Reptile Taxon Advisory Group Best Practice Guideline for Möllendorff's ratsnake (*Elaphe moellendorffi*)

Version 1

Authors

Charlie Frelon, Adam Radovanovic, Thomas Maunders, Brett Baldwin & Iri Gill

EAZA Reptile TAG Chair

Ivan Rehak (Prague Zoo, Czech Republic)

EAZA Reptile TAG Vice Chair – subgroup snakes

Guido Westhoff (Tierpark und Tropen-Aquarium Hagenbeck, Germany)

Published

2025

EAZA Best Practice Guidelines disclaimer

 The information contained in these EAZA Best Practice Guidelines has been obtained from numerous sources believed to be reliable. EAZA and the EAZA Reptile TAG make a diligent effort to provide a complete and accurate representation of the data in its reports, publications, and services. However, EAZA does not guarantee the accuracy, adequacy, or completeness of any information. EAZA disclaims all liability for errors or omissions that may exist and shall not be liable for any incidental, consequential, or other damages (whether resulting from negligence or otherwise) including, without limitation, exemplary damages or lost profits arising out of or in connection with the use of this publication. Because the technical information provided in the EAZA Best Practice Guidelines can easily be misread or misinterpreted unless properly analysed, EAZA strongly recommends that users of this information consult with the editors in all matters related to data analysis and interpretation.

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 "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.

Recommended citation

Frelon, C., Radovanovic, A., Maunders, T., Baldwin, B., & Gill, I. (2025). EAZA Best Practice Guidelines for Möllendorff's ratsnake (*Elaphe moellendorffi*) – *1st Edition*. European Association of Zoos and Aquariums, Amsterdam, The Netherlands. 42pp.
DOI: 10.61024/BPG2024MollendorffsratsnakeEN

Acknowledgements
Authors would like to thank Jay Redbond & Matt Swatman for providing the time to work on this manuscript and also Chester Zoo's Ectotherm Department for the maintenance and management of the species at Chester Zoo.
Cover photo: Adult female *E. moellendorffi* at Chester Zoo (©Matthew Cook, Chester Zoo)

Introduction

The Moellendorff's ratsnake (*Elaphe moellendorffi*), a rare and elusive species native to the karst forests of southern China and northern Vietnam, is increasingly at risk of extinction due to a combination of factors, including habitat loss, agricultural development, and illegal collection for the exotic pet trade. This species, with its limited distribution and specific habitat requirements, faces compounded challenges in the wild, where human encroachment continues to degrade its fragile ecosystem.

Despite its ecological significance and unique natural history, *E. moellendorffi* remains one of the least studied species in the Elaphe genus. Limited field studies and a small captive population have left gaps in our understanding of its behaviour, diet, reproductive biology, and environmental needs. Captive breeding efforts, therefore, represent a critical component of the conservation strategy for this species. Such programmes not only help preserve the genetic diversity of the species but also provide opportunities to study and refine care protocols that may one day support reintroduction efforts.

The current captive population of *E. moellendorffi* in zoological institutions and private collections remains small and genetically vulnerable. Expanding this population, improving genetic sustainability, and standardizing husbandry techniques are essential steps toward ensuring the species' long-term survival. These husbandry guidelines have been developed to provide a comprehensive framework for the successful care, management, and reproduction of *E. moellendorffi* in controlled environments, with a focus on temperate indoor facilities.

While these guidelines are primarily intended for ex-situ conservation programmes, many sections, such as those on nutrition, breeding behaviour, and incubation, are broadly applicable to both in-situ and ex-situ efforts. Special attention has been given to addressing the challenges associated with replicating the natural conditions of the species' native karst habitat, such as humidity, temperature gradients, and shelter availability.

It is hoped that these guidelines will encourage a wider range of institutions, conservation organizations, and private keepers to engage in the long-term preservation of *E. moellendorffi.* By contributing to the establishment of self-sustaining captive populations and supporting further research into the species' biology, these efforts will play a vital role in ensuring the survival of this remarkable and highly threatened snake species for future generations.

Key husbundry points

- Providing appropriate lighting, heat, UV radiation and humidity levels are crucial for the health and husbandry of *E. moellendorffi.* These parameters must be tailored to reflect the species natural environment. Special attention should be paid to daily and seasonal fluctuations in these conditions, replicating the temperature and photoperiod cycles found in their native habitat in Southeast Asia.
- *E. moellendorffi* should be housed in terrariums and tanks that allow for an arboreal and terrestrial lifestyle. The enclosure should include ample vertical climbing structures, naturalistic hiding spots, access to thermoregulating spots, and access to clean water. The enclosure should be long enough to allow the snake to stretch the full length of its body and more.
- An effort to replicate seasonal environmental changes have a positive effect on reproduction. The shift in temperature, rainfall and photoperiod will aid in getting *E. moellendorffi* to brumate which will influences breeding success of the species. Failure to provide this may results in reproductive stasis and in more severe situations a decline in health.
- Juveniles of *E. moellendorffi* may be reluctant feeders and require careful management. Rigorous feeding strategies as well as frequent monitoring of weight and growth is recommended to ensure proper development.
- Handling should be kept to a minimum and performed only by trained and experienced personnel. If handling is necessary, it must be done with minimal stress to the animal, using appropriate tools if required. Both The safety of the handler and the welfare of the animal must be prioritised at all times.

Contents

Section 1: Biology and field data

Biology

1.1 Taxonomy

Order	-	Squamata
Family	-	Colubridae
Genus	-	*Elaphe* Fitzinger (in Wagler), 1833
Species	-	*Elaphe moellendorffi* (Boettger, 1886)
English common name(s)	-	Mollendorff's ratsnake / Hundred-flower snake / Red headed ratsnake / Trinket snake

This snake was named in honour of Otto Franz von Möllendorff (1848 – 1903), a German malacologist who spent many years in China (O'Shea, 2018). *Cynophis moellendorffi* Boettger, 1886 is the type species of the genus *Orthriophis* Utiger et al., 2002. *Orthriophis*, along with the eastern trinket snake (*E. cantoris*), Hodgson's ratsnake (*E. hodgsoni*) and beauty ratsnake (*E. taeniura*) has recently been synonymised with *Elaphe* by Chen, et al. (2017).

1.2 Morphology

E. moellendorffi is a large colubrid (Fig. 1), with average adult lengths attaining 180cm up to 250cm, weighing up to 2kg (Gumprecht, 2004). There have been some rare, exceptional specimens recorded at 290cm (Zhao, 2004).

The species has a distinct elongated red head (fig. 1), grey labials and the eyes have red irises. Its body is light grey, patterned with irregular, light centred, dark boarded, rusty brown blotches arranged dorsally and laterally, which continue onto the posterior body and tail, where the ground colour may be partially obscured by a wash of red pigment. Some specimens lack any patterning except the red head (O'Shea, 2018). The ventral surface is cream in colour with interspersed black spots (Gumprecht, 2004). Scales are keeled in this species and have 25-27 dorsal scales, 265-284 ventral scales, 79-100 sub-caudal scales, supra-labial scales 9-10 and number of supra-labials in contact to the eye is 2. *E. moellendorffi* show sexual dimorphism, males being significantly larger than females and have much wider heads (Gumprecht, 2004).

1.3 Physiology

There is limited information on E. *moellendorffi* specific physiology, with that said some studies looking into the neural regulation of the pulmonary vasculature in a semi arboreal snake such as *Elaphe obsoleta* (Donald et al., 1990) do provide insights of the physiological processes that could be considered general among colubrids. This lack of information could be seen as an opportunity for future research.

1.4 Longevity

As the species has only been propagated a handful of times in captivity, and mainly in private collections, longevity record data is limited. From historic records in North America, the San Diego Zoo (San Diego, California) acquired a wild caught, adult male specimen living 21 years, 1 month and 15 days (Snider, 1992), some other historical records from Sand Diego Zoo have seen some individuals live up to 29 years old (Baldwin, pers. comm. 2024). At the time of writing the longest living specimen according to ZIMS is 17-year-old male, held by Singapore Zoo (ZIMS, 2023).

Field data

1.5 Conservation status/Zoogeography/Ecology

1.5.1 Distribution

E. moellendorffi has a very narrow distribution (Zhou & Jiang, 2004). It is confined to extreme Southern China and Northern Vietnam (O'Shea, 2018) (Fig. 1). Range description has been recorded from Northern Vietnam, and from Guangdong, Guangxi Yunnan provinces in China (Zhao & Alder, 1993; Zhou, 2012). Schulz (1996) lists the Northern Vietnam provinces as Bac Thai, Cao Bang, and Hoa Binh, where the species occurs. It is found at elevations of 30 to 300m above sea level (Zhou, 2012). The distributional range of this species lies in the transition area between the tropics and sub tropics and the climatic profile here is described as long, warm summers and short, cool winters (Gumprecht, 2004).

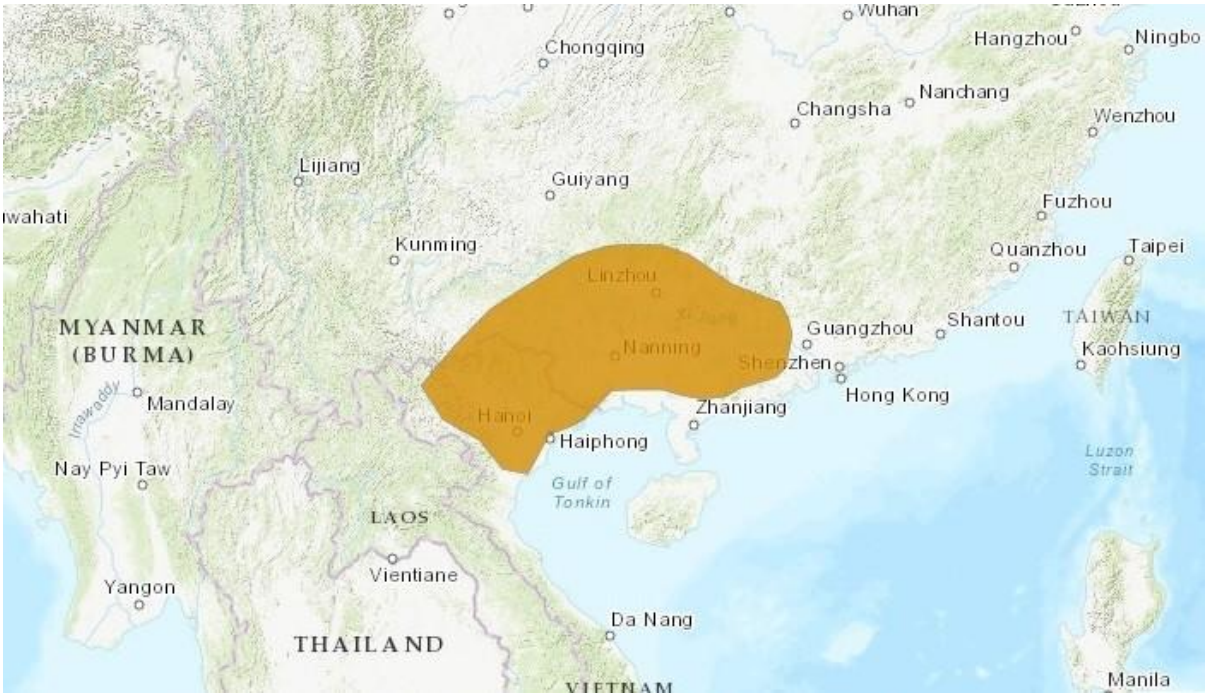

Figure 1: Distribution of *E. moellendorffi* (IUCN, 2011)

1.5.2 Habitat

E. moellendorffi inhabits deciduous forest hillsides (Fig. 2), edge of rice fields, meadows and bamboo thickets near water (O'Shea, 2018; Zhou, 2012; Gumprecht, 2004). The species does also favour crevices, rocky outcrops and caves systems of karst limestone, particularly during its hibernation period (Fig. 3), which begins in November (Gumprecht, 2004).

Figure 2: Showing image of Xindong village in Gangdong Province (Journey beyond the horizon, 2018)

Figure 3: Research team (A) and *E. moellendorffi* (B, C) in a cave in Cuc Phuong, Vietnam (Brett Baldwin, pers. comm., 2019)

1.5.3 Conservation status & population

This species was assessed by the IUCN as Vulnerable in 2012 (Zhou, 2012). The species is heavily traded, and overexploitation is the main threat to this species. Its meat is used for food, medicinal liquor, and the skin is used for making clothing accessories (Zhou, 2012).

In the 1950's the estimated population, in China, was 600, 000 and dropping to 50,000 in the 1990's (Zhao, 1998; Zhou, 2004). And as of the last assessment by IUCN their numbers are still decreasing.

The conservation of species with a narrow distribution, specialized habitat requirements, low fecundity, large mature body size, and high commercial value like *E. moellendorffi* is of urgent concern. It has been reported that some traits will increase the vulnerability of a species to outside pressure (Zhao, 2004). Zhou and Jiang (2004) reported that 340,390 live snakes and 195,700 pieces of skin of this species were exported from China 1990-2000, while 30,000 pieces of skin were imported into China from 1991-2001. He & Peng (1999) report the quantity of snakes consumed in the markets of Guangzhou, Guandong province of China was about 1.4 x 10^7 kg each year (Alves et al., 2008) Wexue (2013), describes an *E. moellendorffi* contained medicated wine for preventing a hyper-lipidemic disease, dispelling wind and dredging collaterals. The snake medicated wine is composed of: Chinese herbal *Pimpinella diversifolia* powder and white spirit in a ratio of 20-200g/L. The Chinese herbal *Pimpinella diversifolia* powder is prepared from *Pimpinella diversifolia*, honeysuckle, common bombax flower and dry *E. moellendorffi* powder. The dry powder is prepared by removing internal organs, getting rid of teeth, then drying and crushing into a powder. Considering all this information it is safe to assume that this species is most likely on the decline. There are no conservation actions currently known for this species (Zhou, 2012). To address this conservation crisis there are a number of recommended actions that are to be considered and are outlined by Zhou (2004).

1.6 Diet and feeding behaviour

Based on data collected in the wild, adults from this species have been reported to feed on a diverse diet of bats, birds, lizards and frogs (Mehrtens, 1987; Zhao, 1998; Gumprecht, 2004), but do prefer mammalian prey (O'Shea, 2018).

1.7 Reproduction

Little is known about the reproductive biology of this species (Gumprecht, 2004), but like most other rat snakes it is oviparous (O'Shea, 2018). Imported wild catches from Hong Kong regularly sold clutches of 6 to 12 eggs (Gumprecht, 2004), this clutch size is also supported by Köhler (2005). Zhao (1998) reports that 5 to 15 eggs are laid measuring 5 to 7 cm in length. From wild data we know that January gives place to the coldest months where the snakes would be brumating as the temperatures are as low as 8^{o}C, from May to August the warmest temperatures will be record going as high as 33^{o}C (Time and date,

2023). When these conditions are replicated in a captive scenarios (Fig. 11) we are able to say that the gestation is of approximately 2 months and the average incubation time in captivity is 80 days if kept at a stable temperature of 27C, but with wild temperature fluctuation the incubation will more than likely be extended (Cook, 2022).

1.8 Behaviour

Due to the lack of wild sightings and published research of *E. moellendorffi,* little is known about their daily activity, wild interactions and sexual behaviour; all that can be said is speculative or based on individuals kept in captivity. Based on this information it can be speculated that *E. moellendorffi* is a crepuscular species, who's social behaviour will revolve around aggregating physical resources (Prater, 1993) and mating. Lateral undulation, concertina and sidewinding are the three most common modes of snake locomotion which generates propulsive forces by lateral vertebral flexion (Grays, 1946; Gans, 1974), all of the above locomotion patterns apply to *E. moellendorffi.*

Section 2: Management in zoos and aquariums

2.1 Enclosure

Figure 4: Exhibit measuring 120cm x 120cm x 140cm at San Diego Zoo Global (Brett Baldwin, San Diego Zoo)

Figure 5: Exo-terra enclosure (45 x 45 x 45cm) used to house hatchling *E. moellendorffi off show* at Chester Zoo (©Matthew Cook, Chester Zoo)

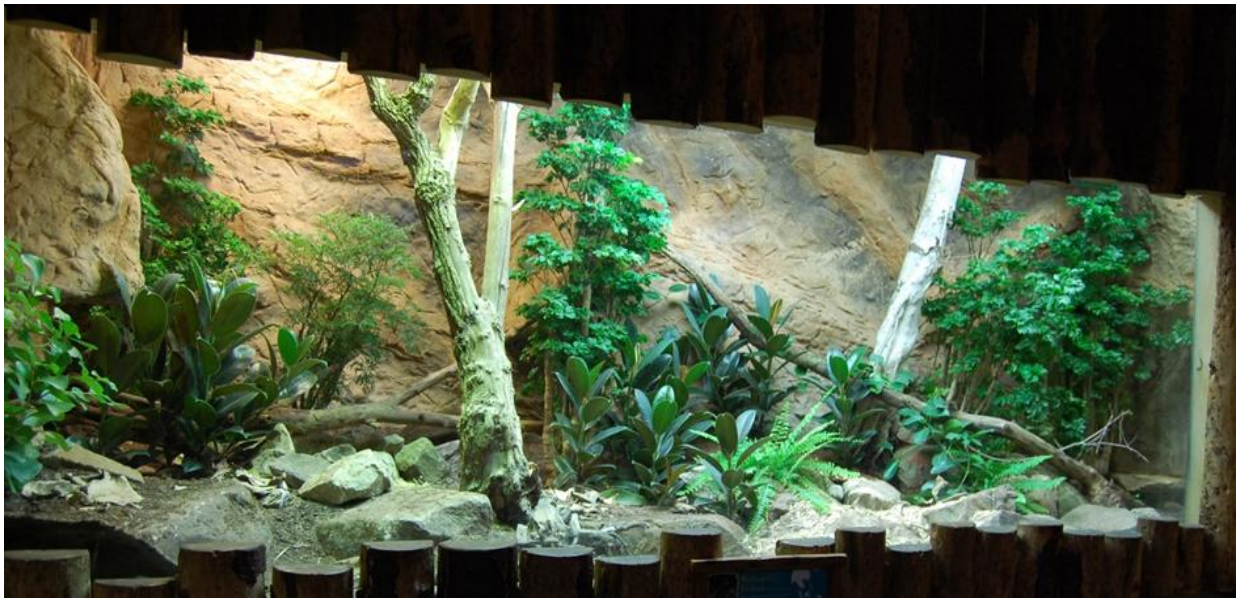

Figure 6: On public display measuring 350 x 120 x 150 cm for *E. moellendorffi* at Chester Zoo (©Matthew Cook, Chester Zoo)

2.1.1 Boundary

The physical boundary will be determined by the type of enclosure the animals are housed in (see section 2.1) When determining an enclosure size for a specimen's permanent housing, considerations must be made to provide a biologically appropriate environmental gradient, specific to the species needs, whilst also taking into account the natural niche this species occupies, and the number of animals housed together.

Choosing an adequately sized enclosure is key for the welfare of the individuals, as it will play a significant role in their physical and physiological development. The enclosures chosen will vary with time as the animal grows from neonate to adult (Fig. 6). Enclosures must be large enough to allow individuals to explore and extended the full length of their body but small enough that they can be monitored safely without excessive disturbance. Both on-show or off-show enclosures should always aim to encourage natural behaviour by being properly furnished with plenty of climbing and hiding opportunities (Fig. 4,5,6), suitable life support such as lighting, heating, aeration/ventilation and water must be present. The enclosure needs to be escape proof, particularly as snakes are excellent escape artists and are able to get through the smallest of gaps (Holtzman, 1999).

2.1.2 Substrate

Substrate should be loose and absorbate to allow for adequate humidity and heat absorption. A mix of 4 parts compost, 4 parts soil and 2 parts sand with a layer of dense leaf litter is an example of what can be offered. This does not only allow for the substrate to be porous but also retain humidity; the compost allows for a more nutrient rich soil that has potential to support plant life. A box with humid *Sphagnum* moss (Fig. 7) is also highly recommended as it will give individuals more choice of refugia and will be beneficial when snakes go through the ecdysis process.

Figure 7: *Sphagnum* moss (Komodo, 2014)

2.1.3 Furnishings and maintenance

When exhibiting any species it is generally desired to showcase the animal in an environment visually replicating their natural habitat to ensure public are educated not only on the animal but also key features of where they occur naturally. This can be achieved by adding geographically specific plant species to the enclosure (Fig. 8). Strategically placed plants are a great way to create microhabitats or refugia and can provide a dappled light effect.

Figure 8: Region specific plants that could be used in an enclosure housing *E. moellendorffi* *Chlorophytum bichetii (a)*, *Rhapis excels (b), Selaginella uncinata (c)*

Multiple refugia such as (rock crevices, hollow trees, artificial hides...) placed throughout the enclosure give individuals the freedom of choice to select where they feel most secure. Strategically placed perching should be provided to give individual plenty of climbing opportunity but also to provide access to broader thermoregulatory profiles. Hides, branching and other furnishings for this species should be used in such a way that replicates their natural environment, providing plenty of opportunities to exhibit natural behaviours (Cook, 2022). All of the above can be based on the environmental branches of the 5 domains of welfare in which giving an animal the opportunity of free will within its own environment is one of the keys to better welfare (Mellor et al., 2020).

2.1.4 Environment

Modern husbandry practises encourage an evidence-based approach, utilising data from the field to influence captive management (Arbuckle, 2013). Appropriate housing for this species should provide natural, seasonal provisions for heat, light and humidity. An overview of seasonal environmental fluctuations for this species in its natural range can be seen in Figure 9. Based on broad environmental data from Guangxi Province, China, the species requires a relatively cool climate with distinct cool and hot seasons. Ambient temperatures ranging from 23-33°C in the warm season; following this, at the start

of the cool season, temperatures should be dropped slowly until reaching a minimum low of 10°C. Providing seasonal fluctuations in temperatures are an essential step to induce mating at the start of the breeding season (Fig. 10).

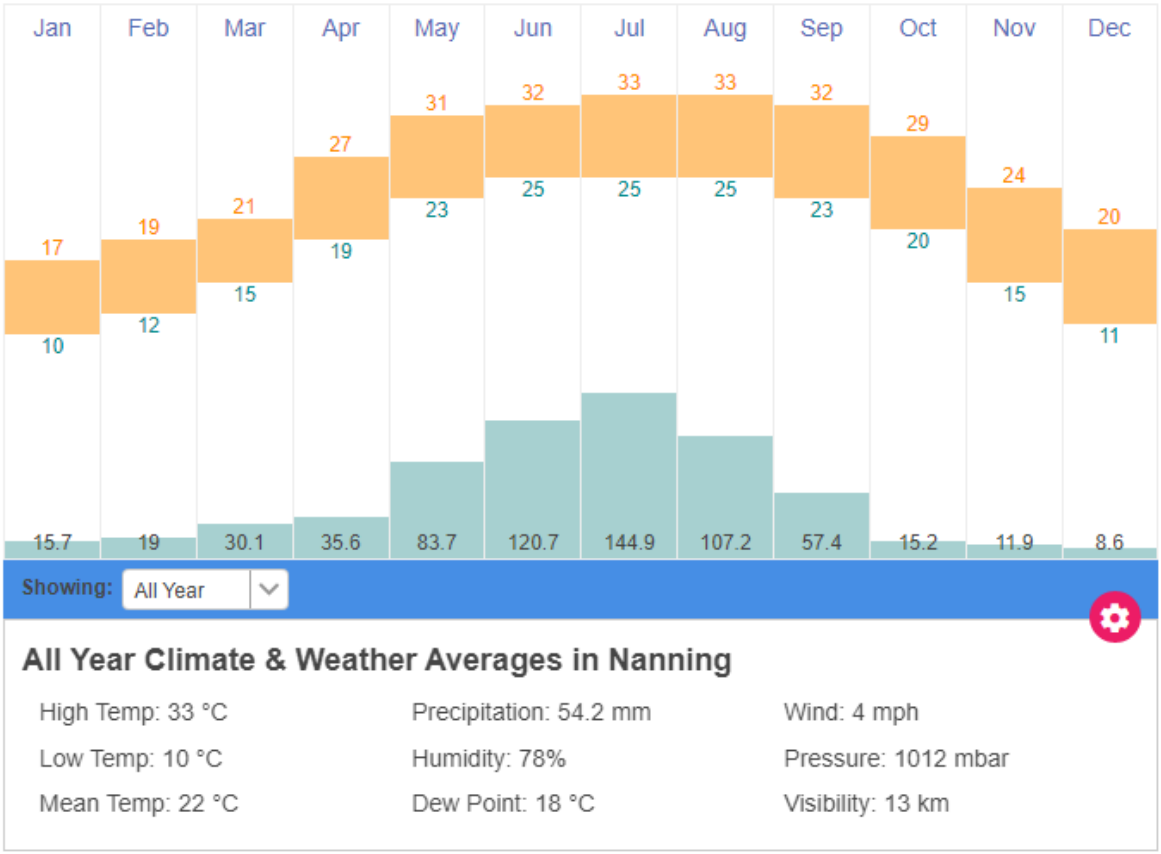

Figure 9: Showing seasonal environmental data for Guangxi province, China (Time and date, 2023)

Key considerations

Providing optimal heating and lighting conditions for *Elaphe moellendorffi* enclosures is crucial to ensure the species thrives in captivity. Recommendations from Baines et al. (2016), Highfield (2015), and Muryn (2018) emphasize the importance of replicating natural environmental conditions to support reptile health and behaviour. These references, available online or through the editors of these guidelines, form the basis of current best practices. When designing lighting and heating setups for *Elaphe moellendorffi,* keep the following factors in mind:

• Use lighting systems that simulate natural daylight, ensuring adequate UV-A and UV-B exposure to support healthy physiological functions and natural behaviour.

• Monitor UV-B output frequently using reliable tools, such as the Solarmeter 6.5 UV Index Meter (Solar Lighting Company, USA) or the Digital UV Index Radiometer (ZooMed Laboratories, USA), to maintain appropriate levels.

• Install basking-zone heating primarily using infrared-A (IR-A) sources, such as halogen bulbs, while

avoiding IR-B and IR-C heating elements, which may not produce the necessary thermal gradients.
• Create temperature zones within the enclosure so the snake can move between warmer and cooler areas, aiding thermoregulation.

Whenever possible, natural sunlight should be incorporated into the enclosure setup, such as by positioning enclosures where light can enter through a skylight. In areas or seasons where natural light is limited, metal halide (MH) lamps are a highly recommended alternative due to their balanced spectrum of light. LED lamps with a 6500K colour temperature can also be used, but they must be combined with UV sources since LEDs alone do not provide the UV radiation necessary for reptiles, neither UVA for complete full-colour vison, nor UVB for vitamin D_3 production.

Lighting

Although there is limited research on the specific light and UV radiation requirements of snakes, and a lack of wild data tailored to individual species, it is generally recommended to provide a combination of UVB and UVA emitting bulbs (Fig. 11). These recommendations are rooted in modern husbandry practices that emphasize evidence-based approaches whenever possible (Arbuckle, 2013).

UVB radiation is essential for reptiles, as it facilitates the synthesis of vitamin D_3, which is critical for calcium metabolism, bone health, muscle function, and overall physiological well-being. Without adequate UVB exposure, reptiles are prone to developing metabolic bone disease due to impaired calcium absorption (Michaels et al., 2015).

In captivity, replicating natural sunlight with appropriate UVB lighting is crucial. T5 High Output (HO) UVB lighting systems are particularly favoured (fig 11) as they are versatile and adaptable method to achieve adequate and stable/long-lasting UV-B radiation for their efficiency and effectiveness. When used in conjunction with reflective fixtures and supplemental heat sources, these systems can mimic the benefits of natural sunlight, promoting healthy behaviours and physiological processes in reptiles (Baines et al., 2025).

Providing UV gradients within enclosures enables reptiles to regulate their exposure, mirroring their behaviour in the wild. This approach helps meet species-specific UV requirements while preventing both deficiencies and overexposure (Baines et al., 2025).

At Chester Zoo, for example, the reptile display enclosure utilized a UV gradient with a UVI range of 0-3. The highest UVI level (3) was recorded in the basking zone, while areas outside the basking zone maintained lower UVI levels, ranging between 0 and 2. For more details on UV provision and optimal levels for reptiles and amphibians, Baines et al. (2016) offer comprehensive guidelines.

Additionally, ambient light levels should also be managed to create a photo-gradient within the enclosure. The basking zone should feature lux levels ranging from approximately 40,000 to 100,000 (Jirene, 2022). Utilizing high-quality lighting units for visible light, along with maintaining adequate lux

levels, can further enhance the health and well-being of captive reptiles by supporting their natural behaviours. Utilising good lighting units for visible light and adequate lux levels will also promote plant health and growth (Bravo et al., 2017).

Heating

Modern principles and standards in reptile husbandry and animal welfare show that, to achieve adequate heat uptake of an animal during basking, the temperature in the basking zone should be evenly distributed to an area larger than the largest animal in the enclosure, so that the animals' whole body is evenly heated when basking.

It is important to select the most appropriate equipment when providing artificial heat to animals. Short-wavelength heaters emit the same solar radiation as the sun (infrared-A) as well as UVB and IR-B and are currently recommended for daytime / basking heat provision (Gill et al., 2023), but in no case should this include ceramic heaters as they do not provide visible heat. IR-A radiation penetrates through skin to the subcutaneous tissues, whereas IR-C (long-wave IR), in other heating units, do not (Porter, 1967; Schroeder et al., 2007; Baines, pers. obs.). Short-wave infrared heaters (Fig. 13, 14) are also much more effective for providing basking warmth and less likely to cause skin damage from localised overheating of the skin surface. Moreover, these shorter wavelengths have a biological effect upon living cells unrelated to warmth. They activate genes responsible for a wide range of effects, which include acceleration of healing and protection against UV damage (Schieke et al., 2003; Schroeder et al., 2007; Baines, pers. comm.). IR-A units (e.g. halogen and quartz-halogen patio heaters) come in a variety of wattages and sizes, so careful selection, control and mounting is required depending on the enclosure size and environmental requirements. See Fig. 12, 13 & 14 for halogen and quartz halogen heaters. Basking areas must be at least equal to the size of the animal in its natural basking position, or, where multiple animals are held, sufficient in size to allow multiple animals to bask simultaneously (Gill, pers. comm.). In addition, localised heat provision should be provided as a thermal gradient, providing freedom of choice for the animal/s to regulate themselves.

Infrared (heat), visible light and UV must cover the same area and be distributed as evenly as possible across the entire basking zone, avoiding small spots of concentrated heat (Gill et al., 2023). The thermal gradient must coincide and overlap with photo-gradient, to ensure the peak of the thermal gradient overlaps directly with the peak of the photo-gradient (Gill, pers. comm).

Heating and lighting unit should be mounted externally on an enclosure for a number of reasons: animals can't access them directly so risk of burns are minimal and changing or replacing lamps can be easier as an incursion into the enclosure is not required. Ambient temperatures also need to be a consideration, alongside the basking zone. Ambient temperatures should mimic the seasonal temperature profile outlined in (Fig. 9).

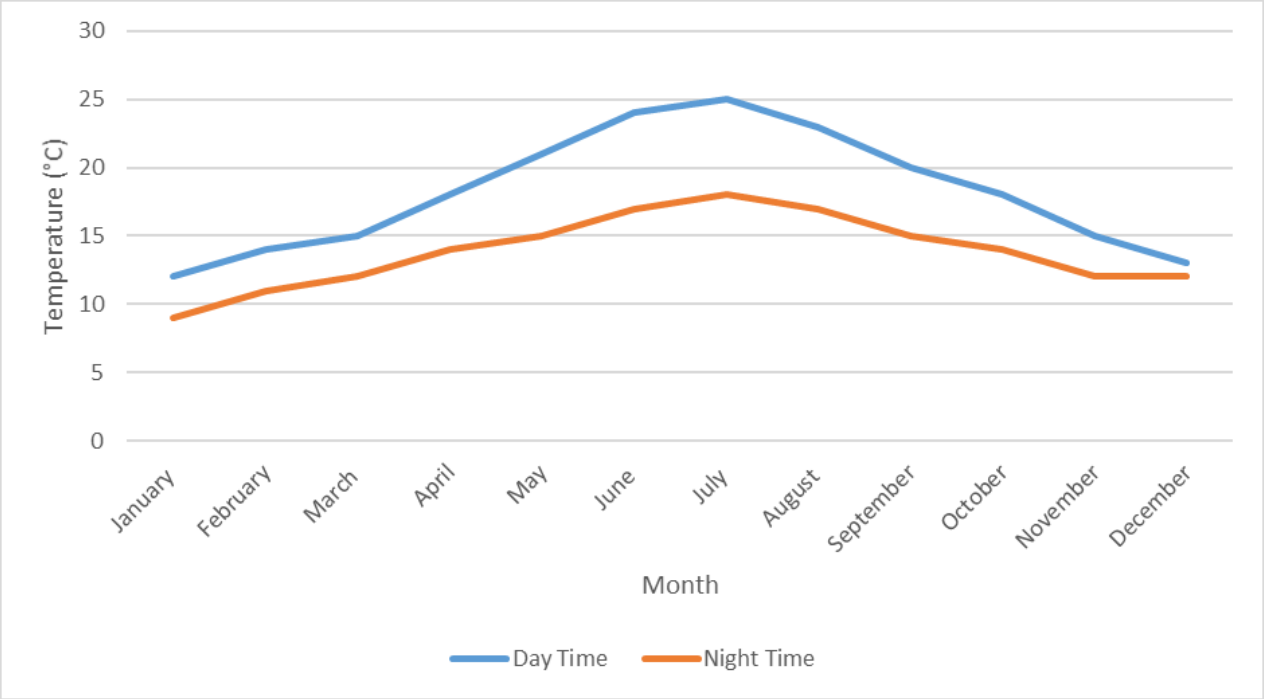

Figure 10: Day and night ambient temperatures of the display exhibit for *E. moellendorffi* at Chester Zoo. Recorded monthly in 2019 at Chester Zoo (Cook, 2022)

Figure 11: Growth Technology "Lightwave" hydroponic unit T5 LW24-HO (Growth technology, no date)

Figure 12: Assortment of halogen lights from Arcadia (Arcadia, 2023)

Figure 13: 1.5kW Heliosa outdoor heater (Sunswitch, 2025)

Figure 14: Specialist Animal Heater – 1.5kW (Sunswitch, 2025)

Humidity

A varied range of humidity should be provided in the enclosure, including an area featuring a refuge with high humidity (e.g. a moss box as mentioned above), kept humid but not wet will help when individuals are going through shedding (Cook, 2022). The entire enclosure may be misted once or twice per day during the warm season; this is reduced to once a day during the cool season and eventually ceased during brumation. Humidity can be obtained through manual spraying or automated misting systems (Fig. 15a, 15b). Manual spraying allows for better control and reactive management as is it easy to see if the humidity is too high or low and also allows the keeper to directly offer and see if individuals are drinking, but as a result this can be time consuming. Timed misting systems are a more time-efficient way of keeping humidity in line with seasonal cycles, but problems such as faulty timers or mister are

common, which can result in under- or over-spraying. Both methods can be used together to assure the best possible results but never automated systems alone.

The water used can be either tap water aged for 24-hours for dichlorination or via a Heavy Metal Axe (HMA) filter (Fig. 15c) which removes dirt, sediment, chlorine, and heavy metals from the water supply. Using reverse osmosis water in misting systems is also an option and has the added benefit of not causing a calcium/lime scale build-up in the nozzles or water marks on any glass and furnishings.

Signs of inadequate humidity will reflect in the in the animal itself, sign of low humidity will cause dysecdysis and dry skin (McCracken et al. 2018), and on the other hand different skin colour patches and soft skin, are signs of excessive moisture and underlying bacterial or fungal infection (Harkewicz, 2002). The average humidity for 9 months of the year should be around 80% and drop to 70% for the last 3 (Time and date, 2023).

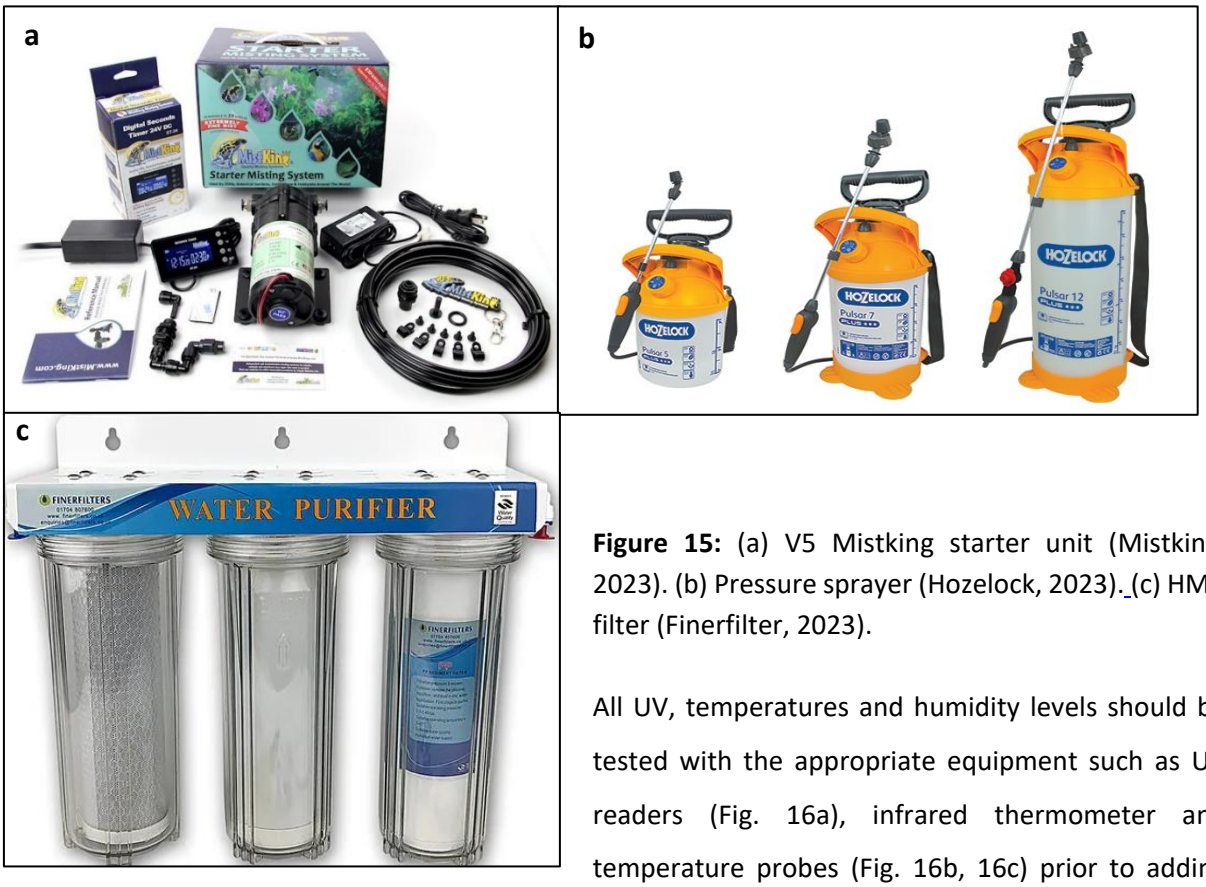

Figure 15: (a) V5 Mistking starter unit (Mistking, 2023). (b) Pressure sprayer (Hozelock, 2023). (c) HMA filter (Finerfilter, 2023).

All UV, temperatures and humidity levels should be tested with the appropriate equipment such as UV readers (Fig. 16a), infrared thermometer and temperature probes (Fig. 16b, 16c) prior to adding animals to an enclosure and ongoing routine monitoring is essential to ensure the required levels are maintained through the respective seasons.

Figure 16: (a) Solarmeter® Model 6.5R Reptile UV Index Meter (Solermeter, 2023). (b) Infrared thermometer (Eti, 2023). (c) Temperature and humidity thermo hygrometer (Eti, 2023).

2.1.5 Dimensions

These snakes are large, active and able climbers and will utilize and require large enclosure spaces with an arboreal focus. In Germany, private keepers have kept them outdoors in aviary style cages (Reptile care database, 2017). It is the keepers' and zoo's responsibility to make sure that individualsin the enclosure are able to stretch the full length of their body; therefore, aspace of 180x150x90cm is a minimum required for adult specimens (Cook, 2022). Neonates can be housed in enclosures approx. 90cm x 45cm x 45cm (e.g. Exo-Terra, Fig. 5). It should be noted that housing for juveniles should be tall and have nonabrasive material as roofing to avoid any skin lesions from juveniles rubbing their skin (Cook, 2022). The size of the enclosure may vary depending on time of years as during brumation a smaller space can used due to lack of activity. Depending on the size of available housing it is often easier to separate individuals to allow them to have more individual space as part of the spatial consideration choosing an appropriate enclosure (Warwick et al., 2019).

2.2 Feeding

2.2.1 Basic diet

As a general rule only whole food items should be presented; this is important to ensure that individuals get the micronutrients needed for their wellbeing. Parts of whole food items (e.g. offering a pinkie mouse head) can be offered as a short-term solution but will tend to be an unbalanced prey, and when without bones, calcium deficient (Card, 1995).

E. moellendorffi will accept a wide variety of prey items (section 1.6). In captivity it is always best to replicate, where possible, the wild diet of a species. A large variety of small to medium sized pre-killed

food items ranging from small/medium rats (*Rattus norvegicus domestica*), mice (*Mus musculus*), gerbils (*Meriones unguiculatus* forma *domestica*), multimammate mice (*Mastomys natalensis*), to available lizard (e.g. *Lepidodactylus lugubris*), amphibians and birds (quail chicks, day-olds chicks), should all be used if possible. Mammalian prey should be favoured. The amount of prey items offered will depend on size of the individuals but also the size of the prey item. As an example for adults, 1 large prey item (e.g. 1 medium rat) can be used per feed or 2 medium prey items (e.g. 2 small rats). Multiple smaller prey items can be used to scatter-feed which can be done when housing a single individual or under strict supervision to avoid multiple snakes grabbing the same prey item. To avoid any complications, a general rule for prey size selection is to offer prey that isn't significantly larger than the thickest part of the snake's body (Gill, 2023). It is important to keep a feeding record for the individuals as this will allow the monitoring of food intake as well as provide information on their seasonal feeding habits and can be used to detect when an individual could be unwell and is stopping *t*o feed.

Water can be injected into prey items to provide added hydration for snakes. A general multivitamin supplement such as Arcadia's EarthPro-A can be used as a nutritional additive to mitigate the potential deteriorated nutritional content during the storage process (Card, 1995; Dierenfeld et al., 2002; Douglas et al., 1994). Supplements can be put into small capsules and then stuffed into the prey item of choice to be fed out; this should not be done more than once every two months.

Size and quantity of offerings will depend on the size of the individual the time of year and whether or not they are in slough; even though some individuals will eat during the ecdysis process, it is recommended not to feed as it may interfere with the sloughing process due to the individual being more sedentary whilst digesting but also could lead to waste due to the poorer likely hood of individuals feeding (Turmo, 1996). In the leadup to brumation and during the warmers months individuals will require an almost weekly feed followed by a period of fasting before and during brumation (Cook, 2022). This period is necessary so that no undigested food is left in the individuals digestive tack whilst bromating which can lead to severe complications (Corbit et al., 2013). Generally, the slow decrease in temperature leading to brumation should prompt individuals to naturally stop accepting food in which case it is safe to brumate, if not at least a month should be left between the last fed and brumation.

2.2.2 Method of feeding

General method of feeding

The prey offered can be prepared in various ways, ether freshly killed or defrosted. Freshly killed prey must be ethically dispatched in accordance with the local legislation and in discussion with a veterinarian. Fresh kill may not be for everyone and or possible depending on available facilities due to the space required to keep live vertebra. Fresh kill can be useful for difficult feeders as it will generally elicits a stronger feed response due to the warmer body and fresh smell. Frozen prey is more widely available and convenient due to ability to store it. Frozen prey must be defrosted fully at room temperature (22°C) and then can be warmed slightly more to mimic the body temperature of live prey. Proteins can be denatured when aggressively warming the prey items. Gloves should be used at all times when manipulating prey items as to not alter scent of the prey item with the scent of feeder. Feeds should happen on a weekly basis during the warmer months and start to decrease in frequency when approaching brumation. Prey items can be offered in different ways; either via strike feeding using forceps or tongs (Fig. 17) of an appropriate length, or as a scatter feed by dispersing food item(s) in the enclosure. Food items should then placed on a clean surface (rock, wood, hide...) to avoid ingestion of substrate or leaf litter which might stick to the prey item and thus put the snake off from ingesting the prey. For animals kept in a group or in pairs it is recommended to not scatter feed unless a keeper is present to keep track of the number of prey items consumed by each individual. There is also a much higher risk of conflict over one prey item which could lead to injury or to one snake consuming the other. Various methods can be used to aid feeding trickier individuals that may refuse food despite following the above recommendation. Piercing the skull to expose the brain often elicits a stronger feeding response (Gill, 2023). Offering food during lower light levels as the species is crepuscular in nature. Raising the humidity a few hours prior to feeding is another technique that is often successful as the wetter season in the wild coincides with peak activity levels and feeding activity (Fig. 9) (Gill, 2023). Force-feeding should be a last resort due to the stress involved for both the keeper and the snake and should only be done by someone with experience. If all options have been exhausted, live feeding can be attempted if legally possible. Giving the snakes a sense of security and presenting optimum environmental parameters are also likely important contributing factors to feeding success.

Juveniles method of feeding

There is a high probability that juveniles of this species naturally feed on lizards and/or frogs (Mehrtens, 1987; Zhao, 1998; Gumprecht, 2004). Ideally, lizards and frogs should be fed. However, if unavailable, the snakes will accept pinky mice when presented through a few important techniques. The feeding

process has been found to be much easier when all the furnishings are removed from the enclosure. Moving the snake into an empty plastic tub can also be done but due to the transfer stress, success seems much poorer. A pinky mouse defrosted at room temperature and then placed in tepid water for a few minutes before offering elicits the best responses. The food item should not be heated but warmed; however, a warm room often dries out the food item and makes it sticky, inhibiting successful feeding. This can be avoided by placing it briefly into water. Offering the pinky mouse on forceps will prevent the keeper's hand from intimidating the snake and hindering the snake focussing on the food. It was found that the best way to elicit a strike response was to poke the body and move towards the head with the food item. Once agitated, the snakes strike quite readily but don't always grasp hold of the food. The most sensitive area to apply pressure with the food item appeared to be around the neck. This frequently prompted the snake to strike sideways around at the target with a wide-open mouth. The pinky was then quickly aimed snout-first into the snake's mouth. This requires a fair amount of skill and luck. If the mouse is held by anything other than the tip of the snout, invariably the snake will drop it and the process must be restarted. If the snake has hold of the snout, they often begin swallowing. Juvenile snakes have never been observed to constrict the prey item as is observed in adults. While grasping and swallowing the food item they were frequently observed vibrating their tail. This is presumably a natural response when feeding to attract possible predators to the expendable tail end whilst in this vulnerable state, which can be exacerbated by the presences of hovering keepers. The swallowing response is usually fairly rapid and juveniles do not appear to hold the prey in the mouth for long periods without swallowing progress. However, seems of vital importance that after the snake had hold of the mouse, the keeper should step back and then remain completely motionless. The snake's vision is very acute and any slight movement by the keeper might prompt the snake to spit out the food or even regurgitate a partially swallowed food item. The food is usually swallowed fairly quickly but the keeper should always wait for the food to be completely consumed before the furnishings can be carefully placed back into the enclosure.

The difficulty of this process will vary between individuals. A few further techniques can be used for trickier feeders, such as snipping off the front legs of the pinky as with some individuals, the snag of the pinky's limb on the snake's jaw can be enough to cause them to spit the food out. Some specimens have poor accuracy when sticking which may result in them biting at the substrate and subsequently getting mouthful of substrate which can be rinsed out, but it may have caused further issues for the snake if it was swallowed; it will also disrupt the feeding response. To combat this issue, a layer of kitchen paper can be placed on top of the substrate and dampened down before feeding.

After a few weeks of feeding, individuals should be large enough to eat two pinky mice per feed. However, this can lead to further problems as the excitement and stress of the feeding method can prompt individuals to regurgitate. Due to the aggravating feeding method whilst already holding one pinky in the stomach seems to be enough to upset the guts and cause regurgitation the following day. The technique of chain feeding a second pinky also proves to be unsuccessful as any disturbance caused

rapid regurgitation. To avoid this, an increased feeding frequency with one single food item rather than more food items per feed is recommended as it seems to be more productive. Juveniles can be observed actively moving around having digested the meal of one pinky after three days. On day 4 the next pinky can be offered (Cook, 2022).

Figure 17: Mouse being tong fed to *E. moellendorffi* (©Blast! Film Productions).

Fresh, dechlorinated water in a bowl/container must be present at all times and replenished as frequently as required. This allows individuals to hydrate and will also, to some extent, increase air humidity which will help with the ecdysis process.

2.3 Social structure

Apart from breeding interactions, little is known about the social life of *E. moellendorffi.* as is generally the case in snakes. Some forms of social behaviours seen are mostly anecdotal, such as the aggregations of snakes in communal den sites, and under cover objects (Gillingham, 1987, 1995). In a case study done on *Natrix maura* by Aubret et al., (2016) it was found that eggs incubated as a clutch were more likely to seek contact with their siblings as opposed to eggs incubated singly where the individuals were seen to be more active and antisocial. Whether or not this applicable to *E. moellendorffi* is unknown but noteworthy, nonetheless.

2.3.1 Sharing enclosure with other species

It is quite difficult to find appropriate species to share an exhibit with *E. moellendorffi* due to predatory risk and stress factors. Suggestions might include large species of invertebrates such as Siamese rhinoceros beetle (*Xylotrupos socrates)* or stick insects from the genus *Phryganistria* which are both a safe strategy as there will be no risk of conflict between each species.

Mixing snakes and chelonians in the same enclosure is generally discouraged by veterinarians due to the risk of *Entamoeba* infection, which can cause severe gastrointestinal disease in snakes. However, a nuanced approach can be adopted by conducting regular checks on chelonians for the presence of *Entamoeba*. If tests confirm the absence of the parasite, the mixing of these species might be considered, contingent upon ongoing monitoring. Seeking advice from a vet advisor with reference to any relevant publications can provide valuable insights into best practices for maintaining the health of both snakes and chelonians in shared enclosures. The mode of transmission of *Entamoeba* is mostly oral, i.e. through contaminated drinking water, so there should not be a significant difference between arboreal and ground snakes in terms of susceptibility to infection. However, other factors such as the species, diet, and stress levels of the snakes, may also influence their risk of *Entamoeba* infection. Therefore, rigorous testing and ongoing veterinary guidance should be established (Westhoff, 2024).

2.4 Breeding

2.4.1 Mating

It is common practise when breeding snakes to separate and reintroduce sexes (Peterson et al., 1995; Kane et al., 2017; Radovanovic, 2013) to improve copulation success, as the breeding response is usually a lot stronger in sexes keep separately due to the lack of familiarity (Cook, 2022). In the case of *E. moellendorffi* a period of brumation should be conducted to allow for a period of sexual rest and to promote spermatogenesis (Girons, 1982). This should be done via a slow but steady decrease in temperatures until the optimal minimal is reached (Fig. 9, 10), followed by a slow and steady increase in temperatures (Fig. 9, 10). As a precaution, it is important to consider an individual's brumation history before subjecting it to its minimal temperature range. If the individual has not previously experienced such temperature fluctuations, this could lead to adverse effects. In such case, brumation can still be carried out but with a less significant temperature, for example going to 15°C instead of 10° C. After brumation, usually during March-April, individuals can have their first feed. A small food item should be favoured to allow an easier restart of the digestive track after months without feeding. As mentioned above it is advised to introduce the male to the female to optimise chances of breeding. After the introduction there seems to be a short period of adaption before both individuals start to interact with

each other, after which the first sign of acknowledgement comes from increased tongue flicking followed by the male chasing the female. After the chase which usually lasts about 30min but can varies depending on how receptive the pair are to each other. Males will start to show signs of courtship such as body jerking and rubbing their face on the female until eventually lining up with female to lock for mating (Fig. 18), (Cook, 2022). After the female and male show a lack of interest in each other and stop locking, the male can be separated from the female if appropriate separate housing is available.

Figure 18: Courtship with male *E. moellendorffi* on top of female (©Blast! Film Productions).

2.4.2 Egg laying and incubation

The gestation lasts approximately 2 months. A few weeks prior to laying a plastic nest box measuring around 40x 26 x 14cm (LxWxH) and half filled with damp sphagnum moss with a lid as a single entrance (Fig. 19, 20) can be placed in the exhibit to encourage laying (Cook, 2022). The box should be placed in an area of the exhibit where it is able to reach 24°C during the day and 18°C at night. The humidity in the nest box should be keep anywhere between 80%-100% with the moss to be kept humid but not wet. The average clutch laid usually comprises of 5-12 eggs usually deposited in a clump (Fig. 21, 22, 23) which can be carefully separated if found within 12h of being laid for better aeration and to help mitigate any fungal development. Separating the eggs might not completely prevent fungal development in which case anti-fungal baby powder can be lightly brushed over the egg. Each egg weighs just under 30g with the average size being 57mm x 27mm. The eggs are incubated in a closed box with light aeration. Eggs should be placed on a Vermiculite to water weight ratio of 1:1. To maintain a constant humidity it is

important to weigh the box on a weekly basis to aerate the box and replace any lost weight to its original weight by carefully adding water. In captivity incubation should last approximately 80 days if kept at a stable temperature of 27°C and over 80% humidity (Cook, 2022). Fertility can be checked prior to hatching using a method called “candling” from 10 days into incubation. The method consists of using an LED flashlight or egg candler in a darkened room, holding the bright light on one side of the egg and looking for strands of blood vessels Candling is not a guaranteed method and after a couple of attempts the egg should be left alone. It is best to minimise time spent handling eggs. Eggs which collapse, turn from white to yellow, begin to dimple, grow excessively mould or start to smell will require more inspection as they may have turned bad and might contaminate other eggs. In this case the bad egg should be removed and appropriately disposed of; prior to disposal the egg can be cut open to check for any indications of fertility.

Figure 19: Female *E. moellendorffi* in nest box used to lay eggs (©Matthew Cook, Chester Zoo).

Figure 20: Nest box (Chester Zoo, 2018).

Figure 21: Female *E. moellendorffi* at Chester Zoo shortly after laying a clutch of eggs (©Blast! Film Productions).

2.4.3 Hatching

After approximately 80 days incubation, neonates will start pipping the egg and hatching (Fig. 22); this procedure can take several days for all eggs to fully hatch. Once hatched it would be advisable for the neonates to be left in the incubator for a period of 24h to acclimatise to the "outside world" before moving on to a rearing tank (Cook, 2022). In the process of moving neonates, a full body check should be done for any deformities, proper absorption of the yolk sack and closing of the umbilicus. Full weights and morphometric of all neonates should also be taken. Hatchlings will weigh anywhere between 17g to 20g (Fig.24) and should steadily grow up to the age of 7 years old before plateauing and only naturally going up and down in weight due to seasonal fluctuation (Fig.25)

Figure 22: Snake hatching Chester Zoo (©Blast! Film Productions)

Figure 23: Clutch of seven eggs set up for artificial incubation (©Blast! Film Productions).

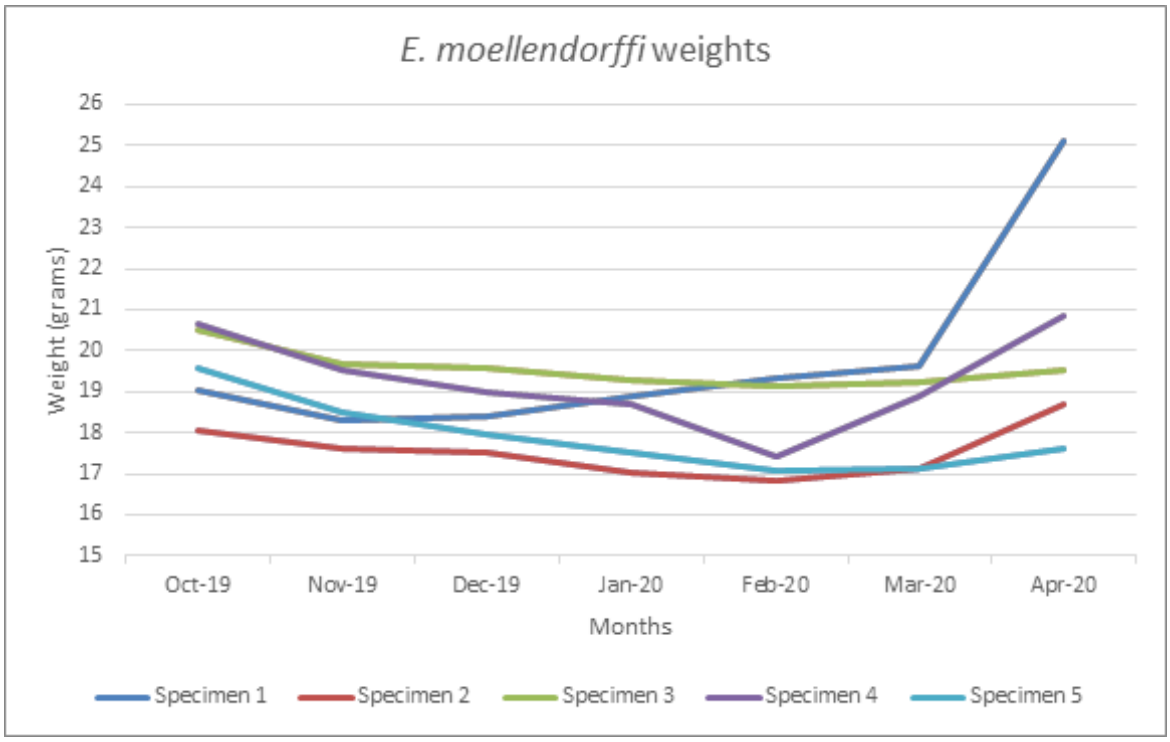

Figure 24: Rates of weight increase in 5 juveniles *E. moellendorffi* at Chester Zoo.

The stable and slight decrease in weight can be attributed to episodes of regurgitation. It is also likely that the feeding technique only allowed for small meals to be consumed. The weight gain from March is attributable to the method of increased feeding frequency (every 4 days).

Figure 25: Seasonal weight fluctuations of Chester Zoo's adult female *E. moellendorffi*.

2.4.5 Population management

As there are no managed species programmes for this species, there is no current recommendation for population management. The number of animals in collections is low, and there are challenges in finding specimens in Europe and globally. However, the inclusion of the species in the 2024 EAZA regional collection plan for ophidians, as monitored by the EAZA Reptile-TAG (Westhoff, 2024), provides an opportunity for institutions to determine their level of involvement in fostering conservation. This aligns with the RCP's approach, which emphasizes granting "holders the autonomy to determine their level of involvement, thus fostering a proactive and adaptable approach to its management." To support population viability, it is advisable that the species is bred—when possible—to provide new bloodlines and sustain the population, particularly where suitable holding is available. The species is considered conservation-dependent, and a number of recommended actions, including captive breeding, are outlined by Zhou (2004).

2.5 Behavioural enrichment

As a rule, it is crucial to provide the most important features of nature except for disease and predators (Burghardt, 2013). This will include targeting wild activity budgets for animals as well as diet, habitat, and environmental parameters (Crockett and Ha, 2010).

Snakes are seen to exhibit more simplicities and behaviour enrichment is often overlooked or improperly implemented, despite that fact that recent studies have shown that snakes which use enrichment when it is available to them will show a change in general behaviour reflective of

improved welfare (Hoehfurtner et al., 2021). Keeping in mind that institutions should be aiming to replicate wild behaviour as much as possible for the species in their care (Gray, 2017), this should be used as the starting block for any enrichment ideas. Enrichment can come in many forms such as cognitive, social, physical, environmental, sensory or food based. All the aforementioned enrichment can be used to create a programme that will ultimately better the welfare of an individual on a cognitive level but also on a physical level by increasing physical activity and consequently fitness. An example of a sensory enrichment can be a scent trail (scented water or prey item) spread around the exhibit of a solitary individual (to avoid conflict over feeding response); this will promote the individual to use senses and physical activity by investigating.

2.6 Handling

If restraint is needed, it can be accomplished by hand with one hand fixating the head with a firm grasp around the neck (if necessary for unpleasant individuals) or by supporting the upper body (for more habituated individuals), and the other hand around the tail. For the more aggressive individuals the use of a snake hook would be a more appropriate handling tool. A head cover works well to keep the animal calm, reduces stress and the likelihood of an accidental bite. If potentially gravid females have to be captured, special care needs to be taken that this is done very quickly and without potentially damaging internal eggs. The handling should be concise so that the restrained individual does not have any excessive pressure applied to any parts of the animal's body.

2.6.1 Individual identification and sexing

There are multiple ways of sexing individuals at various stages of maturity. In adults, morphological sexing is possible as males tend to be larger around 2kg and heavier bodied than females, with considerably larger heads and slight but visible hemipenile bulges (Gumprecht, 2004).

Other possible methods of sexing adults and juveniles over the age of 6 months is probing which consists of using an adequately sized probe (in proportion to the size of the individual and without spermicidal lubricant) and inserting it carefully into the hemipenal/hemiclitoral pocket caudally until resistance is meet. The sex is determined by how far the probe could be inserted. In males the distance before resistance is met will be significantly longer (Fig. 26). This procedure is delicate and should be done with the animal properly restrained by two experienced people to prevent injury of the animal in hand by pushing the probe too far and causing damage to the thin membrane delineating the hemipenal/hemiclitoral pockets.

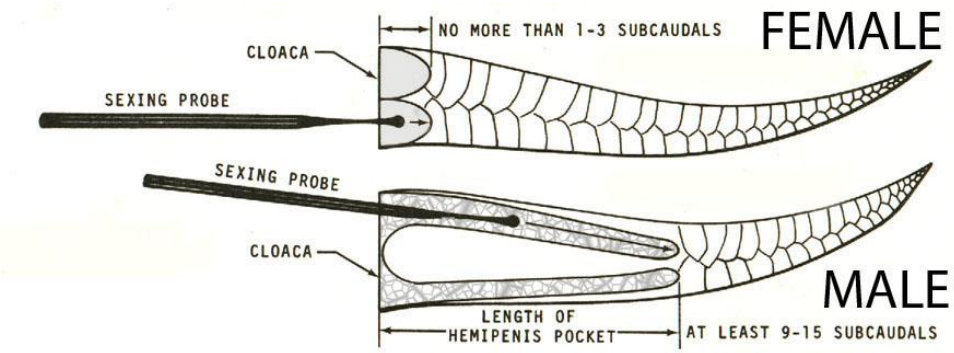

Figure 26: Using probes to determine the sex of specimen (Laszlo 1975).

Microchipping is a reliable and frequently used method for identifying adult *E. moellendorffi.* ISO-compliant transponder microchips, such as the 1.4 x 8.0 mm or smaller 1.25 x 7.0 mm variants (Trovan, 2023; AgnThos, 2024), are recommended for subcutaneous insertion. The procedure involves two individuals: one to securely restrain the snake and the other to implant the microchip. The microchip

should be placed subcutaneously on the left rear side of the body, just posterior to the ventral scales, avoiding sensitive structures like the spine and major blood vessels. Careful restraint is essential to prevent sudden movements that could lead to injury during the procedure. Once the snake is restrained, a small incision is made in the skin using the microchip applicator. The microchip is inserted just beneath the skin, ensuring that no damage is caused to underlying tissues or organs. The placement can be verified by palpating the microchip after the applicator is withdrawn. Proper closure of the incision is critical to avoid complications. Surgical adhesive can be applied to seal the site, or gentle pressure can be used to encourage natural closure. It is crucial to ensure the microchip remains under the skin rather than migrating into the body cavity, as intracoelomic placement risks internal damage or migration of the chip. Some mild, localized bleeding may occur at the site, usually as a result of minor trauma to small blood vessels. This can typically be controlled with light pressure. Adverse effects like reduced activity or appetite are rare, and healing usually occurs without complications. However, in rare instances, microchips have been known to migrate or become dislodged, possibly during shedding or if the insertion site fails to heal completely. For snakes that are particularly stressed by handling, extra support should be employed to minimize distress and ensure precise implantation. While this is not necessary for most individuals, it can be a useful option in specific cases. Overall, subcutaneous microchipping has proven to be an effective and straightforward method for the identification of *E*. *moellendorffi*.

2.6.2 General handling

As a rule, individuals should only be handled when needed and with great care as to prevent any injury and excessive stress in the animal.

Multiple circumstances could justify handling an individual such as:

- Sex determination
- Obtaining samples
- Examination of a medical issue
- Treatment of a medical issue
- Assist-feeding
- Removal of retained slough skin
- Transport to another facility

Approaches will vary depending on age and size of the individuals. Juveniles being small and delicate will require a light-handed, attentive approach as their speed and size can make them awkward to handle and puts them at higher risk of injury or escape. Adults, due to their large size, temperament and aggressive demeanour will require equal amounts of attention. The main concern is not only over a possible bite wound itself but the likelihood of teeth breaking within the wound, potentially causing infection. To prevent this a wound should be inspected for teeth, cleaned, bandaged and if necessary, a

tetanus shot may be required (HealthLink BC, 2023). Depending on the country some certification may be required to handle this species, so care should be taken to look up in country certification.

2.6.2 Safety

Although *E. moellendorffi* is a non-venomous species, its bite can still cause painful puncture wounds that may lead to infection if not treated properly. Their sharp, recurved teeth are designed for gripping prey and can easily break the skin during defensive strikes. For this reason, wearing bite-resistant gloves is recommended when working with unaccustomed or defensive individuals. Care should also be taken to avoid provoking the snake into defensive behaviour. Sudden movements, rough handling, or attempting to remove the snake from an elevated position may increase the likelihood of a defensive strike. As this species is naturally shy and quick to retreat, handlers should approach them calmly and ensure minimal disturbance during interactions. In addition to bites, *E. moellendorffi* may use rapid, evasive movements to escape when startled, increasing the risk of injury to itself or nearby handlers. Enclosures should be well-secured during maintenance to prevent accidental escapes, and all exits should be checked before opening the enclosure.

2.6.3 Catching/Restraining

In the case of manually restraining an adult individual, bite-proof gloves for extra protection can be used in conjunction with a snake hook; the idea being to make the individual's body feel supported during the catching process to avoid any unnecessary stress. If needed two people can be involved for better restraint in case of invasive procedures (one for the head and one for the body). Juveniles will need to be handled with more delicate care- a small hook and a pair of gardening gloves are ideal and less cumbersome than heavy duty bite-proof gloves.

Snake hooks always feature amongst a snake keeper's collection of tools regardless of whether they are working with venomous species or not. Hooks come in a multitude of shapes, sizes, weights and designs (Fig. 27). As a handler it is important to find a specific type of hook that one is comfortable with. Hooks are used as an extension of your arms to lift, move and guide animals from point to point (Fig. 28). They can also be used to move décor, open and close doors on enclosures or trapping boxes etc. They provide the flexibility needed to work at a distance from the animal (Gill, 2016).

Figure 27: Snake hooks and handling (Gill, 2016).

Figure 28: Hooking to move an animal from point to point (Gill, 2016).

To use hooks effectively a few considerations should be made in selecting the right hook for the job. It is important to know the strike range and capability of the species you are dealing with and selecting a hook of an appropriate length; as a rough guide, if the snake is 30cm then use a snake hook at least 30cm long to keep yourself at a safe distance from the animal. This works as a general rule; however, with large snakes it does not make sense to use hooks longer than 150cm (Gill, 2016).

When restraining non-venomous snakes, most handlers would favour grasping the snake behind the head in order to carry out procedures. A much safer restraint technique is the use of restraint tubes (Fig. 29).

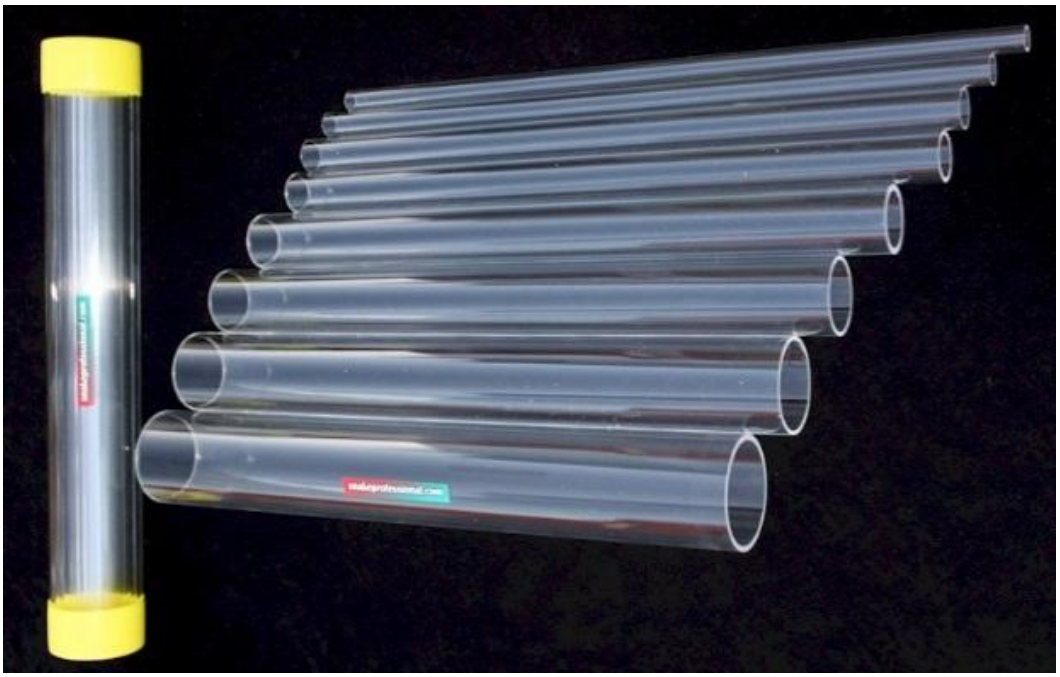

Figure 29: Snake tubes are commercially available from a large variety of vendors.

The tubes are transparent and can be made from plastic or acrylic, depending on supplier. Snake tubes are available in various lengths and diameters and will suit the needs of most, if not all species (Gill, 2016).

The principle of tubing is simple: the animal's head is gently guided into the tube and when the head is far enough inside the tube that the animal cannot quickly or easily back out, the snake's body is grasped gently but firmly at the junction of the tube. The handler should immediately reach down to restrain the rest of the snake's body with the other hand. Remote handling tools, like hooks, can be used to guide the snake's head into the tube, but can also be used to hold the tube (Murphy, 1971). The chosen tube should be wide enough to allow the snake to comfortably get in the tube but narrow enough that the snake cannot turn on itself and bite the handler, if needed a smaller tube can be inserted into the lager tube to further restrain the head. Selection of the tube size id dependent on the size of the snake, be careful the snake doesn't get stuck in the tube.

By modifying restraint tubes, the possibilities of carrying out different tasks increases. Perforating the tube will allow access to specific areas of the snake, to carry out blood draws or inject medication etc. (Fig. 30) (Ball, 1974). A larger aperture can also be created in the tube to allow retained eye caps to be manually removed (Murphy, 1971).

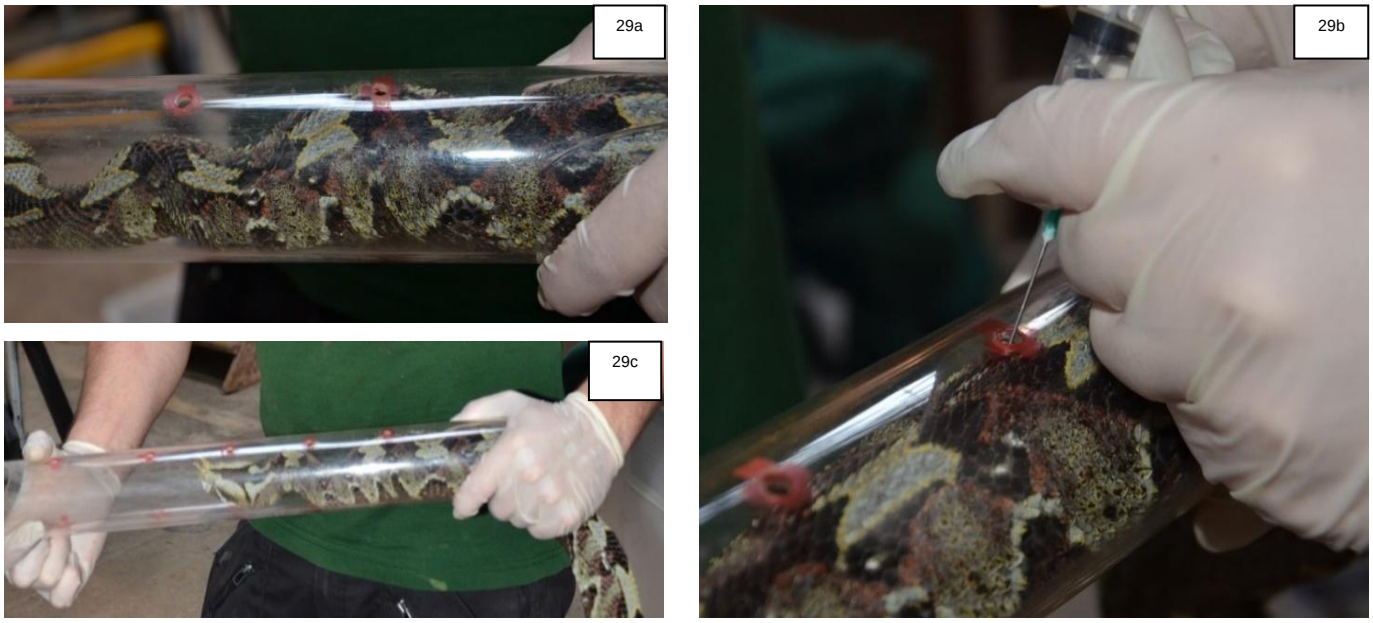

Figure 30: Blood sampling of *Bitis nasicornis* via a hole in the tube (Gill, 2016).

Tubing is a much more considerate way of restraining snakes, and the majority of animals seem to tolerate it much more than pinning. In the authors' experience when probing a snake to determine the sex, more accurate results are obtained when an animal is tubed rather than other forms of restraint. This is due to the animal being calmer under confinement of the tube (Gill. I, 2023).

2.6.4 Transportation

Transport of *E. moellendorffi* for long distance/periods can be done in an insulated crate of appropriate size. The crate will require appropriately sized aeration holes and should be able to be fully secured with the lid screwed down to avoid any escape (Fig. 31). Each snake should be individually packed in appropriate cloth bags, keeping the animals in the dark to reduce stress. Any remaining space in the crate should be filled with a soft, breathable material that will allow air flow and cushion the animal (Fig. 32). Temperature of the crate can be maintained by having a false insulated wall within the crate lined with bottles filled with water slightly above ideal temperature for long distance travel or during cooler periods of the year where additional heating will be required. During this period temperatures should be maintained between 20°C and 25°C. In case of air travel the crate must be compliant with IATA Live Animal Regulations (IATA, 2023); temperature during air travel for international flights should be considered as the holed of airplanes are usually

under ideal temperature. It would be advisable to avoid international air travel in the winter between cooler countries as there is no guarantee how long individual will be kept in holding and or on runways. These external circumstances may cause an exceeding amount of thermal loss within the crate which will jeopardise the individual's health. For short distances, no more than two hours, temperature should be between 20°C and 25°C. Transporting animals for short distances within a facility can generally be done in an appropriately sized secured container capable of retaining temperature and resisting thermal loss such as a polystyrene box or a refrigeration box.

Figure 31: External view of a transportation crate.

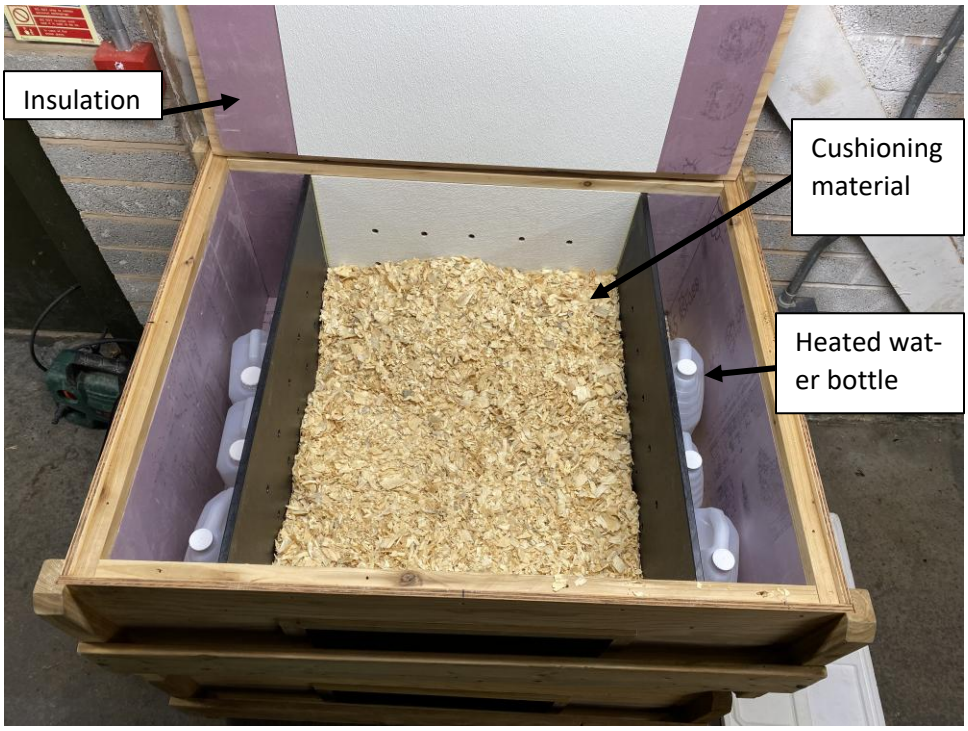

Figure 32: Internal view of a transportation crate.

2.7 Veterinary considerations for health and welfare

Generally, individuals should be observed on a daily basis in order to detect any unusual behaviours. Body scoring and behavioural observations are key as they will be indicators of any decline in an individual's health. Scales should be in alignment with the body (unlike the specimen on Fig. 33) and without lifted or protruding scales. The eyes should be clear and bright, the mouth should close neatly so that both jaws are in alignment.

Females may encounter egg retentions after laying due stress or dehydration, amongst other negatively influencing environmental parameters which may sometimes be unknown. Retained eggs should be removed through veterinary intervention, usually by first collapsing them through extracting the contents of each egg with a needle and syringe (Fig. 34, a). The collapsed eggs can then be removed with forceps through the cloaca (Fig. 34, b), (Cook, 2022).

Figure 33: Scale defect on juvenile snake at Chester Zoo (©Matthew Cook, Chester Zoo)

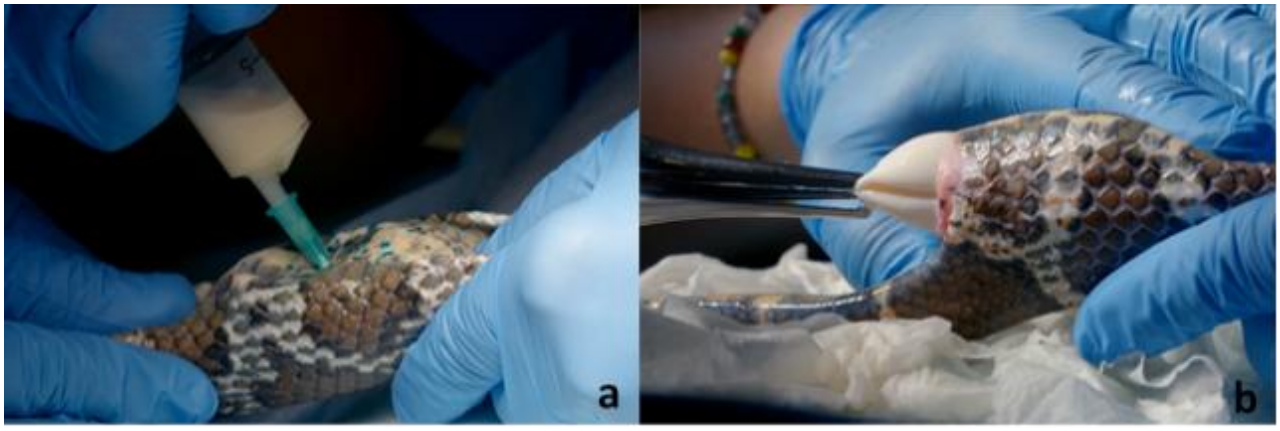

Figure 34: Showing removal of retained eggs. (a) egg contents being extracted via needle through ventral scales, (b) collapsed egg removed with forceps via the cloaca (©Blast! Film Productions).

To prevent such occurrence and other issues, routine health screening should be undertaken on both adults, and hatchlings. Airflow and humidity levels need to be well balanced when managing the species in indoor vivaria to ensure no issues occur during sloughing and to prevent respiratory problems. New animals arriving at a collection should be subjected to a suitable quarantine period as well as appropriate screening based on recommendations from the institution's veterinarians. A full postmortem should be performed if an animal is found dead to identify the cause and put potential measures in place to safeguard the rest of the collection. See Appendix 1 for a sample postmortem for ophidians.

2.7.1 Specific problems

Skin lesions and regularity of feeding seem to be a reoccurring problem in neonates (Cook, 2022). The skin lesions may develop due to too high humidity, insufficient air flow and a lack of options for thermoregulation. This stresses the importance of an appropriately sized exhibit with a wide thermo- and photo gradient and adequate furnishings. For consistent feeding see section (2.2.1 Basic Diet).

Section 3: References

Alves da Nóbrega, R.R., Vieira da Silva, W.L., Santana, G.G. (2008). *Reptiles used in traditional folk medicine: conservation implications*. Biodiversity and Conservation, 17(8), pp.2037-2049.

Arbuckle, K. (2013). *Folklore husbandry and a philosophical model for the design of captive management regimes*. Herpetol Rev, 44(5), pp.448-452.

Arcadia. (2023). *Halogen heat lamp*. https://www.growthtechnology.com/product/lightwave-t5-lw24-ho. Downloaded August 23rd 2023.

Aon2. (2023). *Illuminance*. https://www.aon2.co.uk/illuminance. Downloaded September 3rd 2023.

Aubret, F., Bignon, F., Kok, P., Blandvillain, G. (2016). *Only child syndrome in snakes: Eggs incubated alone produce asocial individuals*. Scientific Reports, 6, 35752.

Ball, D. (1974). *Handling and restraint of reptiles*. International zoo year book, 14, 138-140.

Baines, F., Chattell, J., Dale, J., Garrick, D., Gill., Goetz, M., Skelton, T., Swatman, M. (2015). *How much UV-B does my reptile need? The UV-Tool, a guide to the selection of UV lighting for reptiles and amphibians in captivity.* Journal of zoo and Aquarium Reseach 4(1) 2016.

Burghardt, G.M. (2013). *"Environmental Enrichment and Cognitive Complexity in Reptiles and Amphibians: Concepts, Review, and Implications for Captive Populations."* Applied Animal Behaviour Science 147(3):286–98. doi: https://doi.org/10.1016/j.applanim.2013.04.013.

Boulenger G.A. (1894). *Catalogue of the Snakes in the British Museum (Natural History). Volume II. Containing the Conclusion of the Colubridæ Aglyphæ.* London: Trustees of the British Museum (Natural History). (Taylor and Francis, printers). xi + 382 pp. + Plates I-XX. (*Coluber moellendorffi*, p. 56).

Boettger, O. (1886). "*Diagnoses Reptilium Novorum ab ill. viris O. Herz et Consule Dr. O. Fr. de Moellendorf in Sina meridionali reportorum* ". Zoologischer Anzeiger **9**: 519-520. (*Cynophis moellendorffi*, new species, p. 520). (in Latin).

Bravo, E.R., Klinkhamer, G.L.P., Leiss, A.K. (2017). *Interactive Effects of UV-B Light with Abiotic Factors on Plant Growth and Chemistry, and Their Consequences for Defense against Arthropod Herbivores*. Frontiers Plant Science, volume 8.

Card, W. (1995). *"Monitor Lizard Husbandry."* Bulletin of the Association of Reptilian and Amphibian Veterinarians 5(3):9–17. doi: 10.5818/1076-3139.5.3.9.

Chen, X., Lemmon, A.R., Lemmon, E.M., Pyron, R.A., Burbrink, F.T. (2017). *Using phylogenomics to understand the link between biogeographic origins and regional diversification in ratsnakes*. Molecular phylogenetics and evolution, 111, pp.206-218.

Warwick, C., Arena, P., Steedman, C. (2019). *Spatial considerations for captive snakes.* Journal of Veterinary Behavior Volume 30.

Cook, M. et al. (2022). *Reproductive husbandry of the rat snake* Elaphe moellendorffi*.* The Herpetological bulletin 159, 2022: 1-5.

Corbit, A.G., Person, C., Hayes W.K. (2013). *Constipation associated with brumation? Intestinal obstruction caused by a fecalith in a wild red diamond rattlesnake* (Crotalus ruber). Journal of Animal Physiology and Animal Nutrition Volume 98, Issue 1.

Crockett, C.M., Renee R.H. (2010). *"Data Collection in the Zoo Setting, Emphasizing Behavior."* Wild Mammals in Captivity: Principles and Techniques for Zoo Management. The University Of Chicago Press, Chicago 386–406.

Feng, D., Wang, M., Zhangzhen, I.A., Yongming, G.L., Yan, P. (2020). *The complete mitochondrial genome of* Orthriophis moellendorffi *and implications for its taxonomy,* Mitochondrial DNA Part B, 5:2, 1652-1653, DOI:10.1080/23802359.2019.1586486.

Dierenfeld, E.S., Alcorn, L.H., Jacobsen, K.L. (2002). *Nutrient Composition of Whole Vertebrate Prey (Excluding Fish) Fed in Zoos*. US Department of Agriculture, Agricultural Research Service, National.

Douglas, C.T., Pennine, M., Dierenfeld, S.E. (1994). *"Vitamins E and A, and Proximate Composition of Whole Mice and Rats Used as Feed."* Comparative Biochemistry and Physiology Part A: Physiology 107(2):419–24. doi: 10.1016/0300- 9629(94)90401-4.

Ernst, C.H,. Ernst, E.M. (2003). *Snakes of the United States and Canada*. Smithsonian Books.

Eti. (2023). *Infrared thermometer* https://thermometer.co.uk/infrared-thermometers/525-raytemp-3-infrared-thermometer-for-precise-targeting-5024368140401.html. Downloaded 3rd September 2023.

Eti. (2023). *Temperature and humidity thermo hydrometer https://thermometer.co.uk/humidity-meters-loggers/623-therma-hygrometer-thermometer-with-maxmin-alarm-5024368101556.html* Downloaded 3rd September 2023.

Finerfilter. (2023). *HMA filter* https://www.finerfilters.co.uk/3-stage-10-hma-heavy-metal-reduction-water-filter-system-push-fit. Downloaded 24th August 2023.

Gans, C. (1974). *Biomechanics: An Approach to Vertebrate Biology*. Ann Arbor: University of Michigan

Press.

Gill, I. (2016). EAZA Reptile Taxon Advisory Group Best Practise Guidelines for Venomous Reptile Management. Reptile - EAZA venomous reptile management guidelines_April2016.pdf - All Documents (sharepoint.com). Downloaded 24th February 2024.

Gill, I., McGeorge, I., Jameson, T.J.M., Moulton, N., Wilkie, M., Forsater, K., Gardner, R., Bockreib, L., Simpson, S., G. Garcia (2023). *EAZA Best Practice Guidelines for Sand Lizard (*Lacerta agilis*)* - First edition. European Association of Zoos and Aquariums, Amsterdam, The Netherlands.

Gillingham, J.C. (1987). Social behaviour. In R. A. Siegle, J. T. Collins and S. S. Novak (Eds.), *Snakes: Ecology and evolutionary biology* (pp. 184-209). New York: Macmillan.

Gillingham, J.C. (1995). Normal behaviour. In C. Warwick, F. L. Frye and J. B. Murphy (Eds.), *Health and welfare of captive reptiles* (pp. 131-164). London: Chapman and Hall.

Girons, H.S. (1982). *Reproductive Cycles of Male Snakes and Their Relationships with Climate and Female Reproductive Cycles*. Herpetologica Vol. 38, No. 1, Reproductive Biology of Reptiles (Mar., 1982), pp. 5-16 (12 pages).

Gumprecht, A. (2004). *Die Blumennatter* (Orthriophis moellendorffi). Natur und Tier – Verlag.

Grays, J. (1946). *The mechanism of locomotion in snakes*. *J. exp. Biol*. 23, 101–120.

Gray, J. (2017). *Zoo Ethics: The Challenges of Compassionate Conservation*. CSIRO PUBLISHING.

Growth technology. (no date). Lightwave T5LW24-HO. https://www.growthtechnology.com/product/lightwave-t5-lw24-ho. Downloaded 24th August 2023.

Harkewicz, K.A. (2002). *"Dermatologic Problems of Reptiles."* Pp. 151–61 in Seminars in Avian and Exotic Pet Medicine. Vol. 11. Elsevier.

He, H., Peng, X. (1999). *Tentative survey on snake market in Guangzhou*. Sichuan J Zool, 18(3), pp.139-141.

HealthLink BC. (2024). *Snake and Lizard Bites.* https://www.healthlinkbc.ca/health-topics/snake-and-lizard-bites. (14/06/2024).

Highfield, A.C. (2015). *The effect of basking lamps on the health of captive tortoises and other reptiles*. http://www.tortoisetrust.org/articles/baskinghealth.html.

Holtzman, A.D., Hariss, W.T., Aranguren, G., Bostock, E. (1999). *Spatial learning of an escape task by young corn snakes,* Elaphe guttata guttata. Animal behaviour Volume 57, Issues 1, January 1999, Pages 51-60.

Hozelock. (2023). *Pressure sprayer (*https://www.hozelock.com/product/pulsar-plus/).

Jirinec, V., Rodrigues, P.F., Amaral, B.R. and Stouffer, P.C. (2022). *Light and thermal niches of ground-foraging Amazonian insectivorous birds*. *Ecology*, *103*(4), p.e3645.

Donald, A.J., O'shea, E.J., Lillywhite, B.H. (1990). *Neural regulation of the pulmonary vasculature in a semi-arboreal snake*, Elaphe obsoleta. Journal of Comparative Physiology B volume 159, pages677–685.

Journey beyond the horizon. (2018). *Trekking in Chuandiding Mountain.* https://journeybeyondhorizon.com/trekking-in-chuandiding-guangdong-province. Downloaded

24th August 2023.

Köhler, G. (2005). *Incubation of Reptile Eggs*. Krieger Publishing Company, Malabar.

Komodo (2014a). *Komodo coconut coir*. https://www.komodoproducts.com/komodo-tropical-terrain-compact-brick.html. Downloaded 3rd September 2023.

Komodo (2014b). *Komodo habitat moss.* https://www.komodoproducts.com/products/substrates/komodo-habitat-moss.html. Downloaded 3rd September 2023.

Laszlo. (1975). *Using probes to determine the sex of specimen. https://www.researchgate.net/figure/Using-probes-to-determine-the-sex-of-specimen-Laszlo-1975_fig14_319622836.*

McCracken, H., Carmel, B,. Chitty, J., Doneley, B., Johnson, R., Lennox, M.A., Olsson, A. (2018). *"Differential Diagnoses: A Problem-Based Approach."* Reptile Medicine and Surgery in Clinical Practice 217–53.

Mellor, D.J., Beausoleil, J.N., Littlewood, E.K., McLean, N.A., McGreevy, D.P., Jones, B., Wilkins, C. (2020). "*The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare*" *Animals* 10, no. 10: 1870. https://doi.org/10.3390/ani10101870.

Micheales, C.J., Antwis, R.E., Preziosi, R.F. (2015). *Impacts of UVB provision and serum vitamin D3, growth rates, skeletal structure and coloration in captive oriental fire-bellied toads (*Bombina orientalis*).* Journal of Animal Physiology and Animal Nutrition (Berlin), volume 99, issue 2, page 391-403, DOI 10.1111/jnp.12203.

Mistking. (2023) *V5 Mistking starter unit(*https://www.mistking.com/Starter-Misting-System-v5.0.html).

Murphy, J. (1971). *A method of immobilising venomous snakes at Dallas Zoo*. International zoo yearbook, 11, 233.

Muryn, R. (2018). *Sunlight heat and basking. 01 Temperature and Heat* #10.1. Download with permission on 12.12.21 from https://www.facebook.com/groups/AdvancingHerpHusbandry.

O'Shea, J.M. (2018). *The Book of Snakes: A life-size guide to six hundred species from around the world*. University of Chicago Press.

Mehrtens, J.M. (1987). *Living snakes of the world in color*. (No. 598.12 M4).

Prater, S.H. (1933). *The social life of snakes.* Journal of the Bombay Natural History Society, 36, 496-476

Peterson, K.H., Lazcano, D., Galavan, R.D.J. (1995). *Captive reproduction in the Mexican milksnake* Lampropeltis triangulum annulata*.* Litteratura Serpentium, 15(5), pp. 128-132.

Hoehfurtner, T., Wilkinson, A., Nagabaskaran, G.H.P., Burman, O. (2021). *Applied animal behaviour science*. Volume 239, 105324.

Kane, D., Gill, I., Harding, L., Capon, J., Franklin, M., Servini, F., Tapley, B., Mitchaels, C.J. (2017). *Captive husbandry and breeding of* Gonyosoma boulengeri. Herpetological Bulletin, (139).

Radovanovic, A. (2013). *Captive management and reproduction of the Savu Island python* Liasis mackloti savuensis (Brongersma, 1956). Herpetological Bulletin, 123, pp. 19-22.

Schulz, K.D. (1996). *A Mono-graph of the colubrid snakes of the Genus* Elaphe*, Fitzinger.* Koeltz scientific

books.

Snake professional. (2023). *Snake restraining tube set.* [Online]. https://snakeprofessional.com/collections/snake-restraining-tube-sets. Downloaded 3rd November 2023.

Snider, A.T., Bowler, J.K. (1992). *Longevity of reptiles and amphibians in North American collections*. Second Edition. Herpetological Circulars No. 2.

Sunswitch. (2025). *Baskzone infrared heater*. https://www.baskzone.co.uk/product/baskzone-infrared-animal-reptile-heater-1-5kw. Downloaded 3rd February 2025.

Sunswitch. (2025) . *Heliosa 11 1.5kW Outdoor heater*: Heliosa 11 1.5kW Outdoor Heater – Grey • SunSwitch. Downloaded 3rd February 2025.

Solarmeter. (2023). *Model 6.5R Reptile UV Index Meter (*https://www.solarmeter.com/product/model65r/).

Tatjana, H., Anna, W., Gokulan, N., Oliver, H.P.B. (2021). *Applied animal behaviour science*. Volume 239, 105324.

Time and date. (2023). *Climate & weather averages in Nanning, Guangxi, China*. https://www.timeanddate.com/weather/china/nanning/climate. Downloaded 3rd September 2023.

Turmo R.J. (1996). *The Effects of Ecdysis on Feeding Frequency and Behavior of the Common Garter Snake* (Thamnophis sirtalis). NORTHERN ILLINOIS UNIVERSITY.

Utiger, U., Helfenberger, N., Schätti, B., Schmidt, C., Ruf, M., Ziswiler, V. (2002). *Molecular systematics and phylogeny of Old and New World ratsnakes,* Elaphe *Auct., and related genera (Reptilia, Squamata, Colubridae)*. Russian Journal of Herpetology, 9(2), pp.105-124.

Westhoff, G., Aparici Plaza, D., Martincova, I., Hausen, N. (eds.) (2024). *Regional Collection Plan – Ophidia - for the EAZA Reptile Taxon Advisory Group – Edition One.* EAZA Executive Office: Amsterdam.

Wexue, S. (2013). Elaphe moellendorffi - *contained medicated wine*. https://patents.google.com/patent/CN103565896A/en. Downloaded 31st March 2020.

Zhao, E. (1998). *China red data book of endangered animals: Amphibia and Reptilia*. Endangered species scientific commissiom, PRC, Science press.

Zhao, E., Adler, K. (1993). *Herpetology of China*. Society for the study of Amphibians and Reptiles.

Zhou, Z., Lau, M., Nguyen, T.Q. (2012). *Orthriophis moellendorfi*. The IUCN Red List of Threatened Species 2012: e.T192040A2031924. http://dx.doi.org/10.2305/IUCN.UK.20121.RLTS.T192040A2031924.en. Downloaded 31st March 2020.

Zhou, Z., Jiang, Z. (2004). *International trade status and crisis for snake species in China.* Conservation Biology, 18(5), pp.1386-1394.

ZIMS. (2023). *Species Holdings: ZIMS Species Holdings* (Elaphe moellendorfi). Species360 Zoological Information Management System. http://zims.species360.org/.

Appendix I: Snakes – disease surveillance and opportunistic health screening protocol, Chester Zoo.

Infectious disease of concern:	Relevance to the collection:	Testing frequency and rationale:	Consequence of a positive diagnosis:
Ferlavirus / Ophidian paramyxovirus (OPMV).	**Extremely important**. Our *Bitis parviocula* have tested positive on serology – these snakes will remain in permanent quarantine.	• Depending on sending collection's disease status – testing within 30 days prior to transfer or during post-import quarantine period. • Clinical suspicion. • Post-mortem examination.*	Positive animals must not enter the collection. Euthanasia of positive animals OR maintain animals under strict permanent biosecure measures.
Reptarenavirus (causative agent of 'Inclusion Body Disease').	**Extremely important**. Our *Morelia boeleni* and *Corallus batesii* have tested positive on PCR. These snakes remain in permanent quarantine.	• Depending on sending collection's disease status – testing within 30 days prior to transfer or during post-import quarantine period. • Clinical suspicion. • Post-mortem examination.*	Positive animals must not enter the collection. Euthanasia of positive animals OR maintain animals under strict permanent biosecure measures.
Nidovirus.	Our *Morelia boeleni* group is considered positive for nidovirus.	• Testing within 30 days prior to transfer (pythons). • Clinical suspicion. • Post-mortem examination.*	Positive animals must not enter the collection. Treatment (and quarantine) or euthanasia of positive animals.
Reovirus.	Low concern.	• Clinical suspicion. • Post-mortem examination.*	Positive animals must not enter the collection. Treatment or euthanasia of positive animals.
Adenovirus	Not previously diagnosed at CZ.	• Testing within 30 days prior to transfer.	Positive animals must not enter the collection.

	Has caused disease and death in captive and wild snakes.	• Clinical suspicion. • Post-mortem examination.*	Treatment or euthanasia of positive animals.
Ophidiomyces ophiodiicola (causative agent of 'Snake Fungal Disease', SFD).	Important to maintain our disease-free status.	• Clinical suspicion. • Post-mortem examination.*	Positive animals must not enter the collection. Treatment or euthanasia of positive animals.
Enteric bacterial pathogens (primarily *Salmonella* sp.).	Some *Salmonella* sp. have zoonotic potential.	• Faecal culture for *Salmonella* sp. is not recommended due to likely carrier status and intermittent shedding of these organisms.	Positive results are unlikely to impact on decision to import the animal. Treat or not (as appropriate).
Endoparasitism, e.g. *Cryptosporidium serpentis*; *Entamoeba invadens*.	Dependent on pathogen.	• Testing within 30 days prior to transfer or during post-import quarantine period. • Routine testing and treatment as appropriate (see separate parasitology testing protocols). • Clinical suspicion. • Post-mortem examination.*	Animals positive for *Cryptosporidium* sp. and or *Entamoebe invadens* must not enter the collection. CZ animals: treat or not (as appropriate).
Ectoparasites, e.g. *Ophionyssus natricis* (snake mites).	Dependent on pathogen.	• Clinical suspicion.	Positive animals must not enter the collection. Treat or not (as appropriate).

Testing instructions:

Disease of interest:	**Sample required:**	**Test to be performed (laboratory):**	**Comments:**
Ophidian paramyxovirus (OPMV)/ferlavirus.	Tracheal wash (preferable) or swab.	PCR (Laboklin).	All snakes are susceptible; however, viperids are considered most at risk. CZ's *Bitis parviocula* vipers are serologically positive for Strain 4688.
	0.5ml serum or 0.2ml heparin plasma.	Serology (Laboklin).	
Reptarenavirus (causative agent of 'Inclusion Body Disease').	Plain oesophageal (tonsil) swab AND EDTA blood (live animals). Brain (post-mortem).	PCR (Laboklin).	Most often diagnosed in boa and python species. Reptarenavirus has been diagnosed by post-mortem PCR of brain tissue. IBD has also been diagnosed post-mortem in a *Corallus batesii*.
Nidovirus	Plain oropharyngeal/tracheal swab.	PCR (Laboklin).	Most often diagnosed in pythons. CZ's Boelen's pythons are considered positive for nidovirus.
Reovirus.	Plain	PCR (Laboklin).	Most often diagnosed in boa and

	oropharyngeal/tracheal swab.		python species.
Adenovirus.	Cloacal swab. Tracheal lavage fluid.	PCR (Laboklin).	Adenovirus has been associated with hepatitis, enteritis and respiratory disease in captive and wild snakes.
Cryptosporidium sp. (*C. serpentis*).	Gastric lavage fluid.	PCR (Laboklin).	Most often diagnosed in colubrids.
'Snake fungal disease' (SFD) (*Ophidiomyces ophiodiicola*).	Plain swab of suspicious skin lesion.	PCR (Laboklin).	Colubrids and viperids are most commonly affected by SFD. Several fungal agents (formerly classified under the CANV-complex) have caused morbidity and mortality in different snake species. *Paranannizziopsis* sp is a well-known cause of mortality in tentacled snakes (*Erpeton tentaculatum*).
	Formalinised biopsies of skin lesions.	Histologic evaluation (Leahurst).	
Enteric bacterial pathogens.	Faeces.	Bacteriological culture (Leahurst).	Only perform if clinically indicated.
Endoparasites.	Faeces.	In-house direct examination.	

Additional samples to be collected opportunistically:	**Purpose:**	**Comments:**
Toe, muscle and skin (plus liver, heart and or eye if possible).	Nature's Safe biobank	Submit within 3-4 days of death/biopsy – keep tissues refrigerated (not frozen).
Ovary or testis	Nature's Safe biobank	Submit within 24h of death – tissues must not be frozen.

*Only if clinical suspicion

Appendix II: Suggested products

Heating and lighting equipment

Sunswitch Heliosa 11 1.5kW Outdoor heater: Heliosa 11 1.5kW Outdoor Heater – Grey • SunSwitch

Growth Technology "Lightwave" hydroponic unit T5 LW24-HO: LightWave T5 | Propagation Lighting System - Slims Place

Halogen heat lamp: Halogen Infrared Heater - Arcadia Reptile

Arcadia D3 fluorescent lamps: Lighting - Arcadia Reptile

Sunswitch Specialist Animal Heater – 1.5kW: Specialist Animal Heater - 1.5kW • SunSwitch

Nutrition

Arcadia Earth Pro A: EarthPro-A - Arcadia Reptile

Transponders

Agnthos: Implantable chip for animal ID: Microchips for Animal ID

Trovan: Microchips for animal ID: Animal ID | Implantable ISO chip | AgnTho's

Humidity and water

Mistking ultimate misting system: Jungle Hobbies Ltd. > Misting Systems > MistKing Ultimate Misting System ver 5.0

Hozlocke pulsar 7 Sprayer: Pulsar 7 (4407)

FinerFilters HMA filter: 3 Stage HMA Heavy Metal Removal 10" Drinking Water Filter System with 1/4" fittings & Faucet Tap by Finerfilters - Finerfilters

Environment equipment

ETI (Electronic Temperature Instruments LTD), ETI therma-hygrometer: Therma-Hygrometer with max/min & alarm functions

SolarMeter, model 6.5R: Solarmeter® Model 6.5R Reptile UV Index Meter - SOLARMETER | Solar Light

ETI (Electronic Temperature Instruments LTD), ETI mini ray temperature gun: Mini RayTemp Infrared thermometer - low cost infrared thermometer with laser alignment