EAZA Reptile Taxon Advisory Group

EAZA Best Practice Guidelines for Henkel's leaf-tailed gecko (*Uroplatus henkeli*)

Version 1 - 2024

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Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “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.

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Introduction

The genus *Uroplatus* represents one of the most charismatic lizard groups in Madagascar. Their incredible morphological features provoke awe in zoologists and fear in local Malagasy communities (Gehring, 2020). They have adapted into a rainforest niche with one of the most remarkable examples of camouflage in nature. Their appearance gives them strong appeal to zoological collections for exhibitions, but they represent an important conservation story as well. Madagascar has been long recognised as a trove for unique fauna with a very high percentage of endemism including *Uroplatus* (Goodman, 2022). Unfortunately, the island is stricken with poverty as a least developed country (United Nations, 2024). The habitat is changing with rapidly declining rainforest for logging and agriculture (Morelli et al., 2020). *Uroplatus* are one of many species under threat of this changing landscape.

Following high success with *Uroplatus henkeli* propagation in AZA zoo collections, the species was targeted as a prime candidate for an EAZA Ex-situ Programme (EEP). It has become apparent that, although the species can be maintained and bred in captivity with great success, the species is not very forgiving with even slight errors in husbandry care. It is therefore hoped that these Best Practice Guidelines will offer keepers the advice and information needed for success to build a strong captive population within the EAZA community.

Key husbandry points

- The species can be maintained in various terrariums and tanks suitable for an arboreal lifestyle. Specimens have a preference for sitting on flat surfaces during the day including the sides and glass doors of the terrarium.

- Snails are a very important, perhaps essential part of the diet, in particular for reproductive females. The long-term health and reproduction in females has been seen to be markedly improved with the presence of snails in the diet.
- Seasonal environmental changes have a very positive effect on reproduction. The shift in temperature, rainfall and photoperiod all influences breeding of the species. Failure to provide this results in reproductive stasis and in more severe situations a decline in health.
- Specimens in poor health often decline rapidly with little opportunity for veterinary intervention before death. Fatality in the species can also occur with little warning.
- The sensitivity of the species means that very close keeper observations to environmental conditions are needed if they are to be maintained in good health.
- Incubation of the eggs has been found to be straightforward. They successfully hatch in commercially available incubators as well as simplistic containers. The preference appears to be incubating the eggs under similar environmental conditions as required for the animals themselves. The fluctuation in day and night temperature has a positive influence on hatch rate and health of the offspring.

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Section 1. Biology

1.1 Taxonomy

- Order: Squamata
- Family: Gekkonidae
- Genus: *Uroplatus* Duméril, 1806
- Species: *Uroplatus henkeli* Böhme & Ibisch, 1990

Common English names: Henkel's Leaf-tailed Gecko, Henkel's Flat-tailed Gecko, Frilled Leaf-tailed Gecko

Malagasy names: Fisaka (Haut Plateau communities), Sisikia (West of Madagascar)

Other notes: The population occurring in the northernmost part of Madagascar has been proposed to be a separate species based on both genetic and morphological differences (Ratsoavina et al., 2013). This was confirmed in 2023 when the species was formally described as *Uroplatus garamaso* (Glaw et al., 2023).

Etymology: The species was named after German herpetologist Friedrich-Wilhelm Henkel, who collected the holotype. The genus name *Uroplatus* derives from the Greek words "ourá" (οὐρά) meaning "tail" and "platys" (πλατύς) meaning "flat".

Other species: *Uroplatus henkeli* is currently (April 2024) one of 22 described species in the genus, listed below (The Reptile Database, 2024):

- *Uroplatus alluaudi* (MOCQUARD, 1894)
- *Uroplatus ebenaui* (BOETTGER, 1879)
- *Uroplatus fangorn* (RATSOAVINA, GLAW, RASELIMANANA, RAKOTOARISON, VIEITES, HAWLITSCHEK, VENCES & SCHERZ, 2020)
- *Uroplatus fetsy* (RATSOAVINA, SCHERZ, TOLLEY, RASELIMANANA, GLAW & VENCES, 2019)
- *Uroplatus fiera* (RATSOAVINA, RANJANAHARISOA, GLAW, RASELIMANANA, MIRALLES & VENCES, 2015)
- *Uroplatus fimbriatus* (SCHNEIDER, 1797)
- *Uroplatus finaritra* (RATSOAVINA, RASELIMANANA, SCHERZ, RAKOTOARISON, RAZAFINDRAIBE, GLAW & VENCES, 2019)
- *Uroplatus finiavana* (RATSOAVINA, LOUIS JR, CROTTINI, RANDRIANIAINA, GLAW & VENCES, 2011)
- *Uroplatus fivehy* (RATSOAVINA, GLAW, RASELIMANANA, RAKOTOARISON, VIEITES, HAWLITSCHEK, VENCES & SCHERZ, 2020)
- *Uroplatus fotsivava* (RATSOAVINA, GEHRING, SCHERZ, VIEITES, GLAW & VENCES, 2017)
- *Uroplatus garamaso* (GLAW, KOHLER, FANOMEZANA, RATSOAVINA, RASELIMANANA, CROTTINI, GEHRING, BOHME, SCHERZ & VENCES, 2023)
- *Uroplatus giganteus* (GLAW, KOSUCH, HENKEL, SOUND & BÖHME, 2006)
- *Uroplatus guentheri* (MOCQUARD, 1908)
- *Uroplatus henkeli* (BÖHME & IBISCH, 1990)
- *Uroplatus kelirambo* (RATSOAVINA, GEHRING, SCHERZ, VIEITES, GLAW & VENCES, 2017)
- *Uroplatus lineatus* (DUMÉRIL & BIBRON, 1836)
- *Uroplatus malahelo* (NUSSBAUM & RAXWORTHY, 1994)
- *Uroplatus malama* (NUSSBAUM & RAXWORTHY, 1995)
- *Uroplatus phantasticus* (BOULENGER, 1888)
- *Uroplatus pietschmanni* (BÖHLE & SCHÖNECKER, 2004)
- *Uroplatus sameiti* (BÖHME & IBISCH, 1990)
- *Uroplatus sikorae* (BOETTGER, 1913)

There are still a number of undescribed taxa within the genus, so this list is expected to grow in the coming years. All are endemic to Madagascar.

1.2 Morphology

The Henkel's Leaf-tailed Gecko is one of the largest in the genus *Uroplatus*, reaching a total length of up to 300 mm. The snout–vent length (SVL) is typically 120-160 mm (Glaw & Vences, 2007). However, more recent study suggests that specimens at the lower end of this range likely belong to *Uroplatus garamaso* (Glaw et al., 2023). Males may weigh 50-70g and females 60-80g based on data from captive animals (Species360, 2022; Marushchak et al., 2023). They share many of the key characteristics of the genus such as a flattened tail (**Fig. 1**), large eyes with vertical pupils (**Fig. 2a**), a large triangular head (**Fig. 2, Fig. 4**). The tail is round and flat with little means to store fat like many other lizards (**Fig. 3a**). The tail also only has one fracture plane at the base for autotomy (Glaw & Vences, 2007) but can be regenerated to a similar appearance. The toes possess adhesive lamellae and retractable claws for excellent grip including flat surfaces (**Fig. 3b**).

Figure 1. Body structure of *Uroplatus henkeli*. **A)** Dorsal view and **B)** ventral view. **Steve Rawlins & Matthew Cook, Chester Zoo.**

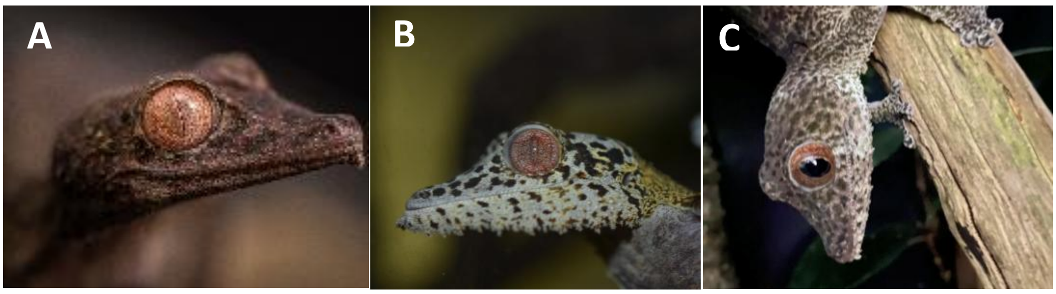

Figure 2. A) The irises of *U. henkeli* typically have a beige background with red or dark brown veins. **B)** Colour change can be rapid, particularly when stressed. The black spotting is a typical stress response and the colour of the eye becomes more vivid. **C)** Dilated pupil during the night for excellent nocturnal vision. **Steve Rawlins & Matthew Cook, Chester Zoo.**

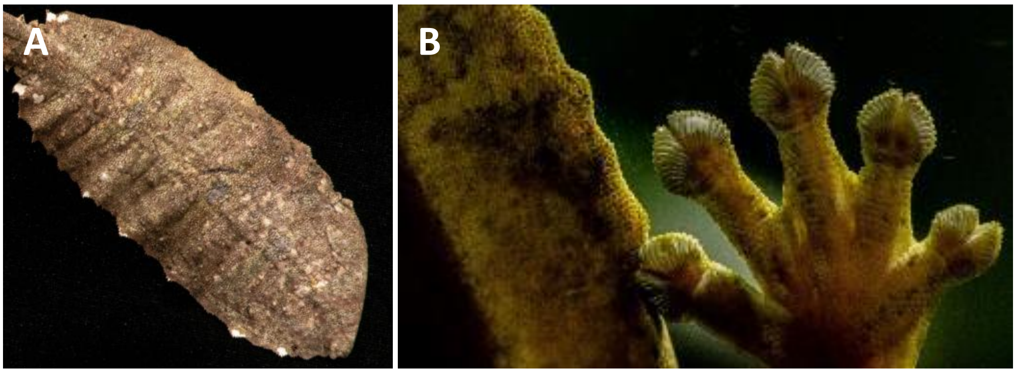

Figure 3. Close-ups of **A)** the flattened tail and **B)** the toes of *U. henkeli,* showing adhesive lamellae as well as retractable claws. **Steve Rawlins, Chester Zoo & Florian Ploetz, Tropen-Aquarium Hagenbeck.**

As is typical for the genus, *U. henkeli* have a very high number of small teeth on both the upper and lower jaw (**Fig. 10**) They have cutaneous flaps, along the margins of the lower jaw, body and limbs (**Fig. 4a, Fig. 9**). These features are a highly specialised means of camouflage as while at rest, the fringes flatten against the tree to expertly break the outline of the gecko (**Fig. 4b**). The camouflage morphology is further developed by the highly variable and adaptable colouration (**Fig. 6**). The body may be beige, grey, tan, or brown with varying degrees of darker markings that may include a mottled pattern or transverse bars, and as with many geckos, the scales are tiny & delicate (**Fig. 5**). Certain individuals exhibit light and dark banding, commonly referred to as a 'pied' variant (**Fig. 7**). The coloration is not only varied between individuals, but it is also very responsive to various cues (**Fig. 8**). The colour change could be a response to camouflage, time of day, thermoregulation, conspecific display, stress, or health (Svatek & Van Duin, 2001). This is not limited to the skin as the colour of the eyes can also change for example due to a stress response (**Fig. 2**). The colour change may alter the contrast of the entire body obscuring other patterns and markings (Cook, pers. obs.). The colour of the iris is light yellow, pinkish brown or beige with red spots (**Fig. 2a**) (Glaw & Vences, 2007). The tongue has black pigmentation on the tip (**Fig. 7b**) (Glaw et al., 2023).

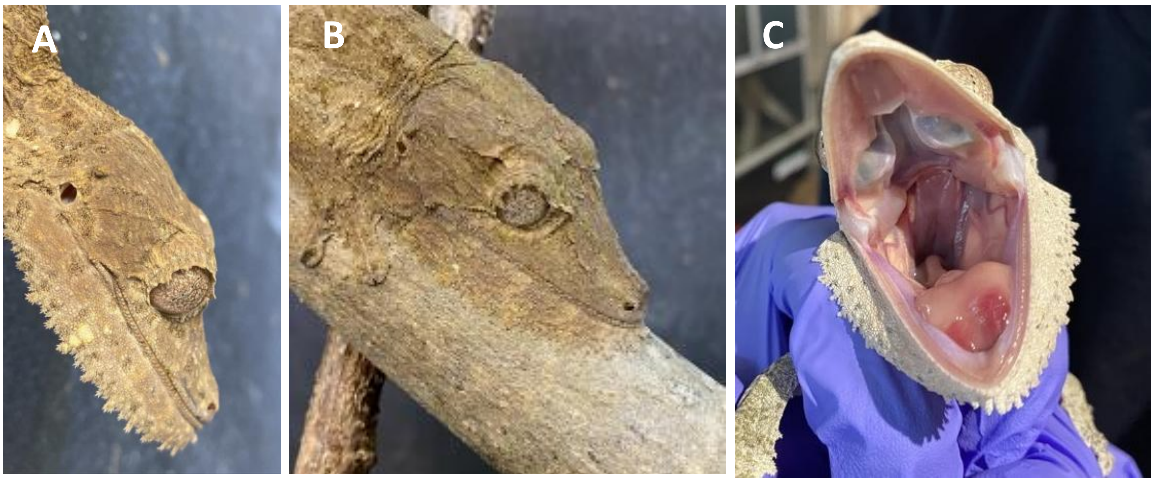

Figure 4. Head morphology of *U. henkeli*. **A)** The ear is a small, round opening at the back of the head. **B)** When lying flat against a tree, the cutaneous flap under the chin merges the outline of the head with the bark underneath the gecko. **C)** The inside of the mouth. **Matthew Cook, Chester Zoo.**

Figure 5. Close up of dorsal scales. **Matthew Cook, Chester Zoo.**

Figure 6. Different specimens of *U. henkeli* demonstrating colour and contrast variation due to the surrounding environment and light levels prior to being handled for photography. **Matthew Cook, Chester Zoo.**

There are a few morphological traits that were used alongside genetic analysis to distinguish the northernmost populations of *U. henkeli* as a separate species, *Uroplatus garamaso.* The most pronounced is the uniform-coloured tongue (*U. henkeli* has a black tip to the tongue) and the more extended reddish or yellowish colour in the iris. Specimens in Ankarana and Montagne des Francais also have a yellow outline to the eye (**Fig. 12**). More subtle features that differentiate *U. garamaso* from *U. henkeli* are a smaller body size and a narrower tail (Glaw et al., 2023).

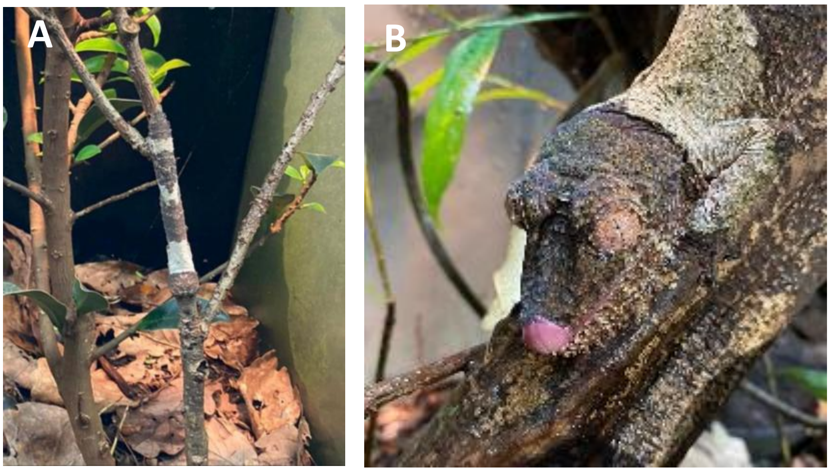

Figure 7. A) Juvenile exhibiting the 'pied' coloration**. B)** The tip of the tongue of *Uroplatus henkeli* (shown here) is black unlike *U. garamaso* which has a uniform pink tongue. **Matthew Cook & Adam Trimmings, Chester Zoo.**

Figure 8. One-month-old *U. henkeli*, showing it already possesses the colour-changing abilities this species is known for. **Mickaël Leger, Beauval Zoo.**

Figure 9. Cutaneous flap under the chin lifted away from the bark. **Sean Foley, Riverbanks Zoo and Gardens.**

Figure 10. Skull of *Uroplatus henkeli*. Note the very high number of teeth. **Jean-Christophe Theil.**

1.3 Physiology

There has been little study on many aspects of *Uroplatus* physiology. There are gaps in knowledge regarding respiratory rate, heart rate and body temperature.

Sex determination mechanisms in geckos are very varied, with some species displaying temperature-dependent sex determination (TSD) and some species displaying chromosomal sex determination (Gamble, 2010). A study (Pensabene et al., 2023) of the chromosomes of several *Uroplatus* species, including *U. henkeli*, showed that the genus as a whole all use chromosomal sex determination, with males having ZZ chromosomes and females having ZW. These sex chromosomes are in the same position on the genome as those of Gila monsters, monitor lizards, and banded geckos (*Coleonyx variegatus*); however, as each of these groups also has relatives using different sex determination mechanisms, each is thought to have evolved independently (Pensabene et al., 2023).

Vocalisation is not common among lizards with the exception of geckos being a group to use sound for communication (Marcellini, 1977; Doody et al., 2021; Paschoal et al., 2021). The anatomy of the laryngotracheal in *Uroplatus* is adapted to create a build-up of pressurised air resulting in a louder vocalisation (Russel et al., 2014). This type of vocalisation is a distress call to startle potential predators but may also be directed to conspecifics.

1.4 Longevity

Captive specimens have been known to reach 11 years of age, but the average is 7-10 years. The years of highest fecundity are 2-7 (data from species360, 2022). There is no data for longevity in the wild but as with most species kept successfully in captivity, it is expected to be lower.

Field Data

1.5 Conservation status, zoogeography and ecology

1.5.1 Distribution

This species is endemic to Madagascar where it has a disjunct population divided in three main areas. In 2010, the total distribution was estimated at approximately 12,000 km² (Raxworthy & Vences, 2010). This figure should now be considered much reduced following the description of *Uroplatus garamaso* by Glaw et al. (2023).

The species occurs in the north-western region of Sambirano (Raxworthy & Vences, 2010). The species is also found on the north-west island Nosy Be (Andreone, 2003) as well as neighbouring island Nosy Komba (Roberts & Daly, 2014). On the mainland the population stretches down to Ankarafantsika National Park. The most southerly region they occur in is in the west in Tsingy de Bemaraha (Raxworthy & Vences, 2010) (**Fig. 11**).

Further records state Kelifely, Ankara (Rakotondravony & Goodman, 2011), Tsarakibany (Durkin et al, 2011), Benavony, Manongarivo, Sahamalaza, Ambohimarina (Gehring, 2020).

The animals occurring in the most northerly regions in Ankarana and Bobaomby were long considered as a separate species (Ratsoavina et al., 2013). This was confirmed in 2023 when a new species was described, *Uroplatus garamaso* (**Fig. 12**). The same was not found when studying the genetic divergence between other isolated populations such as those from the north-west island Nosy Be and the southernmost region of Tsingy de Bemaraha, which was found to be negligible (**Fig. 13**) (Glaw et al., 2023).

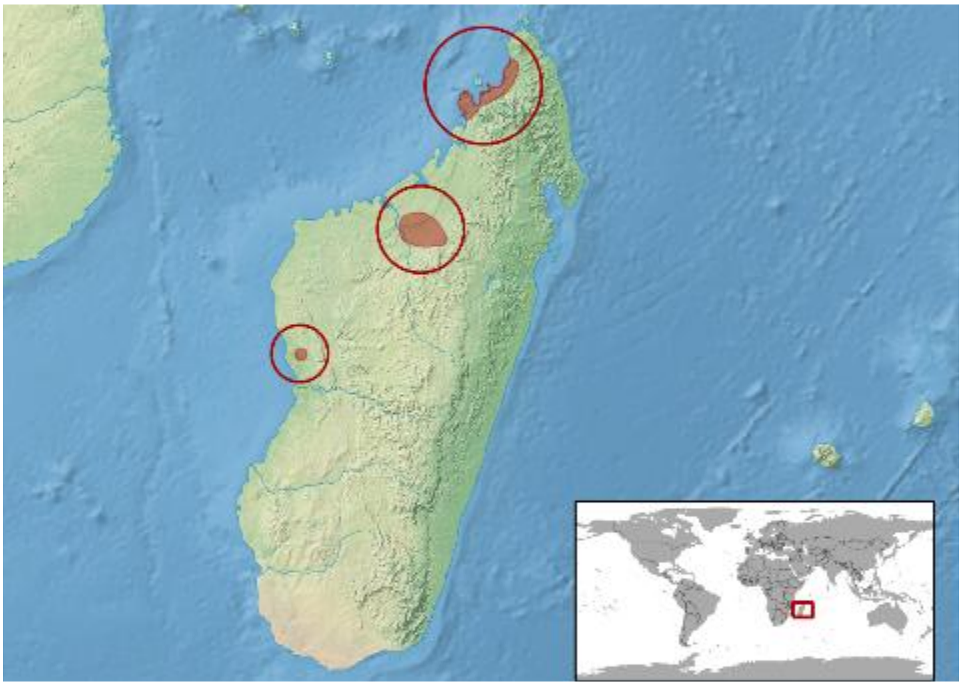

Figure 11. The distribution of *Uroplatus henkeli* according to the IUCN red list by Raxworthy & Vences (2010). Note this map does not show the species as present on Nosy Be, in error.

Figure 12. Wild *Uroplatus garamaso* from the Bobaomby region ('Beantely Forest'), previously considered conspecific with *U. henkeli*. **Madagasikara Voakajy.**

Figure 13. Distribution map illustrating the divide in range of *U. henkeli* and *U. garamaso*. **From Glaw et al., 2023 (Fig. 2).**

1.5.2 Habitat

This is a forest dwelling species which is not dependant on a single niche as they are found in at least three forest types.

1) Primary low-altitude rainforest (e.g. Sambirano region) (**Fig. 14, Fig. 16a & c**)
2) Deciduous dry forest (e.g. Tsingy de Bemaraha) (**Fig. 15, Fig. 16b**)
3) Bamboo forest (e.g. Lokobe)

On Nosy Komba they are found in closed canopy forest. A single juvenile specimen was also found on a coffee plantation. However, the close proximity of forest is thought to be essential as they have not been found in open plantations (Blumgart et al., 2017).

Figure 14. Primary rainforest habitat in Ankarafantsika, inhabited by *U. henkeli.* **Gerardo Garcia, Chester Zoo.**

Figure 15. Dry forest habitat in Beantely forest. **Madagasikara voakajy.**

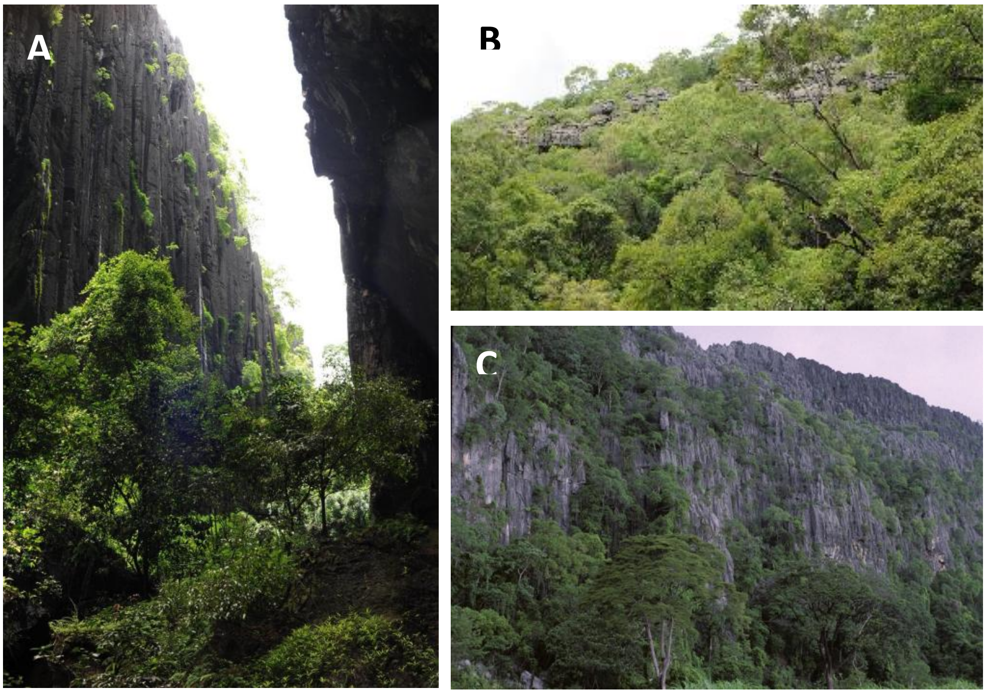

Figure 16. Limestone karst reserve in Ankarana. Mostly dry forest on the surface (B), with moist rainforest able to grow in the humid limestone ravines (A, C). Christopher J. Raxworthy & Gerardo Garcia.

Animals are typically found during the day head down on tree trunks. By pressing their body directly against the base, the animals merge with their environment. Usually, they are on the lower portion of the trunk – 70-130 cm above the ground with a preferred trunk diameter of 2 – 6 cm (Gehring, 2020) (**Fig. 17**). At night time when they are active, they ascend to higher regions (**Fig. 18**). They have been frequently observed 1-2 m above ground (Glaw & Vences, 2007). They may be found in close proximity to brooks and rivers (Svatek & van Duin, 2001). The habitat preference of juveniles is not well understood as they are very infrequently observed in the wild (Goodman, 2022). It is not known if the juveniles occupy a different microhabitat to the adults or they are extremely difficult to detect.

Figure 17. *Uroplatus henkeli* from Ankarafantsika. **Gerardo Garcia, Chester Zoo.**

Figure 18. *Uroplatus henkeli* from Nosy Be. **Charlotte Dale.**

1.5.3 Climate

The climate is tropical with only slight fluctuation in temperature (**Fig. 19, Fig. 21**). The rainfall seasonality is more significant with the rainy season occurring November to March and the dry season being May to September (**Fig. 20, Fig. 22**). Humidity averages 83% and varies between 75 and 88% (Gehring, 2020).

Nosy Be - Tropical monsoon climate. Most months are marked by significant rainfall. Climate is tropical to subtropical with a permanent high humidity and a small temperate-cool zone in the central highlands. The average temperature is 22.7°C. With a short dry season, the rainfall is about 891 mm / 35.1 inch per year. In December the highest number of daily hours of sunshine is measured in Nosy Be on average. The minimum temperature is 16.8°C occurring in July (Climate Data, 2022).

Ambanja – Tropical monsoon climate. Most months are marked by significant rainfall. The short dry season has little impact. The average temperature is 24.5°C. Precipitation is about 2437 mm / 95.9 inch per year. The month with the most hours of sunshine in Ambanja is August (Climate Data, 2022).

Figure 19. Temperature data from Nosy Be island. Daily maximum (red line), minimum (blue line) and historical averages (white dots), with daily data from 2023. **MSN weather records, 2024.**

Figure 20. Precipitation data from Nosy Be island. Blue line shows data from 2023, white line shows historical average. **MSN weather records, 2024.**

Mahajanga (east of Ankarafantsika National Park) – Tropical savanna climate. The climate in the dry deciduous forests of this region is characterized by a hot rainy season (November-April) and a relatively cooler dry season (May-October) (Klein et al., 2018). The average temperature is 26.8°C. The rainfall here is around 1324 mm / 52.1 inch per year. In Mahajanga, the month with the most daily hours of sunshine is October. The minimum temperature is 20.2°C occurring in July (Climate Data, 2022).

Maintirano (southwest of Tsingy de Bemaraha) – Tropical wet and dry savanna climate. Pronounced dry season, no cold season. The rainfall here is around 1128 mm / 44.4 inch per year. The average temperature is 26°C. In October, the highest number of daily hours of sunshine is measured in Maintirano on average (Climate Data, 2022). Temperature and precipitation graphs are very similar to those from Ankarafantsika below (**Figs. 21-22**).

Figure 21. Temperature data from Ankarafantsika National Park. Daily maximum (red line), minimum (blue line) and historical averages (white dots), with daily data from 2023. **MSN weather records, 2024.**

Figure 22. Precipitation data from Ankarafantsika National Park. Blue line shows data from 2023, white line shows historical average. **MSN weather records, 2024.**

The extent of ultraviolet-B radiation a gecko habitat receives will vary greatly depending on habitat features, season and time of day (**Fig. 23**) but the exposure that *Uroplatus henkeli* will be exposed to on their diurnal sleeping sites is not well understood. During the daytime the species is well known to rest on exposed branches in a camouflaged position. It is unknown whether or how the animals react or move to varying levels of sunshine over the course of a day. Further study would be beneficial to determine activity patterns in relation to light, thermoregulation and light and UV exposure, as this has been found to be significant in other studies with nocturnal lizards e.g. Wheler & Fa, 1995.

B	Date	Time	UVI	Weather	Shading
	27.01.2023	11:40	12.6	Hazy blue sky	No shade
	27.01.2023	11:41	0.5	Hazy blue sky	Fully shaded
	27.01.2023	14:15	8.8	Partly overcast	No shade
	27.01.2023	16:15	5.2	Fully overcast, sun just peeking through	No shade
	30.07.2022	14:40	0.2	Clear blue sky	Fully shaded

Figure 23. A) taking ultraviolet-B -Index **(**UVI) readings in Ankarafantsika National Park. **B)** table showing data obtained from those readings. **Pierre Krizan, Jersey Zoo.**

1.5.4 Conservation status

Uroplatus henkeli is listed as Vulnerable on the IUCN red list (Raxworthy & Vences, 2010). The population trend is unknown, and the last IUCN assessment was 30 June 2009, and this assessment now needs updating.

The primary forest areas in Madagascar are disappearing at a very high rate (**Figs. 24**). During the 2nd half of the 20th Century (1950 - 2000), about 40.4% of the remaining forest areas were destroyed (Harper et al., 2007; Allnutt et al., 2008).

The forest habitat is essential for this species. Due to their high ecological specificity, most *Uroplatus* species are very sensitive to interference in their natural habitat (Gehring, 2020). Aside from the report of one being found in a coffee plantation (see section 1.5.2) they are not known to be found in altered habitat. The logging and agricultural development is likely to be a very significant conservation threat. The logging not only removes trees that the geckos live on, but also disrupts the canopy causing increased temperatures due to increased sunlight penetration. The logging is partly attributed to the exotic wood trade which causes further felling and deforestation to remove these desired woods out of the forest (**Fig. 24**). The result is larger areas being uninhabitable for many species but particularly pristine forest dwellers like *Uroplatus* (Gehring, 2020).

Figure 24. Forest clearing by burning to use land for agriculture, and Logging for agriculture and the exotic wood trade removes habitat for *U. henkeli*. **Gerardo Garcia & Claire Raisin, Chester Zoo.**

Leaf-tailed geckos are directly threatened due to collection for the pet trade (even within protected areas). Along with chameleons and day geckos, leaf-tailed geckos represent one of Madagascar's most trafficked reptile groups for the international pet trade (Todd, 2011; UNEP-WCMC, 2015; Marshall et al., 2020). The species is found in three protected areas – Lokobe, Ankarafantsika and Tsingy de Bemaraha (Gehring, 2020). There has been a ban on exports of *U. henkeli* since 2013 but illegal shipments still occur. *Uroplatus* may be held in cages by traders for some time before export. Due to poor captive conditions, many may die before or during shipment because of dehydration or stress, which creates a higher demand of individuals to ensure some survive.

All these factors may impact the species but are poorly understood; additional research is required into each of them in order to understand the conservation status better. Based on the inconclusive data on the threat posed by collection for the pet trade all species of the genus *Uroplatus* were listed in 2005 on suggestion of the authorities of Madagascar in CITES Appendix II.

The taxonomy of the genus has been previously poorly understood and recent works are discovering new species at a high rate. In the past 10 years, 8 new species have been described. The northern population of *U. henkeli* was recently described as a new species (*Uroplatus garamaso*) therefore the distribution of *U. henkeli* has been effectively reduced. This increases the value of re-assessing the conservation status of both species.

Madagascar's contrasting biological richness and human poverty creates a challenging environment in which to balance conservation and development. In 1960 Madagascar achieved full independence having been under European control for almost a century. In 2003, then-President Marc Ravalomanana announced his commitment to more than triple the area of protected land in Madagascar over the next 5 years, in a move known as the Durban Vision (Virah-Sawmy et al., 2014; Gardner et al., 2018). In addition, it was mandated that 50% of entrance fees to Madagascar's national park system were routed back to local communities, ensuring that those who might be disadvantaged by conservation initiatives actually received a direct benefit (Butler, 2010).

A coup d'etat in 2009 sought to overthrow the government. This was internationally condemned, and the political instability caused some major donors to withdraw support for a number of years (for example Norway froze its $14M/yr aid funding and the United States suspended all non-humanitarian assistance to Madagascar). Much of this international funding had been used to support protected area management and other national conservation activities.

A transitional government was later formed, but the environmental impacts of the instability were significant - forests had been degraded, natural resources unsustainably accessed, and ecotourism dropped away. During this time, protected area management was poorly enforced and laws that had prevented export of rosewood were repealed in 2009. Extraction of this highly valuable timber product also impacted other tree species as new access paths were cut in the forests and lighter tree species were used to float the rosewood down river. In periods following political crisis and instability, the reliance of households (particularly poorer ones) on hunting and bushmeat are increased and traditional taboos (*fady*) are no longer respected (Estrada et al., 2018). Natural disasters such as drought and cyclones also created further pressures (**Fig. 25A & B**). Gangs cutting and exporting these trees also likely contributed to an increase in bushmeat hunting, illegal mining and slash and burn agriculture in these protected areas (**Figs. 25C, 26**). Illegal mining continues to impact many forests, including protected areas, and the fauna populations for which they provide vital habitat (Estrada et al., 2018).

Figure 25. A & B) Roads and infrastructure are often damaged by cyclones and can take many months to be repaired. **C)** Fire from *tavy* (slash and burn) and charcoal production can easily get out of control and burn areas of native forest. **Claire Raisin, Chester Zoo.**

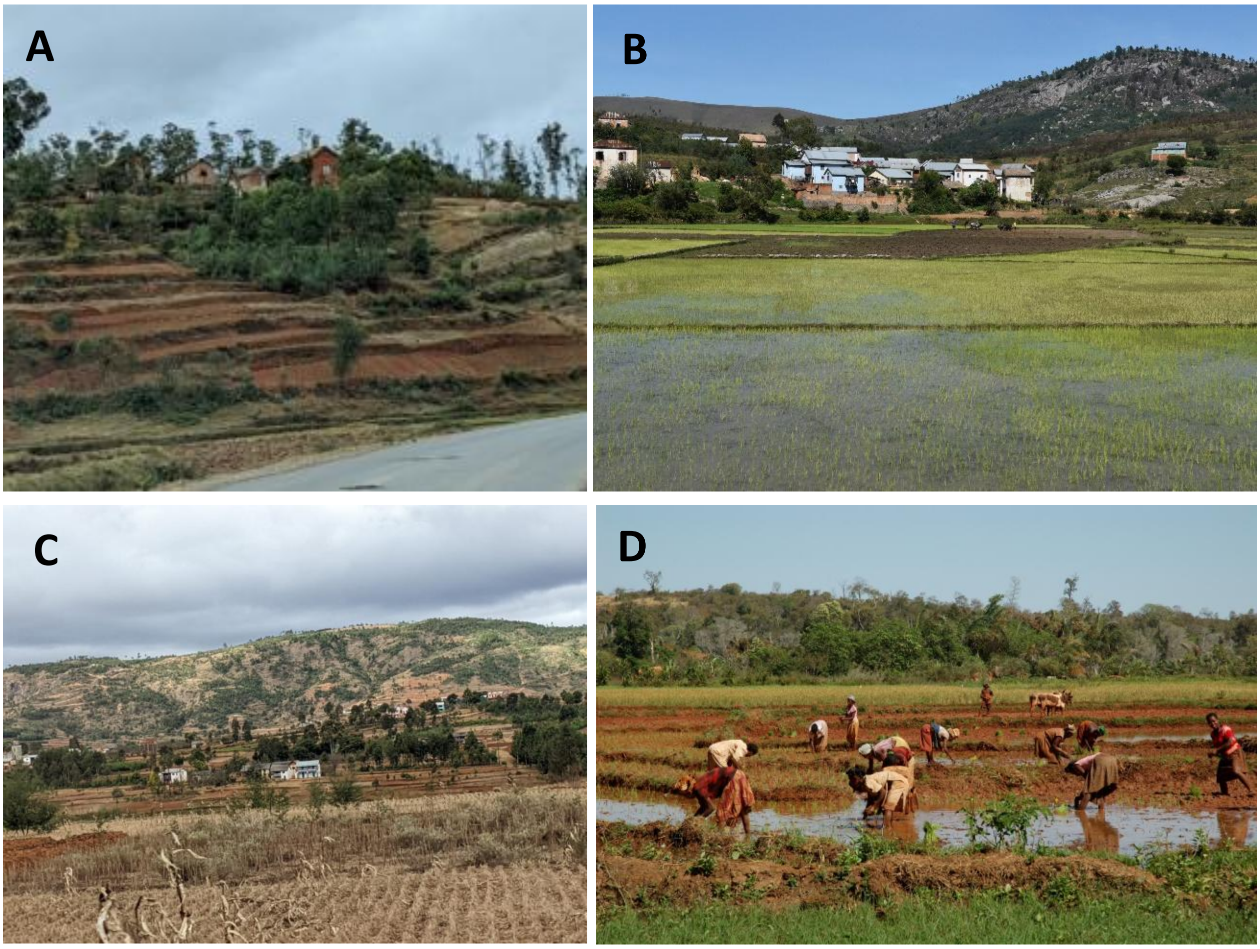

Figure 26 A) Hillside habitat cleared to create terraced farming. **B-D)** Agriculture. **Claire Raisin & Gerardo Garcia, Chester Zoo**

1.6 Diet and feeding

The species is considered mostly insectivorous (**Fig. 27**). A faecal study of the related species *Uroplatus giganteus* identified various insect and spider species including a large percentage of crickets (Gehring, 2020). *Uroplatus* sp. have also been known to feed on ripe fruits in the wild (Goodman, 2022).

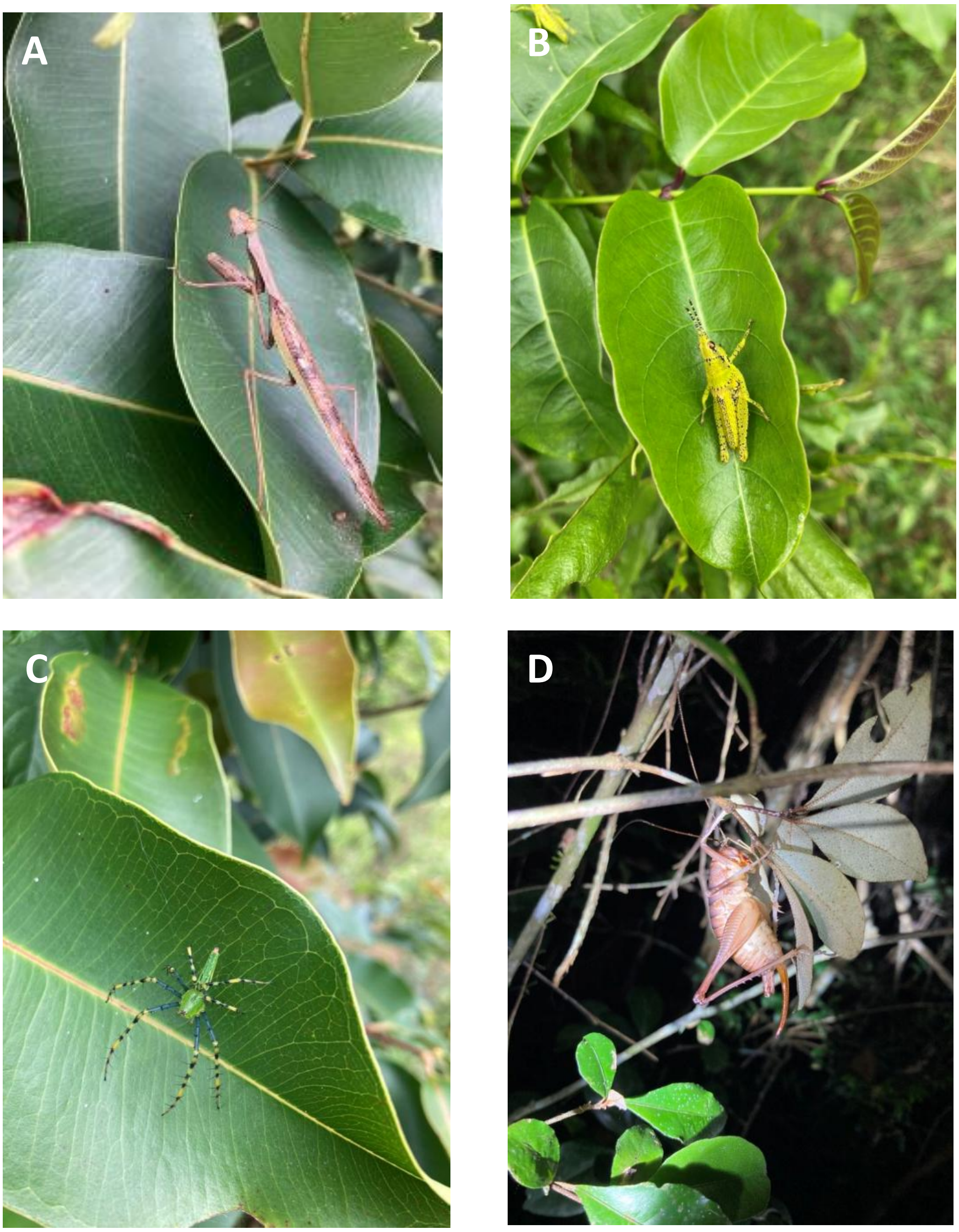

Figure 27. A variety of invertebrates make up the *Uroplatus* diet. **A)** *Polyspilota aeruginosa* - Madagascan marbled mantis. **B)** *Pyrgomorphidae* sp. – Grasshopper. **C)** *Peucetia madagascariensis* - Green lynx spider. **D)** *Ensifera* sp. – Bush cricket. **Adam Trimmings, Chester Zoo.**

1.7 Reproduction

The natural conditions of the *Uroplatus henkeli* environment demonstrates slight seasonal variation that influences reproduction. The period between October-April sees increased rainfall and higher ambient temperatures (**Figs. 19-22**). These conditions provide an optimal environment for egg incubation and food abundance for hatchlings (Gehring, 2020).

The majority of data on reproduction for the species is based on captive animals therefore can be found in **Section 2.5** of this document.

Mating and egg deposition more than likely occurs during the most active nighttime hours, in keeping with other *Uroplatus* species.

In the wild, juveniles were recorded as measuring 60 mm although the author does not state an estimated age (Glaw & Vences, 2007).

1.8 Behaviour

1.8.1 Activity

Uroplatus henkeli is almost exclusively nocturnal in all activities. The daytime is usually spent in a camouflaged stationary position. They will usually flatten themselves against a tree trunk to blend into the bark (**Fig. 28**). They may also occasionally rest in a curled position with the tail mimicking a leaf (**Fig. 29A**). This is more frequently observed in other, smaller species of *Uroplatus* such as *Uroplatus phantasticus* (**Fig. 29B**).

The seasonal movements of the species are poorly understood. The habitat experiences a distinct wet and dry season (see Section 1.5.3). Specimens are much more frequently observed in the wild prior, during and following the wet season when heightened activity such as reproduction occurs. The middle of the dry season provides unfavourable conditions for activity with lower rainfall. The movement of the geckos during this period is unknown but due to lower field observations it may be presumed they seek shelter into more humid retreats.

Figure 28. Incredible crypsis of *Uroplatus henkeli*, mimicking the coloration so precisely that it even appears to mimic the texture of the bark (captive specimen). **Sean Foley, Riverbanks Zoo and Gardens.**

Figure 29. A) Specimen resting with tail in a curled position to mimic a leaf (captive specimen). This should not be confused with 'Flopping tail syndrome' which is a health defect. **B)** Wild *Uroplatus phantasticus* mimicking a leaf by tail curling. **Adam Trimmings & Gerardo Garcia, Chester Zoo.**

1.8.2 Locomotion

Uroplatus henkeli move with a crawl that is usually of a slow, deliberate pace unless evading predators or capture. Due to their adhesive toe pads (McCann & Hagey, 2024), they can move around their entire environment in this way. However, they will also leap forward. This type of locomotion is used for capturing prey and evading predators. When leaping greater distances, they will spread their limbs and toes to create a larger surface area. This along with the flat tail will slow down the fall for a safer landing.

1.8.3 Predation

In their native home of Madagascar, *Uroplatus* have many predators across a wide range of taxa. Many birds of prey feed on lizards therefore are likely predators of *Uroplatus* including nocturnal species such as the Madagascan Owl (*Asio madagascariensis*) (Goodman et al., 1993). Multiple species of snakes frequently feed on lizards with *Dromicodryas bernieri* and *Ithycyphus miniatus* (**Fig. 30**) being confirmed predators of *Uroplatus henkeli* (Gehring, 2020). Arboreal small mammals such as mouse lemurs feed on lizards therefore are likely predators of *Uroplatus*. The largest carnivore in Madagascar, the Fossa (*Cryptoprocta ferox*) was found to have *Uroplatus* remains in a scat analysis (Dollar et al. 2007).

Figure 30. *Uroplatus henkeli* being predated by *Ithycyphus miniatus* in Nosy Be. **Charlotte Dale.**

Section 2. Management in Zoos and Aquariums

2.1 Enclosure

2.1.1 Boundary

Various enclosure types have been utilised successfully to keep *Uroplatus*. Tall enclosures cater for the arboreal lifestyle of the species (**Figs. 32-35**). Flat sides are beneficial to increase options for resting areas. They may also often rest on glass windows (**Figs. 34-35)**.

Glass tanks such as those made by Exo Terra (Exo Terra, 2024) (**See Fig. 37**) work well particularly for young animals. Adults are best housed in larger enclosures such as the mesh cages produced by Muji Chameleons (Chameleon World Muji, 2024) (**See Fig. 36**). Other species of *Uroplatus* have been successfully kept in giant greenhouses. The rendered rock work sometimes used in zoo displays may lead to abrasions on the snout, sustained when capturing prey. In this instance, size of the enclosure is likely to be an important factor with larger enclosures being less likely for this problem to occur (**Fig. 31**).

Figure 31. Large display mixed exhibit with *Uroplatus henkeli*, *Calumma parsonii* and *Zonosaurus maximus* at Chester Zoo. **Matthew Cook, Chester Zoo.**

Figure 32. Exhibit for *Uroplatus henkeli* at Jersey Zoo. **Matt Goetz, Jersey Zoo.**

Figure 33. *Uroplatus henkeli* exhibit at Edinburgh Zoo. **Craig Close, Edinburgh Zoo.**

Figure 34. Display exhibit at Riverbanks Zoo. **Sean Foley, Riverbanks Zoo and Gardens.**

Figure 35. Off show enclosure at Riverbanks Zoo. It measures 50 x 50 x 150cm (W x D x H). **Sean Foley, Riverbanks Zoo and Gardens.**

Figure 36. Off show enclosure for *Uroplatus henkeli*. The enclosure is made by 'Chameleon World Muji' with a Laguna tub as the base. It measures 100 x 80 x 180cm (W x D x H). **Matthew Cook, Chester Zoo.**

Figure 37. Off-show enclosure for juvenile *Uroplatus henkeli.* Tank is a 'Small Tall' Exo-Terra terrarium measuring 45 x 45 x 60cm (WxDxH). **Matthew Cook, Chester Zoo.**

Newly acquired specimens should be housed in quarantine while disease and/or faecal screening and health observations are conducted. The set-up should resemble the outlined description below with some alterations. Paper towel can be used for the substrate to aid faecal collection and simplify substrate changes to quickly remove pathogens. However, flowerpots of soil large enough for animals to get into should be provided to offer potentially gravid females nesting provision. The use of plastic plants makes cleaning and sterilising easier, especially in the event of a parasitic problem. The reduction in soil and live planting reduces ambient humidity; therefore, more frequent spraying or fogging is required. Barrier management for each enclosure must be put in place to avoid cross-contamination.

2.1.2 Substrate

Soil should be used as the base-layer of the substrate. A small amount of sand may be mixed in to assist drainage. Additionally, a layer of clay granules (Approx 10cm), also known as Hydroleca (Hanleys, 2024) can be placed beneath the soil with a separating membrane to further improve drainage (**Fig. 38b**). It is important that the substrate only remains slightly damp and never wet. Although the geckos rarely descend to the ground, this is especially important for nesting females. Furthermore, overly damp substrate is likely to harbour mould spores and reduces the quality of any live planting. The substrate is completed with a layer of leaf litter on top of the soil (**Fig. 38a**). Dropped leaves from tropical or native European trees may be used. The leaves should be small – medium sized, as large leaves may obstruct females attempting to nest. Leaves that do not break down quickly should be selected.

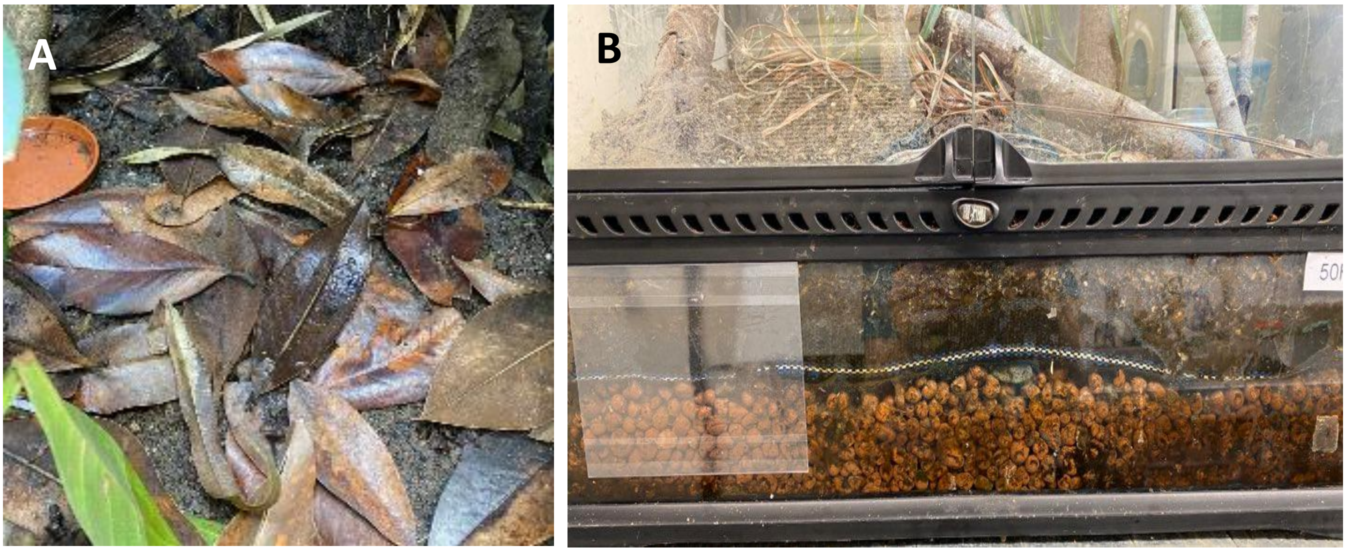

Figure 38 A) A moisture retaining substrate with drainage is ideal and is completed with a good layer of leaf litter. **B)** A layer of clay granules such as 'Hydroleca' at the base of the tank with a membrane between this and the soil aids drainage. **Matthew Cook, Chester Zoo.**

2.1.3 Furnishings

A variety of branches should be offered as the species spends much of its time amongst trees. The best choices are vertically positioned trunks and branches. There should be consideration to bark type when choosing branches. Bark that is overly abrasive should be avoided. Oak

(*Quercus* sp.) is a very good and easily sourced option. Branching can vary in diameter from 2.5 cm to 10cm but diameters of at least 6 cm are generally preferred for resting (**Fig. 39**). Even though the geckos regularly position themselves during the daytime on the flat sides of the terrarium, the branches offer visual barriers and provide different options particularly during nighttime activity. Tree trunks with off-shooting smaller branches are ideal to offer a more complex environment. Liana may also be used to offer resting points and perching for nighttime activity (**Fig. 40a**). All branching should be placed securely so that it is stable for active and resting geckos.

Figure 39. Vertically positioned trunks offer good resting points as well as aiding nocturnal movement. **Matthew Cook & Adam Trimmings, Chester Zoo.**

Figure 40. A) Liana being used for daytime resting is also useful in providing a more diverse environment during periods of activity. **B)** A variety of branching offers a more diverse environment for the animals. **Adam Trimmings, Chester Zoo & Ciaran Westgate, Jersey Zoo.**

Plants are almost essential to create the most naturalistic environment. Not only do plants improve the aesthetics, but they also provide much improved arboreal cover and increase relative humidity. In situations where live plants cannot be used such as quarantine, plastic plants can be used. Suitable plant species include:

Native to Madagascar

Dracaena marginata (Madagascar dragon tree)

Dracaena reflexa (Song of India)

Dypsis lutescens (Golden cane palm) (**Fig. 41**)

Platycerium ellisii (Staghorn fern)

Sansevieria (Mother-in-law’s tongue)

Stephanotis floribunda (Madagascan Jasmine)

Figure 41. A) *Dypsis lutescens* creates dappled light. **B)** *Uroplatus henkeli* resting on a *D. lutescens* frond. **Matthew Cook & Addie Jones, Chester Zoo.**

Non-native to Madagascar

Calathea rufibarba (Furry feather calathea) (**Fig. 43a**)

Dracaena surculosa (Gold dust dracaena) (**Fig. 43b**)

Epipremnum aureum (Devil's ivy)

Epipremnum pinnatum (Devil's ivy)

Ficus benjamina (Weeping fig) (**Fig. 43c**)

Ficus cyathistipula (African fig tree) (**Fig. 43d**)

Ficus elastica (Rubber plant)

Monstera deliciosa (Swiss cheese plant)

Spathiphyllum (Peace lily) (**Fig. 42**)

Figure 42. Two specimens resting on the large leaves of a Giant peace lily *(Spathiphyllum).* **Adam Trimmings, Chester Zoo.**

Figure 43. Examples of plants that although not native to Madagascar work well as cover or perching. **A)** *Calathea rufibarba* **B)** *Dracaena surculosa* **C)** *Ficus benjamina* and **D)** *Ficus cyathistipula.* **Matthew Cook, Chester Zoo.**

2.1.4 Environment

2.1.4.1 Temperature

As is illustrated in the 'Climate' section of this document (1.5.3) the average temperature in the natural environment of *Uroplatus henkeli* is around the mid-20s°C during the day. This translates to experiences of the species in captivity with the daytime average range of 22-26°C being optimal. The natural environment may reach temperatures exceeding this to the high 20s°C or low 30s°C. However, climate data from the natural habitat should be treated with caution: although it is sourced from the correct area, it does not reflect temperatures in the microhabitat that *U. henkeli* occupy. There are many gaps in the knowledge of the species. The movements of these animals during peak temperatures of the dry season are unknown. Observations in captivity suggest that prolonged high temperatures can be detrimental. In the most extreme instances, ambient temperatures above 32°C cause a rapid decline in health. The animal becomes restless searching for its preferred temperature and subsequently refuses to feed. Once the body condition starts to rapidly decline, death quickly follows. It has been reported that even consistent temperatures of above 27°C will result in a similar, if less rapid, effect and if not corrected will ultimately prove lethal (Foley, 2005). However, it seems that this species can tolerate high temperatures of this range for short periods such as a peak seasonal temperature spike. These factors should be considered when selecting housing for the species including having a good understanding of summer temperature highs of the building. A nighttime drop in temperature is vital; temperatures in the range of 17 - 21°C are ideal. However, temperatures consistently at the lowest end of this range may result in health issues such as egg binding (Svatek & van Duin, 2001). A small degree of seasonal temperature change is necessary to induce breeding, for example maintaining temperatures at the higher end of the range listed above during the summer months and the lower end during winter. This is usually easy to achieve in the European climate as buildings naturally fluctuate by a few degrees. In rooms maintained exclusively with temperature-controlled equipment, the settings will need to be adjusted accordingly. It should be noted that it is logical to reverse the natural seasonal cycle. The lowest temperatures in Madagascar occur in July. Therefore, to avoid working against the natural conditions in Europe, this period should be reversed to January.

2.1.4.2 Humidity

Fairly high levels of humidity (60-100%) should be maintained. This is usually achieved by misting the terrarium once or twice per day either manually or with an automated system (Mistking, 2024. It is important that the enclosure has good ventilation to ensure that the air does not become stagnant. It is also preferable that the enclosure does not remain wet all day in between sprays. Ventilation panels on the top and on the bottom of the front panel are usually sufficient to create a fresh air pathway. The geckos may be sprayed directly to encourage drinking; however, this is why a certain degree of evaporation is essential as it is very undesirable to have animals sitting wet for long periods. The presence of moisture-retaining substrate, wood and natural plants should all aid in maintaining high air humidity in between sprays. A fogging system such as the 'HabiStat Humidifier' (Habistat, 2024) increase humidity levels. This is a better method to attain high humidity without the enclosure remaining constantly wet. The geckos will gain hydration from breathing in the damp air. The humidity should match the natural conditions as much as possible. It would not be advisable to run a fogging system constantly. A fogging system should run for a few hours in the morning to simulate the natural morning dew and fog.

Both temperature and humidity should be checked with reliable equipment every time the enclosure is serviced to ensure parameters remain appropriate (**Fig. 46a & b**). A complete example of environmental parameters for maintaining this species throughout the year can be seen below in **Fig. 44**.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp °C (day ambient)	20°C	22°C	23°C	24°C	24°C	25°C	26°C	25°C	24°C	23°C	22°C	20°C
Temperature °C (night ambient)	17°C	18°C	19°C	20°C	20°C	21°C	21°C	21°C	20°C	19°C	18°C	17°C
Basking spot temperature °C	32°C	32°C	32°C	32°C	32°C	32°C	32°C	32°C	32°C	32°C	32°C	32°C
Cool spot temperature (day) °C	17.5°C	18°C	19°C	20°C	20°C	21°C	21°C	21°C	20°C	19°C	18°C	17°C
Photoperiod (No. of hours of light)	8	10	12	12	13	13	13	13	12	12	10	9
UVI	0-2	0-2	0-2	0-2	0-3	0-3	0-3	0-3	0-2	0-2	0-2	0-2
Humidity %	50-70%	50-70%	60-70%	60-80%	70-100%	70-100%	70-90%	70-90%	70-80%	60-80%	60-80%	50-80%
Breeding introductions			YES	YES	YES	YES	YES	YES	YES	YES		
Feed schedule	2 times per week	3 times per week	3 times per week	3 times per week	3 times per week	3 times per week	3 times per week	4 times per week	4 times per week	3 times per week	3 times per week	2 times per week

Figure 44. Table of environmental data across the year. The data was compiled by Chester Zoo using natural environmental data from the wild (see Section 1.5.3) and captive experience from the most experienced breeders **(Foley, 2005; Gehring, 2022).**

2.1.4.3 Heating & Lighting

This species is highly nocturnal in activity. During the daytime, animals may sit exposed but camouflaged on trees within the dappled light of a forest. The species can largely be labelled a thermoconformer, meaning that it allows its body temperature to remain roughly equal to that of its surroundings, without intense basking to raise its body temperature. However, basking behaviour may occasionally be observed, particularly in gravid females. This should all be taken into account when choosing lighting and heating equipment. There are many different types of equipment and brands available. It is essential to understand the design and performance of each fixture and bulb used. The principles of how this equipment is expected to perform to meet the requirements of reptiles has been outlined in published works (Ferguson et al. 2009; Baines et al., 2016).

To achieve all the required light outputs, multiple fixtures are likely to be needed. Firstly, a UVB-emitting lamp, for example an Arcadia D3 fluorescent tube (**Fig. 45**). These tubes can be placed over the width of the enclosure, preferably externally. The enclosure's planting should create the dappled light effect with spots of UV radiation reaching furnishings the geckos rest on.

It is essential to have a UV Index meter (**Fig. 46C**) to measure the output throughout the entire enclosure. A UV Index (UVI) range of 0-3 should be offered as a gradient throughout the enclosure with a maximum UVI of 3 on exposed, higher branches and of 0 in the shade created by plants at the lower enclosure levels. The highest levels of UVB should occur in the basking zone: a UVI of 3 should be offered directly beneath the basking lamp. The lamps' output will diminish with age and plant growth may inhibit UV penetration over time. Therefore, routine checks for UVI levels and temperatures should always be kept on a regular schedule (**Fig. 47**).

With the importance of live planting already outlined here and earlier in this document, excellent plant care is worth investing in. Although UVB lamps offer plants some of the light waves needed for good health, additional light sources will help them thrive. An LED can run parallel to the UVB tube to ensure coverage of the entire required light spectrum.

The necessity to offer UV radiation to nocturnal geckos has been disputed with some authors stating that is not necessary for *Uroplatus* (Svatek & van Duin, 2001; Wheler & Fa, 1995). Further research on activity of wild individuals concerning this would be very desirable. However, considering it is a natural resource that occurs in their environment and with knowledge that it is of vital importance to many reptiles it should be catered for.

Figure 45. Arcadia D3 UVB lamps. The 6% and 12% may be used depending on the size of the enclosure.
Arcadia Reptile, 2023

Figure 46. A) Mini Ray Temp Infrared Thermometer. **B**) Therma-Hygrometer. **ETI (Electronic Temperature Instruments LTD), 2023. C)** Solarmeter® Model 6.5R Reptile UV Index Meter. **SolarMeter, 2023.**

Figure 47. Basking lamps should provide appropriate levels of UVI and temperatures checked with reliable equipment. **Matthew Cook, Chester Zoo.**

The photoperiod should correlate with seasonal temperature changes (**see Section 2.2.1).** The summer season should have a photoperiod of 12-14 hours while it should be reduced to 8-10 hours in the winter season. This variation is known to have a positive effect on overall reproduction (Foley, 2005).

The effect of the lunar cycle on reptile activity is poorly understood (Perry & Fisher, 2013). It is advantageous to locate enclosures in the view of windows where possible. However, direct sunshine must be avoided to prevent over-heating the enclosure. A small amount of natural moon- or streetlight that penetrates the windows at night helps the geckos orient themselves (Svatek & van Duin, 2001). This is particularly true to cater for crepuscular behaviour as well as creating a much more natural light cycle. If the enclosures are placed in a room without a natural light source, an additional softer light source, e.g. a short, dimmed-down LED strip should be provided for the crepuscular period.

Secondary to the light emitting fluorescent tubes, a basking lamp should be provided. It is important to select the most appropriate equipment when providing artificial heat to animals. Short-wavelength heat lamps such as halogen bulbs, emit the same solar radiation as the sun (infrared-A) and are currently recommended for daytime / basking heat provision (Gill et al., 2023). IR-A radiation penetrates through skin to the subcutaneous tissues, whereas IR-C and the majority of IR-B (long-wave IR), in other heating devices, does not (Porter, 1967; Schroeder et al., 2007). Short-wave infrared heaters 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. comms). IR-A lamps come in a variety of wattages and sizes, so careful selection, control and mounting is required, depending on the enclosure size.

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. In addition, localised heat provision should be provided as a thermal gradient, providing freedom of choice for the animal(s) to regulate themselves. To avoid overheating the enclosure and to best replicate spots of light in their forest habitat, low wattage lamps are the most appropriate option. Depending on the size of the enclosure and the number of animals within, a 35w, 50w or 75w halogen bulb should be provided (**Fig. 48**). If *Uroplatus* are kept in large mixed species exhibits there are larger short-wavelength heaters available (**Fig. 49**). These heat lamps may be operated on a shorter light cycle than the other lighting if overly high temperatures are experienced for a prolonged period. To best mimic the natural conditions of sunlight, the heat lamps should be placed in conjunction with the UV emitting fluorescent tubes. Certain commercial tank designs can make this difficult to achieve with limited space on the roof canopy. However, every effort should be made to facilitate this setup because a naturally basking *Uroplatus* will be obtaining some degree of UVB radiation. The various mercury vapour bulbs that emit both heat and UV may be utilised. However, these should be treated with caution due to the exceedingly high levels of UVB some of the bulbs can emit, especially when brand new: always confirm their UVB output with a Solarmeter 6.5 reading. Any heating and lighting units are better mounted externally. Firstly, animals cannot access them directly so risk of burns are minimal; secondly, changing or replacing lamps can be easier as an incursion into the enclosure is not required.

Figure 48. Halogen heat lamps are available in a range of wattages. Enclosure size will dictate which bulb is selected. **Arcadia Reptile, 2023.**

Figure 49. Infrared lamp units are available in a range of wattages that are suitable for very large enclosures such as mixed species zoo exhibits. **Reptile systems, 2024.**

2.1.5 Dimensions

The enclosure dimensions for an adult pair of animals should be at least 60 x 60 x 100 cm (length x depth x height). A group of 3-5 animals (see also **Section 2.3.1**) may be housed in 90 x 90 x 120 cm (L x D x H) (**Figs. 46-48**). A larger enclosure will offer a more enriching environment, and suitable thermal gradients are easier to achieve. For sizes suitable for juvenile specimens see **Section 2.5.6**.

2.2 Feeding

2.2.1 Diet

The species is predominantly insectivorous. Based on captive experiences, the following species can be offered:

Acheta domesticus – House cricket

Arianta arbustorum – Land snail

Blaberus cranifer – Death's head cockroach

Blabtica dubia – Dubia roach (**Fig. 53a**)

Calliphoridae sp – Blow flies

Carausius morosus – Common stick insect

Cepaea hortensis – Garden banded snail

Cornu aspersum – Garden snail (**Fig. 52**)

Drosophila hydei – Fruit fly

Galleria mellonella – Wax moth and larvae (**Fig. 53b**)

Gromphadorhina sp. – Madagascar hissing cockroach

Gryllodes sigillatus – Tropical house cricket

Gryllus assimilis – Jamaican field cricket (**Fig. 50b**)

Gryllus bimaculatus – African field cricket (**Fig. 50a**)

Gryllus campestris – European field cricket

Lissachatina fulica – African giant land snail

Schistocerca gregaria- Desert locust (**Fig. 50c**)

Locusta migratoria – Migratory locust

Musca domestica – House fly

Otala lactea- Milk snail

Shelfordella tartara – Turkestan cockroach

Tegenaria domestica – House spider

Tenebrio molitor – Mealworm

Tettigonia sp. - Katydid

Zophobas morio – Morio worms

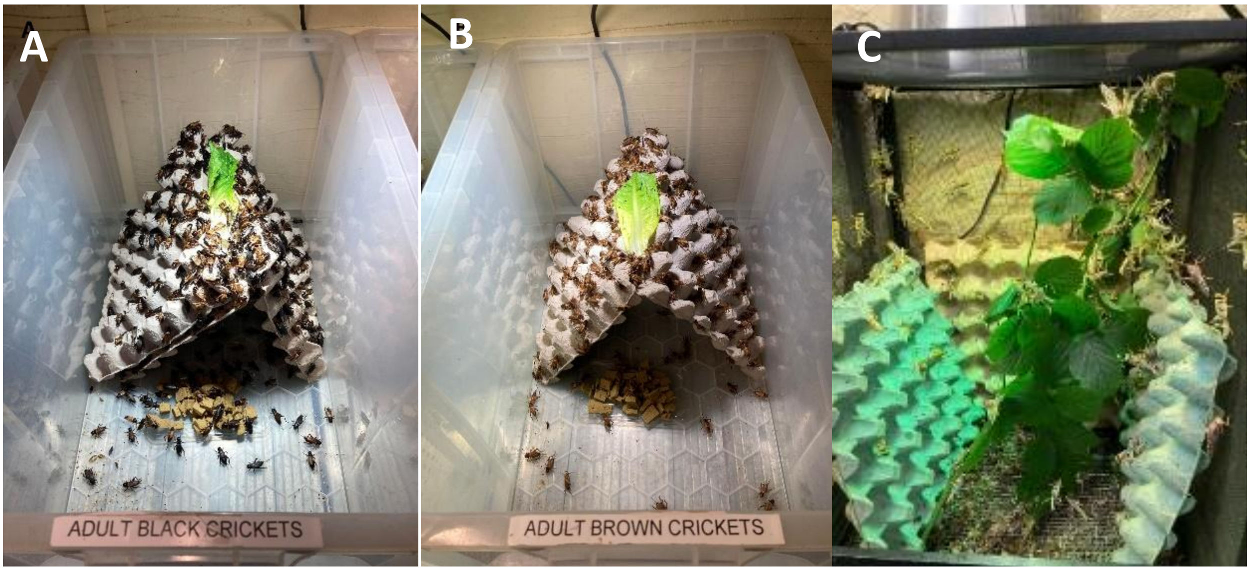

Figure 50. Commonly used live foods – **A)** Black crickets (*Gryllus bimaculatus*). **B)** Brown crickets (*Gryllus assimilis*). **C)** Desert locust (*Schistocerca gregaria*). The care and diet of the 'feeder' insects should not be overlooked. **Adam Trimmings, Chester Zoo.**

Additional to invertebrates, many gecko species eagerly feed on fruit-based pastes. The brand 'Repashy' (Repashy, 2024) offer a variety of nutrient-enriched pastes for reptiles. While it seems that this food type is not essential to *Uroplatus henkeli*, it should not be ruled out that certain individuals may eat it.

A varied diet in many captive reptiles proves pivotal in keeping and breeding healthy specimens for their life expectancy. It may be expected that, like many reptiles, *Uroplatus* can become biased towards certain food items and therefore may not accept the full list above. The vast majority of captive *Uroplatus henkeli* have been offered the more commercially available species listed above such as the crickets, locusts, cockroaches, and wax worms. A diet almost solely on these food groups has been fruitful in propagation of the species (Foley, 2005). It is, however, vital that the nutritional value of all food items are increased and diversified through excellent diets for the feeder invertebrates ('gut-loading'). There are commercially available powder or gel formulas for feeder insects that are comprised of a wide variety of ingredients and vitamins such as Repashy Superload (**Fig. 51a**). There are also good number of supplementation powders that can be dusted onto insects before being fed out (**Fig. 51**). For guidance on correct dosing, the instructions on the selected product should be followed. With increased emphasis on providing captive reptiles with the most nutrient rich diets there should be consideration also made to over-supplementation. Providing a reptile with a diet that is too rich may lead to health complications. In *Uroplatus*, the health defect known as 'floppy tail syndrome' (**Fig. 95**) is attributed to this (**See Section 2.8)**. *Uroplatus* overfed with a rich diet store excessive calories in the base of the tail and the muscles are unable to support the additional weight. This simply causes the tail to unnaturally flop over from the base and is particularly obvious when the gecko is resting with the head pointed down. This is not only a poor aesthetic for zoo display but can cause the animal hindrance in mobility and social/courtship display reducing reproductive viability. This condition is irreversible but is preventable with the appropriate diet.

Figure 51 A) Repashy offer a range of products including invertebrate gut-loading formulas (Superload), pre-mix gecko feeds (Grubs 'N' Fruit) and supplementation (Calcium plus). **Repashy, 2024.** There are a variety of other supplemention products widely available. **B)** ZooMed ReptiCalcium. **ZooMed, 2024 C)** Arcadia EarthPro-A. **Arcadia, 2024 D)** Vetark Nutrobal. **Vetark, 2024**

Another method to offer additional supplementation such as calcium is to offer it in dishes in the enclosure. A dish may be filled with ground-up cuttlefish bone, broken eggshells, or calcium lactate. The advantage of this method is that animals can regulate their own calcium needs. Although, the disadvantage being that keepers will unlikely know which animal in a group accepted the calcium presented this way. It will also become wet and unpalatable from misting and needs changing regularly.

A further additional supplement used in captive *U. henkeli* is vitamin D3. Even though it is recommended to let the animals regulate their vitamin D3 requirements through the provision of suitable UVB emitting light bulbs (see **Section 2.1.4**), a secondary option is to use vitamin D3 supplement drops (Woodstock, 2024) once per week if suitable lighting cannot be provided.

A food item of special note and high importance for long-term health are snails (**Fig. 52**). It is clear from behavioural observations that *Uroplatus* often become excited by the presence of snails and feed on them eagerly. This is particularly pronounced in reproductively active females. The benefits witnessed have been a rapid recovery from reproductive strain as well as healthier eggs and offspring. Female specimens may develop large calcium sacks through the addition of snails to the diet. If a female is to reproduce regularly whilst maintaining good health, the provision of snails in the diet seems essential. The propagation of *Uroplatus henkeli* has been comparatively much higher with snails in the diet versus no snails in the diet (Marushchak et al., 2023). Snails have also been noted to be consumed by juveniles of both sexes, while adult males usually refuse them. In specimens that accept snails, they are either eaten whole or crushed and swallowed. If a snail is too large, the specimen will either spit it out or even regurgitate it. A good guide for selecting the size of snail is that the shell should be about the same size as the gecko's eye. There may be difficulty in obtaining appropriately-sized snails, but efforts should always be made to find them if long-term reproductive success is desired.

The collection of wild snails comes with risk. Firstly, they may be carrying a bait poison or insecticide and herbicide residues. Secondly, there is potential risk posed from parasites. Molluscs are intermediate hosts for the canine lungworm (*Angiostrongylus vasorum*) (Bolt et al., 1993; Grewal et al., 2003; Wilson, 2012). This parasite is known to be potentially life threatening in dogs but there is little study on reptiles. It should be considered a potential risk, and captive bred snails should be sourced instead. Both European garden snails and African land snails, as well as the milk snail (*Otala lactea*), are easy to breed.

Figure 52. Snails are seized eagerly by females and are either swallowed whole or crushed in the jaws first. **Matthew Cook, Chester Zoo.**

2.2.2 Method of feeding

The frequency of feeding depends on the age, season, and reproductive activity of the specimen. Juveniles should be offered food 3 times per week (with at least 1 day in between feeds). The amount of food is dependent on prey sized for example 4 brown crickets, 3 small locusts or 10 *Drosophila* fruit flies. Consideration to the food presentation and tank set up should be made. By offering food on tweezers (**Fig. 53b**), the keeper can be certain of quantities eaten which is invaluable for new-born animals. This is a good method to be sure any individual is feeding properly. However, it offers little in the way of enrichment. For most animals, live food can simply be released into the enclosure to disperse and encourage active hunting. It is best to release the insects up on branches rather than on the ground. Additional food items may need to be introduced to ensure the gecko finds enough food, particularly if kept in groups. Sub-adult and adult geckos should be fed 2-4 times per week. The quantity and frequency are dependent on season and reproductive status. Females, prior, during and after reproductive activity may need increased food allocation. It is also important not to over-feed, as overweight individuals will be less viable. During the cool season, feeding can be reduced to twice per week. The table of environmental data in this document (**Fig. 44**) provides a general guide to the frequency of feeding for adults. However, the amount of food offered is clearly going to be dictated by the health and body size of each specimen. Collecting regular weights will allow keepers to have a good understanding of how to adjust quantities of food over the seasons. Juveniles should be weighed every 1 – 2 months and adults every 3 – 6 months. If there is further concern for the body condition and health of an individual, then more frequent weights should be taken. However, the stress of handling needs to be taken under consideration as to not have a negative impact if the specimen has an underlying health issue. Observing feeding is the best cause of action to confirm an underweight specimen is eating. This could be aided with the use of a trap camera with night vision.

Figure 53 A) *Uroplatus henkeli* eating a dubia cockroach. **B)** Waxworms are best offered in a dish or on tweezers. Tweezer feeding is a good way of knowing that an individual is eating but offers little exercise or stimulus. **Adam Trimmings & Matthew Cook, Chester Zoo.**

Uroplatus henkeli is mostly nocturnal therefore feeding times should reflect this. The best time to feed is late in the day but should preferably include keeper observation time. The lights should be timed to turn off before keepers finish work to aid animal observation under torch light. This is greatly beneficial to not only observe feeding behaviour but other activities to determine the health of the geckos. Following feeding, no manual spraying or automated misting should occur to prevent any supplementation powder on the food from being washed off.

2.2.3 Water

A water bowl should always be provided. Although highly arboreal, the geckos may be observed to lap water from a bowl placed on the floor of the enclosure. It is beneficial to place the bowl at the base of a branch for easy access for the animal. The water should be replenished daily. The sufficient hydration of animals is clearly dictated by appropriate humidity (**See Section 2.1.4**). Specimens will often be stimulated to drink from direct fine misting. After spraying, individuals may also be seen lapping water droplets from their own eyes (**Fig. 54**), from plants or the sides of the enclosure. Signs of dehydration are sunken eyes, poor ecdysis, curling and wrinkling of the tail, subsequent stress colouration (only when chronic) and cutaneous flaps tucked under the tail.

Figure 54. Misting animals directly stimulates them to drink and they will lap water droplets with their tongue around the mouth and eyeballs. **Matthew Cook, Chester Zoo.**

2.3 Social structure

2.3.1 Basic social structure

Uroplatus are solitary animals; however, unlike many lizards including Gekkonidae, *Uroplatus henkeli* demonstrates little aggression between individuals, even amongst males (**Fig. 55**). There has been reported suppression of smaller sized animals in groups (Marushchak et al., 2023). It is best practice to house groups of animals of a similar size.

Pairs or small groups of animals may be housed together without problem. This also includes single-sex groups of females or males. This is particularly useful during periods of suspended reproduction. Separation and re-introduction may also improve reproductive success. It should also be noted that, although a pair of animals may coexist without issue, they may not be reproductively compatible (**See Section 2.4.2**).

Figure 55. *U. henkeli* are not often aggressive to one another and may rest near each other. **Matthew Cook, Chester Zoo.**

In rare instances, aggression may be observed, usually between males. This is usually mild and short-lived but careful observations should continue to ensure a possible escalation causes no harm to any individual, such as small wounds caused by bites (**Fig. 56**). Introducing any specimens together for the first time should take place in the morning to allow animals to settle before the evening peak of activity. The animals should be checked the next morning to inspect for any signs of injury through aggression. Injuries more severe than superficial should result in immediate separation. Introducing a new animal (female or male) to an already established group may also result in aggression. This could be the result of territorial behaviour.

An instance of likely male-to-male aggression occurred in an exhibit at Chester Zoo. The exhibit was large, measuring 4.8 x 2.4 x 2.1m (L x D x H) and housed two male *Uroplatus henkeli,* one male *Calumma parsonii* and one male *Zonosaurus maximus*. One *U. henkeli* sustained a small wound to the top of the head which required veterinary treatment (M. Cook, pers. obs., 2023).

All introductions should be monitored carefully at the beginning. It is far more likely that interactions occur at night during their active period. With this in mind, when introducing new specimens, it is best practice to manipulate the lighting to begin the night-time cycle before keepers leave work, to prolong the hours of close observations before the work day ends.

Figure 56. Female with a chunk of tail bitten off by a male. Rare instances of aggression can happen, but injuries such as this could also occur accidentally during feeding. **Craig Close, Edinburgh Zoo.**

2.3.2 Sharing enclosure with other species

Uroplatus henkeli have been successfully mixed with other species of *Uroplatus* including *U. fimbriatus, U. lineatus* and *U. sikorae*. They have also been mixed with other gecko species such as *Phelsuma standingi* and *P. grandis (***Fig. 59b**), chameleons (*Furcifer pardalis* and *Rieppeleon brevicaudatus*) and frogs (*Dyscophus* sp.) (**Fig. 59c**) (Foley, 2005). At Chester Zoo, *U. henkeli* have been mixed with *Zonosaurus maximus* (**Fig. 59a**) and *Calumma parsonii (***Figs. 57-58***)*.

Clearly, enclosures inhabiting multiple species must be large enough to provide the different environmental niches they require. The size of the enclosure is of vital importance to allow animals to move away from each other. Multiple species in a limited space is likely to result in stress.

The size of the additional species is of high importance. Large male specimens of *Furcifer pardalis* or *Calumma parsonii* may be capable of predating on immature specimens of *Uroplatus*. Likewise, *Uroplatus* would be capable of predating or attempting to predate young *Phelsuma*. Despite being insectivorous, this could occur by mistake due to sudden movement triggering a feeding response. After rearing a *Uroplatus henkeli* successfully in an enclosure shared with *Lygodactylus williamsi*, once the *Uroplatus* reached near-adult size, there has been an instance of possible attempted predation by the *Uroplatus* on the *Lygodactylus* male, resulting in tail loss and bite wounds to the back (Goetz, pers. obs.).

A note of caution regarding the mixing of any amphibian species with *Uroplatus* is the possible transmission of diseases such as Ranavirus. Although typically associated with mortality in amphibians, there is a recorded case of Ranavirus that caused lesions in the oral cavity which led to fatality in *Uroplatus fimbriatus (*Marschang et al., 2005).

Figure 57. *Calumma parsonii* (Parson's Chameleon) is a large species that may predate on vertebrates and should therefore only be mixed with adult *Uroplatus henkeli.* **Addie Jones, Chester**

Figure 58. Mixed species exhibits will result in interaction. Here, a *Calumma parsonii* tolerates a *Uroplatus henkeli* clambering on its head and body! **Adam Bland, Chester Zoo.**

Figure 59. Examples of species that can be mixed with *U. henkeli*. **A)** *Zonosaurus maximus* (Southeastern girdled lizard) can be mixed with *Uroplatus henkeli* in large enclosures. ***B)*** *Phelsuma grandis* (giant day gecko) is one of several species of *Phelsuma* suitable for mixing with *U. henkeli* in exhibits. **C)** *Dyscophus* sp. (tomato frog). When mixing any species, potential disease transmission should always be considered. **Matthew Cook, Joshua Fulford & Addie Jones, Chester Zoo.**

2.4 Breeding

2.4.1 Preparation

U. henkeli reach sexual maturity at 12-18 months. Animals to be mixed for breeding should be in excellent condition; particularly the females who will carry the biggest energetic strain. The signs of good body health are a little less obvious than with many other species of gecko.

This is because they carry a rather fragile body and store little fat in their tails. Instead, the muscle tone should be good with a solid body and a flat tail. Another good sign that a female is well stocked with nutrients in preparation for egg production is the presence of large calcium sacs on either side of the neck (**Figs. 60 - 61**). Healthy breeding females can weigh 70 – 115g. As recommended in the feeding section of this document (**Section 2.2.2**) weights should be collected every 3 – 6 months for adults. This should include before and after the breeding season to ensure a female has recuperated before the next breeding season. By collecting regular weights, it can be ensured any animals introduced for breeding are not losing condition. The best time to mix animals for breeding is the onset of the warmer season after a period of cooling.

Figure 60. Calcium sacs (two lumps on the neck) on a female are a good sign a female is healthy for breeding**. Matthew Cook , Chester Zoo.**

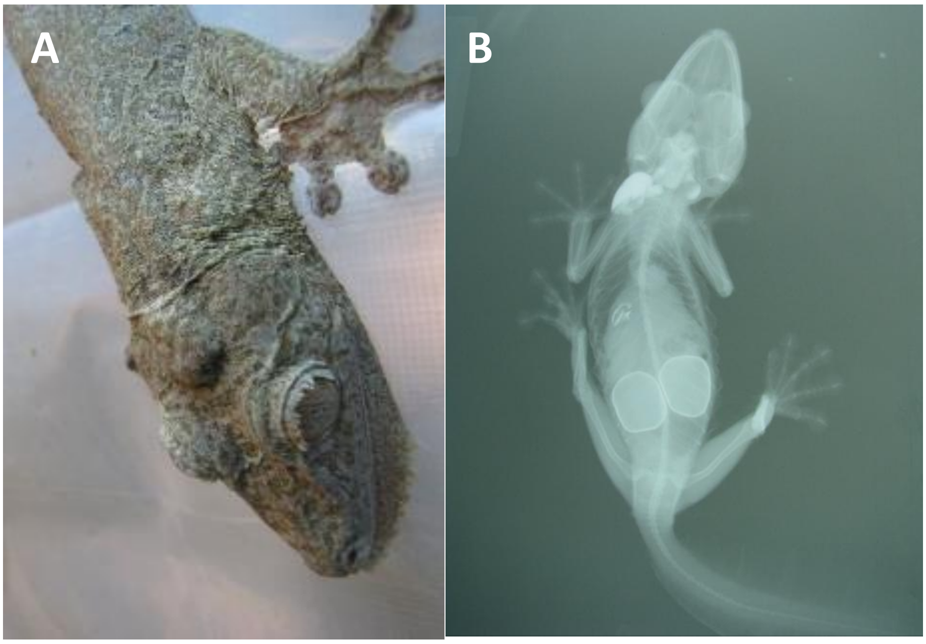

Figure 61. A) Unusual instance of a calcium sac developed on the top of the head. **B)** Radiograph of same specimen with calcium sac on head. Also note the other calcium sac in the usual position of the side of the neck. There are also two eggs present. **Sean Foley, Riverbanks Zoo and Gardens.**

2.4.2 Mating

As previously discussed, breeding groups may consist of almost any ratio and be successful. *Uroplatus henkeli* are not overly selective when it comes to forming mating pairs. On occasions when pairs do not appear compatible, separation for a short period may prove useful. Closer examination of environmental parameters and breeding condition would be the other factors to consider. In groups with a few animals, compatibility will be less of an issue and multiple males in a breeding group may provide higher stimulation to successfully mate. However, if multiple males are present this does present the problem of likely not knowing the Sire of the resulting offspring. If multiple males are available, it would be recommended to swap different males to be mixed with a female until breeding success is achieved.

Multiple males during breeding season is the most likely time aggression between animals will be seen though. Males will gape their mouths at one another and sometimes vocalise. This sounds like a high-pitched screech. This cry is also emitted by unreceptive females. If these nonphysical threats do not alleviate confrontation, fighting may ensue. It is not usually violent; however, if any signs of superficial injury are observed, animals should be separated to avoid more serious injury. Once any dominance has been settled and compatible pairs have been established, courtship begins. This mostly consists of tail waving. The male mounts the female but does not bite hold of the neck. The male wraps his tail underneath the females to reach the cloaca and copulation occurs (**Fig. 62**). Copulation may last several hours. As with most of *Uroplatus* behaviour, this largely occurs at night, sometimes going through to the early morning. Females can store sperm to fertilise multiple clutches from a single mating

(Foley, 2005). Females may also store viable sperm for almost one year (data from Species360, 2022).

Figure 62. *Uroplatus fimbriatus* mating. The technique is very much the same in *U. henkeli*. **Sean Foley, Riverbanks Zoo and Gardens.**

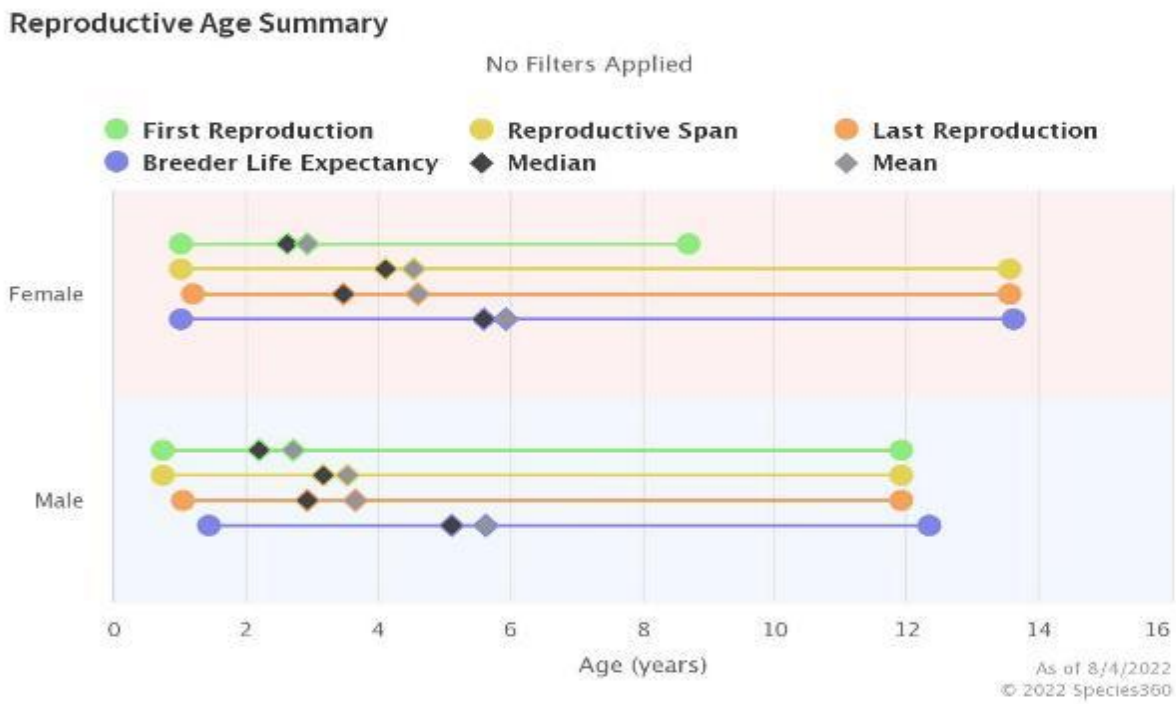

Figure 63. Graph illustrating the ages of reproduction. **Exported from ZIMS for studbooks, Species 360.**

Female first reproduction data and reproductive span taken from population of 110 breeding animals.

Female last reproduction data taken from population of 73 breeding animals.

Female breeder life expectancy data taken from population of 72 breeding animals.

Male first reproduction data and reproductive span taken from population of 100 breeding animals.

Male last reproduction and breeder life expectancy data taken from population of 70 breeding animals.

2.4.3 Egg laying

A gravid female can be identified by observing eggs through the translucence of their ventral skin (**Fig. 64)** and will show up readily on X-rays **(Fig. 65)**. The large eggs may also be detected from above as they bulge outward slightly on the flanks of the body. Egg deposition usually takes place at night, but daytime observations have been made on occasion. A few days prior to laying, females may be observed positioned closer to the ground and may appear unsettled. This could be a period of searching for suitable nesting sites. Females reproducing multiple times within the same environment demonstrate nest site fidelity.

Infertile eggs are scattered on top of the ground or may be stuck to foliage as they are dropped. In rare instances fertile eggs may be deposited this way. If fertile eggs are scattered, care should be taken to review the health of the female and if the nesting options are correct. Especially substrate that is too wet is avoided. Infertile eggs will usually appear soft, malformed and/or discoloured. The female will often consume these infertile eggs (**Fig. 66**).

Nesting sites are on the ground, where the female lays her eggs underneath leaves and lightly buried in the substrate (**Fig. 67**). The female will use her hind feet to roll the egg in the substrate. The soft, moist egg becomes coated in soil and then the egg hardens. Other than the substrate on the floor of the enclosure, the base of potted plants may also be utilised (**Fig. 68**). The ideal substrate is slightly moistened soil with a layer of leaf litter. The leaf litter provides cover for the female to reduce stress. The density of cover although aiding the female may increase difficulty in finding the eggs. While eggs hatching within the environmental parameters of the adult's enclosure is not uncommon, artificial incubation has the benefit of containing hatchlings in a small container for transfer to rearing tanks. Females in oviposition should be left undisturbed and the eggs can be collected when she has left the nesting site, which also allows time for the eggshell to harden (**Fig. 69**). Due to most of this species' activity including egg laying occurring at night, it is more likely that eggs will be laid when keepers are not present. In tanks with breeding animals, eggs should be carefully searched for quite frequently. As they are not laid very deep, they are usually easy to find. The eggs should be handled carefully, and the orientation of the egg should not be altered.

Average clutch size is 2 eggs after approximately 1-2 months of gestation. Sometimes only a single egg is laid and on very rare occasions up to 4 may be laid (Henkel & Schmidt, 1995). The eggs are spherical and hard-shelled. Based on 100 eggs produced at Riverbanks Zoo, the mean weight was 3.05g (range 2.0-4.1g) and the mean diameter was 20.72mm (range 19.25-22.25mm).

Females should be given annual recuperative periods away from males. It is ideal to give a 3-month hiatus from males to replenish nutrients and recover from oviposition. This is best timed in the cool season when males will be less reproductively active anyway. However, if a female has been particularly prolific during the breeding season, it is best for long term health to isolate from males sooner. This will be prompted from a loss of body condition or weight. Following every clutch laid, the female(s) in the enclosure should be carefully examined and monitored for signs of declined health. This will help identify that no eggs have been retained and that the female is healthy enough for future clutches. Females are capable of storing sperm and may lay several clutches following only a single mating. They may lay up to 5 clutches per season.

Figure 64. Eggs are visible through the thin, transparent underbelly. **Renārs Rozentāls, Riga Zoo.**

Figure 65. A single egg is very obvious on an x-ray. **Lisa Grund, Wuppertal Zoo.**

Figure 66. Female *U. henkeli* with the remaining white residue of an infertile egg she has likely eaten. **Matthew Cook, Chester Zoo.**

Figure 67. A female under leaves in oviposition. **Tim Baker, Drayton Manor.**

Figure 68. Females in oviposition. **Sean Foley, Riverbanks Zoo and Gardens.**

Figure 69. Freshly laid *U. henkeli* eggs, hidden underneath the leaves before the photograph was taken. **Renārs Rozentāls, Riga Zoo.**

2.4.4 Incubation

Incubation of fertile eggs may be completed in a small plastic tub. The most successful incubation media are Vermiculite or *Sphagnum* moss. *Sphagnum* moss should be prepared by soaking in water then squeezing all excess water out to leave damp moss. If using Vermiculite, a 1:1 weight ratio with water should be used. A potential drawback to using Vermiculite is the possibility of newly hatched neonates accidentally consuming chunks of it. This has been reported by Riverbanks Zoo, even resulting in a fatality (Foley, 2005). Although rare, caution to prevent this type of tragedy can be to use a different incubation medium or by covering the Vermiculite within a fine material such as stocking hose. Whichever incubation media are chosen, the eggs should be embedded halfway into the substrate and not covered. The eggs require quite high relative air humidity (above 70%). This needs to be achieved without accidentally saturating the egg. A method that has proven successful is to sit the egg on a small dish of dry incubation medium (Vermiculite) which sits on top of the damp Vermiculite (**Fig. 70**). This ensures the egg is surrounded by high humidity but the egg itself remains dry. Care should also be taken not to allow water droplets formed by condensation on the lid of the box to drip onto the eggs.

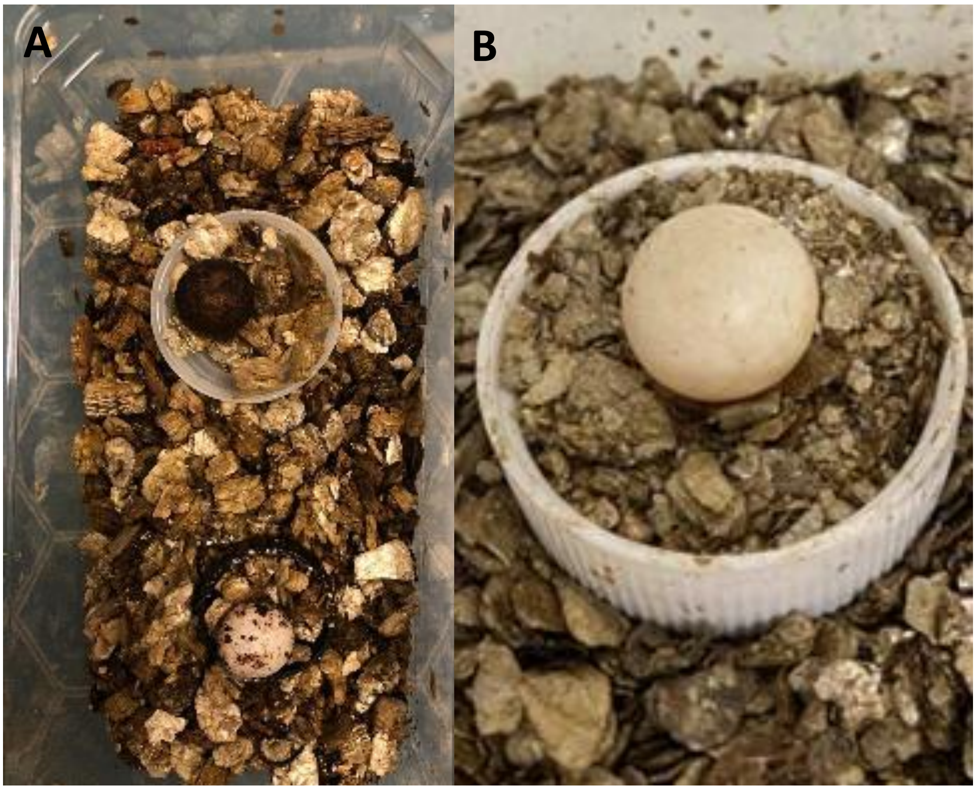

Figure 70. Incubation media of *U. henkeli* eggs. The base layer is a weight ratio of Vermiculite :water of 1:1; the individual eggs are sitting in a saucer of dry Vermiculite. Note the colouration of the eggs. **A)** The top egg has been rolled in soil by the female, but the bottom egg was freshly laid and has little substrate covering. Both eggs are viable. **B)** This egg has not been rolled in substrate and in this case proved to be infertile. **Matthew Cook, Chester Zoo**

The eggs should be incubated at temperatures between 18-26°C. As mentioned previously, it is not uncommon for eggs to incubate within the adult's enclosure which will experience this range of temperatures. The eggs may be incubated in a secure container in the same room as the adult's enclosure, provided the desired temperatures are achieved. Incubators offer more control of the parameters. Although eggs may hatch successfully at a set temperature of 24-26°C, a night-time drop results in a higher hatch success rate. The night-time setting should be 18-22°C. The disadvantage of an incubator is that they are usually very efficient at reaching these set temperatures; therefore, a gradual rise and fall in temperature is not achieved (**Fig. 71**). The most ideal conditions will be a temperature range of 18-26°C with a steady rise and fall. If the eggs are subjected to temperatures outside this range for any length of time it will likely result in failure and death of the embryo. Whether using a container in a temperature-controlled room or using an incubator, it is vital that alert systems are in place if equipment fails and temperatures fall below or rise above the critical range detailed above.

Figure 71. Good quality incubators can be very efficient and reliable at maintaining set temperatures but do not offer the gradual fluctuation of temperature. **Matthew Cook, Chester Zoo.**

The incubation period may last between 100-230 days with an average of 165 days (data from Species360, 2022). A shorter incubation period is associated with average temperatures at the higher end of the recommended range and vice versa. It should also be considered that the time of egg discovery may be different from the time of egg deposition as the eggs will often develop well within the enclosure. Naturally, this missed gap could create the perception of a shorter incubation period.

Temperature-dependant sex determination has not been well studied in the genus. It is difficult to ascertain given that optimum hatching conditions require a fairly wide temperature range. There are accounts of incubation temperature influencing sex determination in other species of *Uroplatus* (Gehring, 2020), so it is possibly true for *Uroplatus henkeli* as well.

During incubation, fertility of eggs can be confirmed by ‘candling’. In a dark room, a soft light is shined against the egg (e.g. using a small LED torch) to detect blood vessels. Later in incubation, this is not possible as the growing lizard occupies the egg. The egg will not expand as the egg is hard shelled instead of leathery and therefore no to very little expansion is seen.

2.4.5 Hatching

Eggs from the same clutch usually hatch within a few days of each other but up to a week apart is possible (Foley, 2005). The freshly hatched babies initially should be left in the incubation box (**Fig. 72**). The high humidity will assist with the first slough. Afterwards, if the hatchlings appear alert, are properly formed with a healed umbilicus site and appear healthy, they can be transferred to a rearing tank. The SVL of hatchlings has been recorded as 41-46mm and a total length of 70-72mm (data from species360, 2022) (**Figs. 98-100**).

Figure 72. A freshly hatched *Uroplatus henkeli* with its empty egg. **Matthew Cook, Chester Zoo.**

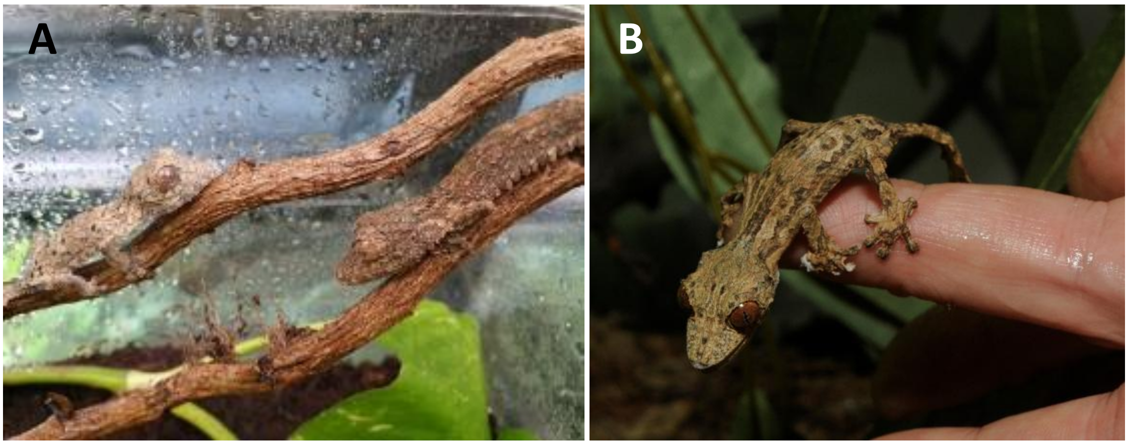

Figure 73. Hatchling *U. henkeli.* **A) Ivan Cizelj, Zagreb Zoo** and **B) Mark de Boer, Rotterdam Zoo.**

Figure 74. Many hatchling *Uroplatus henkeli*! **Sean Foley, Riverbanks Zoo and Gardens.**

2.4.6 Development and care of young

Juveniles are best reared in a miniature version of the adult set up (**Fig. 75b**). A small glass terrarium such as from the brand Exo-Terra make an ideal housing option (**Fig. 75a**). The minimum enclosure size for 1-2 individuals should be 30 x 30 x 45cm (W x D x H). As with many hatchling reptiles, plastic tubs appear an easy and inexpensive option but are flawed with lacking potentially vital design features of a custom glass tank. The ventilation is generally far better in custom tanks and since plastic does not allow UVB radiation to penetrate, UVB provision can also be more difficult for geckos housed in plastic tubs. Multiple offspring can be housed together, with increasing tank size with increasing number of animals. It is naturally far easier to keep track of very young individuals in very small groups or by housing them individually. Groups of no more than four are advisable at least until animals are established feeders and growing healthily. If the growth rates are equal, then this group housing can be continued and the size of the enclosure upgraded as the animals grow. If any individual does not grow as quickly as the other conspecifics it should be transferred to individual rearing. If space and resources permit, juveniles should be reared individually from hatching to facilitate observations on behaviour and feeding. It should be noted that it is possible to sex hatchlings immediately through their markings (**See Section 2.6.2**).

Figure 75. A) Exo-Terra terrariums are a good choice for rearing. This model measures 45 x 45 x 45cm. **B)** Setup for juvenile *U. henkeli.* Note the gecko sitting on the right-side branch. **Matthew Cook & Adam Trimmings, Chester Zoo.**

Juveniles should be provided a daytime ambient temperature of 23 - 25°C and nighttime temperature of 19 - 21°C. A low wattage halogen heat lamp such as a 35w should be used to provide a bask zone temperature of around 30°C. It is imperative that there is a thermal gradient, and the enclosure does not overheat as juveniles are more susceptible to a decline in health at high temperatures. As previously outlined (**Section 2.1.4**), it is vital that the environmental parameters are measured using reliable equipment (**Fig. 46**). The temperatures of the tank should be tested and checked before the introduction of animals.

Any food items from the list in **Section 2.4.1** that are small enough to fit easily in the mouths of the juveniles can be offered. Fruit flies (*Drosophila hydei*) and small crickets are excellent options to begin with. For further feeding instructions see **Section 2.2.2**. Add a supplementation powder (**Fig.51**) to every feed unless otherwise stated on the product specific label instructions. The lighting provision should also be carefully reviewed. The basic principles outlined in **Section 2.2.3** still apply. In smaller tanks, a lower UVB output bulb is likely required. A Solarmeter should be used to ensure the UVI level is appropriate. It should not reach levels above 3.0 and the tank should offer a full range gradient of 0 – 3 UVI. The highest UVI levels should only be met within the basking zones and the highest regions of the tank. Plants (live or plastic) can be used to dapple the levels.

A very useful product that caters for the small rearing tank is the Arcadia Pro T5 UVB Kit Shade Dweller 7% (Arcadia Reptile, 2023) (**Fig. 76**). This is a neat and compact unit that offers UVB in low levels and not overly bright illumination.

Figure 76. Arcadia 'Shade Dweller' 7% Pro T5 lamp is a good lighting option for juveniles. **Arcadia, 2023.**

2.4.7 Population management

A set of 13 new genetic markers (microsatellites) were developed to assess genetic diversity, structure, and relatedness of captive *U. henkeli* population. A total of 68 individuals from 20 EAZA institutions were sampled in 2019 and genotyped at the 13 loci. This work was carried out in the labs of Dr Sarah Griffiths and Prof. Richard Preziosi at Manchester Metropolitan University (MMU) over 2019-2021 (Whatley, 2020).

Geckos were sampled by inserting a sterile cotton swab into the mouth and lightly sweeping it around the buccal cavity (**Fig. 80**), which was then preserved in a 5ml cryovial containing self-made Nucleic Acid Preservation (NAP) buffer (Camacho-Sanchez et al. 2013). Samples were stored at room temperature during postage to MMU, and upon arrival were subsequently stored at -20°C until DNA extraction. Multiplex PCR and fragment length analysis using capillary sequencing were used to genotype individuals at the 13 microsatellite loci.

To identify population genetic clusters in the data, the Bayesian algorithm implemented in STRUCTURE (Pritchard et al. 2000; Falush et al. 2003) were used, and k-means clustering with Discriminant Analysis of Principle Components (DAPC) method implemented in the adegenet package in R (Jombart et al. 2010). Both methods identified four distinct genetic clusters within the captive population (**Figs. 77-79**).

The four clusters were well-distributed across different institutions, with all institutions having representatives of at least two different genetic clusters. The only exception to this Łódź Zoo, which only had one individual genotyped in the sample set.

The STRUCTURE analysis also shows individual admixture proportions (i.e., the degree of ancestry an individual has from each genetic cluster). Individuals were found to have ancestry primarily in a single genetic cluster, meaning that there has not been significant interbreeding between the clusters.

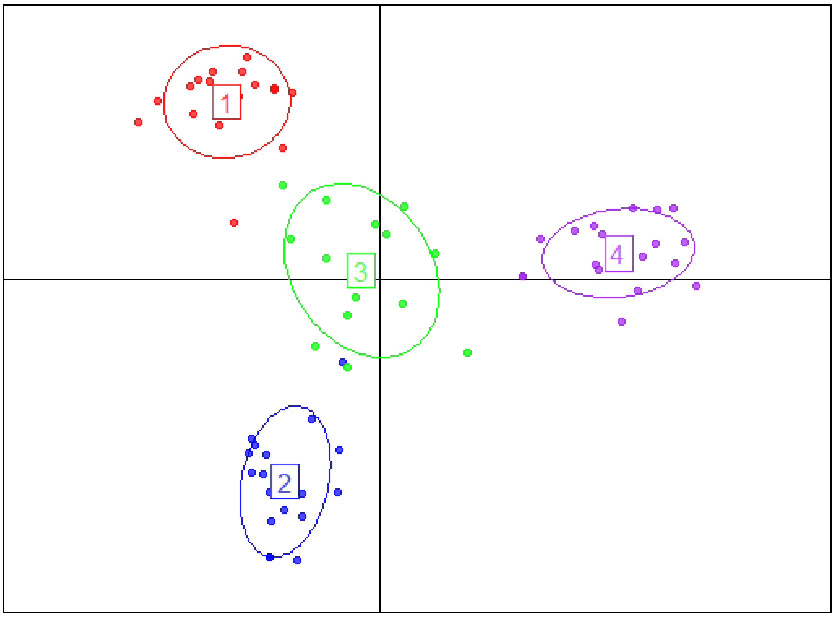

Figure 77. Discriminant analysis of Principle Components (DAPC) showing the relationship between *Uroplatus henkeli* individuals and genetic clusters. Each point represents a single individual; the numbers and colours represent genetic clusters (1-4), and the large inertia ellipses (rings) represent summaries of the point clouds for each cluster. More genetically similar points are plotted more closely together.

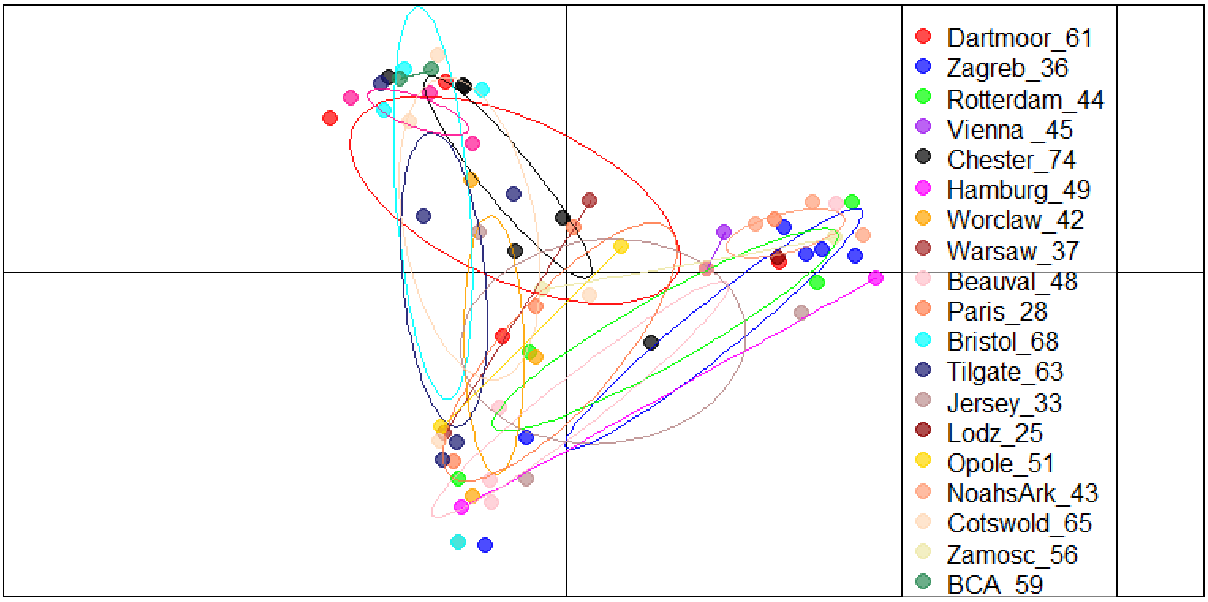

Figure 78. As in Figure 105, this shows the results of the Discriminant Analysis of Principle Components (DAPC). However, the points (individuals) are this time colour-coded by institution, and inertia elipses (rings) show the summary of the point clouds for each institution.

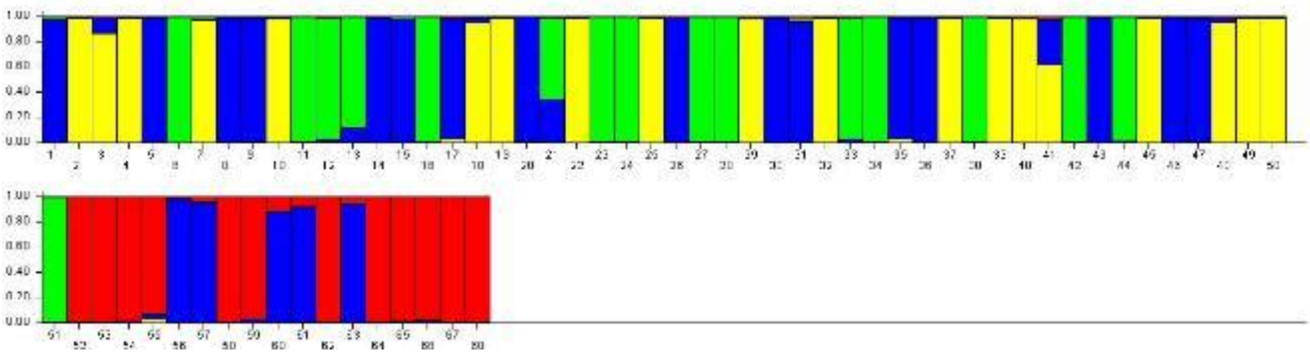

Figure 79. STRUCTURE plot showing individual admixture proportions across four genetic clusters for 68 captive *Uroplatus henkeli* individuals. Vertical bars represent individuals; colours represent genetic clusters, and the colour ratios in each bar represent the proportion of ancestry in each genetic cluster for that individual.

Genetic diversity (expected heterozygosity/ Nei's gene diversity, allelic richness) was high within the captive population. Number of alleles per locus ranged from 3 to 24 (average over all loci: 8.8), while expected heterozygosity (Nei's gene diversity) per locus ranged from 0.353 to 0.938 (average over all loci: 0.716). As no data exists for wild *U. henkeli* populations, this should be interpreted with caution as this data cannot be compared to 'natural' populations, which may theoretically be even higher. However, other gecko species analysed using microsatellites show comparable genetic diversity.

Despite the high genetic diversity, heterozygosity excesses indicate a possible recent bottleneck (rapid genetic diversity reduction). This is potentially due to a founder effect as a result of establishing a captive population.

The average inbreeding coefficient (F_{IS}) across all loci was -0.010, thus showing no evidence for inbreeding.

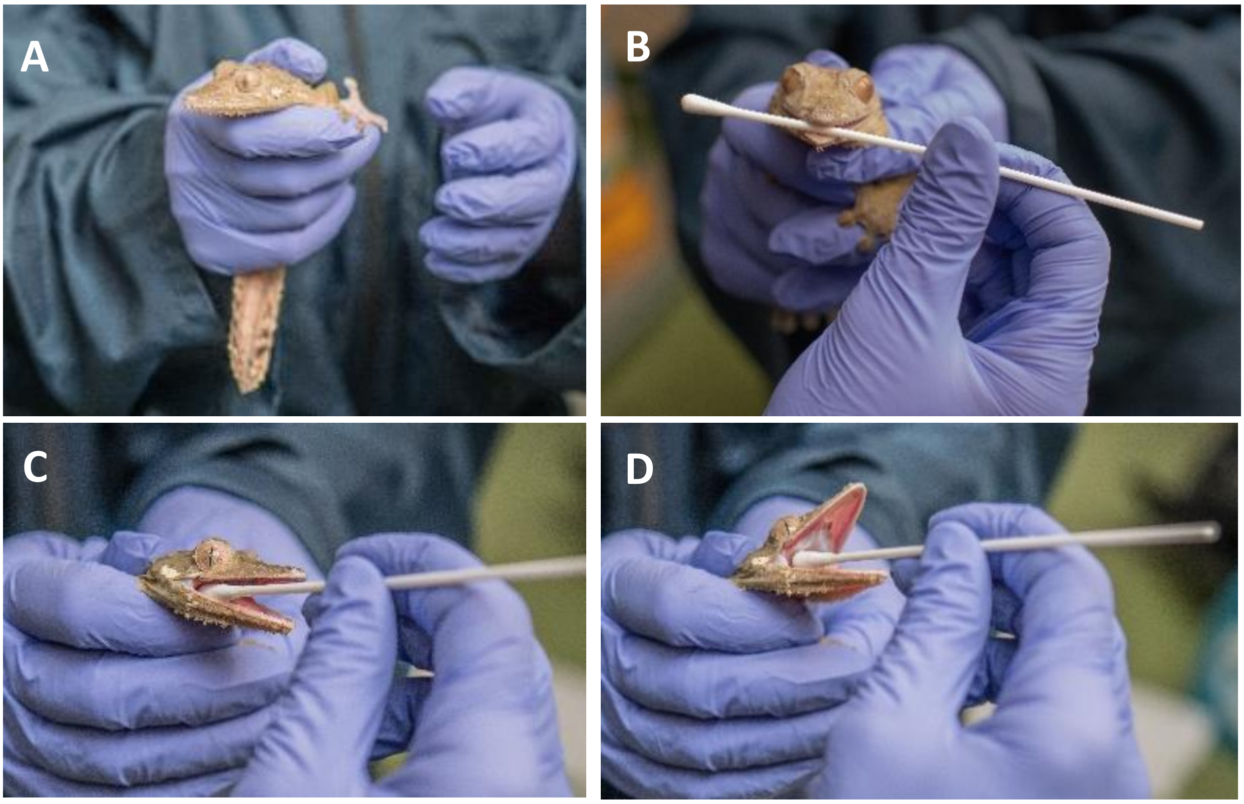

Figure 80. Swabbing technique to collect buccal samples for genetic analysis. **A)** Specimens must be held firmly but there is no need for excessive restraint. **B)** The side of the swab may be used to assist opening the mouth. **C&D)** Sweeps of the upper and lower jaw on both sides. **Steve Rawlins, Chester Zoo.**

Once receiving a recommendation to breed, this document should be followed to give the highest chance of reproduction success. If animals are not recommended to breed, then consideration must be taken to avoid accidental hatchings. It may be recommended by the EEP coordinator to separate animals into solitary holding or single sexed groups. In the case of single sexed groups extra attention should be given to confidence of the gender. This is particularly true for animals reaching sexual maturity because hemipenal bulges may be less apparent (see **Section 2.6.2**). As *Uroplatus henkeli* are known to store sperm, it should be expected that isolated females may continue to lay fertile eggs even into the cool season. It is important that the enclosure floor is routinely searched for eggs. As previously stated in this document, the eggs successfully incubate at the species enclosure temperature therefore undetected eggs are likely to hatch if they are viable. This may even occur through the cool season as cooler temperatures may still be sufficient to hatch eggs but with a longer incubation period.

It may also be recommended or necessary to house breeding animals together with no recommendation to hatch the eggs. This can identify the reproductive viability of the animals. In this instance, eggs should be routinely searched for as detailed above. This should occur every 2 weeks to avoid development of the embryo within the adult's enclosure. All discovered eggs should be examined to determine fertility (see **Section 2.4.4**). Eggs may then be discarded/euthanised.

2.5 Behavioural enrichment

It can sometimes be difficult to distinguish enrichment from excellent husbandry practices. In terms of enclosure design, a walk-through greenhouse with dense planting and a rain system (**Fig. 81**) would certainly be more enriching than a glass tank with one plant and couple of branches. A complex environment is likely to produce healthier animals through fitness from prolonged activity such as hunting. A simple environment offers little challenge for a gecko when hunting. However, there must be consideration to ensuring geckos can obtain enough food. Invertebrates will disperse in large enclosures and may remain hidden. In this instance it would be necessary to add food into the enclosure for the invertebrate prey to ensure their nutritional value is not lost. Larger quantities of food, feeding stations and target feeding can mitigate this but reduce the goal of creating an enriching environment. A balance between these methods is needed for healthy and stimulated animals.

A good diversity of furnishings can also promote enriching behaviour. *Uroplatus* will often adopt a flat posture against tree trunks; if offered spindly branches, they may be observed adopting the posture of a dead, folding leaf on a branch.

Diet is another factor that is an outlet for enrichment. Offering every or almost every item accepted on the food list as opposed to one or two will not only offer a more nutritious and balanced diet but will also be a source of enrichment. The hunting technique for different species of prey is likely to be at least a little different.

Figure 81. A large enclosure with a wide variety of plants and branching offers an enriching environment for *Uroplatus.* **Adam Trimmings, Chester Zoo.**

2.6 Handling

2.6.1 Individual identification and marking

Microchip (PIT-tag) implantation is a frequently used method for the permanent individual identification of reptiles. This usually straightforward procedure may be complicated by the small size of certain individuals and the need for restraint. The location of a microchip placement is based on the desire to minimise local trauma and transponder migration, and to allow easy scanning and identification of that individual.

The size of sub-adult and adult *U. henkeli* makes this a suitable species for subcutaneous microchip placement (**Fig. 82**); however, careful preparation and good technique are required for a successful outcome due to this species' thin skin and often fractious nature when handled. Inappropriate handling may result in tail dropping (autotomy) and whilst tail loss may not cause the same deleterious effects on body condition noted in species which rely on the tail as a site for fat storage (such as *Eublepharis)* (Naya et al., 2007), it may cause considerable stress and potentially lead to death. The aesthetic consequences of autotomy are also undesirable with regards to the animal being an attractive exhibit species.

Any Trovan/ISO compliant transponder microchips are a suitable option for subcutaneous placement in adult *U. henkeli*. Standard sizes available are 1.4 x 8.0mm (Trovan, 2023) and, even smaller, 1.25 x 7.0mm (AgnThos, 2024).

Microchip placement requires two people: one person to restrain the animal and the other to place the transponder. The left flank is the preferred location for microchip placement as the risk of serious trauma in that area is low and tissue movement is minimal.

The person handling the gecko should grip the head and foreleg with one hand and hold the hind leg and tail in the other, leaving clear space around the chosen microchip site. With this technique the geckos are usually calm in this position and therefore do not require a great deal of pressure when restrained. The handler's grip should be largely focused on the hind legs with minimal tension placed on the tail, in order to reduce the risk of autotomy. Geckos may frantically flap the tail around during restraint. This appears a little alarming however no instances of tail autotomy have occurred during microchipping.

It is important that the person placing the microchip is confident and that their arm is resting on a stable surface, in order to minimise sudden and inadvertent movements which may cause harm to the lizard. Once suitably restrained, a very small superficial hole is made in the gecko's skin using the microchip applicator: this is the point of entry. The applicator is then inserted and advanced directly under the skin, being careful not to penetrate the underlying musculature. If placed correctly, the applicator can be observed beneath the skin during the procedure and the microchip can be seen *in-situ* after withdrawal. The entry site is then sealed with the use of surgical adhesive and forceps (**Fig. 83**).

If the microchip applicator is pushed too deep into the body, the microchip will be injected into the gecko's coelomic cavity rather than under the skin. Intra-coelomic microchip placement is commonly performed in some reptilian species although it carries the risk of causing iatrogenic damage and migration of the transponder throughout the body cavity.

There may be mild localised haemorrhaging following microchip placement, presumably resulting from localised trauma to the skin's vascular supply. In these cases, haemostasis can be achieved by exerting pressure on the area. No behavioural changes, such as loss of appetite or reduced mobility, were observed following microchip placement in any individual.

If the entry point is not fully healed, it is possible for the microchip to be ejected. There have also been a few other instances of lost microchips even months after being placed. It is unknown how by this point they could be expelled. However, in most cases subcutaneous microchipping has been a successful and straight forward method of individual identification.

Another zoo institution has immobilised specimens with isoflurane/oxygen for the microchipping procedure with no adverse side effects. This is an option for individuals that react particularly negatively to restraint, but it is not necessary for most specimens.

Figure 82. Microchipping is the preferred method of individual identification. **Steve Rawlins, Chester Zoo.**

Figure 83. The process of microchipping *Uroplatus henkeli.* **A)** A Trovan mini-transponder microchip next to a *U. henkeli*. **B)** The microchip applicator pierces the skin. **C)** The needle is straightened to insert the microchip just under the skin. **D)** Surgical glue is used to seal the entry site. **E)** The skin may be pinched with tweezers to aid closure. **F)** The microchip is clearly visible underneath the skin. **Steve Rawlins, Chester Zoo.**

For short term identification, nail varnish has been used on the skin with mixed success (**Fig. 84**). This method allows quick identification. However, it is clearly temporary due to skin shedding. This may present a problem considering that *Uroplatus* exhibit keratophagy (feeding on shed skin); therefore, this method should be avoided even if non-toxic nail varnish is used. However, no individuals presented ill health following this marking technique (M. Cook, pers. obs., 2023). Another problem encountered was that the blob of dried nail varnish would completely come away and drop off the skin.

Figure 84. Nail varnish has been used as a temporary identifier but is not preferred. **Matthew Cook, Chester Zoo.**

Certain specimens display obvious markings on the body and tail such as black or white spotting (**Fig. 85**). This could be used to identify individuals; however, using coloration and markings to ID a specimen is problematic due to the keen ability to change colour. Although, certain spots of colour will not disappear, they may fade or be lost in the contrast of the background colour of the animal. Certain specimens exhibit no distinct patterning, and the mottled coloration makes describing a key characteristic very difficult particularly in the eyes of more than one keeper.

Figure 85. Certain specimens have distinctive markings such as white or black spotting that can be used for individual ID. However, some markings will change with age, environment, and behaviour. **Matthew Cook, Chester Zoo.**

2.6.2 Sexing

Mature adult specimens are often very easy to identify. The males have distinct hemipenal bulges at the base of the tail. They are best viewed from the underside (**Figs. 86-87).**

Figure 86. Adult male specimens can be distinguished from females by the presence of distinct hemipenal bulges. **Matthew Cook, Chester Zoo.**

Figure 87. The hemipenal bulges on the male on the left side are very distinguishable next to a female. **Renārs Rozentāls, Riga Zoo.**

There is evidence of sexual dimorphism in coloration. One described distinction can be identified best at nighttime. The males have a pattern of large dark brown to black patches and the females have fine dark spots (Svatek & Van Duin 2001). There may also be distinction in markings directly after hatching. In female neonates, there is a transverse black marking at the base of the skull, whereas in male neonates this is not present, but there is a vertebral black stripe along with dorsal striations (Foley & Pfaff, 2005) (**Figs. 88-89**).

Figure 88. The vertebral stripe indicates these hatchlings are male. The third, right hand individual has a more subtle vertebral stripe, but also dorsal striations therefore it is a male. **Sean Foley, Riverbanks Zoo and**

Figure 89. These hatchlings can be sexed as female by the transverse black marking at the base of the skull. **Sean Foley, Riverbanks Zoo and Gardens.**

2.6.3 General handling

Uroplatus henkeli are usually non-aggressive. Animals can usually be gently scooped up from their resting position. The feet have phenomenal grip due to the microscopic lamella which allows them to stick onto almost any surface. When picking a gecko up, care should be taken to peel the feet away slowly from the surface it is stuck to. The tail should not be gripped at all to prevent autotomy. The body can be gripped by hand loosely around the mid-body. There are occasional aggressive specimens that will react by opening the mouth, screeching and biting to being handled. The bite may draw blood. A pair of workman gloves may be used for protection. The gecko's general first reaction to handling is to leap away.

2.6.4 Restraining

If an individual is too aggressive to be handled without restraint or needs closer examination such as veterinary care, then restraint can be used. The animal may be gripped around the body and the head without much pressure to securely restrain it (**Fig. 90**).

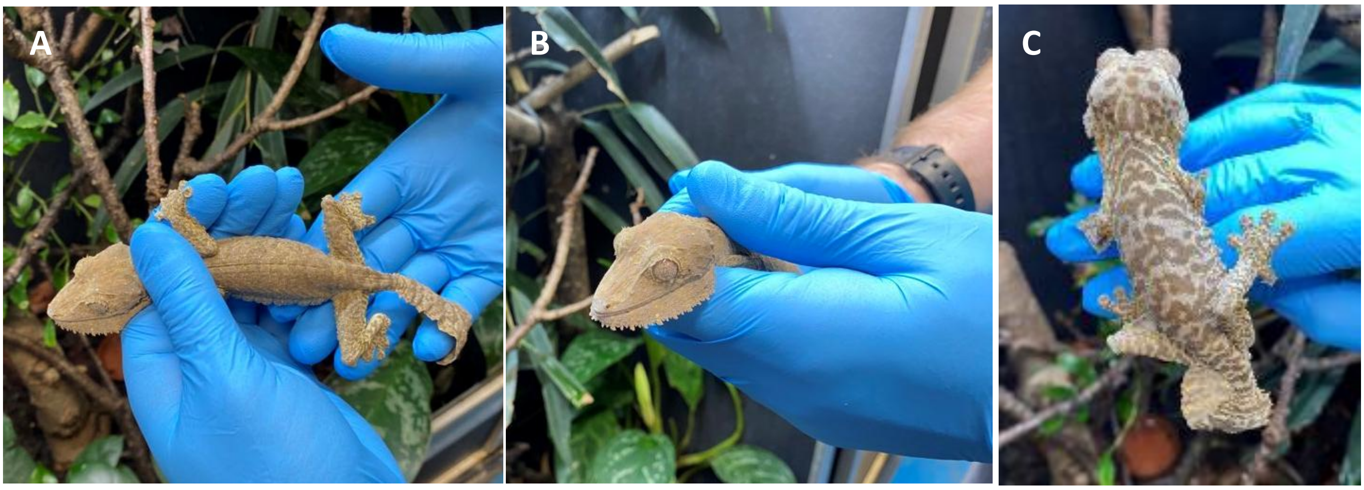

Figure 90 A&B) Safe and secure restraint of *Uroplatus henkeli.* For more invasive procedures such as administering medication via injection, the body may need to be fully grasped. The tail should remain free and not be gripped. **C)** Even gentle handling will result in colour change due to a stress response. **Matthew Cook, Chester Zoo.**

Figure 91. *Uroplatus* often sit on glass which can provide the opportunity for close inspection or collecting measurements without the need to restrain the animal. **Matthew Cook, Chester Zoo.**

2.6.5 Transportation

Transportation is best achieved using cloth bags. For external transportation i.e., from one zoo collection to another, moist sphagnum moss should be added to the bottom of the bag. A good handful of dampened moss should be used (**Fig. 92**). Only one gecko should occupy each bag. The cloth bags can subsequently be placed in a polystyrene box or shipping crate. The box should be packed with a packing material such as shredded paper to secure the bags in place (**Fig. 93**). Any material that may extract moisture from the bags should be avoided. The temperature inside the shipping crate should be maintained between 17-24°C. For international shipments by commercial transport, IATA-compliant transport crates need to be used (IATA, 2024).

Figure 92. Animals should be individually bagged with a clump of sphagnum moss to maintain humidity. **Matthew Cook, Chester Zoo.**

Figure 93. IATA-compliant transportation crate for international shipping of *Uroplatus henkeli*. **Ciaran Westgate, Jersey Zoo.**

2.7 Veterinary considerations

No novel or species-specific disease processes have been diagnosed in captive zoo-held *Uroplatus henkeli*. Sick individuals often present with non-specific clinical signs, such as sunken eyes and an unusual tail posture, which may require further investigation. As with all reptile species, a review of the patient's environmental parameters, including but not limited to temperature and humidity, should be performed alongside any veterinary intervention.

Uroplatus henkeli individuals may be housed alone to facilitate medical treatment and or for quarantine purposes.

Whenever possible, it is preferable not to capture and restrain *Uroplatus henkeli* for examination as this may cause unnecessary stress to the animal (Divers & Stahl, 2019). The use of clear see-through boxes and or the glass frame of a vivarium may allow sufficient visual examination in the first instance (**Fig. 91**).

It is common for *Uroplatus* to be dehydrated when observed in the state of sunken eyes and a curled tail. The activity and strength of the animal must be assessed to determine whether it can hydrate on its own. Firstly, water can be sprayed or dripped onto the snout to see if the specimen can be stimulated to drink. Handling animals should be avoided to minimise stress. It is important to quickly determine whether the animal is feeding; it may be useful to use a bowl of preferred food to confirm feeding. If the individual has a different food preference and these are actively released in the enclosure, remaining food should be removed the following day. A faecal sample analysis may offer helpful information or at least rule out potential problems such as a parasite burden (Mans & Braun, 2014).

Dehydrated animals may be recovered by placing them in a 'rain chamber'-like setup with water constantly running with a pump and spray bar. Weak animals should never be placed in a setup like this due to the risk of drowning. Even with healthy animals, furnishings to exit the water body and pump should be carefully placed. The 'rain chamber' should only be used as a temporary measure to rehydrate. A few hours is long enough to improve some specimens.

The tail is often an early indicator of poor health. The tail is not used as a fat store in this species, but a health problem may be indicated by an unnatural posture of the tail such as curling or flopping. The fringes of the tail may curl downwards or upwards (**Fig. 94**). This could be an indicator of incorrect environmental conditions such as low humidity. Another problem seen with the tail is 'floppy tail syndrome' (**Fig. 95**). It can best be seen when a specimen is resting vertically with the head pointing down. In this position, the tail flops over and hangs over the back rather than sitting flush against the branch. This abnormality has been linked to an overly rich diet (Gehring, 2020) (see **Section 2.2.1**). In the worst cases, it is possible for the tail to autotomize even without handling. The tail can be regenerated (**Fig. 96**); however, tail loss is a severe sign of poor health and can lead to fatality. It is vital to identify early signs of any of these beforementioned problems to intervene with changes before it becomes a serious issue.

Uroplatus can be a voracious hunter and they may launch themselves fiercely to capture prey. This can lead to nose abrasions. This is usually associated with small enclosure size and/or rough surfaces such as rock work. Other physical injuries may be sustained by conspecifics, hungry live food or entrapment of a digit or limb in furnishings or the glass door of the enclosure. Injuries that present an open wound will likely need treatment to prevent infection and more severe injury (**Fig. 97**).

Figure 94. A juvenile with the fringes of the tail upturning and folding over. This may be the result of inadequate humidity. **Matthew Cook, Chester Zoo.**

Figure 95. 'Floppy tail syndrome' is a condition when the tail is too heavy to be supported and is due to a rich diet. **Sean Foley. Riverbanks Zoo and Gardens.**

Figure 96. Regenerated tail. Note the coloration difference as the right side of the tail was shaded by a plant before the photo was taken. **Matthew Cook, Chester Zoo**

Figure 97. Specimen with amputated leg due to an infection. The gecko lived a normal lifespan following the procedure. **Sean Foley, Riverbanks Zoo and Gardens.**

Blood sampling:

Blood samples may be obtained from the ventral coccygeal vein and submitted for haematology and biochemistry profiles; however, care should be taken during handling to minimise the risk of tail autotomy occurring (Oldfield, 2014).

Anaesthesia:

General anaesthesia is most easily achieved with the use of inhalational anaesthetic gas, such as isofluorane or sevofluorane, (Ferreira & Mans, 2022) either via placement into an induction chamber or under manual restraint. Injectable options include alfaxalone which may be administered by intra-muscular (Edis, 2017) or intravenous routes (Morici et al., 2018).

Diagnostic imaging:

Wherever possible, diagnostic imaging should be performed with minimal restraint and stress to the patient. Conscious dorso-ventral radiography is easily achieved in most cases. Trans-illumination may be performed in the conscious animal with the patient placed on a piece of clear Perspex; however, precautions should be taken to prevent trauma due to the gecko leaping unexpectedly. Handling is usually required to perform ultrasonography of the coelom; however, the small size and often flattened shape of these patients may complicate image collection and interpretation.

Coelioscopy may be performed to visually assess the liver and other coelomic viscera.

Preventative health:

Parasitology:

Faecal samples may be examined opportunistically or routinely for the presence of endoparasitic ova, larvae and or coccidian oocysts. Treatment options are as for other lizard/gecko species. External parasites, such as ticks and mites, are rarely observed in captive geckos.

A single-celled protozoan parasite, *Cryptosporidium varanii*, has an intestinal predilection and has long been associated with disease in lizard species, particularly leopard geckos (*Eublepharis macularis*) (Terrell et al., 2003). Clinical signs of disease may include: loss of muscle mass; anorexia; lethargy and diarrhoea. Faecal screening, including positive Ziehl-Neelsen staining (Diapath, 2024) of oocysts and or polymerase chain reaction (PCR) to identify the specific organism, may aid diagnosis; however, *Cryptosporidium* sp. oocysts are only shed intermittently, and the aforementioned techniques rely on oocysts being present within faeces at the time of screening. Intestinal biopsy and histological evaluation is required for a definitive diagnosis of disease (Divers & Stahl, 2019).

Treatment and eradication of *C. varanii* is a priority for lizard collections as the disease is not self-limiting and chronic shedding occurs, increasing the risk of exposure to naïve animals. Treatment options may include paramomycin, trimethroprim sulphur and or metronidazole (Divers & Stahl, 2019); however, the pharmacokinetics and efficacy of these drugs in *Uroplatus* sp. have not been determined.

Cryptosporidiosis is spread via the faeco-oral route, either by direct contact between lizards or via contaminated objects or enclosures. Ingestion of sporulated oocysts may lead to infection and environmental stressors, including high stocking density and reduced health status, may promote spread of the pathogen.

Good environmental hygiene and the removal of faecal material and contaminated substrate is essential to reduce the risk of exposure to infective oocysts (**Fig. 98)**.

Cryptosporidium varanii is very host-specific and is therefore not considered to be a significant zoonotic risk to humans.

Faecal culture and *Salmonella sp.*:

Salmonella species are perhaps the most well-known bacteria associated with reptilian patients. The genus *Salmonella* is divided into two species, six subspecies and thousands of serotypes, some of which have been associated with disease in humans (Pees et al., 2023). Patients at most risk of zoonotic disease include children, geriatrics and the immune-compromised (Divers & Stahl, 2019).

Whilst *Salmonella* sp. may cause (typically enteric and or multi-systemic) disease in reptiles, these organisms are often present in the faeces of normal, clinically healthy animals. A positive culture does not necessarily mean that it is causing disease and antibiotic use should be avoided unless there are clear signs of disease. In addition, the low sensitivity of bacteriological culture, coupled with the intermittent nature by which these organisms are shed, means that routine faecal culture is not recommended for the isolation of *Salmonella* sp. *Salmonella* sp. should be considered present within the enteric biome of most captive lizards (Pees et al., 2023) and eradication is not feasible.

Good standards of biosecurity and personal hygiene should be implemented when managing and handling captive reptiles to minimise the risk of contamination and human exposure to potentially zoonotic pathogens.

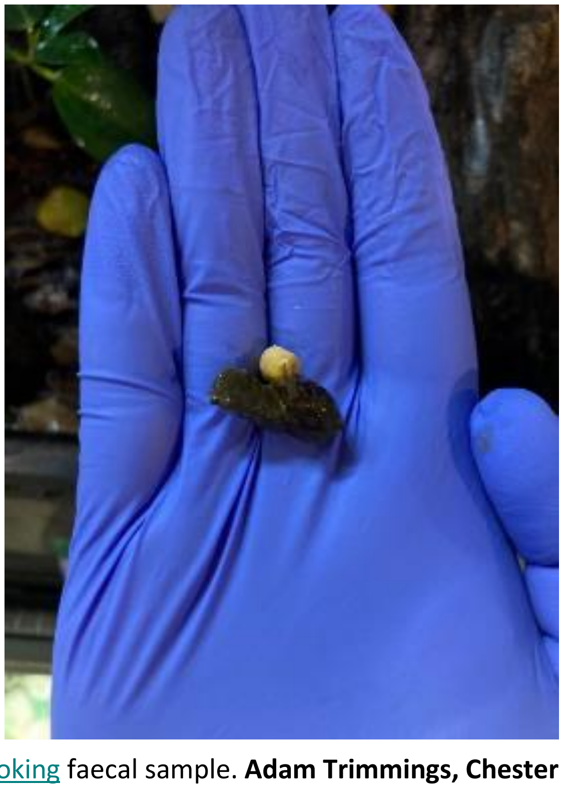

Figure 98. A healthy-looking faecal sample. **Adam Trimmings, Chester Zoo.**

Reproductive disease:

Reproductive disease, including pre-ovulatory follicular stasis, dystocia ('egg-binding') and yolk coelomitis have been diagnosed in captive *U. henkeli* (Graham et al., 2020; Sykes, 2010).

The cause of these disease processes are often multifactorial and may include stress; inappropriate nesting site provision; dehydration; malnutrition; obesity; broken/damaged eggs and or reproductive tract disease (Divers & Stahl, 2019).

Clinical signs associated with follicle or egg retention include restless behaviour (i.e. female lizards pacing and looking for somewhere to lay their eggs), increased coelomic distension (often with reduced body condition) and or anorexia (Garner et al., 1999).

Diagnosis of such conditions may involve a combination of palpation, blood-work (such as to assess calcium levels) and or diagnostic imaging, such as radiography and ultrasonography (Sykes, 2010).

Treatment of follicular stasis and or dystocia requires changes made to the animal's environment, such as increased nest-box provision, alongside any medication intervention (Graham et al., 2020). Oral or parenteral calcium supplementation may be required in some cases. Injectable hormones, such as oxytocin, have been used with limited success in cases of non-obstructive dystocia in lizards (Divers & Williams, 1993). If medical management of these cases is not successful, reproductive surgery (such as ovariosalpingectomy or salpingotomy) may be required. Assuming the patient is otherwise of good health status and bright, such surgery procedures are usually associated with a positive prognosis and future breeding potential may be retained (Divers & Stahl, 2019).

Yolk coelomitis is a serious and potentially fatal disease process, usually occurring as a consequence of pre-ovulatory follicular stasis. In such cases, retained ovarian follicles may become degenerate or damaged, causing leakage of their contents into the coelom (Garner et al., 1999). Free yolk material causes an inflammatory response with secondary bacterial infection and subsequent sepsis which often proves fatal if no intervention is performed (Divers & Stahl, 2019) (**Fig. 99**).

Clinical signs are similar as for pre-ovulatory follicular stasis; however, the patient may present as weak or obtunded if the disease process is advanced. In addition to the previously mentioned diagnostics, aspiration of free flocculent yellow-tan coloured material from within the coelom is highly suggestive (Garner et al., 1999).

Surgical intervention under general anaesthesia is usually required for the treatment of severe cases of yolk coelomitis; however, prognosis will depend on the severity of disease and how stable the patient is. Ovariectomy and or salpingotomy is often indicated and aggressive post-operative medical support, in the form of systemic antimicrobials, anti-inflammatories and analgesics are required.

Figure 99. Damage caused by a ruptured follicle. **Tristan Ningler, Thoiry Zoo.**

Aggression injuries:

Conspecific aggression injuries occasionally occur in *U. henkeli* (see **Section 2.4**). Most cases are treated successfully using topical preparations which are generally well tolerated; however, further medical and or surgical intervention may be required in some cases.

Antibiotics:

Antibiotic resistance has been reported in a variety of free-ranging and captive reptiles so, wherever possible, the use and choice of antibiotic should be based on evidence-based recommendations. It is also important to note that there are few pharmacokinetic and pharmacodynamics studies to support the use of most drugs in reptiles; therefore, drug dosages are often extrapolated from doses used in other animals.

Whenever antibiotic usage is indicated, their use should ideally be based upon culture and sensitivity testing and the narrowest spectrum of activity should be selected. Where this is not possible, or whilst waiting for these results, the use of so-called 'first line' empirical antibiotics is preferred. Such drugs include: trimethoprim-sulphonamides, tetracyclines and aminoglycosides. Fluoroquinolone and 3/4/5th generation cephalosporin use should be avoided unless there is a specific indication to do so (Gibbons, 2013; Hedley et al., 2021).

Nutrition and environment-related issues:

Prolonged exposure to sub-optimal environmental conditions may manifest as problems with skin shedding, including retained or infected spectacles (**Fig. 100**), general ill-thrift and other ophthalmologic issues such as keratitis resulting from over-exposure to UVB light.

Nutritional diseases have not been commonly reported in leaf-tailed geckos; however, renal disease, gout, obesity and or hepatic lipidosis are all possible consequences of sub-optimal husbandry and feeding practices (Mans & Braun, 2014). Similarly, captive *U. henkeli* may become anorexic and lose body condition if they are not provided with appropriate food items and environmental conditions, or they are suffering from chronic underlying medical issues.

'Metabolic bone disease' in the form of generalised osteopenia (rather than fibrous osteodystrophy) has been diagnosed in captive *U. henkeli*, presumably resulting from insufficient dietary calcium intake and sub-optimal exposure to UVB radiation (Juan-Salles & Boyer, 2020; Sykes, 2010).

Ophthalmological issues:

Retained spectacles have been associated with underlying hypovitaminosis A in geckos (Divers & Stahl, 2019), often resulting in secondary bacterial infection and keratitis (**Fig. 100**). Spectacle removal may be achieved with the use of a moist cotton swab or topical application of artificial tears to hydrate and aid lubrication. If the retained spectacle cannot be removed easily then waiting until the next shed to try again is best (Divers & Stahl, 2019).

Pseudo-buphthalmus occurs when the nasolacrimal system is blocked, causing fluid to accumulate within the sealed sub-spectacular space. This results in 'bulging' of the spectacle (**Fig. 101**). The condition may be temporary; however, further imaging and or surgical intervention to treat the blocked nasolacrimal duct or create a drainage canal in the spectacle may be required. Any fluid removed from the sub-spectacular space should be examined under the microscope for evidence of bacterial infection or the presence of flagellates (Divers & Stahl, 2019).

Figure 100. Inflammation beneath the spectacle can result in damage to the surface of the eye. This may be linked to vitamin A deficiency. **Newquay Zoo.**

Figure 101. Pseudo-buphthalmus is a swelling of the spectacle caused by a build-up of fluid in the eye due to blocked ducts. **Wuppertal Zoo.**

2.8 Recommended research

- This species and the genus' nocturnal activity means that much of the behaviour and activity occurs outside of zoo staff work hours, therefore more knowledge could be gained through night vision cameras. A study to catalogue observations would be beneficial with a particular focus on social dynamics. This species is recommended to be kept in mixed-sex groups with little conspecific aggression (see section 2.4.). However, a more detailed look into social behaviours would be insightful into how best to decide on numbers and sex ratio for each enclosure. Males are not overly aggressive towards each other however suppression may occur effecting long term health and welfare. It would also be beneficial to document and record footage of courtship and mating behaviour.

- Buccal sampling of wild specimens for genetic analysis to build a comparative baseline to the already completed captive genetic analysis. This will allow a better interpretation of the data rather than comparing to other gecko species.

- We do not have a clear explanation for many health issues seen in captivity. It could be presumed that follicular stasis and organ failure may be linked to nutrition, but further study is required.

- The importance of the lunar cycle effecting activity and behaviour. Enclosures kept indoors lack the light levels emitted by the moon. It has been proposed that situating enclosures near windows may be preferable (Svatek & van Duin, 2001). The lighting equipment available for reptiles is generally always improving, however, the dim light levels emitted at dusk, dawn and night are rarely catered for.

- Using audio recording equipment to study acoustic conspecific communication.

There are many gaps in knowledge of the ecology and natural history in the wild. For example:-

- The levels of UVB radiation the species is exposed to directly. What is the species (or the sun ray's) movement during periods of sunshine in the dappled forest?
- The movements of animals during peak dry season. What microhabitat do they occupy during these harsher environmental conditions?
- Natural history and ecology of juveniles
- Diet analysis
- Lifespan
- The physiology of the species and genus including heart rate, respiratory rate and body temperature are unknown from wild and captive animals.

- As highlighted in Section 1.5.5, the taxonomic revision is of urgent need due to the ramifications on the conservation status of *U. henkeli* and newly described species.

- Regardless of the taxonomy, the conservation of this species and others requires protection and support in Madagascar.

- The population trend is unknown but considering the known threats it may be assumed that it is in decline and that attention should immediately focus on support for local communities and the land.

Section 3. Acknowledgements, Bibliography & Suggested products

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3.3 Suggested products

Enclosure decor

Hydroleca. Hanley's. Webpage at: https://www.hanleysofcork.com/product/hydroleca

Enclosures

Chameleon World Muji screen enclosures. Webpage at: https://chameleonworldmuji.co.uk/shop/

Exo Terra terrariums. Webpage at https://exo-terra.com/products/terrariums/

Environmental measuring equipment

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

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

SolarMeter: model 6.5R. Webpage at: https://www.solarmeter.com/product/model65r/

Heating and lighting equipment

Arcadia D3 fluorescent lamps. Webpage at: Lighting - Arcadia Reptile

Arcadia Pro T5 UVB Kit Shade Dweller 7%. Webpage at: ShadeDweller - Arcadia Reptile

Halogen heat lamp. Webpage at: Halogen Infrared Heater - Arcadia Reptile

Reptile systems gold infrared unit. Webpage at: Gold infrared lamp unit UK

Humidity equipment

HabiStat: Humidifier. Webpage at https://habistat.com/product-details/humidity-and-water/humidifier

MistKing: Ultimate misting system v5.0 Webpage at https://www.mistking.eu/Ultimate-Value-Misting-System-v5.0.html

Nutrition

Arcadia Earth Pro A. Webpage at EarthPro-A - Arcadia Reptile

Repashy: Grubs N Fruit Webpage at: Grubs N Fruit - Repashy UK

Repashy Calcium Plus. Webpage at Reptile Products Archives - Repashy UK

Repashy Superload. Webpage at SuperLoad - Repashy UK

Vetark Nutrobal. Webpage at Nutrobal

Woodstock: Vitamin D3. Webpage at: https://woodstockvitamins.com/blog/vitamin-d-sunshine-supplement-for-bones-blood-and-the-blues/

Zoo med Repti Calcium. Webpage at Repti Calcium® with D3 | Zoo Med Laboratories, Inc.

Transponders

Agnthos: Implantable chip for animal ID. Webpage at: https://agnthos.se/implantable-chip/1033-implantable-chip.html

Trovan: Microchips for animal ID. Webpage at: https://www.trovan.com/en/product-lines/trovanunique-animals/microchips-for-animal-ID