194-195.

Cohen, J. A., 1978, Cuon alpinus, *Mammalian species*, no.100, Pp. 1-3.

Davidar, E.R.C., 1965, Wild dogs (Cuon alpinus) and village dogs. *Journal of the Bombay Natural History society* 62 (1), Pp. 146-148.

Davidar, E.R.C., 1969, An encounter between wild dogs and sambar, *Journal of the Bombay Natural History Society* 66 (2), Pp. 372–375.

Davidar, E.R.C., 1973, Dhole or Indian wild dog (Cuon Alpinus) mating, *Journal of the Bombay Natural History Society* 70, Pp. 373-74.

Davidar, E.R.C., 1974, Observations at the dens of the dhole or Indian wild dog (Cuon alpinus, Pallas), *Journal of the Bombay Natural History Society* 71 (2) 183-187.

Davidar, E.R.C., 1975, Ecology and behaviour of the dhole or Indian wild dog (Cuon alpinus, Pallas), Pp. 109-119 in M.W. Fox, M.W. ed., *The Wild Canids*, Van Nostrand Reinhold, New York, NY, USA.

Devaki, K., Senthilumar, K., Nasrullahkhan, P. and M. G. Jayathangaraj, 2006,

Ancylostomiasis in dholes *Cuon alpinus*, *Zoosprint journal* 21(1) 2141-2142
www.zoosprint.org/ZooPrintJournal/2006/January2141-2142pdf.

Durbin, L., 1998, Individuality in the whistle call of the Asiatic wild dog (*Cuon Alpinus*), *Bioacoustics* 9, Pp. 197-206.

Durbin, L.S., Hedges, S., Duckworth, J.W., Tyson, M., Lyenga, A. & Venkataraman, A. 2008. *Cuon alpinus*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>.

Ellerman, J.R. and Morrison-Scott, T.C.S., 1966, Checklist of palearctic and Indian mammals, British Museum (Natural History), London, UK.

Fox, M. W. and Johnsingh, A.J.T., 1975, Hunting and feeding in wild dogs, *Journal of the Bombay Natural History Society* 72 (2), Pp. 321-326.

Fox, M.W., 1984, *The whistling hunters: field studies of the Asiatic wild dog (Cuon Alpinus)*, State University of New York Press, Albany, NY, USA.

Fox, J. L., Sinha S. P. and Chundawat, R.S., 1992, Activity patterns and habitat use of the Ibex in the Himalaya Mountains of India. *J. Mamm.* 73 (3), Pp. 527-534.

Gewalt, W, 1978: Some remarks on keeping and breeding the Red dog or dhole at Duisburg zoo. *Int. Zoo Yb.* 18, Pp 173-176.

Ginsberg, J.R. and Macdonald D.W., 1990, *Foxes, wolves, jackals and dogs: an action plan for the conservation of Canids*, IUCN/SSC Canid specialist group, Gland, Switzerland and Cambridge, Switzerland.

Graphodatsky, A.S., Perelman, P.L., Sokolovskaya, N.V., Beklemisheva, V.R., Serdukova, N.A., Dobigny, G., Brien, S.J.O., Ferguson-Smith, M. A. and Fentang, Y., 2007, Phylogenomics of the dog and fox family (Canidae, Carnivora), revealed by chromosome painting, *Chromosome Research* 16, Pp. 129-143.

Grassman, L. I., Tewes M. E., Silvy N.J and Kreetiyutanont, K., 2005, Spatial ecology and diet of the dhole *Cuon alpinus* (Canidae, Carnivora) in north central Thailand, *Mammalia* vol. 69(1), Pp. 11-20.

Grisham, J., Smith, R. and Brady, C., 1999, Minimum Aza Guidelines for keeping medium and large canids in captivity, Online publication:
www.species.net/Carnivora/Canidae/GuideLD.html

Harris, R.B., 2006, Attempted predation on blue sheep *Pseudois Nayaur* (Hodgson) by dholes *Cuon alpinus* (Pallas) in China, *Journal of the Bombay Natural History society* 102

Hayward, M. W., S. Lyngdoh and B. Habib (2014): Diet and prey preference of dholes (*Cuon alpinus*): dietary competition within Asia's apex predator guild. *Journal of Zoology* 294, 255-266.

HO-Gee, L. and S. He-Ling (1984): Status of the Black muntjac *Muntiacus crinifrons*, in eastern China. *Mammal. Rev.* 14 (1), 29-36.

Hood, R., 1897, Wild dogs. *Journal of the Bombay Natural History Society* 10 (1), Pp. 127-132.

Huy L.Q., 2006, In search of the endangered Dhole,
<http://vietnamnews.vnagency.com.vn/showarticle.php?num=04SUN241206>

Inverarity, J. D., 1900, A wild dog's earth. *Journal of the Bombay Natural History Society* 13 (3), Pp. 528-530.

Iyengar, A., Babu, V.N., Hedges, S., Venkataraman, A.B., Maclean, N. and Morin, P.A., 2005, Phylogeography, genetic structure, and diversity in the dhole (*Cuon alpinus*), *Molecular Ecology* 14, Pp. 2281–2297.

Jenks, K.E., Songsasen, N, Leimgruber, P. (2012): Camera trap records of dhole *Cuon alpinus* (Canidea, Carnivora) in Khao Ang Rue Nai Wildlife Sanctuary, Thailand. *Canid News*. URL:<http://www.canids.org>

Jenks, K.E., Songsasen, N, Leimgruber, P. (2012): Mapping the distribution of dholes, *Cuon alpinus* (Canidae, Carnivora), in Thailand. *Mammalia* 76, Heft 2, 175–184.

Jenks, K.E., Songsasen, N, Kanchanasaka, B., Leimgruber, P. and T K. Fuller (2014): Local people's attitudes and perceptions of dholes (*Cuon alpinus*) around protected areas in sotheastern Thailand. *Tropical conservation Science*, Vol. 7 (4): 464-480.

Johnsingh, A.J.T., 1979, Ecology and behaviour of the dhole or Indian wild dog (*Cuon Alpinus*), with special reference to predator prey relationships at Bandipur, Ph.D. dissertation, Madurai Kamaraj University, Madurai, India

Johnsingh, A.J.T., 1980, Are dholes (*Cuon alpinus*) a real threat to tigers?, *Tigers paper* 7 (2), Pp. 29-30.

Johnsingh, A.J.T. 1982a. Thesis Title: Ecology and behaviour of dhole or Indian wild dog (*Cuon alpinus* Pallas 1911) with special reference to predator-prey relations at Bandipur. Ph.D. Thesis, Madurai Kamaraj University, Madurai

Johnsingh, A.J.T., 1982b, Reproductive and social behaviour of the dhole, *Cuon Alpinus* Canidae, *Journal of Zoology* 198: Pp. 443-63.

Johnsingh, A.J.T., WII, Yonten, D., Wangchuck, S., 2007, Livestock-dhole conflict in West

Jog, M. et al. (2005) *Journal of Tropical Ecology* 21: 479-482.

Kamler, J. F., Johnson, A., Vongkhamheng, C. and A. Bousa, 2011: The diet, prey selection and activity of Dholes (*Cuon alpinus*) in northern Laos. *J. Mammal.* 93, 627-633.

Karanth, K.U., 1988, Analysis of predator-prey balance in Bandipur tiger reserve with reference to census reports, *Journal of the Bombay Natural History Society* 85(1) 1 – 8.

Karanth, K.U. and Sunquist, M.E., 1995, Prey selection by tiger, leopard and dhole in tropical forests, *Journal of animal Ecology* 64, Pp. 439-450.

Karanth, K.U. and Sunquist, M.E., 2000, Behavioural correlates of predation by tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon Alpinus*) in Nagarahole, India. *Journal of zoology*, London 250, Pp. 255-265.

Khatiwada, A. PD. et al. (2011): The Pack Hunter (Dhole): Received Little Scientific Attention. *The Initiation*, 4, Pp 8-13.

Kawanishi, K., Sunquist, M. E., 2008, Food habits and activity patterns of the Asiatic golden cat (*Catopuma temminckii*) and dhole (*Cuon alpinus*) in a primary rainforest of Peninsular Malaysia, *Mammal Study* Dec 2008 33 (4), Pp. 173-177.

Kenji, I., Sakura, I. and U. Aiko (2006): Reproduction of dhole, *Cuon alpinus*, in Captivity and Caring-behaviour by young-adults in a pack. *J. of Jap. Ass. of Zoos and Aquariums*, 47 (3), 85-94. Japanese translated by Yoshihiko Takaki.

Kumaraguru, A., R. Saravanamuthu, K. Brinda and S. Asokan (2011): Prey preference of large carnivores in Anamalai Tiger Reserve, India. *Eur. J. Wildl. Res* 57, 627-637.

Ludwig, W., 2004, *Haltung & Zucht: Rothunde im Zoo - Überraschungen garantiert*, Arbeitsplatz Zoo 3 (in German).

Ludwig, W., 2005, *Zum Sozialverhalten des Rothundes (Cuon alpinus Pallas, 1811) unter Gehegebedingungen: Strategien von Kohäsion und Suppression*. Dissertation an der Universität Kassel (in German).

Macdonald, D., Editor, 2001, *The new encyclopaedia of mammals*, Andromeda Oxford Ltd., Pp. 66-67.

Madhavan, D. (2013): Dhole power at city zoo with five new births. *The Hindu*, January 30th, 2013.

Maisch, H., 2003, Helpers at the dhole den: Pup raising behaviour of males and non-pregnant females, *Mammalian Biology, Supplementheft zu Bd. 68 (Beiträge zur 77. Jahrestagung der DGS in Bern 2003)*: 43.

Maisch, H., 2005, Ist das Fortpflanzungsverhalten bei Rothunden *Cuon alpinus* die Ursache oder eine Konsequenz des Rudellebens. Dissertation zur Erlangung des Grades Dr. rer. nat. an der Universität Osnabrück. www.ub.uni-osnabrueck.de / (in German).

Maisch, H., 2006, Der Rothund *Cuon Alpinus*, Pp. 375-389 in U. Gansloßer, C. Sillero-Zubiri (copywriter), ed. *Wilde Hunde*, Filander Verlag. (in German).

Mehrdadfar, F., Chuyen, J. Casavant, K. and Barnes K, 2003, Husbandry of dholes at San Diego Wild animal park, *International zoo news* 50 (8) No: 329, Pp.462-466.

Morris R.C., 1925, Wild dogs and jungle tragedies. *Journal of the Bombay Natural History society* 30 (3), Pp. 691-693.

Morris, R.C., 1927, Wild dogs attacking cattle, *Journal of the Bombay Natural History Society* 32 (1), Pp. 211.

Morris, R. C., 1934, Wild dogs killing a panther. *Journal of the Bombay Natural History Society* 36 (3), Pp. 744.

Morris, R. C., 1934, Wild dogs driving a panther from its kill. *Journal of the Bombay Natural History Society* 36 (3), Pp. 744-746.

Morris, R.C., 1942, Widespread rabies among wild dogs on the Billigirirangan Hills (S. India), *Journal of the Bombay Natural History society* 43, Pp. 100.

Muliya S. K. et al 2016: Chemical immobilisation of dholes (*Cuon alpinus*), Indian jackal (*Canis aureus indicus*) and Indian wolf (*Canis lupus pallipes*) with ketamine hydrochloride-xylazine-hydrochloride. *Vet. Medicine and Science* 2, pp. 221-225.

Murthy, K.L.N., Srinivas, V., and Pandey R., 2008, A note on *Escherichia coli* infection and treatment in Dholes (*Cuon Alpinus*) at Indira Gandhi Zoological Park, Visakhapatnam, *Zoo's print* 23 (3), Pp.1.

Pandey, R. (2013): Ex-situ and in-situ conservation: Experiences from Andhra Pradesh. Online publication about a case study from Indira Gandhi Zoological Park, Vishakhapatnam, www.teriuniversity.ac.in/mct/pdf/assignment/Rahul-Pandey.pdf

Paulraj, S., Sundarajan N., Manimozhi A. and Walker S., 1992, Reproduction of the Indian wild dog, (*Cuon Alpinus*) in captivity, *Zoo biology* 11, Pp. 235-41.

Peacock, E. H., 1928, Note on the Malayan Wild dog (*Cuon rutilans*). *Journal of the Bombay Natural History Society* 33 (1), Pp. 200-201.

Pérez Ripoll, M. et al. (2010): Presence of the genus *Cuon* in upper Pleistocene and initial Holocene sites of the Iberian Peninsula: new remains identified in archaeological contexts of the Mediterranean region. *J. of Archaeological Science*, 437-450.

Pocock, R.I., 1936, The Asiatic wild dog or dhole (*Cuon javanicus*), Proceedings of the Royal Society of London. Series B, Biological Sciences, Pp. 33–55.

Pudyatmoko, S., D. S. and Y. Sabarno (2007): Evidence of Banteng (*Bos javanicus*) Decline in Baluran National Park, Indonesia. *J. of Biol. Sciences* 7: 854-859.

Ramalingam, G. and K. L. N. Murthy (2014): Captive breeding of Asiatic Wild Dogs at Indira Gandhi Zoological Park, Visakhapatnam. *Zoo's PRINT*, Vol. XXIX, (10) 1-6.

Riordan, P. et al. (2015): New evidence of dhole *Cuon alpinus* population in north-west China. *Oryx*, 49 (2), 201-206.

Salakij C. et al. 2009, Morphology and Cytochemistry of Blood Cells form Asian Wild Dog (*Cuon alpinus*), *Nat. Sci* 34, 518-525.

Schaller, G.B., 1967, The deer and the tiger, The Chicago University press, Chicago.

Schaller, G. B. and E. S. Vrba (1996): Description of the Giant Muntjak (*Megamuntiacus vuquanensis*) in Laos. *J. Mamm.* 77 (3), 675-683.

Selvan, K. M, Gokulakannan, N. and N. Sridharan (2013): Food habits of dhole *Cuon alpinus* in Kalakad-Mundanthurai tiger Reserve in Tamil Nadu, India. *Asian J. of Cons. Biol.* (2), 69-72.

Sheldon, J., 1992, Wild dogs: The natural history of Wild dogs of the Nondomestic Canidae. Academic Press, Inc.

Shilo et al. 1994: Haltung und Zucht von Rothunden (*Cuon alpinus*) im Zoo Novosibirsk, *Zool. Garten N. F.* 64, Pp 52-54.

Shilo, O.V., Vorobyeva, S.V., Cherniy, V.V., 2007.
Dholes (*Cuon alpinus*) in Novosibirsk zoo.

Sillero-Zubiri, Hofman and Macdonald, 2004, 8.1 Dhole, IUCN/SSC Canid Specialist group, 2004 Published in *Canids: Foxes, Wolves, Jackals and Dogs, Status Survey and Conservation action plan*, IUCN, Gland, Switzerland and Cambridge, UK

Singh Doe, R. S., 1939, Curious behaviour of wild dogs and a panther at a kill. *Journal of the Bombay Natural History Society* 40 (1), Pp. 115.

Sosnovskii, I.P., 1967, Breeding the red dog or dhole *Cuon alpinus* at Moscow zoo. *International zoo yearbook* 7: Pp. 120-122.

Thapa K., et al. (2013).: First camera trap recoded of pack hunting dholes in Chitwan NP, Nepal. *Canid Biology & Conservation*, 4-7. published online: www.canids.org

- Venkataraman, A. B., Arumugam R. and Sukumar R., 1995, The foraging ecology of dhole (*Cuon alpinus*) in Mudumalai Sanctuary, southern India. *J. Zool.*, London 237, Pp. 543-561.
- Venkataraman, A.B.,1998, Male-biased sex ratios and their significance for cooperative breeding in dhole, *Cuon alpinus*, pack. *Ethology* 104, Pp. 671-684.
- Venkataraman, A.B. and Johnsingh, A.J.T. 2004, The behavioural ecology of dholes in India, Pp. 323-356 in D.W. Macdonald and C. Sillero-Zubiri, eds. *The biology and conservation of wild canids*. Oxford University press, Oxford, UK.
- Volodin, I. A., Volodina, E.V., Isaeva, I.V., 2001, Vocal repertoire in the dhole *Cuon alpinus* in captivity. *Zoologičeskij žurnal* 80 (10), Pp. 1252-1267 (in Russian).
- Volodin, I. A., Volodina, E.V., Isaeva, I.V., 2001, Two sounds simultaneously is not a problem for the dhole *Cuon alpinus*, *Advances in Ethology*, 2001 36, Pp. 183-184.
- Volodin, I. A., Volodina, E.V.,2001, Biphonation in the Dhole *Cuon alpinus* vocal behaviour, *Canid Biology and Conservation, An International Conference*, Oxford.
- Volodin, I.A., Volodina, E.V., 2002, Biphonation as a prominent feature of Dhole *Cuon Alpinus* sounds, *The International Journal of Animal Sound and its Recording* 13, Pp. 105-120.
- Volodin, I.A., Volodina, E.V., Isaeva, I.V., Unck, C., 2006, Biphonation may function to enhance individual recognition in the dhole, *Cuon alpinus*, *Ethology* 112 (8), Pp. 815-825.
- Volodina, E.V., Volodin, I.A. and Neprinzeva, E.S., 2004, The dhole locked up in nature, www.zoo.ru/Moscow (In Russian).
- Wang, S.W. and Macdonald, D.W., 2006, Livestock predation by carnivores in Jigme Singye, Wangchuck National Park, Bhutan, *Biological conservation* 129 (4), Pp.: 558-565.
- Wang, S.W., and Macdonald, D.W., 2009, Feeding habits and niche partitioning in a predator guild composed of tigers, leopards and dholes in a temperate ecosystem in central Bhutan, *Journal of Zoology* 277, Pp.: 275–283.
- Wayne, R.K., Geffen, E., Girman, D.J., Koepfli, K.P., Lau, L.M. and Marshall, C.R., 1997, Molecular systematics of the Canidea, *Systematic biology* 46, Pp. 622-653.
- Xue Y. et al. (2015): Records of the dhole (*Cuon alpinus*) in an arid region of the Altun Mountains in western China. *Eur J Wildl Res* 61, 903-907.
- Zhang H. and L. Cheng (2010): The complete genome of dhole *Cuon alpinus*: phylogenetic analysis and dating evolutionary divergence within the Canidae. *Mol. Biol. Rep.* 38(3), 1651-1660.

A full list of articles, books and online publications of dholes in the wild and in zoos can be obtained from the coordinator via heike.maisch@erfurt.de