EAZA Best Practice Guidelines

Burmese Brow Antlered Deer

(Rucervus eldii thamin)

Editors: Dr Matt Hartley and Ellis Wall
Zoo and Wildlife Solutions Ltd supported by NEZS Chester Zoo
Email: matt@zooandwildlifesolutions.com / ewall4@rvc.ac.uk
EAZA Deer Taxon Advisory Group

TAG Chair: Noam Werner (wernerny@jerusalemzoo.org.il)
The Tisch Family Zoological Gardens, Jerusalem
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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.

**Summary**

These guidelines are composed of two sections. The first provides an 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. duvauceli) and, formerly, the now extinct Schomburgk’s deer (R. schomburgki) (Corbet and Hill, 1992).

<table>
<thead>
<tr>
<th>Order:</th>
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<tr>
<td>Family:</td>
<td>Cervidae</td>
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<tr>
<td>Genus:</td>
<td>Rucervus</td>
</tr>
<tr>
<td>Species:</td>
<td>Rucervus eldii</td>
</tr>
<tr>
<td>Subspecies:</td>
<td>Rucervus eldii thamin</td>
</tr>
<tr>
<td>Common name:</td>
<td>Burmese Brow Antlered deer</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>Head-body length: 1.5 - 1.8 m</th>
</tr>
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<tbody>
<tr>
<td>Shoulder height: 114 cm</td>
</tr>
<tr>
<td>Antler length: 99 cm</td>
</tr>
<tr>
<td>Tail length: 20 - 30 cm</td>
</tr>
<tr>
<td>Weight: up to 150 kg</td>
</tr>
</tbody>
</table>

**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).

1992 - Questionnaire distributed by Wildlife Department of Myanmar - 2,200 deer estimated to be left, 1,200 thought to be in CWS

1996 - Regular transect surveys in CWS (since 1983) - decline of >40% - estimated population of 500

1997 - 23/24 townships surveyed reported sightings or evidence of deer

2003 - repeat of 1997 surveys, 4 townships had no evidence of deer, 4 more reported declines (some reported stable or increasing populations)

2007 - reported in only 14 townships

2008 - CWS declared only viable and secure population left

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 Inthaing 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 10m² 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).](image)

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).

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

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 result 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).

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

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

<table>
<thead>
<tr>
<th>Feed Frequency</th>
<th>Feed Timings (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0730 1130 1530 2300</td>
</tr>
<tr>
<td>3</td>
<td>0730 1530 2100</td>
</tr>
<tr>
<td>2</td>
<td>0730 1530/2100</td>
</tr>
<tr>
<td>1</td>
<td>0800</td>
</tr>
</tbody>
</table>

**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).

**Immuncontraception**
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).
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).

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

<table>
<thead>
<tr>
<th>Drug</th>
<th>Commercial Name &amp; Company</th>
<th>Dose Rate (mg kg(^{-1}), average)</th>
<th>Route of Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylazine hydrochloride</td>
<td>Rompun® (100mg/mL injectable), Bayer Animal Health, Germany</td>
<td>0.25</td>
<td>i/m</td>
</tr>
<tr>
<td>Ketamine hydrochloride</td>
<td>Ketaset® (100mg/mL injectable), Zoetis, UK</td>
<td>2.0-2.5</td>
<td>i/m</td>
</tr>
<tr>
<td>Etorphine</td>
<td></td>
<td>0.05-0.075</td>
<td>i/m</td>
</tr>
<tr>
<td>Naltrexon</td>
<td></td>
<td>0.06-0.3mg/kg</td>
<td>i/v</td>
</tr>
<tr>
<td>Yohimbine hydrochloride</td>
<td>Antagozil® (10mg/mL injectable), Sigma Chemical Co., MO</td>
<td>0.3</td>
<td>i/v</td>
</tr>
<tr>
<td>Medetomidine</td>
<td></td>
<td>0.05-0.11mg/kg</td>
<td>i/m</td>
</tr>
<tr>
<td>Ketamine</td>
<td></td>
<td>1-4mg/kg</td>
<td></td>
</tr>
<tr>
<td>Atipamezole</td>
<td></td>
<td>0.25-0.5mg/kg</td>
<td>i/v or part i/v and part i/m</td>
</tr>
<tr>
<td>Tiletamine/Zolazepam Medetomidine</td>
<td>Zoletil</td>
<td>0.7-1.3mg/kg</td>
<td>i/m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.08-0.12mg/kg</td>
<td></td>
</tr>
</tbody>
</table>
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).](image1)

![Figure 2.6: This Way Up label (IATA, 2006).](image2)
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, ophthalmia, 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
4 References

4.1 Books


4.2 Publications


Thomas, O. (1918); The nomenclature and the geographical forms of the panolia deer (Rucervus eldii) and its relatives. J Bomb Nat Hist Soc., 23: 363-367.


4.3 Online material


4.4 Other material


Appendix 1

EAZA Group on Zoo Animal Contraception overview for Burmese brow antlered deer
Burmesse brow antlered deer (Rucervus eldi thamin)

## Hormonal Contraception

<table>
<thead>
<tr>
<th>Contraceptive METHOD</th>
<th>GnRH agonist (Implant)</th>
<th>GnRH antagonist</th>
<th>Progestogen</th>
<th>Progestogen (SC)</th>
<th>Progestin</th>
<th>FP Duration</th>
<th>Surgical intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNRH agonist (implant)</td>
<td>Porcine Zona Pellucida</td>
<td>-</td>
<td>-</td>
<td>Implant suppression</td>
<td>Implant suppression</td>
<td>N/A</td>
<td>Surgical intervention</td>
</tr>
<tr>
<td>PZP vaccine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td>N/A</td>
<td>Surgical intervention</td>
</tr>
</tbody>
</table>

### GnRH agonist (implant)

- **Porcine Zona Pellucida**: Data deficient
- **Improvac**: 2ml dose contains 300 ug of GnRH antagonist
- **Regu-mate**: 2.2ml/mg oral solution

### GnRH antagonist

- **Suprelorin**: 2.2ml/mg implant
- **Suprelorin**: 4.7mg implant

### Progestogen (implant)

- **Depo-Provera**: 50mg subcutaneously
- **Depo-Progevera**: 50mg subcutaneously
- **Regumate**: 0.044 mg/kg

### Use during pregnancy

- 100 ug of prergesterones given 2-3 weeks before breeding activity.

### Use during lactation

- Suppression is dose-dependent.

### Product Availability

- Not commercially available in Europe. Can be imported from the USA.

### Use during lactation

- Suppression is dose-dependent.

### Mechanism of action

- GnRH agonists suppress the reproductive endocrine system, preventing production of adequate and potent hormones. As a result, the GnRH agonist products inhibit the reproductive system, which can enable the female and male to continue breeding activities.

### Use during lactation

- Suppression is dose-dependent.

### Subcutaneous injection

- **Suprelorin**: 2.2ml/mg, 4.7mg implant

### Oestrus is inhibited, although ovulation and cycling system are not suppressed.

### Sterilisation

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### Sterilisation

- Oestrus is inhibited, although ovulation and cycling system are not suppressed.
GnRH agonists are not effective in male ungulates.

- **Use in seasonal breeders:**
  - 45-90 days in general. However, effects could last 1-2 years in some individuals. In horses, effects can last up to 3 years.
- **Use in prepubertals or neonates:**
  - Similar to surgical castration but has a short-acting effect.

**Reversibility**

- **Duration and Reversibility**
  - Lupron® is designed to be fully reversible, and we have records of reversal in mammals.
  - Data deficient in most species. Improvac® cannot be reversed.

**Side effects**

- **In general weight gain and changes in secondary sexual characteristics as would be seen with ovariectomy or oophorectomy:**
  - Weight gain is associated with ovarian failure in some cases. The possibility of increased aggression, development of male secondary sex characteristics, etc.

**Notes**

- GnRH agonists are not effective in male ungulates.
- GnRH agonists are not effective in male ungulates.

**References:**