EAZA Best Practice Guidelines

Burmese Brow Antlered Deer
(Rucervus eldii thamin)

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EAZA 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.

Citation

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Summary

These guidelines are composed of two sections. The first provides and overview of biology, ecology and behaviour in the wild summarising published information referenced at the end of the document. The second section provides information on management in captivity. This section was written using published information and from the findings of a specific study which was published as:

Wall E.L & Hartley M (2017) Assessing enclosure design and husbandry practices for successful keeping and breeding of the Burmese Brow Antlered Deer in European Zoos. Zoo Biology 36(3) 201-212

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Section 1 Biology & Field Data

1.1 Taxonomy

1.1.1 Taxonomic History

First described from Manipur Valley, India, in 1839, the Brow Antlered deer was initially named *Cervus frontalis* (Angom & Hussain, 2013). McClelland (1841) later renamed the deer *C. eldi* after its discoverer, Captain Percy Eld. Subsequently, this species was placed in the genus *Rucervus* (Thomas, 1918). This genus includes the swamp deer, or barasingha (*R. duvaucelii*) and, formerly, the now extinct Schomburgk's deer (*R. schomburgki*) (Corbet and Hill, 1992).

Order:	*Artiodactyla*
Family:	*Cervidae*
Genus:	*Rucervus*
Species:	*Rucervus eldii*
Subspecies:	*Rucervus eldii thamin*
Common name:	Burmese Brow Antlered deer

Figure 1.1: Classification of the Burmese Brow Antlered deer (*Rucervus eldii thamin*) (Myers *et al*, 2015).

1.1.2 Subspecies

There are three historically recognised subspecies of *R. eldii*; the Indian ssp. (*R. e. eldii*), the ssp. found in Cambodia, Lao PDR, Thailand and Vietnam (*R. e. siamensis*) and the ssp. found in Myanmar and western Thailand (*R. e. thamin*) (Angom & Hussain, 2013; Gray *et al*, 2015). More recently, another subspecies, *R. e. hainanus*, has been identified on Hainan Island in China (Gray *et al*, 2015).

1.1.3 Common Names

Other common names for the Burmese Brow Antlered deer are Eld's deer and Thamin. Common names in other languages include Cerf d'Eld (French) and Ciervo di Eld (Spanish) (Gray *et al*, 2015).

1.2 Morphology

The Burmese Brow Antlered deer is a medium sized tropical species; they are sexually dimorphic, with stags weighing around 100kg and hinds weighing about 60kg (Pan *et al*, 2011).

Head-body length: 1.5 - 1.8 m
Shoulder height: 114 cm
Antler length: 99 cm
Tail length: 20 - 30 cm
Weight: up to 150 kg

Figure 1.2: Physical measurement ranges of the Burmese Brow Antlered deer (MacDonald, 2001).

1.2.1 General description

This species is slender with long legs, large ears and a short tail. Stags have large bow-shaped antlers, which sweep backwards with a smaller branch growing forwards towards the face. The antlers are regrown each year (Pickrell, 2002). They have a red-brown coat with lighter underparts; during summer months, the coat is redder than in the winter months, when it turns a darker brown. Males are usually a darker colour than the females and have a thick mane of long fur on the neck. Younger animals possess white spots, which fade with increasing age (MacDonald, 2001).

1.3 Physiology

1.3.1 Antlers

Unique to cervids, antlers are found only in males; female reindeer (genus *Rangifer*) being the only exception to this rule (Shah *et al.*, 2008). The only mammalian organs with the ability to fully regenerate, antlers are bony structures that grow from a 'pedicle' on the deer's frontal skull bone (Sherwood *et al.*, 2008; Li, 2012; Li, 2013). The pedicle develops around puberty due to the elevated testosterone levels and antlers begin to grow with a soft epidermal covering called 'velvet'. This skin is highly vascularised and is present throughout the growth phase of the antlers (Sherwood *et al.*, 2008; Li, 2012).

When the antlers are fully grown and calcified, the velvet is shed (usually by rubbing against trees and other plants (Currey *et al.*, 2009)) and the 'hard' antlers are exposed (Gomez *et al.*, 2013). The hard antlers, as shown by Currey *et al.* (2009), are completely dry and are effective for fights during the mating period. At the end of the breeding season each year, the antlers are cast and new antlers grow in their place (Gomez *et al.*, 2013).

Male Burmese Brow Antlered deer grow antlers that are usually around one metre in height. The antlers are distinctive in that they have a “rocking-chair configuration”; the brow tine and main beam grow horizontally from the pedicle, from a T-shaped joint, in a continuous arc and are often referred to as “lyre-” or “bow-shaped” (Nowak, 1999; Goss, 1983; Naish, 2012). The main beams grow backwards and the ends turn inwards, the brow tines are particularly long and several small tines grow from the apex of the main beam (Goss, 1983).

Reports suggest that in the wild, males cast their antlers annually between June and September, and captive animals exposed to natural photoperiodic rhythms shed them by mid-summer (Monfort *et al*, 1993b; Goss, 1983). In the study by Monfort *et al* (1993b) in captive males, new velvet antler growth was recorded between the end of summer to early winter. By the January, the same males had shed their velvet.

1.3.2 Digestive system

Burmese Brow Antlered deer, like all cervids, are ruminants. They are foregut fermenters with a compartmentalised stomach; this is the site of anaerobic microbial fermentation. This fermentation results in the end products, volatile fatty acids (VFAs), which are the primary energy source available to ruminants. Ruminants often regurgitate ingested food material to chew again, known as “rumination” or “chewing the cud” (Cheeke & Dierenfeld, 2010).

1.4 Longevity

Life expectancy of wild Eld’s deer is 5.29 ± 3.57 years (Nie *et al*, 2011) in comparison to 5.07 ± 1.88 years in European zoos. There is no significant difference recorded in lifespan of wild males and females. Captive animals can live much longer than the average life expectancy however; one female recorded in the EEP was over 18 years old.

1.5 Zoogeography and ecology

1.5.1 Distribution

The Burmese Brow Antlered deer was once widely distributed across Myanmar, and populations were still relatively widespread as late as the 1980s. However, it is now recognised that this species is restricted to small, fragmented populations across its former range, with a large proportion of individuals residing in protected wildlife areas, including Chatthin Wildlife Sanctuary (CWS), Hlawga Wildlife Park and Shwesettaw Wildlife Sanctuary (Gray *et al*, 2015).

1.5.2 Habitat

Burmese Brow Antlered deer favour 'indaing' forest, or deciduous dipterocarp forest, which is the most abundant of forest types in southeast Asia (McShea *et al*, 1999). The tree, *Dipterocarpus tuberculatus*, dominates this forest type. There are two other forest types utilised by this species; dry (thandahat) and mixed (teak) deciduous forests. Annual rainfall is between 100-200 cm for all three types (Prescott 1987, Bronson 1989, McShea *et al*, 1999, McShea *et al*, 2001, Myint Aung *et al*, 2001). Indaing forest provides fruits and grasses required by the deer, and the abundance of fruits is higher during the rainy season. This species will also avoid densely vegetated areas and very open habitats, such as grasslands (McShea *et al*, 2001).

Studies have shown that this species prefer mature indaing forest to younger forest, and favour either indaing forest type above degraded forest. However, the deer will use degraded forest areas during the rainy season. In the Chatthin Wildlife Sanctuary, the boundary of the protected area is mainly degraded forest. It has been hypothesised that the deer utilise these outskirts during the rainy season to avoid the increases in flooding, biting insects and vegetation cover (McShea *et al*, 2001). The movement of this species during the dry-season is relatively dependent on the location of available water sources (Gray *et al*, 2015).

The Burmese Brow Antlered deer will shift their choice of habitat at the end of the cool season when crops are being harvested. There is a heavy reliance on cultivated crops by this species, including lentils, rape, peas, rice and maize, despite the availability of natural food sources. As a result, crop-damage is common and can lead to human-wildlife conflict (McShea *et al*, 2001).

It is thought that there are no remaining areas of pristine habitat left within the Myanmar range (McShea *et al*, 2005).

1.5.3 Population and conservation status

According to the IUCN Red List criteria, the Burmese Brow Antlered deer is listed as Endangered (EN). CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) has classified this species as Appendix I as of 1975, meaning that international trade is restricted (Gray *et al*, 2015). The monitoring of the population across the last few decades is outlined in Fig. 1.3.

1.5.4 Threats

Burmese brow antlered deer are the most vulnerable subspecies of Eld's deer to poaching in response to meat consumption (Salter & Sayer, 1986). Hunting parties are most often accompanied by dogs, which are a problem for fawns in particular. Domestic dogs have been found to predate upon fawns of other subspecies of Eld's deer in areas such as Lao PDR (Tordoff *et al*, 2005).

The real impact of exploitation of Eld's deer for medicinal products is as yet unknown; there are, however, reports that the products obtained from these subspecies are more valuable than those from other species of deer (Zeng *et al*, 2005). This species may also be hunted for their antlers to be used as trophies (Gray *et al*, 2015).

There is little evidence of human-wildlife conflict between local communities and Burmese brow antlered deer, despite the rice and other agricultural crops being part of the deer's diet (McShea & Myint Aung, 2001). The absence of conflict is thought to be due to the low population sizes of this species and, therefore, minimal problems with crop raiding (Duckworth in litt, 2008).

Habitat loss has had a significant impact on the populations of Eld's deer; human encroachment, agricultural expansion, extraction of minerals and developments such as roads are just a few examples of the large-scale conversion of habitats (Gray *et al*, 2015). Since the political events in 2011, the expansion of commercial agriculture has gathered pace at an "unprecedented rate", meaning that the biodiversity of Myanmar is now at risk more than ever before (Myanmar Now, 2015).

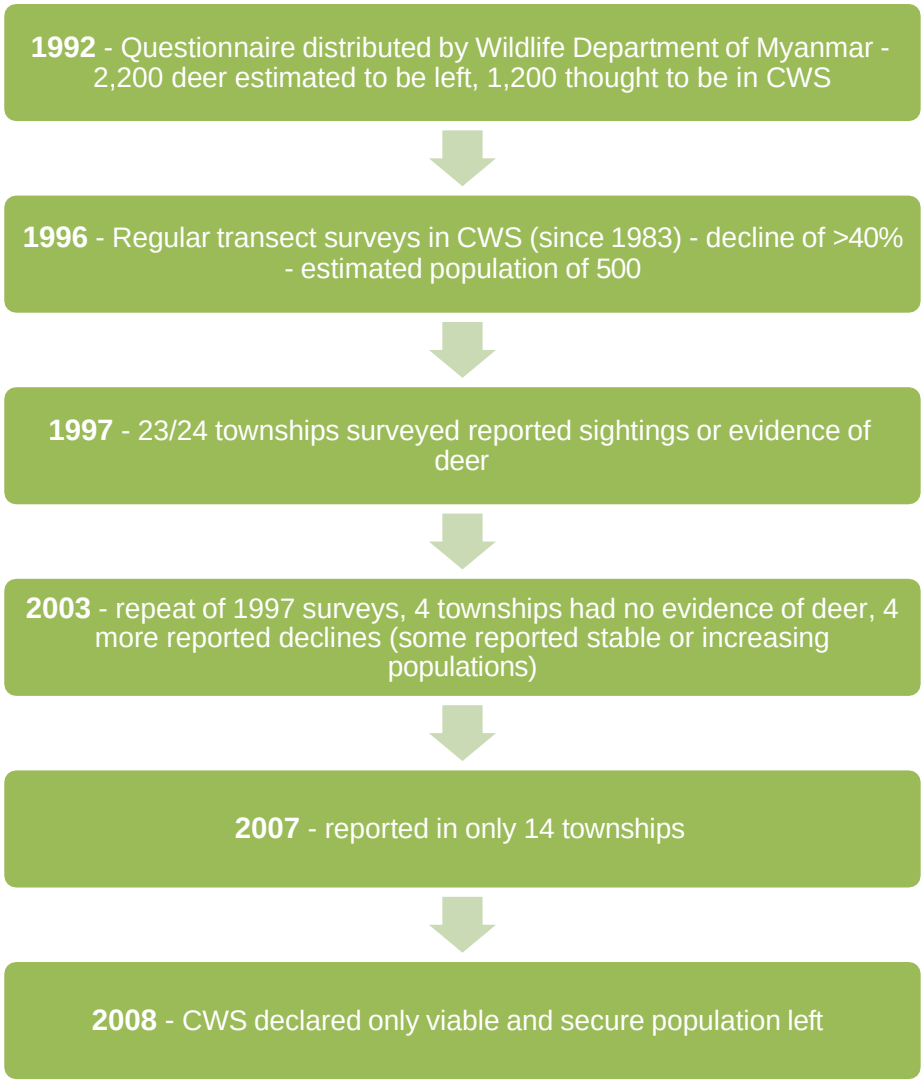


Figure 1.3: Population of the Burmese Brow Antlered deer in the wild.

1.5.5 Conservation actions

There are several wildlife sanctuaries in the Burmese Brow Antlered deer's native range, most notably the Chatthin Wildlife Sanctuary (CWS). Established in the Sagaing region in 1941, the CWS covers 103 sq miles of protected indaing forest, ideal habitat for the species. CWS currently employs 34 staff members, who carry out patrols of the protected areas. Historically, these rangers would hear gunshots and be able to locate and arrest poachers. However, since the Smithsonian Institute withdrew funding for CWS in 2003, there are fewer patrols and populations have declined; it is not known if this is a causal link (Gray *et al*, 2015; Myanmar Now, 2015). Poachers have also developed new hunting methods, including steel and wire traps, which cannot be heard and traced in the same way as gunshots. It is thought that the lack of funding for the CWS may be detrimental for many native species that live in the protected area (Myanmar Now, 2015).

1.6 Diet and feeding behaviour

1.6.1 Food preference

Burmese Brow Antlered deer are predominantly grazers, eating a variety of plant species, but are also "opportunistic browsers", supplementing their diets with fallen wild fruits and cultivated crop species such as rice (McShea *et al*, 1999).

1.7 Reproduction

Burmese Brow Antlered deer have 58 chromosomes, or 29 pairs. Sex determination is as follows; male deer have XY chromosomes and females have XX (Neitzel, 1979; Thévenon *et al*, 2000).

1.7.1 Sexual maturity

Both male and female Burmese Brow Antlered deer reach sexual maturity at approximately 1.5-2 years of age and females remain fertile for 12-14 years (Wemmer & Grodinsky, 1988, Grzimek, 1995). Records of the captive European population, however, show that females can become pregnant before the recorded age of sexual maturity.

1.7.2 Seasonality

The Burmese Brow Antlered deer is a tropical, roughly seasonal breeder; the mating season, or the 'rut', occurs during late winter to early spring (Monfort *et*

al, 1990; Monfort *et al*, 1993a). This seasonality remains when animals are translocated to northern hemisphere environments. As this species inhabits tropical areas without distinct seasonal patterns, they are thought to breed in response to rainfall patterns instead of photoperiodic rhythms (Aung *et al*, 2001).

1.7.3 Reproduction in females

Female Burmese Brow Antlered deer are seasonally polyoestrus and are spontaneous ovulators. They experience regular cyclic activity, which starts in January to March, and continues until August to October each year. The average oestrus cycle lasts for 21.5 days, although this is highly variable between individual females (Monfort *et al*, 1990; a).

Behavioural oestrus was recorded during 42 out of 65 oestrus cycles, in a study by Monfort *et al* (1990). Exposure to stags and chemosignals from stags may advance the onset of behavioural oestrus and the preovulatory luteinising hormone (LH) surge. This preovulatory LH surge precedes ovulation and lasts between 2-3 hours, which is much shorter than in other deer species (Hosack *et al*, 1999).

1.7.4 Reproduction in males

Male Burmese Brow Antlered deer exhibit “circannual hypothalamic-pituitary-gonadal” rhythms with regards to their hormonal cycles. Testosterone secretion peaks in January (early winter), resulting in maximal antler lengths, body weights and chest spans between December and January, in preparation for the rut. In addition, scrotal circumference and testes weight are greatest in mid-winter. Behavioural aggression and neck girth of males peak between March and May. While motile spermatozoa are produced year-round in this species, the largest numbers of spermatozoa per ejaculate are observed across winter and spring (Monfort *et al*, 1993b).

1.7.5 Gestation period and birth

The gestation period of the Burmese Brow Antlered deer is around 35 weeks, or 240 days. 80 % of births occur between September and November and hinds will give birth to a single calf (Wemmer & Grodinsky, 1988; Monfort *et al*, 1990; Pan *et al*, 2011). Post mortem examination of a Burmese Brow Antlered deer placenta showed five large, flat cotyledons, an umbilical cord of 15cm in length and a placental weight of 550g (Hamilton *et al*, 1960).

Burmese Brow Antlered deer are a ‘hider’ species (mothers hide their calves after birth), which is thought to be an anti-predation strategy. Calves are born at the time of year with the most vegetation cover for shelter and protection, and after the monsoon season to reduce the risk of thermoregulatory problems (Aung *et al*, 2001). Wild neonates are vulnerable to accidents, starvation and, most notably, predation (Linnell *et al*, 1995). Fawns are born with spots that fade over the first few months after birth (Grzimek, 1995).

This species are especially susceptible to neonatal mortality in captivity (death before 30 days of age), with mean mortality rates of 51% in male neonates and 38% in female neonates recorded in European zoos. Maternal inexperience, cold weather and disease are some of the causes of neonate deaths. Due to the seasonality of the breeding period and the incorrect timing of conception, captive calves are subject to an increased risk of mortality and lower growth rates (Asher *et al*, 1999).

1.8 Behaviour

1.8.1 Activity

This species is crepuscular in its activity patterns, with peaks in activity occurring at dusk and dawn. However, a study by Pan *et al* (2011) showed that this species becomes more nocturnal with closer proximity to human populations.

1.8.2 Predation

Historically, predation of the Burmese Brow Antlered deer was mainly by tigers (*Panthera tigris*), leopards (*Panthera pardus*) and dholes (*Cuon alpinus*). More recently, due to the extirpation of tigers from Myanmar, leopards, dholes and jackals are responsible for the predation mortality of this species. Staff members of the Chatthin Wildlife Sanctuary have reported hunting of this deer by feral dogs (Aung *et al*, 2001).

1.8.3 Sexual behaviour

In wild populations, males are solitary until the rut, when they will begin to form groups with several females. Stags of this species have adopted a “tending-bond” mating strategy, defending their harem of females against advances and competition from other stags until mating occurs (Hosack *et al*, 1999).

Burmese Brow Antlered stags in captive environments have been recorded as using “latrines”, areas in which they defecate and urinate frequently. It is thought that these areas are important markers of the stag’s status within the herd, or his body condition (Hosack *et al*, 1999).

Hand-reared stags can become extremely aggressive towards humans during the breeding season if they are not castrated. Due to the potential physical threat that they pose, hand-reared males are rarely a favourable option (Gilbert, 1974).

Section 2 Zoo Management

2. Enclosure

Due to the natural tropical climate of the Burmese Brow Antlered deer, both indoor and outdoor facilities should be provided when kept in the northern hemisphere; both are described in this section.

2.1 Indoor enclosure

The indoor enclosure should be completely off-show to the public for privacy; these deer are incredibly susceptible to visitor presence. 24-hour access to indoor enclosures should be available to the deer to allow refuge and retreat from the public, or other individuals in the enclosure. During periods of particularly cold or icy weather, the deer may be kept indoors possibly with access to a small hardstand outside.

Figure 2.1: Example of an indoor enclosure for the Burmese Brow Antlered deer; fully and partially slatted side panels to allow visibility of the deer, while reducing stress of keeper presence (Prague Zoo, Czech Republic).

2.1.1 Indoor boundary

All boundaries when holding this species should be at least 8 feet (2.5m) high (AZA Cervid TAG, 2015). It is advised that the bottom half of boundaries should be full panelled and the top half slatted to allow visibility of the deer, while reducing the stress of keeper presence (shown in Fig. 2.1).

While negative interactions between male conspecifics has not been reported frequently in European collections, male animals may need to be housed separately in individual stalls, especially during the rut. The use of metal sheet panels in male enclosures can reduce the chance of aggression between individuals, particularly if more than one male is kept (Reed, 2011).

2.1.2 Indoor substrate

Indoor flooring is usually concrete or other hardstand material, with the provision of other substrates, such as straw, wood shavings or bark, for use as bedding. Extra bedding is advised in winter for warmth.

2.1.3 Indoor furnishing and maintenance

Hard surfaces should be swept or cleaned with water and substrate should be raked over daily. Males can cause damage to the enclosure and facilities during the rut, and indoor furnishings should be safe for males to prevent injury to antlers, in velvet and hard stages. Water troughs or buckets should be provided in the indoor enclosures; appropriate sturdy water receptacles should be given to males to prevent tipping and injury.

2.1.4 Indoor environment

It is strongly recommended that heating be provided in indoor facilities in temperate climates. Facilities should be heated above 12-15°C, depending on the time of year (i.e. increase temperatures during particularly cold or icy periods). The life expectancy of this species increases with increasing average annual temperatures (Wall & Hartley, 2017). Heating can be provided from panel heaters, radiant heaters and heated floors and walls.

Desensitising the animals to keeper presence is important to avoid risk of injury, as this species is incredibly flighty. The use of a radio has been used in some institutions at low volumes to familiarise animals to human voices and louder volumes can “muffle” unfamiliar noises and sounds (Reed, 2011). Quick and quiet work is important for reducing the time spent in indoor enclosures.

2.1.5 Indoor dimensions

Indoor stalls for overnight or winter housing should be approximately 10m^2 and can hold several individuals; this species tend to herd together in captive environments. Males may be kept in similar sized stalls, but housed individually due to their temperament.

2.2 Outdoor Enclosure

2.2.1 Outdoor boundary

As in indoor enclosures, boundaries should be 2.5m (8 feet high. Appropriate fencing materials include walls, deer stock and chain link fencing, and electric fencing. The use of dry and water-filled moats is also useful.

The distance between visitors and enclosure boundaries should be as large as possible; high visitor presence can have detrimental effects on this species' life expectancy and reproduction, particularly in female Burmese Brow Antlered deer (Wall & Hartley, 2017). The use of additional fencing, screening and camouflaging (e.g. vegetation, bamboo screens, netting, etc.) around the outdoor boundary is recommended as a buffer to high levels of visitors. The high distance between boundaries is also useful in preventing aggression and risk of injury by males in rut that may attack the fencing.

2.2.2 Outdoor substrate

The outdoor enclosure should offer adequate grass for grazing, as these deer are predominantly grazers (as described in section 1.6) and grass can provide a significant part of their diet, especially in summer months. The deer should have access to some hard surface areas, such as concrete hardstands, as well as areas of dirt or sand. The outdoor substrates used in European zoos are shown in Fig. 2.2.

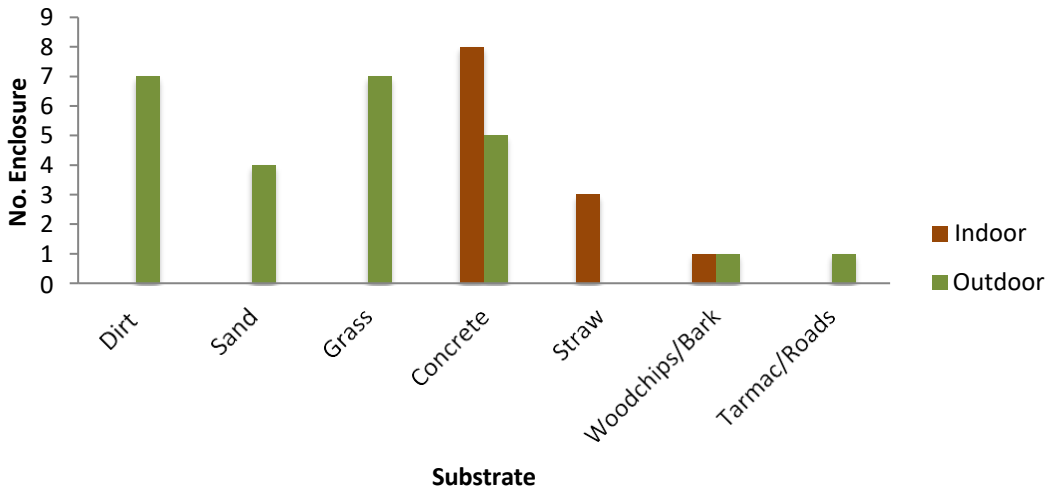


Figure 2.2: Frequency of substrates used in outdoor enclosures for Burmese Brow Antlered deer in EAZA zoos (Wall & Hartley, 2017).

2.2.3 Outdoor furnishing and maintenance

In the wild, this species favour medium canopy forests, and therefore require a good level of cover or shelter in the outdoor enclosure. Poor enclosure cover has been linked to neonatal mortality of female Burmese Brow Antlered deer in

European zoos (Wall & Hartley, 2017). Provision of sufficient natural cover (e.g. trees, vegetation) and man-made shelters are advised to mimic their wild habitat preferences and allow retreat.

If trees and shrubs are provided in the enclosures, they should be well protected against over-browsing and bark stripping. In mixed-species exhibits, species-specific shelters are recommended; this is discussed further in section 2.4.3. Dead trees and logs provide ideal rubbing posts for males shedding their antler velvet.

It may be advisable to provide several hayracks in the outdoor enclosure (for hay or lucerne), in order to encourage movement and interaction within the enclosure (C Galeffi, pers. comm.).

2.2.4 Outdoor dimensions

Outdoor enclosure area should total approximately 200m^2 per individual; i.e. a herd of 7 Burmese Brow Antlered deer should be housed in a 1400m^2 enclosure. As a secretive species, deer tend to hide away from visitor boundaries and fences and remain at the rear of enclosures. It is important that enclosure shape takes this into consideration and does not force deer into close proximity to visitors.

2.3 Feeding

2.3.1 Basic diet

Good quality lucerne (alfalfa) hay should be available throughout the day, rather than fed at separate 'mealtimes'. Pelleted diets should be provided in addition to hay and increased during times of poor hay quality; there are many commercial grazer and browser diets available (Nijboer, 2015). Alfalfa pellets (12.5% protein) are ideal and should be fed at 2-3% of body weight daily. The daily ration per adult animal should be roughly 1kg of hay and pellets (Pukazhenthi *et al*, 2003).

Daily provision of browse can be used as a form of enrichment, as well as supplementing the main diet. Some of the species that are regularly offered to the deer are listed below:

- Acacia (*Acacia spp.*)
- Willow (*Salix spp.*)
- Oak (*Quercus spp.*)
- Birch (*Betula spp.*)
- Beech (*Fagus spp.*)

Care should be taken with trees and plant species in the enclosure as the deer may browse these in addition to their diet.

Root crops can also be used to supplement the winter seasonal diet (Miller & Fowler, 2014). If supplementing the diet with fruits and vegetables, the amounts should account for <10% of the total diet (Nijboer, 2015).

Usually, mineral levels in pasture are sufficient for deer species; mineral supplements, such as copper, should only be used when grazing areas and forage are deficient in dietary minerals (Miller & Fowler, 2014). It is advised that commercial trace mineral blocks and salt licks (such as cattle products) are provided *ad libitum* for this species.

2.3.2 Special dietary considerations

The body condition of the deer should be monitored regularly. When overwintering this species indoors, and in order to reduce the risk of obesity, supplementary feeding can be reduced as energy requirements will be lower. Additionally, overfeeding of dams in late pregnancy can result in dystocia during parturition due to large calves (Miller & Fowler, 2014). Nutritional management plans should take into account the higher energy requirements of lactating females.

2.3.3 Method of feeding

For pelleted diet rations, deer can be fed using buckets, troughs or ground-level feed pans. When feeding groups, multiple feeding stations are advisable, to reduce the chance of dominant individuals from “monopolising” the food (Pukazhenthi *et al*, 2003). Deer can be fed once daily. Hayracks should be suspended at approximately 1.5m high, preferably in the indoor stalls.

Browse can be suspended from different furnishings within the indoor and outdoor enclosure areas. If feeding fruits and/or vegetables, these can be scattered within the enclosure as a form of environmental enrichment.

2.3.4 Water

Clean fresh drinking water should be provided *ad libitum* (DEFRA, 2012). Water may be provided in troughs, buckets and self-feeders, as well as natural sources of water (e.g. ponds, streams, moats).

2.4 Social Structure

The social behaviours of wild Burmese brow antlered deer are described in section 1.8.3.

2.4.1 Basic social structure

Female Burmese brow antlered deer can be kept in relatively large groups within captivity; in European zoos, female group sizes range from 4 to 14 individuals. Hinds can be housed together all year round with minimal risk of

aggressive behaviours, as dominance hierarchies are quickly established within groups (Pukazhenthi *et al*, 2003).

Keeping and housing multiple stags of this species, however, can prove much more challenging in terms of management. During the rutting season, males should be housed singly to prevent injury (or fatalities) as a result of aggressive displays. If housing deer indoors during the winter months, males should be kept separate again, due to the confinement and proximity to one another. Outside of these periods, this species can be kept in single-sex groups in paddocks and animals can be moved between enclosure areas to allow mating (Pukazhenthi *et al*, 2003).

2.4.2 Changing group structure

It should be noted that prior to any introductions, deer should be allowed appropriate visual, olfactory and auditory exposure.

Introducing a new female: Females can be introduced with few issues, again because their hierarchies are established relatively quickly.

Introducing a new male: Introductions of males to females outside of the breeding period can be relatively straightforward. Introducing male conspecifics should only be completed outside of the breeding season.

Introductions for breeding purposes: Hosack *et al*. (1999) established that housing a group of female Burmese brow antlered deer with a stag improved ovarian function and oestrus synchronisation.

2.4.3 Sharing enclosure with other species

The Burmese Brow Antlered deer has been successfully housed with a number of different species, mostly hoofstock, outlined in the table below. Housing this species with, or alongside, more popular and well-recognised species is useful for highlighting their conservation status and threats (Veasey & Hammer, 2010).

Mixed-species exhibits can result in negative interspecific interactions between individuals including displacement behaviours and aggression. Burmese Brow Antlered stags have previously shown slight aggression towards males of other species within the same enclosure, particularly during the rut, although no serious direct negative interspecific interactions have been recorded in European zoos. Males and females have also associated with groups or herds of a different species.

The use of species-specific boundaries can be useful in providing the deer with a retreat area that cannot be access by larger species; for example, using poles inside the perimeter of an enclosure, placing them with just enough space between them to allow the deer through, can offer the deer the opportunity to avoid other individuals and species.

TABLE 1: A list of the species that have been successfully housed with the Burmese Brow Antlered deer (Wall & Hartley, 2017; AZA Cervid TAG, 2013).

Species	Scientific Name
Axis deer	*Axis axis*
Bactrian camel	*Camelus ferus*
Banteng	*Bos javanicus*
Barasingha	*Cervus duvaucelii*
Bar-headed goose	*Anser indicus*
Blackbuck	*Antilope cervicapra*
Eastern bongo	*Tragelaphus eurycerus*
Emu	*Dromaius novaehollandiae*
Fallow deer	*Dama dama*
Formosan sika deer	*Cervus nippon taiouanus*
Gaur	*Bos gaurus*
Greater-one horned rhino	*Rhinoceros unicornis*
Hog deer	*Axis porcinus*
Muntjac	*Muntiacus reevesi*
Nilgai	*Boselaphus tragocamelus*
Pere David's deer	*Elaphus davidianus*
Pig-tailed macaques	*Macaca nemestrina*
Siamang	*Symphalangus syndactylus*
Wallaby	*Macropus rufogriseus*
White-naped crane	*Antigone vipio*

Keepers at some zoos have reported that the deer often have to compete with larger animals, such as gaur (*Bos gaurus*), banteng (*Bos javanicus*) and camels (*Camelus ferus*), for resources, including sheltered facilities. It is recommended that there are an adequate number of shelters available, or that species-specific shelters are provided for the Burmese Brow Antlered deer in large mixed-species exhibits, as well as specialised retreat areas within the enclosures.

The potential for hybridization with other deer must be recognised and managed. There have been cases of hybridization with *Cervus nippon* in the EEP population.

It should also be noted that mixed-species exhibiting can results in increases in parasite transmission and individual burden (Fontenot & Miller, 2014), as well as the risk of other diseases (See *Section 2.8*).

2.5 Breeding

Details of the breeding behaviours and biology of this species are outlined in section 1.7.

2.5.1 Mating

During the mating season (February to June, Pan *et al*., 2011), this species display various behaviours associated with breeding. Typically, males will show aggression towards their male conspecifics, although, less commonly, zoos have reported aggression that is directed at their keepers and handlers. Males will often chase and mount females before mating. Post-copulatory guarding of females is likely to occur, with guarding by dominant males lasting longer than that by subordinate males (Zeng *et al*., 2011). Other male behaviours include rutting with other males and males following females in oestrus. It should be noted that as a secretive species, most behaviours are performed late in the evening or in the night.

2.5.2 Pregnancy

The gestation period for this species is 240 day or 35 weeks. The females do not normally exhibit any specific behaviours during pregnancy (at least whilst under observation), until the period before parturition (see Section 2.5.3). Slight increases in body weight may be observed but it has been noted by some zoos that it can be difficult to accurately detect the start of milk production.

2.5.3 Birth

Zoos and wildlife parks have reported that before parturition, the pregnant female will separate herself from the herd and search for a quiet place to give birth (Questionnaire). Burmese Brow Antlered deer are a hider species, meaning that the dam will find somewhere safe and private to leave the fawn after birth, supposedly as an anti-predator strategy (Aung *et al*, 2001).

Twinning is uncommon in this species, and if it occurs, may prove problematic, due to “placental insufficiency” or dystocia (Njaa, 2012). Dystocia is also a potential issue for overweight dams of this species; obstruction of the pelvic canal by large fat deposits can result in difficulty during parturition (Njaa, 2012). Ingestion of endophyte-infected tall fescue forage can also cause abdominal fat deposits and contribute to problems with parturition (more information in Section 2.8.4) (Wolfe *et al*, 1990; Njaa, 2012). As dystocia can be fatal for both the dam and fawn, emergency caesarean section is usually required. It is also advisable to remove affected dams from the breeding herd or to treat with contraceptives (Njaa, 2012) (Section 2.5.6).

2.5.4 Development and care of neonates

Some zoos have reported poor maternal care of neonates; in these exceptional cases, female neonates may be hand-reared (details in Section 2.5.5), however

this should be carefully considered and used as a “last resort” when all other options have been exhausted.

2.5.5 Hand rearing

Hand rearing of deer should only be undertaken in exceptional circumstances; natural rearing is much preferable in most cases. Hand reared stags can become extremely aggressive towards handlers, especially during the rut, if they are not castrated (Gilbert, 1974; EAZA, 2014). Female Burmese Brow Antlered hand-rears, however, have not been reported to become aggressive towards keepers and may act as ‘Judas’ deer, leading their conspecifics into indoor facilities when called, for example (M Hartley, pers. comm.).

Record Keeping
When hand rearing fawns, good record keeping is essential; fawn weights, food intake and health and behavioural observations should all be recorded regularly and accurately. Fawn weight at the time of removal from the mother, and subsequent daily weights, should be recorded. Composition of milk and amount offered/taken and the occurrence of urination/defecation should also be reported. Until around 7 weeks of age, fawns will need to be stimulated to urinate and defecate. This can be achieved by gently stroking the anogenital region with a warm damp sponge. Whilst fawns may start to urinate and defecate on their own from around 3 weeks old, stimulation should continue (Pukazhenthi *et al*, 2003; SCBI, 2015). During the first 24-48 hours, the fawns will pass dark, sticky faeces called ‘meconium’. The fawn will then pass paler, soft faeces until around 3-4 weeks of age, when dark, firmer pellets will start to form (SCBI, 2015; Bourne, 2016).

Housing
Fawns should be housed in heated stalls, bedded with straw (Pukazhenthi *et al*, 2003). The housing should be draught-free and provide an area or corner in which the fawn can hide (Bourne, 2016). It has been reported that fawns that are housed together during hand rearing are more likely to begin urinating and defecating without stimulation sooner than those which are housed alone (SCBI, 2015).

Equipment
- Lamb bottle, or human baby bottle
- Artificial lamb’s nipple with 1cm opening cut into the top
- Large containers for storing milk/formula
- Equipment for heating milk/formula
- Measuring cups/containers

Equipment should be cleaned between feeding with a sterilising product such as Milton®.

Colostrum
Colostrum should be given to the fawn within the first 24 hours after birth, as immunoglobulin absorption is highest around 12 hours after birth and is critical

for the survival of the neonate (Robbins *et al*, 1987). If the fawn has not fed from the mother or colostrum intake is considered to be inadequate (i.e. passive immunoglobulin transfer has failed), soluble colostrum powder or frozen colostrum should be used within the first 24 hours after birth (Pukazhenthi *et al*, 2003).

Milk Composition

The first feed away from the mother should consist of an oral rehydration fluid to replace the fawn's electrolyte balance; a suitable product is Lectade®.

Eld's deer have been reared successfully on commercial lamb milk replacers with a crude protein of approximately 28% and crude fat of 30%.

Alternatively, when these commercial products are not available hand rears can be fed on evaporated milk (e.g. Carnation® canned condensed milk) either undiluted or in solution with equal parts cooled boiled water (Pukazhenthi *et al*, 2003; SCBI 2015). If fawns are dehydrated, the boiled water can be substituted for an oral rehydration fluid. A few drops of an iron-free paediatric vitamin solution (e.g. Abidec®, Poly-Vi-Sol®) should be added to the milk solution, along with a pinch of table salt. If mixing condensed milk with water, the proportion of milk should be increased gradually from 1 week of age to 3 weeks, when undiluted condensed milk (plus vitamins and salt) should be fed (Pukazhenthi *et al*, 2003). If the proportion of milk is increased too quickly, fawns may suffer from diarrhoea; in these cases, reduce the amount of milk to a level that did not result in diarrhoea. An oral rehydration solution can be added to the milk in this instance (Pukazhenthi *et al*, 2003).

Feeding Regime

Feeding amounts and timings are described in Table 2. Daily food rations should total 18-20% of total body weight. The first feed away from the dam may be delayed in order to increase the fawn's appetite and "bottle acceptance" (Pukazhenthi *et al*, 2003). The first use of a bottle will require patience and encouragement of the fawn, as they are easily distracted (SCBI, 2015).

The calf should be in a standing position when fed, and the bottle should be angled at around 45°, directed up to the roof of the mouth. The fawn's muzzle may be held gently but firmly while the bottle is in their mouth. If the fawn is reluctant to feed, small amounts of milk may be expressed into the mouth from the bottle. Care should be taken when feeding to avoid problems such as tracheal aspiration and pneumonia. The throat and anogenital region can be gently massaged in order to promote suckling (Pukazhenthi *et al*, 2003; Bourne, 2016).

Weaning

Fawns should be weaned from 109-135 days of age; at this point, they should be refusing bottles. Solid food (e.g. alfalfa pellets soaked in warm water and mixed with milk) may be offered *ad libitum* from a few days old, but fawns may be uninterested until around 3 weeks old (Pukazhenthi *et al*, 2003; SCBI, 2015). Fawns should be encouraged to use a trace mineral block and a pan of dirt

should be offered, so that they can obtain minerals, such as iron (SCBI, 2015; Bourne, 2016).

Table 2: A table showing the average milk intakes, daily feed frequencies and average fawn weights, used at SCBI (Reed, 2011).

Day *postpartum*	Milk Intake (ml)	Feed Frequency (feeds per day)	Fawn Weights (kg)
1	170	4 – 5	4.5 – 7
7	230	4	5 – 7
14	230 – 280	3-4	N/A
21	230 – 340	3	7.5 – 10
28	280 – 400	3	8 – 11.5
35	340 – 400	3	9 – 13
42	400	3	10 – 16
49	400 – 450	3	11.5 – 16.5
56	400 – 450	3	14 – 18.5
63	450 – 570	2-3	16 – 19
70	510 – 625	2	16 – 20
77	510 – 625	2	17 – 21.5
84	570 – 625	2	19 – 23
91	570 – 625	1-2	21 – 23
100	570	1	22 – 25
109-135	*Weaned*	0	N/A

Table 3: A table showing suggested feeding times for hand rearing, dependent on feed frequency, used at SCBI (Reed, 2011).

Feed Frequency	Feed Timings (hours)			
4	0730	1130	1530	2300
3	0730	1530	2130	
2	0730	1530/2100		
1	0800			

2.5.6 Contraception

When coordinating breeding animals and genetic management in collections, contraception is a useful way to prevent unwanted pairings or pregnancies within herds of the Burmese Brow Antlered deer.
The information below is a summary of published information. Products may not be available in some countries. The current advice from the EAZA Group for Zo Animal Contraception is in Appendix 1 of these guidelines. They can be contracted for advice and feedback. GnRH implants are currently the most commonly used contraception in the EAZA herd.

MGA implants
The most commonly used progestin in zoos is melengestrol acetate (MGA), a progestin that suppresses ovarian cycling (Patton *et al*., 2007). MGA has been shown to be safe to use in pregnant and lactating animals, without causing deleterious effects in either the mother or nursing young (Asa & Boutelle, 2011). Implants are by far the most common way that progestins have been used since the 1970s; MGA implants may be inserted surgically. Group-living animals should be separated after the insertion to prevent over-grooming of the implant site. Disadvantages of the implants are possible loss or migration, although implants may be sutured to the muscles to prevent this. It is recommended that MGA implants are replaced every 2 years, but the contraceptive effects may last longer than this. It is then important that implants are removed before their contraceptive effects are reversed (Asa & Boutelle, 2011).

Immunocontraception
Vaccinations containing porcine zona pellucida (PZP) antigens are commonly used to prevent fertilisation of ova by effectively blocking sperm receptor sites on the surface of the egg; this method has been successful in Eld's deer (Kirkpatrick *et al*., 2009). PZP treatment initially requires two injections, given 30 days apart, then boostered annually in this species. PZP use is safe to administer during pregnancy and lactation. Short-term use will result in reversible results, however long-term use may cause ovarian failure and is therefore not suitable for 'genetically valuable' animals (Asa & Boutelle, 2011).

Male contraception
Males may be either castrated or vasectomised. Castration is a relatively simple procedure and is irreversible, so should only be considered in animals that are not valuable to the breeding population of this species. The resulting decline in testosterone will disrupt the seasonal cycles of secondary sexual characteristics, including the antler cycle in this species.

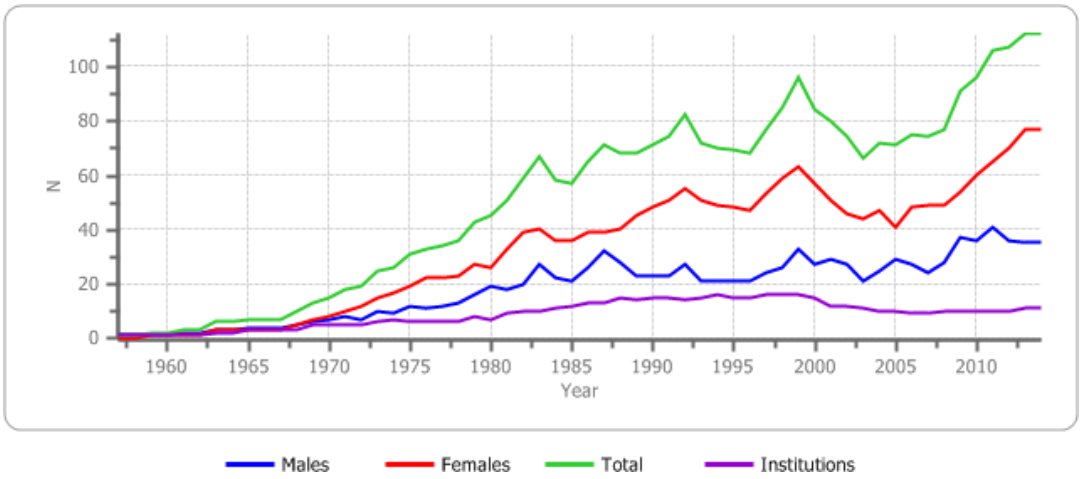
Vasectomy can be carried out in animals in such a way that can be reversed to prevent permanent sterilisation, but requires "highly skilled microsurgery". While vasectomy reversal is not 100% reversible, high pregnancy rates have been recorded. This method is preferable to castration due its potential reversibility and the maintenance of secondary sexual characteristics (i.e. antlers) (Asa & Boutelle, 2011).

2.5.7 Population Management

The first recorded instance of the Brow Antlered deer *(Rucervus eldii simaensis)* in European zoos was in 1957 at Paris Zoo. Imported animals from Rangoon Zoo (Myanmar) to Berlin Zoo and Leipzig Zoo formed the basis of the European captive population that persists today.

Currently there is only a 39% known pedigree. This is due to historical and continued failure to identify parents of offspring due to either multiple males being held or females not being identifiable from a distance. In order to try and reduce this issue in the future all holders will only hold one adult male and it is recommended to use ear tags for identification in females.

In 2013, there was a European StudBook (ESB) programme in place for this species, and this was upgraded to EEP (European Endangered Species Programme) in 2015. As of 2015, there were 10 collections in Europe that kept



this species, and 91 (20.71.0) Burmese Brow Antlered deer kept in European institutions. Unlike some cervid species, the captive Burmese Brow Antlered deer population growth rate has remained relatively low (Figure 2.3) and the species are kept in the same small number of collections.

Figure 2.3: Growth of European captive population of Burmese Brow Antlered deer.

2.6 Behavioural Enrichment

Natural browse can be provided for environmental enrichment; more details are provided in section 2.3.1. Provision of dead trees and logs are useful for males shedding their antler velvet.

During the rut, males can cause substantial damage to enclosure furnishings. In order to reduce damage, Jolly Balls® or Boomer Balls® can be provided to stags as enrichment items. Different sizes are available and smaller sizes should be given to younger males to prevent antler breakage. These have proved successful in reducing “wear and tear” to holding facilities (Reed, 2011).

2.6.1 Training

Habituation of various routine management practices is possible in this species. With the use of suitable handling facilities and restraint devices, such as the Fauna Tamer II (Fig. 2.4, below) which is used for this species by the Smithsonian Institute. Careful handling and training can result in the possibility of carrying out veterinary procedures such as vaccination, venepuncture and general health examinations (Masters & Flach, 2014).

Figure 2.4: Fauna Tamer II (Fauna Research Inc.) Drop Floor Chute for animal restraint.

2.7 Handling

2.7.1 Individual identification

Animals recorded in studbooks should be individually identified with permanent markers, such as transponders and ear tags. While other methods are available (e.g. tattooing, ear notching), the following two methods are preferred, and it is advisable to use both transponders and ear tags. Both can be carried out at the neonatal examination and should be reported to the studbook keeper.

Passive integrated transponders (or PIT tags) are simply microchips that are inserted either under the skin or into the muscle and act as permanent identification method. Each transponder has a unique numeric code and can be read at short distances by scanning the animal with a reader. While the primary permanent method of identification, there are rare occasions (5% of cases) when transponders malfunction, read only sporadically or migrate from the insertion site. The most common cause of transponder failure is lack of retention; transponder losses can be minimised by directing the chip away from the insertion site by manual manipulation or using a surgical adhesive to close the insertion site (Kalk & Rice, 2010).

Ear tags are commonly used in the livestock industry and vary in size, colour and numerical identification. Plastic ear tags are preferable as they are less like to cause infection, as opposed to metal tags. Tags are usually made up of two parts (front and back); one part has a sharp point to pierce the ear, while the other part has a hole for the point. The two parts clip together once the point has pierced the animal's ear. In younger, smaller animals it is recommended that tags pierce the thickest part of the cartilage in the ear, while in older animals, piercing a thinner part of the pinna may be required. In all animals, it is essential that the puncture site does not pass through any large blood vessels. Tags may be lost, either by force or by simply falling out. However, tags are easily identified at a distance (and even further with the use of binoculars) and are cheap and easy to apply (Kalk & Rice, 2010).

2.7.2 Temporary Identification

When animals need to be identified for medical procedures or translocation, temporary methods may be used. Spray paints, dyes and paints can be applied to patches of fur as temporary markings. Paints and coloured adhesive tapes can be used to mark antlers of males. These markings may last anywhere up to a month but are efficient methods of temporary identification (Kalk & Rice, 2010).

2.7.3 Catching/restraining

Beginning hands-on management early with young deer can result in calmer individuals, ensuring that any handling or movement of animals is less stressful and hazardous than with animals that have not been desensitised (AZA Cervid TAG, 2015). The use of a dark room or stall can reduce stress and flight responses of these deer (T Rowlands, pers. comm.; Fowler, 1995).

2.7.4 Chemical restraint

Sedation alone is rarely useful in deer. Diazepam 0.5-2mg/kg IV or oral may be given before a stressful event but the effect is very variable in this highly sensitive species. Long acting intramuscular neuroleptic drugs may be useful in calming animals for loading, transportation and acclimatization, Zuclopenthixol acetate starts to have an effect after 1-2 hours lasting 2-3 days, Perphenazine enanthate starts to have an effect after 1-2 days and will last 7-10 days and Pipothiazine palmitate starts to have an effect after 3 days and lasts up to 3 weeks. Consequently, these drugs are often used in combination for example 100mg Zuclopenthixol plus 100mg perphenazine for an adult male Burmese Brow Antlered Deer.

Any chemical restraint procedure should be carried out "by, or under direct supervision of a trained veterinarian" (Christman, 2010). If chemical restraint of animals is planned, it is advised that the individuals are moved into a smaller enclosure area or a handling facility. In large areas, chasing is often necessary and can increase the risk of injury, hyperthermia or capture myopathy (Caulkett & Haigh, 2004). Use of a compressed air gun for the administration of drugs

may be considered, in order to reduce the stress involved with physical restraint, unless training and 'conditioned restraint' is an option and hand-injection is carried out. Careful monitoring of respiratory and circulatory rates should be conducted from anaesthetic induction through to recovery.

Deer should be kept in a sternal recumbent position rather than lateral recumbency, which can exacerbate hypoxemia in ruminants (Caulkett & Haigh, 2004). For longer procedures, deer should be intubated to reduce risk of regurgitation and aspiration.

These animals should be fully monitored after any procedures that require sedation or anaesthesia, to ensure they are responding normally to the anaesthesia reversal and do not injure themselves during the recovery period.

Surgical anaesthesia may be induced using xylazine hydrochloride (Rompun®) in combination with ketamine hydrochloride (Ketalar®). Xylazine anaesthesia should be reversed with yohimbine hydrochloride (Antagozil®) (Monfort *et al*., 1993; Nimitsuntiwong at al., 2000). For dose rates, see Table 4 below.

Table 4: Chemical restraint agents for Burmese Brow Antlered deer, as reported by Monfort *et al*. (1993) Nimitsuntiwong at al. (2000).

Drug	Commercial Name & Company	Dose Rate (mg kg^{-1}, average)	Route of Administration
Xylazine hydrochloride	Rompun® (100mg/mL injectable), Bayer Animal Health, Germany	0.25	i/m
Ketamine hydrochloride	Ketaset® (100mg/mL injectable), Zoetis, UK	2.0-2.5	i/m
Etorphine		0.05-0.075	i/m
Naltrexon		0,06-0.3mg/kg	i/v
Yohimbine hydrochloride	Antagozil® (10mg/mL injectable) Sigma Chemical Co., MO	0.3	i/v
Medetomidine **Ketamine**		0.05-01.1mg/kg 1-4mg/kg	i/m
Atipamezole		0.25-0.5mg/kg	i/v or part i/v and part i/m
Tiletamine /Zolazepam Medetomdine	Zoletil	0.7-1.3mg/kg 0.08-0.12mg/kg	i/m

2.7.5 Transportation

Burmese Brow-Antlered deer can be travelled loose in compartments in crates, trucks or on trailers during non-air travel transportation. Crate training should be considered as an option for this species to reduce the stress of confinement, should the animal need to be moved.

This species can be moved in groups providing that there is no instance of aggression between the animals, the animals are familiar with each other and that there is no significant size and/or weight difference between individuals. The latter point does not apply to the transport of dependent young and mothers.

Males may be transported with their hard antlers but must be transported in an individual container to avoid risk of injury to conspecifics. Sexually mature males should not be transported with other animals. Males with antlers in velvet must not be transported (CITES, 2013).

Deer should be transported in such a way that the head remains above the level of the rumen to prevent regurgitation and consequently, inhalation of rumen contents (Christman, 2010). Animals should be able to stand comfortably in crates, but not have enough space to fall onto their backs. Blindfolds are recommended for cervid species during transport to further minimise stress (Fowler, 1995).

Crates and trailers should allow good ventilation throughout the transportation. It is recommended that water is offered to the deer in bowls during breaks in the journey, and subsequently removed to avoid injury by fixed water containers. During shorter journeys, fresh vegetables may be offered as an alternative.

When using crates, at least one IATA 'Live Animals' label (Figure 2.5) should be attached and clearly visible on each crate. 'This Way Up' markings (Figure 2.6) on at least two opposite sides of the crate should also be used.

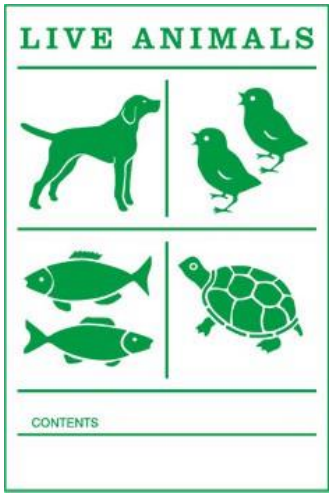


Figure 2.5: Live Animals label (IATA, 2006).

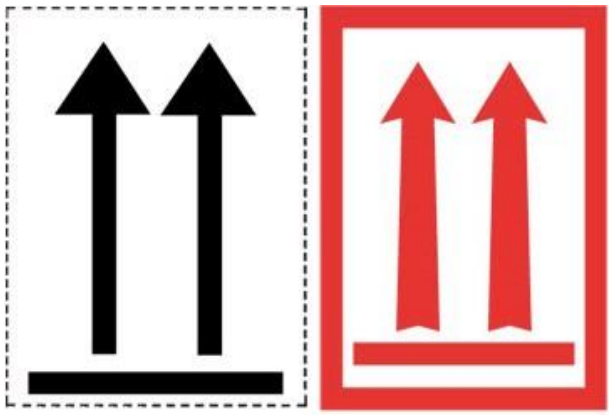


Figure 2.6: This Way Up label (IATA, 2006).

2.7.6 Safety

The primary safety concern is that of the personnel when capturing, restraining and transporting animals. This species may be unpredictable when handled and transported, and is large enough to cause severe injury to itself, conspecifics or keepers. Keepers should be aware of the position of the animal and its ability to strike out with limbs and antlers (when handling male animals).

When the animal is released, all personnel should have knowledge of the animal's potential reactions (e.g. fight, flight) and position themselves safely with an easily accessible escape route (Christman, 2010).

2.7.7 Stress

One serious consideration that should be taken into account when capturing these animals is capture myopathy. Capture myopathy is a disease syndrome that can result in sudden death of animals in response to overexertion and stress. Deer are particularly susceptible to this condition and the duration of capture, handling and restraint should be kept as short as possible to avoid the instance of capture myopathy (Christman, 2010; Blumstein *et al* 2015).

2.8 Veterinary considerations

2.8.1 Medical procedures

Blood sampling
Blood biochemical information can be useful in determining health status in animals (Nimitsuntiwong at al., 2000); regular monitoring of haematological and serum biochemical values in this species may prove useful for improving their care and welfare. Blood samples may be taken from the jugular vein whilst under sedation, due to the skittish nature of the deer. Sedation can improve the compliance of patients and reduce stress and risk of injury (Laberski & Fuller, 2014). For sedation protocols, see section 2.7.4.

Neonatal examinations
Neonates should be examined with the consideration of the mother-calf bond in mind. Sexing, health checks and identification (e.g. tags, ear notches, chips) of the calves can be carried out during their initial examinations.

2.8.2 Infectious diseases

Burmese Brow Antlered Deer are susceptible to the common major infectious diseases of deer managed in zoos. These include clostridial diseases, pasteurellosis (particularly after transport or stress) yersiniosis (especially in weaned calves) and paratuberculosis (Johne's disease). The use of clostridial vaccine should be considered in neonates.

Malignant catarrhal fever
Malignant catarrhal fever (MCF) is a viral infection that affects both domestic and wild species. MCF has been reported in many captive ungulate species and is a particular problem in mixed-species exhibits (Jessup, 1985). The Burmese Brow Antlered deer has been reported as susceptible to this disease (Heuschele *et al*., 1984). As this disease is spread through nasal shedding, grazers in mixed-species enclosures are vulnerable to infection.

Clinical signs include high fever, nasal discharge, opthalmia, severe oral, conjunctival and nasal mucosal inflammation and necrosis in oral and nasal cavities (Heuschele *et al*., 1984). Deer may also present with haemorrhagic diarrhoea, blood in urine and CNS signs, including aggression, depression, trembling and convulsions (Callan & Lear, 2016).

There is currently no treatment for MCF and mortality rates are extremely high. Separation of infected animals may assist with reducing infection in the wider herds (Callan & Lear, 2016).

Anthrax
Anthrax is a bacterial disease caused by the pathogen *Bacillus anthracis* and has the potential to infect a large number of different species from a range of taxonomic groups. Ruminants are among the most susceptible species.

Anthrax can survive outside of a host for extremely long periods of time as a “highly resistant spore”. Transmission of *B. anthracis* is thought to be predominantly through ingestion of contaminated vegetation or water. Anthrax outbreaks throughout wild populations have been a particular issue for this species (Bhumpakphan *et al*., 2004).

Clinical signs of this disease include ataxia, respiratory distress, seizures and disorientation. These signs usually precede acute death. Animals will often be in good body condition and carcasses generally display opisthotonic (or ‘star-gazing) posturing with their forelimbs extended away from the body (Bengis, 2011).

2.8.3 Parasitic diseases

A wide range of parasitic diseases can be found in deer including gastrointestinal nematodiasis, liver fluke and lungworm. *Cryptosporidium spp.* has also been found in Eld’s deer kept in US zoos (Santin & Fayer, 2015).

Deer may also be host to lice, ticks, mange mites and keds, the populations of all may increase during the winter if the animals have limited shelter. Clinical signs include pruritis and hair loss.

2.8.4 Non-infectious diseases

As a tropical species, the Burmese Brow Antlered deer may be susceptible to severe drops in climate temperature, which can be a problem in some areas of Europe where this species is kept in captivity (Wall & Hartley, 2017). Loss of

condition and hypothermia can prove fatal, especially in neonates, and nutritional supplementation should be provided during periods of particularly cold weather.

Traumatic injuries are not uncommon in captive deer; this species is reported as nervous and flighty and are therefore prone to injuries caused by flight responses. Collisions with fencing and enclosure facilities can occur when deer are startled or during a poorly planned capture (which may also be associated with capture myopathy, section 2.7.7).

During the rut, males may be injured by conspecifics. Antlers may cause puncture wounds to the face, neck and body during fights between males, although females may also be injured during the breeding season. Lameness can be a result of fighting, infection, foreign bodies or laminitis.

3 Glossary

AZA – American Zoo Association
CITES – Convention on International Trade in Endangered Species
DEFRA – Department for Environment, Food and Rural Affairs
EAZA – European Association of Zoos and Aquaria
EEP – European Endangered species Programme
ESB – European StudBook
IATA – International Air Transport Association
IUCN – International Union for Conservation of Nature
MGA – Melengestrol acetate – progestin contraceptive
PZP – Porcine zona pellucida
TAG – Taxon Advisory Group

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Appendix 1

EAZA Group on Zoo Animal Contraception overview for Burmese brow antlered deer

Burmese brow antlered deer *(Rucervus eldii thamin)*

Fact Sheet Compiled by: Veronica Cowl
Last Updated: September 2018
Fact Sheet Reviewed by: Yedra Feltrer D.V.M., M.Sc. Dipl. E.C.Z.M. (Z.H.M.), M.R.C.V.S.

We would recommend assessing the efficacy of any contraceptive bout with behavioural and hormone monitoring. For more information on this, please contact contraception@chesterzoo.org

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Contraceptive methods:	GnRH agonist (implant)	GnRH agonist (injection)	GnRH Vaccine	Progestogen (injection)	Progestogen (oral)	Progestogen (implant)	PZP vaccine	Surgical/ Permanent
Contraceptive Product:	Deslorelin acetate	Leuprolide acetate	GnRH protein conjugate	Depot medroxyprogesterone acetate	Altrenogest	Etonorgestrel 68 mg	PZP vaccine main components are antigens derived from porcine zona pellucida glycoproteins and an adjuvant to stimulate the immune response (Freund's modified complete adjuvant for primary vaccination and Freund's incomplete adjuvant for boosters).	N/A
Commercial Name:	Suprelorin ® implants of 4.7 mg and 9.4 mg	Lupron ®	Improvac® 2ml dose contains 300 ug of GnRH analogue-protein conjugate	Depo-Provera®, Depo-Progevera®	Regu-mate®	Implanon® Nexplanon®	Porcine Zona Pellucida	Vasectomy
Product Availability:	Implants containing 4.7mg ('Suprelorin® 6') and 9.4 mg ('Suprelorin® 12') widely available through veterinary drug distributors in the EU. 9.4 mg ('Suprelorin® 12') is also available through Virbac.	Leuprolide acetate is licenced for human use	Available through veterinary drug distributors.	Manufactured by Pfizer. Widely available throughout Europe through human drug distributors.	Regu-mate® Equine 2.2ml/mg oral solution and Regu-mate® Porcine 0.4% w/v oral solution widely available through veterinary drug distributors.	Manufactured by Organon. Available through human drug distributors	Not commercially available in Europe. Can be imported from the USA.	N/A
Restrictions and/or permit required by Importing Country:	EGZAC recommends: always check with your local licencing authority	Data deficient	Current knowledge: widely available throughout European countries. EGZAC recommends: always check with your local licencing authority	EGZAC recommends: always check with your local licencing authority	EGZAC recommends: always check with your local licencing authority	EGZAC recommends: always check with your local licencing authority	License required UK and France; all other Countries unknown. EGZAC recommends always checking with local licencing authority	N/A
Mechanism of action:	GnRH agonist suppress the reproductive endocrine system, preventing production of pituitary and gonadal hormones. As agonists of the GnRH these products initially stimulate the reproductive system, which can result in oestrus and ovulation in females or temporary enhancement of testosterone and spermatogenesis in males. Therefore this stimulation phase needs to be managed either by administering additional contraception (progestogens) in the females to suppress it or by separation of the sexes (males and females).	GnRH agonist suppress the reproductive endocrine system, preventing production of pituitary and gonadal hormones. GnRH agonists initially stimulate the reproductive system -which can result in oestrus and ovulation in females or temporary enhancement of testosterone and spermatogenesis in males. Therefore additional contraception needed during this time.	Stimulates the production of anti-GnRH antibodies by the immune system, neutralising endogenous GnRH activity. This results in a reduction of FSH and LH production by the anterior pituitary and, ultimately, in a reduction of ovarian follicular development and /or inhibition of testosterone secretion from the testes and spermatogenesis.	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	The PZP antibodies interfere with fertilisation by binding to the ZP glycoprotein receptors that surround the egg of the vaccinated female, blocking the binding and subsequent penetration of sperm.	Surgical procedure in which the ductus deferens are cut, tied, cauterized, or otherwise interrupted
Insertion/Placement:	Sub-cutaneously, in a place where it can be easily detected or seen for removal at a later date; refer to the Suprelorin® fact sheet for effective method of implant placement (tunnelisation)	Injectable intramuscular or subcutaneously	Injectable intramuscularly or subcutaneously	intramuscular injection	Administered orally in feed or by syringe. **Gloves must be worn when administering Regu-mate® (absorption through the skin can cause disruption to the menstrual cycle and prolongation of pregnancies in humans).**	Intramuscular or subcutaneous. EGZAC recommends sub-cutaneous, upper inner arm for visibility (aid for later removal)	Injectable Intramuscularly	Surgical
Females								
Dose	Approximately 1-2 implants are required to contracept this species, depending on body weight. As a general rule, a minimum of 1 implant per 100kg body weight should be used. 4.7mg implants are recommended for a **minimum** duration of 6 months and 9.4mg implants are recommended for a **minimum** duration of 12 months. **Please contact EGZAC for more information.**	There are various formulations ranging from 1-6 months. Please see Baker et al. (2005)[5] for a guide on dosing.	Two injections of 400µg are given 35 days apart and boosters are initially administered every 4 months, before extending to every 5 months.	The recommended dosage for this species is 2-5mg/kg every 45-90 days (if oestrus occurs, dose can be increased incrementally until suppression is achieved).	0.044 mg/kg should be administered daily throughout the duration of the breeding season.	Doses not well established. Recommended 1 implant per 100kg BW. For an individual weighing <100kg, 1 implant should be sufficient.	~ 100 ug of protein. Recommended dose is 2 injections given typically 2+ weeks apart then a booster every 8 months for most species. For species with a well defined and short (2-3 months) breeding season, give first dose 1-2 months prior to the breeding season and the second inoculation no later than 1 month prior to breeding activity. Year-round breeders booster inoculations should be given every 7 to 8 months.	N/A
Latency to effectiveness:	3 weeks average as GnRH agonists initially stimulate the reproductive system (please refer to the Deslorelin datasheet for detailed information). Either separation of the sexes or additional contraception is needed during this time, such as an oral progestogen (~2mg/kg Megestrol acetate pills; Megace/Ovarid or 0.044 mg/kg altrenogest (Regumate)) daily 7 days before and 8 days after the contraceptive has been administered to suppress initial stimulation phase.	Same as for deslorelin - **please refer to Deslorelin datasheet for detailed information**	Unknown for most species, minimum of 6 weeks from primary vaccination	1-3 days post injection. However, if the cycle stage is not known then extra time must be allowed. Therefore, separation of the sexes or alternate contraception should be used for at least 1 week.	It has been demonstrated that 95% of mares will be suppressed within 3 days. However separation or other contraceptive methods should be used for 7-14 days after the contraception is administered.	In general inhibition of ovulation after 1 day when inserted on day 1-5 of cycle or when replacing oral progestogen. As the right stage during menstrual cycle is often unknown, it is advised to use other contraceptive methods for at least 7-14 days after insertion of the implant depending on administration route (intramuscularly or subcutaneously).	2-3 weeks after the last vaccination during year 1 (primary course of vaccination 2 injections 2-4 weeks apart, preferably 3 injections).	N/A
Oestrus cycles during contraceptive treatment:	Initial oestrus and ovulation (during the 3 weeks of stimulation) then no oestrus cycle. To supress the initial oestrus and ovulation you can follow the megestrol acetate/oral progestogen protocol mentioned above.	Same as with Deslorelin	Unknown but it should be suppressed; highly successful at inducing anoestrus in domestic horses.	Oestrus is inhibited, although ovulation and cycling might occur in adequately contraceptive animals at the lower level (this is unlikely and the degree of suppression is dose dependant)	Oestrus is inhibited, although ovulation and cycling might occur in adequately contraceptive animals at the lower level (this is unlikely and the degree of suppression is dose dependant).	Oestrus is inhibited, although ovulation and cycling might occur in adequately contraceptive animals at the lower level (this is unlikely and the degree of suppression is dose dependant)	PZP should not suppress oestrous cycles and may extend the breeding season beyond what is considered typical, resulting in additional oestrous cycles.	N/A
Use during pregnancy:	Not recommended, can lead to an abortion	Same as with Deslorelin	**Data deficient**	Progestogens are not recommended in pregnant animals because of the possibility of prolonged gestation, still birth, abortion, etc.	Progestogens are not recommended in pregnant animals because of the possibility of prolonged gestation, still birth, abortion, etc.	Progestogens are not recommended in pregnant animals because of the possibility of prolonged gestation, still birth, abortion, etc.	Separation of the sexes from the beginning of the initial vaccination course until at least 2 weeks after the last injection during the first year	N/A
Use during lactation:	No known contraindications once lactation has been established; however, treatment during pregnancy may impede proper mammary development and potentially hinder lactation.	Same as with Deslorelin	**Data deficient**	Considered safe for nursing infant.	Considered safe for nursing infant.	Considered safe for nursing infant.	Does not interrupt pregnancy or affect the foetus	N/A
Use in prepubertals or juveniles:	Because deslorelin suppresses gonadal steroids, its use may delay epiphyseal closure of the long bones, resulting in taller individuals, similar to the effects of pre-pubertal neutering in domestic animals.	Same as with Deslorelin	**Data deficient**	The use of synthetic progestogens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	The use of synthetic progestogens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects	The use of synthetic progestogens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects	No known contraindications	N/A
Use in seasonal breeders:	Treatment should be given more than 2 months prior to expected breeding season	**Data deficient.** Should start at least 2 months before the start of breeding season.	Data deficient but if used should be done at least 6 weeks prior to the breeding season.	Should be injected at least 2 weeks before the breeding season starts.	Should be injected at least 2 weeks before the breeding season starts.	Should be injected at least 2 weeks before the breeding season starts.	PZP-treated prepubertal white-tailed deer and feral horses were fertile as adults. Not associated with side effects in elephants. But there are no data for other species	N/A

Duration	Duration of efficacy has not been well established. As a guide: 4.7 mg implants will suppress for a **minimum** of 6 months; 9.4mg will be effective for a **minimum** of 12 months	Lupron® is available in various formulations lasting from 1 to 6 months, but because the release of hormone from the depot formulation varies per individual, actual duration of efficacy can vary considerably.	Data deficient for most of species. Improvac® generates short lived antibodies in the domestic pig (after 7-8 weeks following second injection antibodies start to decline). Data from domestic horses varies: a full season in mares after the first booster.	Dose dependant: 45-90 days in general. However, effects could last 1-2 years in some individuals. In some species, contraception with medroxyprogesterone acetate can extend the breeding season; this requires an extension of the period of contraceptive treatment.	Duration may not be more than one day, so has to be administered daily. Clearance of Regu-mate® from the system can occur in a few days however, latency to conception can very between individuals.	Data deficient in these species, however expected to be effective for 2-3 years.	Can be used in seasonal breeders but initial treatment and annual boosters should be carried out 2 and 1 months before the start of the breeding season respectively.	N/A
Reversibility	Suprelorin is designed to be fully reversible, and we have records of female deer reversing in our database. One female muntjac implanted with 1x9.4mg implant reversed 2 years after initially being implanted, while two female tufted deer implanted with 2 and 3x9.4mg implants gave birth between 4 and 5 years after their initial treatment began. To facilitate reversibility, implants should be removed, and therefore placed in a location with thinner skin e.g. umbilical region, inner thigh, base of the ear.	Lupron® is designed to be fully reversible however there are no current cases of reversal in cervidae , and there are also no cases of this contraception failing.	Data deficient for most of species. Reversibility following Improvac has been demonstrated in white-tailed deer (Miller et al, 2000). Improvac antibodies are short-life and it is presumed to be reversible.	Designed to be fully reversible and we have two records of reversal in moose. Both females reversed 2-2.5 years after initially being treated.	Designed to be fully reversible although variations can occur.	Designed to be fully reversible although variations can occur. To facilitate reversibility, implants should be removed, and therefore placed in a location with thinner skin e.g. umbilical region, inner thigh, base of the ear.	There are species differences on reversibility, and we have one record of a female white tailed deer reversing 3 months after initial treatment. Caution with prolonged use (>3 years) as it may result in infertility. Treatment for over 3 years has been associated with ovarian failure in some cases. The possibility of ovarian damage makes this method unsuitable for animals highly valuable to captive breeding programmes or where reversibility is important.	N/A
Effects on Behaviour	**Data deficient**	**Data deficient**	Similar to surgical castration but short-acting (duration of antibody effect).	Effects on behaviour have not been studied, every individual may react differently. Because it binds readily to androgen receptors and is antiestrogenic, females may experience male-like qualities (increased aggression , development of male secondary sex characteristics, etc.). Further research in the subject is necessary.	Effects on behaviour have not been studied, every individual may react differently. Because it binds readily to androgen receptors and is antiestrogenic, females may experience male-like qualities (increased aggression , development of male secondary sex characteristics, etc.) Further research in the subject is necessary.	Effects on behaviour have not been studied, every individual may react differently.	Since usually the vaccine doesn't suppress oestrus cycles it has almost no effects on social behaviour, and no undesirable behavioural effects have been registered in free-ranging elephants treated for up to 9 years. In some species the failure to conceive can results in longer than usual breeding season and in some cases this can results in aggression and social disruption.	N/A
Effects on sexual physical characteristics	Data deficient in this species, although secondary sexual characteristics might be affected.	GnRH agonists may cause the suppression of physical secondary sexual characteristics.	Similar to surgical castration but short-acting (duration of antibody effect).	Because it binds readily to androgen receptors and is antiestrogenic, females may experience male-like qualities (increased aggression, development of male secondary sex characteristics, etc.)	Data deficient	Data deficient, however no effects are expected	Data deficient	N/A
Males	**GnRH agonists are not effective in male ungulates**	**GnRH agonists are not effective in male ungulates**		**Not Recommended**	**Not Recommended**	**Not Recommended**	**Not Recommended**	
Dose	N/A	N/A	Two initial injections of 400µg are given 35 days apart and boosters are initially administered every 4 months, before extending to every 5 months.	N/A	N/A	N/A	N/A	N/A
Latency to effectiveness:	N/A	N/A	At least 2 weeks following booster.	N/A	N/A	N/A	N/A	Approximately 12 weeks post-vasectomy
Use in prepubertals or juveniles:	N/A	N/A	Data deficient	N/A	N/A	N/A	N/A	Data deficient
Use in seasonal breeders:	N/A	N/A	Unknown, but if used should be done at least 6 weeks prior to the breeding season.	N/A	N/A	N/A	N/A	N/A
Duration and Reversibility	N/A	N/A	Antibodies are short-life and it is presumed to be reversible. Irreversible destruction of testicular stroma has been observed in some deer species so it may cause sterility. Improvac should be used with caution.	N/A	N/A	N/A	N/A	Permanent, although some reversible techniques are being tried.
Effects on Behaviour	N/A	N/A	Similar to surgical castration but short-acting (duration of antibody effect). It may decrease male aggression due to downregulation of testosterone synthesis.	N/A	N/A	N/A	N/A	None
Effects on sexual physical characteristics	N/A	N/A	Similar to surgical castration but short-acting (duration of antibody effect). Effect on secondary sexual characteristics. The antler cycle will be affected; antlers may drop off and become maloformed[1].	N/A	N/A	N/A	N/A	None
General:								
Side effects	In general weight gain and changes in secondary sexual characteristics as would be seen with ovariectomy or castration.	In general weight gain as would be seen with ovariectomy or castration. Increased appetite will result in weight gain, especially in females. **EGZAC recommends always reading the manufacturer's data sheet**	Occasional swelling at the vaccination site - need to inject deep intramuscular in elephants and horses.	Possible weight gain, possible increased or decreased frequency of bleeding during menstruation. **EGZAC recommends always reading the manufacturer's data sheet.**	Possible weight gain, possible increased or decreased frequency of bleeding during menstruation. **EGZAC recommends always reading the manufacturer's data sheet.**	N/A	Treatment for over 5 years has been associated with ovarian failure in some species (species differences). Significant ovarian disruption has been noted in dogs, rabbits, mice and domestic sheep. Oophoritis unknown if transient or permanent. In some species the failure to conceive can result in a breeding season that is longer than usual (aggression and social disruption)	N/A
Warnings	Duration may be reduced if implant is broken. Do not cut the implant.	Causes initial gonadal stimulation	It should be handled with extreme care to avoid handler accidents. **EGZAC recommends always reading the manufacturer's data sheet**	Do not administer to any pregnant female due to the possible duration of efficacy extending beyond the expected time of parturition which has potential deadly effects. **EGZAC recommends always reading the manufacturer's data sheet**	Do not administer to females who have had a previous or current history of uterine inflammation (i.e. endometritis). The use of progestins can intensify existing uterine inflammation in to a serious uterine infection in some cases.	N/A	The only adjuvant used with PZP is Freund's Modified adjuvant, which **DOES NOT CAUSE TB+ TEST RESULTS**, and injection site reactions are less than 0.05%. Following the initial treatments, boosters are required, using only Freund's Incomplete adjuvant. In rabbits and possibly canids PZP vaccine can cause depletion of oocytes, and in some primates it can cause temporary cessation of oestrous cycles. There are few data for its use in carnivores, aside from pinnipeds and bears, and recent research with felids indicates that the antibodies will not cross-react with the sperm receptors.	Infection of the surgical wound might occur. Intradermal closure of the skin is advised together with prophylactic antibiotic treatment and NSAID
Reporting Requirements: **In order to increase our knowledge of the efficacy of contraception methods in the Cervidae family it is recommended that all individuals on contraception be reported to EGZAC**								

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