

REPTILES IN CAPTIVITY

Thermoregulation and Related Health Issues



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ABSTRACT

The keeping of reptiles is an ever-growing global phenomenon resulting from increased animal availability. With an increase in popularity of reptile keeping comes an increase in related health issues. Thermoregulation in reptiles is one of the most important aspects for a reptile's overall health and well-being as it affects all physiological and behavioural aspects. Health issues seen in captive reptiles were directly related to inadequate husbandry by keepers and owners. This lack of knowledge held by reptile keepers is attributed to a sparse amount of appropriate information on reptile care. This is further exemplified by misleading information given to inexperienced reptile owners on the ease of care for their animal. An identified gap in the literature was the direct correlation between husbandry practices, thermoregulation, and health issues. This led to an investigation on how the issues of thermoregulation in home reptile keeping affect the health of the reptiles. The aim of this research was to identify and address shortfalls in reptile husbandry to ultimately move towards better well-being and health for reptiles kept at home. This research study involved conducting industry expert interviews, an online survey, and a cultural probe to address the gap identified in the literature. The analysis and triangulation of these methods gave insights to the various issues around reptile keeping. The results of this research project indicated that thermoregulation and health issues are most likely a result of a lack of accessible and quality information and knowledge by keepers. An improvement in the uptake and accessibility of information is suggested by the findings. This should mitigate the health issues resulting from poor husbandry practices as identified in this research. In response to these findings, a design solution, ReptiZen, was created that improves the delivery and access to quality information on reptile husbandry whilst also increasing the ease of caring for reptiles.

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1.0 INTRODUCTION

The keeping of reptiles as pets is a continuously growing worldwide phenomenon (Burghardt, 2017; Burman et al., 2016; Whitehead & Forbes, 2013). The increase in popularity of exotic pet ownership is credited to wider animal availability and perceived low cost of keeping (Stanford, 2013).

Reptiles are ectotherms (commonly referred to as cold-blooded) meaning they rely on their environment and external heat sources to regulate their body temperature (thermoregulate) (Donoghue, 1998; Ectotherm, 2021). Thermoregulation is a complex process which is achieved through detecting environmental factors, managing information and responding through behaviour to reach an ideal body temperature (Seebacher & Franklin, 2005). A reptile's ability to thermoregulate is crucial for survival as it affects nearly all behavioural and physiological aspects because their fundamental physiological functions are carried out within a narrow range of body temperature (Besson & Cree, 2010; Cadena & Tattersall, 2009; Caldwell et al., 2017; Ortega et al., 2016; Rutschmann et al., 2020; Seebacher & Franklin, 2005).

With a rise in popularity and demand for reptiles as pets, comes a corresponding increase in cases of illness or poor health, suffering, neglect, and mortality resulting from uninformed animal husbandry even at a very basic level (Loeb, 2018; Scott, 2014; Stanford, 2013; Whitehead & Forbes, 2013).

According to Howell and Bennett (2017), 63% of Australian homes kept pets in 2013. A survey of 748 reptile owners found failings in all aspects of welfare needs for reptiles in captivity (Howell & Bennett, 2017). Almost half (47.6%) of the respondents were not aware of appropriate humidity levels needed within the enclosure (Howell & Bennett, 2017). A further 22.5% had no idea of the correct temperature their reptile needed for proper heat regulation but, 65.3% of respondents had a radiant heat source within the reptile's area (Howell & Bennett, 2017). Because reptiles thermoregulate within narrow margins, this kind of inconsistent treatment with temperature and humidity does not bode well for reptiles in captivity (Besson & Cree, 2010; Seebacher & Franklin, 2005).

Given that 70-75% of reptiles die during the first year of captivity (Ashley et al., 2014; Grant et al., 2017; Loeb, 2018; Warwick et al., 2017; Warwick et al., 2018) emphasises the importance of this type of research which is critical for the survival of reptiles in captivity. The most important aspect of a reptile's well-being is thermoregulation (Besson & Cree, 2010; Corkery et al., 2018) hence, the purpose of this project is to investigate thermoregulation and associated health issues for reptiles in captivity with the intention of providing design opportunities to increase the health of reptiles kept at home.



1.1 PROJECT STRUCTURE

PHASE 2

PHASE 1

SECTION 3

DESIGN PROPOSAL
CONCLUSION

SECTION 1

LITERATURE REVIEW

THERMOREGULATION IN REPTILES
REPTILE HEALTH ISSUES IN CAPTIVITY
PUBLIC KNOWLEDGE AND INFORMATION
ON REPTILE KEEPING

RESEARCH DESIGN

METHODOLOGY
INTERVIEWS
ONLINE SURVEYS
CULTURAL PROBE

ANALYSIS & FINDINGS

DISCUSSION

RECOMMENDATIONS

2.0 LITERATURE REVIEW

This literature review focuses on the importance of thermoregulation; the associated health issues and problems found in reptiles; and the knowledge of husbandry practices and information available to reptile keepers and owners. The scope of this literature review specifically concentrates on reptiles, particularly lizards, snakes and turtles, kept in the home as pets.

2.1 THERMOREGULATION IN REPTILES

Thermoregulation is the regulation of body temperature at a constant rate irrespective of the surrounding environmental temperatures and their fluctuations (Seebacher, 2005). Practically every aspect of a reptile's behaviour and physiology such as growth, movement, immunity and feeding is affected by body temperature (Besson & Cree, 2010; Sauer et al., 2016). The importance of thermoregulation cannot be understated (Corkery et al., 2018). Ectotherms optimally carry out physiological and biological functions within a narrow range of body temperature (Besson & Cree, 2010; Cadena & Tattersall, 2009; Caldwell et al., 2017; Ortega et al., 2016; Rutschmann et al., 2020; Seebacher & Franklin, 2005). This temperature range varies amongst reptile species and the thermal quality of their environment (Besson & Cree, 2010; Cadena & Tattersall, 2009; Caldwell et al., 2017; Corkery et al., 2018; Seebacher, 2005).

It is important for reptiles to outweigh the energy costs associated with finding external heat sources enabling them to regulate body temperature (Cadena & Tattersall, 2009; Gvozdik, 2002). If the costs or risks are too high, this can result in thermoregulation compensation and body temperature adaption to less than optimal temperatures (Rutschmann et al., 2020; Seebacher, 2005). The thermal quality of a reptile's environment contributes to an increase (or decrease) in associated costs of thermoregulation (Cadena & Tattersall, 2009). If a reptile needs to

travel long distances to get its energy source, it will generally not take the risk for limited reward; it will stay in its burrow or environment and allow higher fluctuation of body temperature (Cadena & Tattersall, 2009). Although some reptiles may develop thermoregulatory elasticity, if the thermal energy source is insufficient, long term optimal body temperature deviation will generally lead to health risks (Cadena & Tattersall, 2009).

Reptiles usually maintain a body temperature which is higher than that of the immediate environment and adapt to environmentally challenging situations to take advantage of energy sources, known as behavioural adaptations, within reach provided the costs are deemed reasonable (Cadena & Tattersall, 2009; Gvozdik, 2002).



Optimal body temperature in reptiles needs consistent heat exchange with the environment often requiring behavioural adjustments to keep body temperature within a healthy range (Figure 1) (Rutschmann et al., 2020). A typical behaviour used by reptiles to thermoregulate is to bask in a sunny position (Gvozdik, 2002; Molina & Leynaud, 2017; Seebacher & Franklin, 2005). Some reptiles have adapted to sharing of a heat source or to the use of a foreign heat source by cohabitating with other animals such as seabirds to enhance thermoregulation (Corkery et al., 2018).

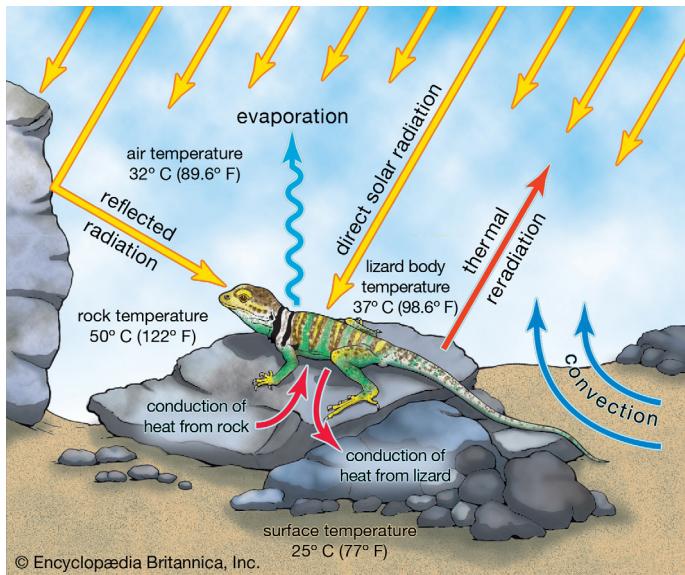


Figure 1. Depiction of reptile heat exchange with its environment (Encyclopædia Britannica, 2021).

The contrary position is also true in that if a reptile's habitat is thermally unfavourable the cost in energy and time allocated to thermoregulation can have a negative impact on health and social aspects (Cadena & Tattersall, 2009; Seebacher, 2005). The impacts of extended thermoregulatory behaviour can affect feeding, predatory risk and reduced reproductive opportunity (Cadena & Tattersall, 2009; Seebacher, 2005).

The literature suggests it is exceedingly clear that reptiles (ectotherms) function within a particular temperature zone. According to Flouris and Piantoni (2015), this fact has now been accepted unanimously by the scientific community.

2.2 REPTILE HEALTH ISSUES IN CAPTIVITY

Reptiles are ectothermic creatures thus the fundamental aspect to a reptile's health is its ability to thermoregulate; they require ambient or external heat sources to moderate their body temperatures (Donoghue, 1998). In the absence of good sources of environmental heat, reptiles develop a variety of behavioural and related health issues specifically concerning energy levels (Donoghue, 1998). Energy is important for maintaining good health as it relates to a reptile's ability to forage, feed, heal, grow and reproduce (Donoghue, 1998).

The selection and occupancy of natural environment aiding thermoregulation by reptiles cannot be replicated in captivity (Warwick et al., 2013). In nature, a single negative event where a reptile cannot thermoregulate can cause or intensify stress and exhaustion (Warwick et al., 2013).

Poor husbandry of reptiles in captivity is associated with deficient thermoregulation which affects, among other things, biological needs such as eating and digestion, reproduction, and stress from being in inadequate enclosures (Donoghue, 1998; Warwick et al., 2018). Barten (1993) states that the majority of health related problems associated with lizards in captivity occur as a consequence of environmental factors, specifically caging, and improper feeding.

Reptiles have been observed to develop fever responses to stress inducing environments in captivity where they deliberately seek higher temperatures which provide a calming influence (Warwick et al., 2013). In addition, reptiles will engage in deliberate hypothermia to combat physiological disturbances or, in the case of animals in captivity, may be the result of stress related to the enclosure's environment (Warwick et al., 2013).

Even in the commercial sector poor reptile well-being is well documented with an industry accepted mortality rate of around 70% in the initial six weeks of captivity with wholesalers alone (Ashley et al., 2014; Warwick et al., 2018).

A study by Ashley et al. (2014), investigated the causes of morbidity and mortality at a major exotic animal wholesaler which included, among other exotic animals, reptiles. The alarming statistics include 12% of the wholesaler's stock (which was mostly reptiles) was discarded every week. In number terms this equates to around 3,500 animals. Given the timeframe for turnover of stock is generally recognised internationally as being six weeks, this amounts to an approximate total of 21,000 or 72% of animals being dispensed with (Ashley et al., 2014).

It is reported that this level of mortality is in keeping with world averages with 70% being the accepted level of mortality for reptiles in the supply chain from breeding or capturing to retailing and home care (Ashley et al., 2014; Loeb, 2018; Warwick et al., 2017). The United Kingdom revealed 81% mortality with the first year of captivity including at the retail outlet and at home (Ashley et al., 2014).

In a more recent study by Warwick et al. (2017), the welfare of reptiles was investigated in 15 European countries which found poor husbandry practices responsible for 70% mortality in the wholesaler's hands and 75% mortality in the home environment. It was also established that some 30 behavioural stress related illnesses were identified (Warwick et al., 2013; Warwick et al., 2017).

Loeb (2018) reported on the results of the British Veterinary Zoological Society (BVZS) conference in which it was noted that poor husbandry, even in the most basic aspects such as temperature, lighting and diet, was responsible for up to 70% morbidity and caused significant mortality.

There is a strong correlation between inadequate reptile husbandry, in all aspects of the supply chain, and a lack of suitable information available for owners and traders, which is recognised by the British Veterinary Association (BVA) and the Animal Welfare Foundation (Burman et al., 2016). This lack of information on reptile keeping disadvantages reptiles and owners alike as noted by the BVA. Because reptiles' needs are highly complex, approximately 50% of these animals are deemed unsuitable for artificial enclosures however, information about this is not readily available (Burman et al., 2016).

Also noted by Grant et al. (2017), reptiles are wild animals and continue to exhibit their wild attributes even if bred in captivity. In the absence of precise information about reptile care and management their care is usually well beyond the capability of many pet keepers who underestimate the difficulties of looking after exotic pets (Grant et al., 2017).

The Australian experience is similar to the international experiences in relation to a lack of good information on reptile keeping. According to Howell et al. (2020), 2.7% of Australian households kept reptiles in 2016 which amounts to approximately 415,500 animals. About 10% of these owners bought a reptile because they believed it was a "low care" pet in comparison to traditional pets (e.g. cats, dogs, etc.) (Howell et al., 2020). This uninformed attitude exacerbates poor health for reptiles in captivity.



2.3 PUBLIC KNOWLEDGE AND INFORMATION ON REPTILE KEEPING

Exotic pets, specifically reptiles, require dedicated and somewhat sophisticated care because they have particular species-specific needs (Burman et al., 2016; Grant et al., 2017; Warwick et al., 2017).

There is a vast difference between reptiles and traditional domesticated animals such as cats and dogs and the like (Warwick et al., 2013). At a biological level, traditional domesticated household pets are innately wired differently such that they are more adapted to share habitation with others (Warwick et al., 2013). On the other hand, reptiles are substantially wild animals with no hard wiring predisposing them to domestication. Their behaviour is such that they meet their needs; biological, psychological and behavioural in the wild or in natural habitat (Warwick et al., 2013).

Reptiles are rarely kept in adequate enclosures and are usually subjected to inadequate husbandry mostly as a result of an absence of clear and useful information (Grant et al., 2017). It is an undeniable fact that, compared to other pets, reptiles will suffer a restricted life in captivity because of inadequate enclosures causing negative impacts on their biology (Warwick et al., 2013).

The biological problems emerging from poor enclosures include metabolic disease and immune suppression ("Yes-sss! A review of better care for captive reptiles," 2015). These biological issues together with reptile behavioural problems remains the principal reason requiring veterinary interventions ("Yes-sss! A review of better care for captive reptiles," 2015).

Information available on the PETA (2021) website, suggests that many reptiles do not survive captivity in the hands of the seller and if they do, they are generally inadequately catered for creating a severe shortfall in addressing the biological needs of the reptile.

According to Warwick et al. (2018), there have been several studies which show that poor husbandry, outside of professional facilities which in themselves are rare, is commonplace even for the most popular reptile species.

One difficulty with the exotic pet market is that pet owners and professional veterinarians alike misinterpret a reptile's good eating and reproduction as affirmative indication of good health (Warwick et al., 2013). Contrary to these indications being misconstrued as positive, these behaviours are by no means a positive indication of a reptile's welfare (Warwick et al., 2013).

There is a negative correlation between the increase in demand for exotic pets and the availability of usable information for reptile owners and keepers generally. The complexities associated with keeping reptiles, when compared with other domestic animals such as cats and dogs is often miscalculated (Grant et al., 2017).

The relatively sparse information available necessary for the caring of reptiles is often confused with misinformation made available by entities with commercial interests. Labels such as "easy to keep" or "great first-time pet" displayed by reptile traders (Figure 2) is both challenging and a major concern for pet owners (Warwick et al., 2018).

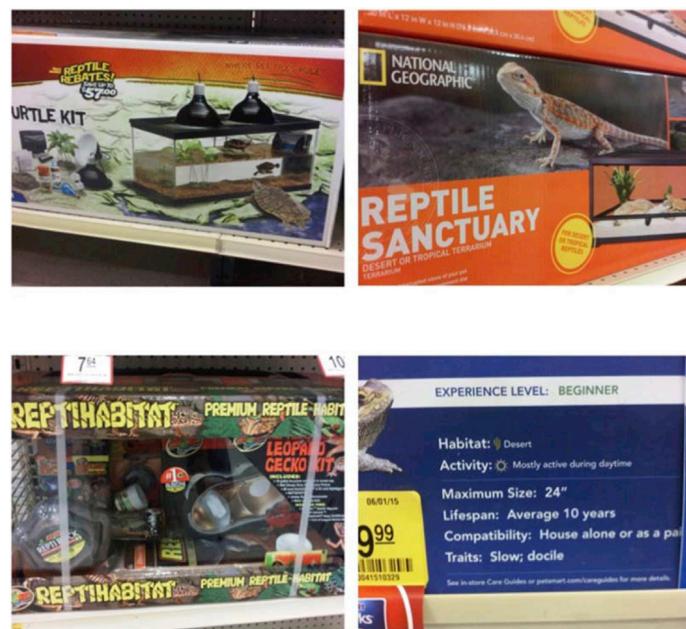


Figure 2. Examples of reptile enclosures available on the market displaying misleading marketing (Warwick et al., 2018).

Despite the relative absence of information on reptile keeping, people view these animals in the same way as other domesticated pets expecting them to be compatible with modern urban living (Warwick et al., 2013; Warwick et al., 2018). This suggests a belief in the availability of information

on reptile husbandry which is sadly lacking (Warwick et al., 2018). Some information made available to reptile owners is misleading; an example of this is an Australian pet store, Petbarn, labelling some reptiles as “best first pets for kids” (Petbarn, 2015). One aspect that is commonly deceptive or misrepresented is the “ease of care” for reptiles kept as pets which most likely drive the desires for keeping these animals at home (Warwick et al., 2018).

The specialised and complex survival requirements needed for reptiles are rarely met by the majority of keepers and owners (Grant et al., 2017; Warwick et al., 2017). This is attributed to a combination of reasons, one of the more important being a severe lack of accurate information on how to properly care for these animals. Most reptile owners do not understand the fundamental needs of their reptiles in captivity which ultimately results in inadequate reptile husbandry and poor reptile health (Grant et al., 2017; Loeb, 2018; Stanford, 2013).

Not only is there a lack of information made available to the public regarding the biological and physiological needs of reptiles, there is also a serious lack of accessibility to existing information for current and prospective owners or keepers (Grant et al., 2017).

The current and easily accessible information available to the public on reptile keeping and husbandry is provided by pet store websites, reptile forums, online videos and other non-credible informative websites. Generic care guides with limited depth of information are commonly available via these sources. The likes of Petbarn (2020), Kellyville Pets (2021), Pet Circle (Lever, 2019), Reptiles Magazine (2021), and Reptile Centre (2021), to name a few, all provide this style of information on the care of reptiles at home. Although the breadth of information available on these websites is surprisingly vast, the information is a basic overview rather than a detailed knowledge source. However, more detailed and in-depth reptile care sheets provided by the RSPCA (2021) dive into some information regarding their biology, behaviour, and health concerns that would be of benefit for both reptile and owner.

The Queensland Government Codes of Practice lack the depth of information that is required to properly care for reptiles at home. The breadth

of information provided could be considered substantial however, the depth of this information extends no further than “general information” and “minimum standards” (Department of Environment and Science, 2020).

2.4 GAP IN LITERATURE

To summarise, the literature would suggest that many reptile owners are not adequately caring for their pets, resulting in poor reptilian health and mortality. Reptile owners and traders lack a complete understanding of the importance of thermoregulation. The literature also suggests that most health issues stem from the inability of a reptile to maintain its body temperature within optimal levels. In addition, whilst some reptile keepers and owners attempt to maintain a good environment for their reptiles, easily accessible and accurate information is lacking (Figure 3).

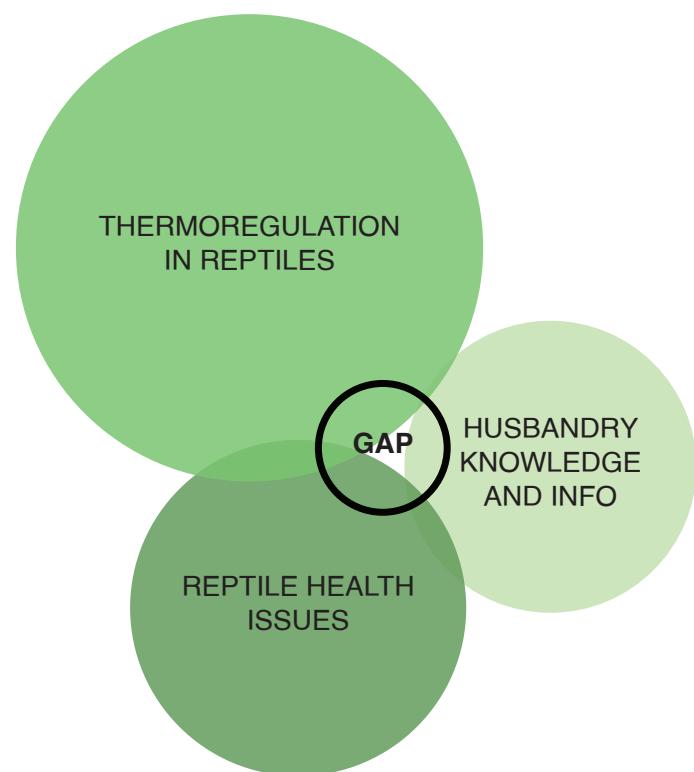


Figure 3. Literature gap summary.

3.0 RESEARCH DESIGN

3.1 METHODOLOGY

To address the identified research gap from the literature, first-hand research will be employed to collect robust and credible findings. The aim of this research is to identify and address shortfalls in reptile husbandry to ultimately move towards better well-being and health for reptiles kept at home.

In response to the research gap and the need for conducting research in this area, the following research question was developed:

How the issues of thermoregulation in home reptile keeping affect the health of the reptiles?

To better address the research question in a more structured approach, three sub-questions have been developed:

- *What are the specific health issues commonly seen in captive reptiles?*
- *What is the level of understanding and attitudes towards reptile husbandry by keepers?*
- *How exactly are reptile owner's enclosures set up for keeping their pets?*

The approach to this research is a mixed-method triangulation strategy. Triangulation refers to using multiple data collection methods within a research study (Figure 4) (Carter et al., 2014).

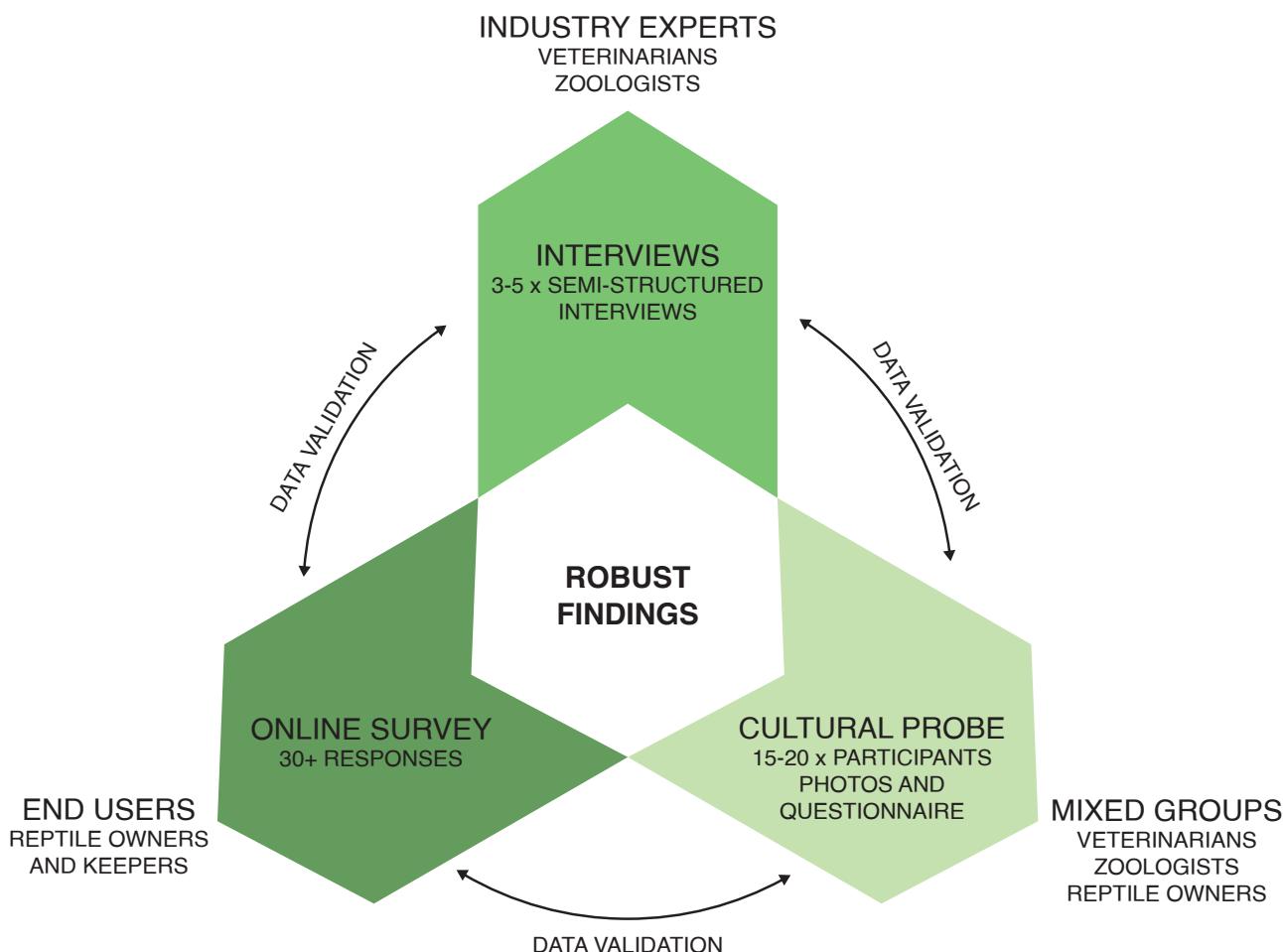


Figure 4. Research framework and triangulation.

The benefits of undertaking triangulation in qualitative research and data collection are the capacity to gain deeper perspectives and validate the results across the collected data (Carter et al., 2014; Wray et al., 2007).

The qualitative research methods that will be employed consist of interviews, online surveys, and cultural probes.

3.2 INTERVIEWS

Interviews can be considered one of the most effective and familiar methods for achieving good qualitative research (Carter et al., 2014; DiCicco-Bloom & Crabtree, 2006). The ability to gather insightful and rich information on personal experiences and viewpoints (Carter et al., 2014) allows for invaluable data collection.

Interviews will be conducted on industry experts or those who have a considerable experience within the reptile keeping community. Participants will consist of, where possible, reptile veterinarians, zoologist, breeders or highly experienced reptile keepers or owners. Specific questions will be asked to determine their knowledge and experiences with reptile health issues particularly relating to thermoregulation in captivity. The data collected from these interviews will ideally strengthen insight into what the current issues are around reptile husbandry practices and provide different perspectives on these issues.

Semi-structured interviews will be undertaken

whereby the participant will be guided through the interview questions in a fluid conversational manner (DiCicco-Bloom & Crabtree, 2006). This type of interview strategy is best suited for attaining sound findings from lower participant numbers (Pathak & Inratat, 2012). The interviewer will be able to probe and interject and ask for an expansion of information where suitable. This is to allow more depth in the topic of conversation that might otherwise be avoided or overlooked with a more rigid or structured interview.

The following is a sample of questions that will be asked during the interviews (Appendix 1.0):

- *What is your experience with dealing with reptiles in your practice or business?*
- *What have you found to be the most common health issues associated with reptile keeping?*
- *In your experience, do recreational reptile keepers have appropriate knowledge for keeping reptiles at home?*

These questions are designed to address the gap as revealed through the literature and provide insights into the specific health issues commonly seen in captive reptiles.



3.3 ONLINE SURVEY

Conducting surveys is greatly advantageous for collecting large amounts of qualitative and quantitative data. Surveys conducted by Howell and Bennett (2017), Howell et al. (2020), and (Whitehead et al., 2017) demonstrate their efficacy for use in research and data collection. A huge benefit of conducting online surveys is the ability to reach a large number of participants that are appropriate and required for the research study within a relatively short period of time (Wright, 2005). Online surveys should provide a mix of closed and open-ended questions (Moreh, 2019). However, open-ended questions provide the opportunity to produce valuable responses and information that would otherwise be left out with closed questions (Moreh, 2019). The online nature of the survey allows participants to answer the provided questions at a time and place convenient for them which could potentially increase the number of responses generated.

The participants of these online surveys will be people who own or keep reptiles at home as these are the end users for this project. Conducting surveys on reptile keepers serves to gain insight into what is commonly practised and known about reptile husbandry. The literature suggests a severe lack of necessary husbandry knowledge amongst reptile owners; however, knowledge surrounding appropriate thermoregulation practices is intended to be discovered with the survey results.

Leveraging online communities to gain access to and recruit participants who meet the research requirements is crucial to the success of the survey results. An online survey will be sent out to a variety of social media reptile groups and forums to ensure a large pool of respondents is acquired. The survey will consist of 16 items that will take approximately 15 minutes to complete. Participants will be asked to answer a number of Likert scale, multiple choice and open-ended questions.

The following is a sample of questions that will included in the online survey (Appendix 1.1):

- *A reptile's environment affects its ability to thermoregulate (adjust its body temperature) (Likert scale – strongly agree – strongly disagree)*

- *Do you currently regulate the temperature of your reptile/s terrarium/enclosure? (Multiple choice)*
- *What equipment or terrarium/enclosure features do you use to regulate your reptile/s temperature? (Open-ended)*
- *Do you know of any health issues experienced by reptiles with inappropriate heating or temperature control? Which of these have you experienced personally and how was this resolved? (Open-ended)*

3.4 CULTURAL PROBE

A cultural probe is another qualitative research method that will be employed for data collection. The purpose of cultural probes are to gain a deeper understanding and insight into certain aspects of life of the participants in the study (Azambuja et al., 2015). Cultural probes generally take the form of the researcher providing participants with a set number of tasks to complete and document in order to gain an understanding of the tasks from the participants perspective (Wyeth & Diercke, 2006).

The participants of the cultural probe will be a mix of industry experts (veterinarians, zoologists, or expert reptile keepers) and end users. Having both user groups partake in the cultural probe will provide information on the reptile enclosures which will be compared and analysed.

The cultural probe will ask participants to take a variety photographs of their current reptile enclosures and equipment they use displaying the overall size and features and details about heating and temperature management or control. An object of reference will also be asked to be included in one of the photographs, such as a ruler or a common item like a soft drink can, for size scale purposes. Participants will also be asked to complete a short questionnaire seeking additional information on alterations made to their reptile terrariums in the event of weather changes, travel, reptile breeding, etc. (Appendix 1.2).

The use of a cultural probe is to gather specific and detailed information on exactly how people are keeping their reptiles at home. The information and images gathered from participants will be cross-referenced and compared with one another to identify "good" and "poor" practises amongst reptile keepers. This research method was informed through the literature and seen as an opportunity to understand the types of enclosures and environments provided by reptile keepers. It has been noted by Loeb (2018) that veterinarians rarely observe client's reptile enclosures.

3.5 SUMMARY

In summary, the research design and methodology adopted will provide sound data and findings to address the research gap. This will be achieved through semi-structured interviews, an online survey, and a cultural probe. Applying triangulation to validate the various research results and data will ensure sound findings and insights are gained.



4.0 ANALYSIS & FINDINGS

4.1 RESEARCH METHODS

The methods that took place for the data collection consisted of interviews, an online survey, and a cultural probe. Three expert interviews were conducted where the participants consisted of two highly experienced reptile veterinarians and one veterinarian graduate with experience working in a reptile veterinary clinic. These interviews were conducted online and were semi-structured allowing for a conversational type of interview to take place. The interviews were recorded to allow for audio transcriptions to be analysed. One expert interviewed also participated in the cultural probe. The interview questions asked can be seen in Appendix 1.0. Two of the interview participants were recruited via email contact with their respective veterinary clinic and the third via direct contact on social media.

The online survey consisted of 16 items and featured an optional email submission to participate in the cultural probe. The survey was created using Google Forms (Appendix 1.1) and was published to eight different reptile Facebook groups. The survey was opened from April 30th until May 26th (about five weeks). During this period, the survey was published twice in each Facebook group; once on April 30th and another May 8th. In total, 34 responses were obtained from the online survey.

The cultural probe took the form of sending out emails with a task sheet to survey respondents who volunteered and gave their email address for participation. Completing the cultural probe consisted of participants taking photographs of their reptile enclosures and specifically highlight features that enabled their reptiles to thermoregulate. Accompanying the photographs were two questions relating to alterations made to participants' enclosures because of seasonal changes, weather, travel or away from home circumstances (Appendix 1.2). Of the 15 survey respondents that volunteered to participate in the cultural probe, only five cultural probes were submitted. Photographs of a total of 12 different

enclosures were submitted from the combined six cultural probe participants.

4.2 INTERVIEW ANALYSIS

The analysis of the interviews took the form of transcribing the audio data into text and proceeding with an inductive coding strategy. Inductive coding consists of analysing qualitative data systematically to discover findings in the data from common themes and relationships (Ozone et al., 2020; Williams & Shepherd, 2017). The coding of the data was undertaken manually which allowed for an intimate and detailed understanding of the themes and concepts discussed throughout the interviews.

A first pass of open coding was carried out to establish an initial legend of themes and codes. Once the initial themes were established from the data, they were categorised and tabulated into more refined and distinct themes and subsequent codes (Appendix 2.0). These new codes were assigned to relevant comments within the interview transcriptions and additional codes that emerged from the data were added to the legend. The key themes that emerged from the interviews were tallied based on frequency of appearance whereby conceptual analysis took place (Holton & Walsh, 2017). Proceeding this, a relational analysis of the principle themes was conducted to explore deeper insights and meaning within the interview data (Mills et al., 2010).

4.3 SURVEY ANALYSIS

To analyse the quantitative and qualitative data collected through the online survey, a mix of univariate, multivariate and thematic analysis took place. These analysis methods were used as it allows for patterns, themes, and relationships to be uncovered in complex data (Allen, 2017; Kent, 2015; Mills et al., 2010). Questions that were multiple choice or Likert scale were tabularised

and tallied based on the frequency of the responses. This same method was performed for short and long response (textual) answers however, the written data was first thematically analysed. Common themes and key words were derived from the textual responses and converted into categorical data then the same tabularisation and tallying method was carried out. For some questions, a considerable amount of interpretation of the qualitative data was required in order to arrive at a level of useful information. For example, a respondent may claim to know the importance of thermoregulation however, does not demonstrate any knowledge in other related questions.

4.4 CULTURAL PROBE ANALYSIS

A thematic image analysis was undertaken for the photographs submitted for the cultural probes (Allen, 2017; Mills et al., 2010; Pauwels & Mannay, 2020). The various equipment and features visible within enclosures that related to heat and temperature management were analysed and assigned codes. The responses to the short response questions were thematically analysed in a similar manner to the interview data. All of the codes were generated inductively then tabularised and tallied (Appendix 2.1).

4.5 INTERVIEW FINDINGS

It was evident from the analysis that the key themes that emerged from the interview data on reptile care included thermoregulation, husbandry practices, health issues, and information available on reptile keeping (Figure 5).

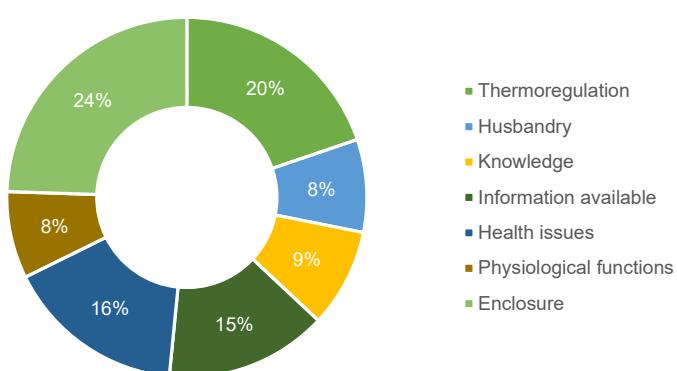


Figure 5. Key themes emerged from the expert interviews.

The theme of thermoregulation that emerged from the interviews relates to factors within the reptiles' environment that impacted their thermoregulatory ability. The responses pointed to exposure to improper temperatures and humidity levels along with seasonal changes as major factors affecting a reptile's ability to thermoregulate. A high level of importance was indicated by the interviewees to thermoregulation:

"I think it would be the most important factor when it comes to managing their own health ... and probably the thing which in captivity would lead to disease the most." – Participant 2.

"... there's probably a dozen other ways I can link heat and thermal to illness, that's probably one of the biggest, biggest problems we see would be thermal related." – Participant 3.

Specific reptile physiological functions that were outlined to be dependent on thermoregulation include the immune system, digestion, nutrition, metabolism, and healing.

In relation to husbandry, experts spoke of practises that varied from extremely poor to very good. Some of what was discussed with all three was information which was given to reptile owners as advice in a clinical context. It stands to reason that a lack of knowledge in one area of reptile care will have negative effects in other areas and in husbandry issues. Participants 1 and 2 mentioned that 90% of the health issues seen in reptiles presented in the clinic were directly related to husbandry issues. Participant 3 shared a similar view:

"...the majority of health issues that we see are going to come back to husbandry concerns." – Participant 3.

Responses to interview questions relating to knowledge levels of reptile keepers and owners indicated that there is a wide range of levels of knowledge within the reptile community. It was found that this range of knowledge extends to both extremes of the spectrum as expressed by Participant 1. This notion was supported by Participant 3 as some reptile owners were said to be completely lacking in any knowledge as a result of "complete ignorance".

Discussion around the theme of information available, concerning reptile care, revealed the degree of information present and accessible to keepers as well as the quality of the various sources available. There was consistency amongst the participants that pet stores were generally felt to be lacking as an information source appropriate to reptile care:

"...there is limited knowledge by people in the pet store industry, when it comes to reptiles in most cases, not all, but most." – Participant 3.

Two of the interviewees talked about contemporary journal articles and textbooks as good sources of information for reptile owners. However, it was suggested that forums and some websites were not, in the main, good sources of information:

"...a lot of people spreading misinformation, there sometimes incorrect information online, and it can get very confusing for people to know what the right thing to do is." – Participant 2.

When participants were asked to comment on what could be improved to mitigate the husbandry and health issues presented in reptiles, a strong connection to education and information accessible to reptile keepers was mentioned by all three interview participants.

There were a number of common health issues identified from the interviews that were said to have resulted from inadequate husbandry, poor thermoregulation, or inappropriate enclosure equipment and features. Some of the issues spoken about in this theme include various infections and diseases, digestion issues, burns, dehydration, immune system issues, and death. It was apparent from the responses that these health issues were linked to a number of other identified themes from the data.

The theme of enclosures relates to the equipment and features in reptile enclosures that affect and impact thermoregulation and health issues. A barrier that was mentioned to inhibit appropriate thermoregulation in reptiles was the size of the enclosure, which was outlined by all three participants. Participant 2 indicated that radiant heat sources (e.g. heat lamps) were preferred over conduction heating (e.g. heat mats) because of the reduced risk of causing equipment related

injuries to reptiles such as burns:

"...heat rocks and heat mats are very prone to burning reptiles because they will sit on that until their entire body heats up and we will see them with burns through to their muscle..." – Participant 2.

Participant 3 also favoured radiant heat because of the efficacy of producing even heating within the enclosure.

Figure 6 outlines the relationship between the key themes discussed in the interviews. These relationships were established based on the codes identified in the responses provided by the interview participants. Although each of these areas are represented as distinct aspects of reptile care, all of the identified themes are interconnected in relation to the well-being of reptiles in captivity. All interviewees clearly made associations between health issues and enclosures and between health issues and thermoregulation.

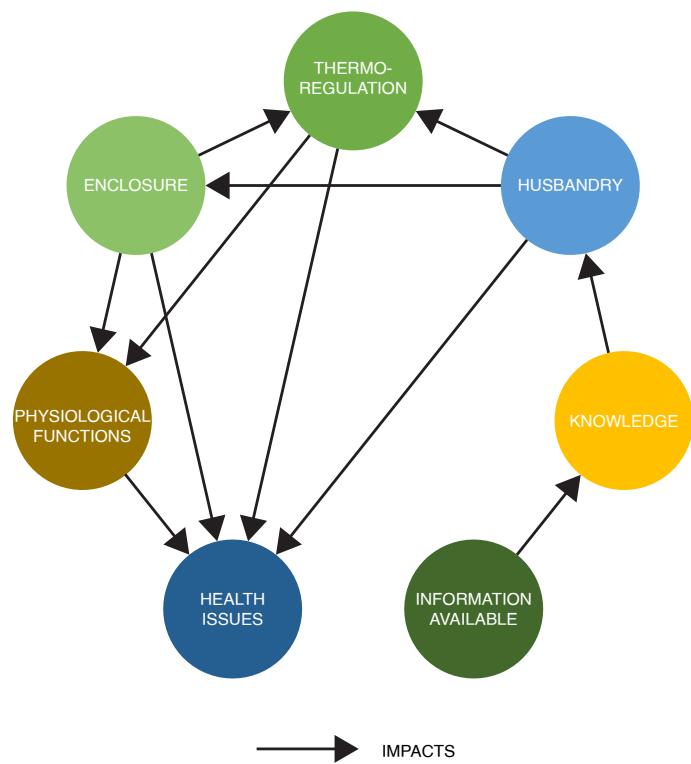


Figure 6. Relationship between key themes.

However, the strongest link was made between thermoregulation and health issues. The strength of this link holds true given that reptiles are ectotherms:

"...that every single bodily process in the reptile

requires heat giving that they're ectotherms to function, including their immune system." – Participant 2.

Nevertheless, all themes are linked, and the subject matter of each theme impacts the subject matter of each other theme. This can be seen in Figure 6 and Figure 7, where readily available quality information on reptile keeping has a direct relationship with knowledge which in turn, has a direct relationship with husbandry practices. Husbandry practices determine enclosure set-ups (size, layout, lighting, heat etc.) which determines thermoregulatory practice; and ultimately, physiological function and health.

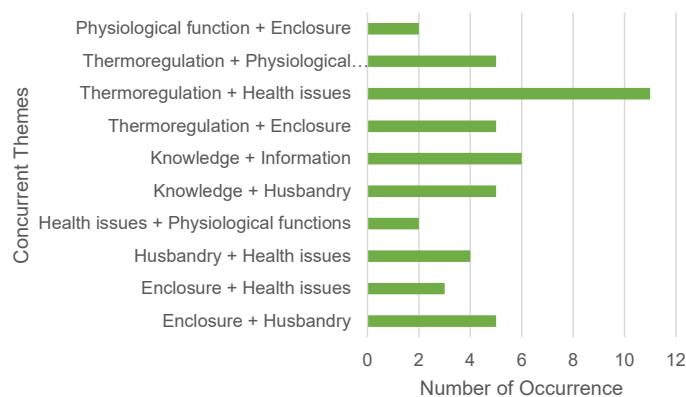


Figure 7. Themes mentioned concurrently in expert interviews.

During the interviews the inverse was also found to be true in that, it was found that a correlation between low levels of knowledge in reptile keeping resulted in poor husbandry practises which led to thermoregulatory issues where reptiles were being exposed to temperatures above or below their optimal temperature zone leading to health issues.

4.6 SURVEY FINDINGS

Through the survey, it was revealed that 79% of participants found keeping reptiles to be between *not difficult* and *somewhat difficult* (Table 1). When survey participants were asked about the types of difficulties they encountered while caring for reptiles, 38% mentioned meeting temperature requirements and 26% mentioned a lack of appropriate information as the largest contributors to difficulties (Figure 8).

Table 1. Difficulty rating of caring for reptiles.

Care Difficulty	Number of Responses	Percentage of Respondents
Not Difficult	9	26%
Slightly Difficult	9	26%
Somewhat Difficult	9	26%
Difficult	6	18%
Very Difficult	1	3%



Figure 8. Most common difficulties experienced when keeping reptiles.

One survey respondent commented in relation to the difficulties experienced in reptile keeping:

"Not necessarily difficult, more just aren't provided with enough information on their full needs when purchasing. ... They are advertised as easy kids pets however after having them, believe that many reptiles would suffer horrendously because of lack of proper care." – Survey Respondent.

Figure 9 demonstrates the answers to the survey question on keepers' level of knowledge on husbandry. Seventy-three percent of respondents claimed they knew *enough* (35%) or *a lot* (38%) of knowledge regarding husbandry prior to owning a reptile.

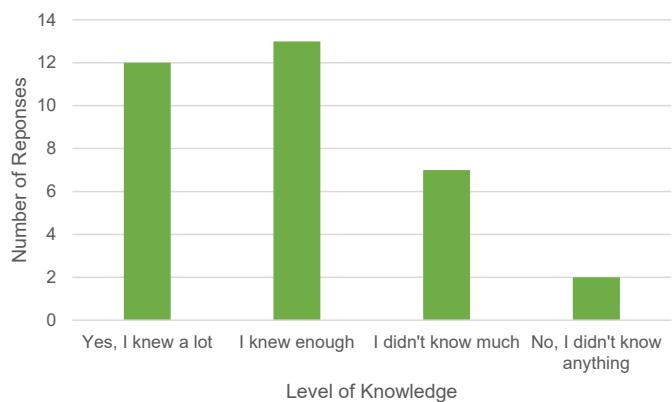


Figure 9. Knowledge of reptile husbandry before owning or keeping.

In relation to seeking information concerning reptiles and reptile keeping, the most common sources of information were websites and online forums or groups (Figure 10). Other top sources of information include veterinarians, academic papers and books, family or friends, pet shops, and other reptile owners.

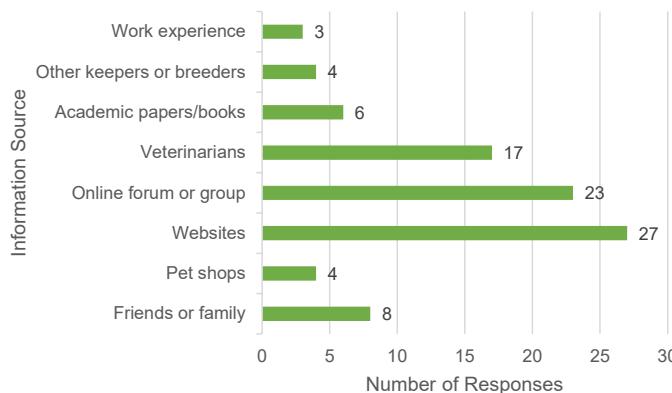


Figure 10. Reptile keepers' sources of information.

Participants were asked about their knowledge of thermoregulation and their understanding of its importance for reptiles' health. Figure 11 shows that the majority of answers (73%) could be categorised as knowledgeable (32%) and somewhat knowledgeable (41%).

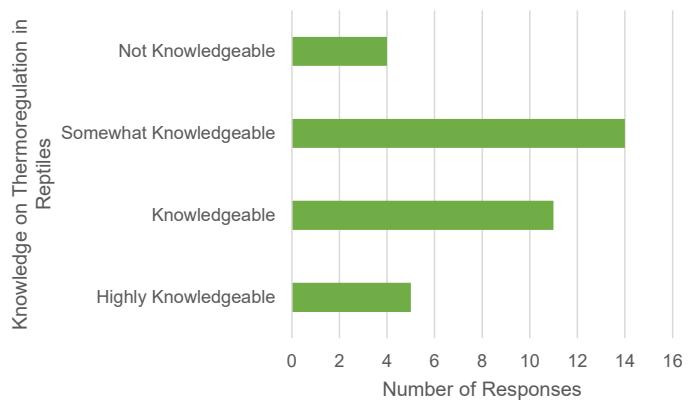


Figure 11. Participants' knowledge of thermoregulation.

Almost all participants (88%) strongly agreed that the environment in which a reptile is in affects its ability to thermoregulate (Figure 12).

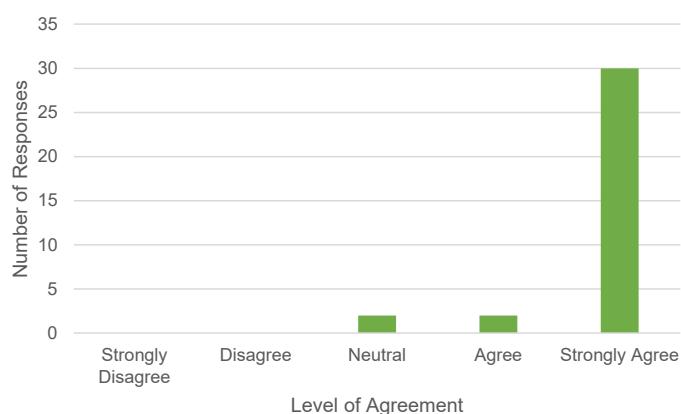


Figure 12. Level of agreement to environmental effects on thermoregulation.

Participants were asked to identify the equipment and features they use to regulate temperature and humidity within their enclosures. The most common of these for temperature control include heat lamps at 30 (88%) respondents, 21 (35%) used thermometers, and 16 (47%) basking rocks under heat lamps (Figure 13). In relation to humidity, as seen in Figure 14, 21 (62%) of the respondents regulated the humidity within their enclosures through the use of a spray bottle and 19 (56%) used a water pool. The next most common method of regulating humidity was to use a specific substrate at 11 (32%) respondents.

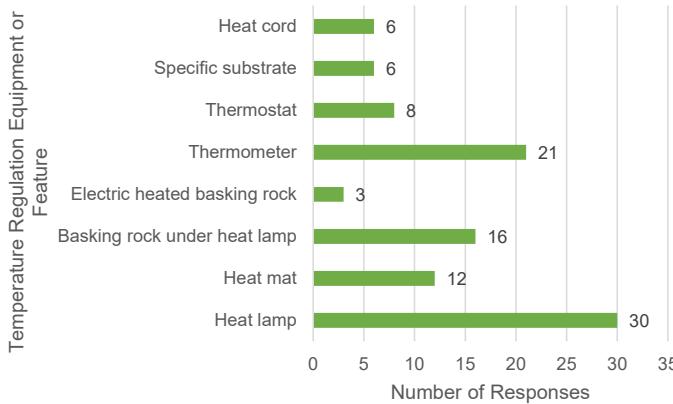


Figure 13. Most common temperature regulation equipment and features.

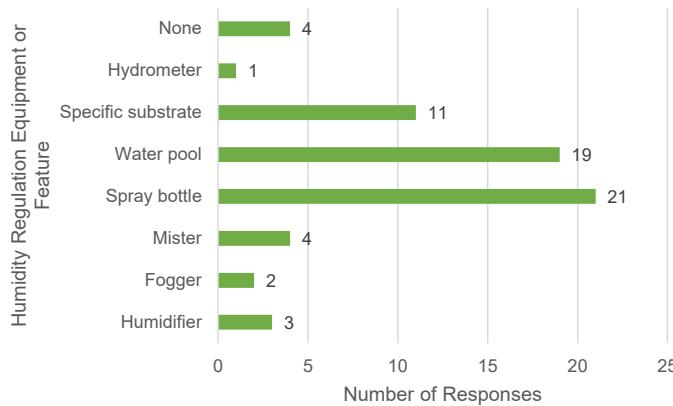


Figure 14. Most common humidity regulation equipment and features.

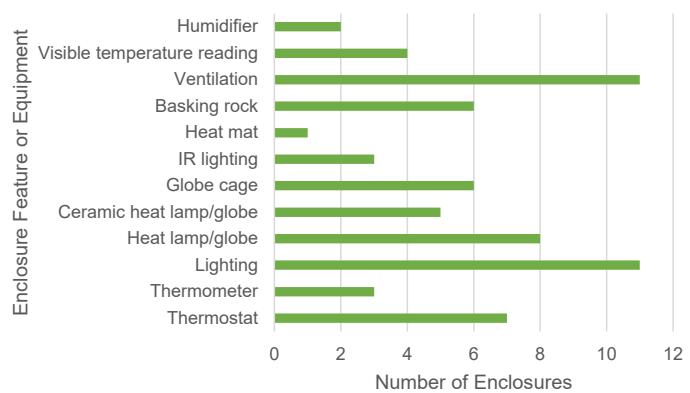


Figure 15. Cultural probe reptile enclosure equipment and features.

Figure 16 demonstrates the most common enclosure sizes seen indicating that large enclosures were favoured most.

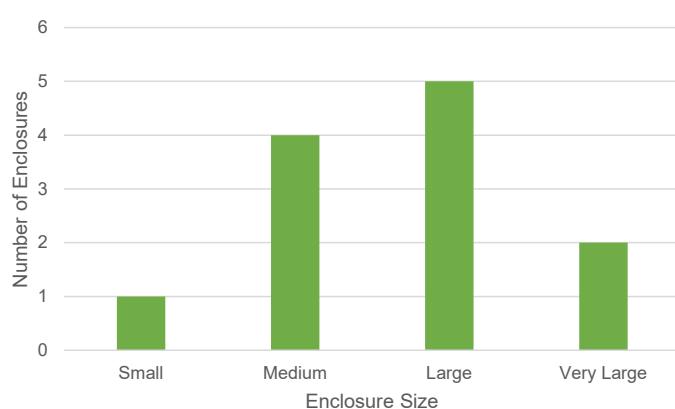


Figure 16. Cultural probe enclosure sizes.

When asked to outline alterations made to participants enclosures because of travel reasons or being away from home, the responses suggested another carer is involved or no alterations are made at all.

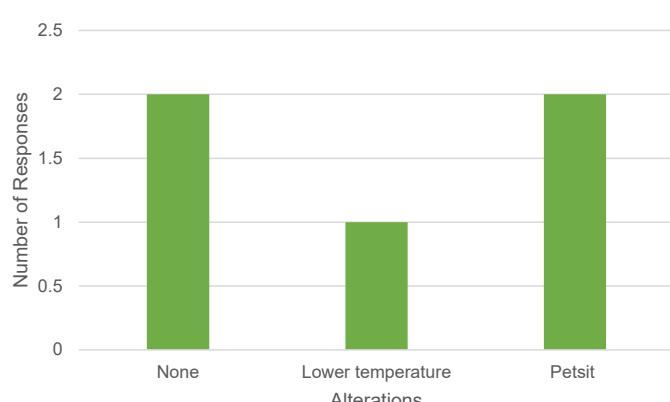


Figure 17. Alterations made to enclosures because of travel or being away from home.

However, seasonal changes did impact alterations made to enclosures. The main alterations mentioned included lowering temperatures, increasing insulation, and increasing heat sources (Figure 18). The responses indicated that these alterations mentioned occurred seasonally. There was no mention of alterations made to reptile enclosures as a result of weather circumstances as all of the enclosure submitted for analysis were kept indoors.

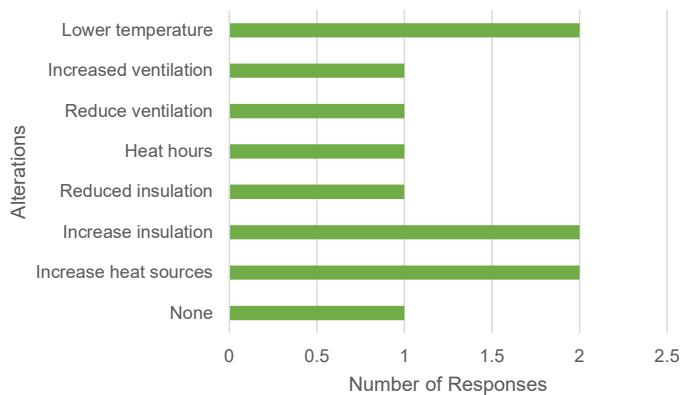


Figure 18. Alterations made to enclosures because of seasonal changes.



5.0 DISCUSSION

The key themes addressed by the research are discussed in terms of the relationship with each other. As mentioned earlier, no one theme stands alone but they are all interconnected (see Figure 6). With regards to information available on reptile husbandry, this is one area where there seems to be unanimous agreement in two respects. The interviewees, some survey respondents, and Grant et al. (2017) agree that there is a dearth of quality and easily accessible information available for reptile owners. Secondly, that quality information is a cornerstone for the theme of 'knowledge'.

Interestingly, responses from the survey indicated that the main sources of information for reptile keepers are websites and online forums and groups. It was mentioned by all the interview participants that these sources are generally poor sources of information because of the amount of misinformation and opinionated husbandry practices they contained. This reflects the literature findings including that of Grant et al. (2017) and Warwick et al. (2018).

The results of the interviews and, to a lesser extent, the survey results demonstrate husbandry as a major theme whereby the practices undertaken by keepers directly impact the health of their reptiles. This finding is supported by Grant et al. (2017), Loeb (2018), PETA (2021), and Stanford (2013) especially given husbandry is an umbrella term which covers all other themes and is verified by the results of the interviews seen in Figure 6. Husbandry is directly linked to thermoregulation which is the principal issue for health in relation to reptiles (Donoghue, 1998; Warwick et al., 2013; Warwick et al., 2018). Not only is this supported by the literature, but it is confirmed by both the interview participants and the survey responses.

In relation to thermoregulation, when survey participants were asked about the types of difficulties they encountered while caring for reptiles, 38% mentioned the importance of meeting temperature requirements. This strongly links back to the literature on thermoregulation needs being very difficult to provide reptiles in

captivity (Warwick et al., 2017) and aligns with the interviewees' responses and the results of the cultural probe on thermoregulation. Analysis of the interviews, online survey, and cultural probe revealed some interesting results in that, the interviews confirmed much of the literature that was reviewed however, the survey and cultural probe seem to be somewhat opposed to the literature in terms of the knowledge possessed by reptile keepers generally.

As outlined in the interview findings, the relationship between thermoregulation and the overall health and well-being of reptiles is critical which supports the literature by Besson and Cree (2010) and Corkery et al. (2018). Some of the health issues outlined as a result of poor thermoregulation include infection, disease, dehydration, burns, and in extreme instances death.

As can be seen in Figure 6, thermoregulatory function is directly linked to good physiological function and health issues as stated by Participant 2 during interview and supported by the literature (Donoghue, 1998). The converse is also true where poor husbandry leads to poor reptile thermoregulation and subsequently a breakdown of physiological function and health.

It was evident from the interview results that in general, the knowledge held by reptile keepers can vary drastically which directly impact their husbandry abilities. In general, however, it was revealed that poor husbandry practices were more prevalent. This finding supports the claims of Grant et al. (2017) and Warwick et al. (2018) that reptiles more often than not are inadequately catered for in terms of enclosures and more specifically are subject to inadequate husbandry.

On the other hand, survey participants were more informed and knowledgeable about husbandry practices and particularly when it comes to thermoregulation. This may be because of some skewing in the participant sample. In other words, those that volunteered to complete the survey are more likely to be enthusiastic owners and

therefore, by virtue of this heightened enthusiasm are more likely to read up on relevant issues and seek advice from veterinarians. This may also be the case for the cultural probe participants.

Considering the potential for slightly skewed results from the survey and cultural probe, it is difficult to conclude that these findings are opposed to the findings of the literature. This is especially the case as the experts interviewed corroborated with the literature findings in many aspects.

Nevertheless, in addressing the research question: *How the issues of thermoregulation in home reptile keeping affect the health of the reptiles?* the research findings clearly address this with a range of responses by interviewees and survey respondents articulating physiological function and health related issues as a direct link to the ability of reptiles to adequately thermoregulate.

knowledge would have abstained from participating in the survey. Thus, the data collected did not have as large a range of knowledge levels as expected from the literature. Another limitation of the cultural probe was the quantity of the images submitted. More specific images could have been requested and more detailed questions asked to gain a deeper insight into how the participants set up their enclosures. The sample size of the research participants in all methods is another limitation. Larger sample sizes would result in more concrete findings however, sample size is also limited by time available for the research project.

5.1 LIMITATIONS

There were various limitations present with this study. A limitation with the interviews conducted was the lack of diversity between participants as all three participants were veterinarians. Conducting interviews with experts from other professions, such as reptile zoologists, pet retailers or breeders, would have given more insight for the study. Some limitations with the data collected from the survey and cultural probe included a lack of responses and information surrounding turtles.

The data from these methods predominantly displayed a high level of knowledge on reptile thermoregulation and husbandry and this is likely because of the online groups the survey was posted to. It can be assumed that members of these online communities are those who seek to gain appropriate knowledge and a better understanding of reptile needs in captivity. Hence, a limitation with the survey was the inability to reach reptile keepers outside of these online groups where a broader range of responses may have been collected.

Additionally, comments mentioned about the survey on a few online groups indicated that some people felt they had inadequate knowledge to complete it. This meant that reptile keepers or owners who felt like they did not have enough

6.0 PROPOSAL

6.1 DESIGN INTENT

It is evident from the literature and research findings that there are substantial areas within reptile keeping that can be improved upon. The aim of the design is to address the issues surrounding inadequate knowledge of reptile keepers and the lack of information provided to them with the goal of increasing the level of husbandry practices and thus, the overall well-being of reptiles in captivity.

6.2 JUSTIFICATION

It is clear from the literature review and the research undertaken that the underpinning theme for bad practice in reptile husbandry is a lack of information and knowledge. Given knowledge comes from quality information and experience, a reptile keeper's greatest asset is to avail themselves of accessible and reliable information.

Figure 6 exemplifies the importance of information. All other themes stem from the information node which illustrates the connection for all other aspects of reptile husbandry. This direction is supported by the survey results where reptile keepers mentioned the two major difficulties with caring for reptiles included maintaining optimal temperature zones and the lack of husbandry information available for their species. However, although temperature was listed as the main issue reptile keepers need to contend with, this too is derived from information; meaning a lack of available information will lead to poor decisions in relation to regulating enclosure temperatures.

Although it has been found that quality information does exist in the form of academic papers and textbooks, not all reptile owners will have access to these resources. Hence, the importance of providing a means for accessible and reliable information to the reptile community.

The research findings, with emphasis by the expert interview participants, strongly suggest that

an improvement in education and the quality of information provided to reptile keepers is needed for better husbandry.

6.3 CONTEXT

The context in which the design aims to be used is within the home environment of reptile keepers. However, this should not limit its use in other contexts such as a veterinary clinics or pet shops. Considering the intent of the design is to ultimately improve the care and health of reptiles in captivity, the end users of this outcome will predominantly be people who keep reptiles at home. This user group is primarily in focus because professionals or experts in the field will generally be more informed and knowledgeable in reptile husbandry.

6.4 KEY CRITERIA

The following key criteria have been developed from the research findings and are intended to be implemented in the design solution. See Appendix 3.0 for a justification of each criteria.

6.4.1 INFORMATION

6.4.1.1 Must provide current and reliable information regarding appropriate reptile husbandry.

6.4.1.2 Must provide a level of information that is deeper than current information available on online groups and forums.

6.4.1.3 Should increase the level of husbandry knowledge of reptile keepers.

6.4.1.4 Should provide regular information updates.

6.4.2 ACCESSIBILITY

6.4.2.1 Must be widely accessible to reptile keepers and owners.

6.4.2.2 Must be easily accessed without the need for specific industry or organisational privileges.

6.4.2.3 Cost of access to information should not be excessively high.

6.4.3 ENCLOSURES

6.4.3.1 Must be suitable for a range of enclosure sizes.

6.4.3.2 Must be applicable to a wide range of reptile species commonly kept.

6.4.3.3 Should be easy to install within reptile enclosures.



6.5 POTENTIAL IDEA 1

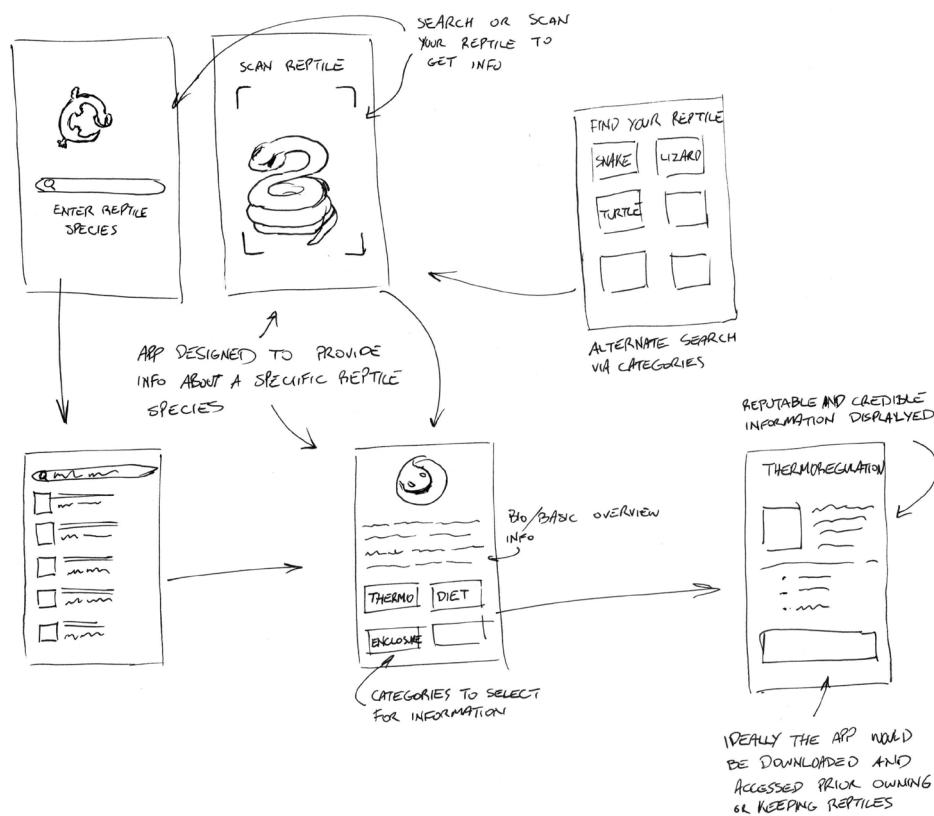
The first potential design idea is a smartphone app that allows reptile keepers to access specific information regarding their species kept. This application will be linked to a database of information relating the captive needs of the specific reptile. Owners can scan their reptiles using their smartphone camera and the app will identify its species. Alternatively, the specific species name can be keyed into a search function within the app. Once the reptile has been identified, a plethora of information will be available to keepers via the app. This app can be promoted via online or communities pet stores as well as recommended via veterinarians and other industry experts.

A key consideration of this concept includes the cost of the app. To ensure its success at being widely adopted within the reptile keeping community, the app should not be costly to the point of deterring users.

Some limitations with the app would include how frequently the information is updated on the database. Ensuring reptile keepers and owners have access to up-to-date information is crucial for the health and well-being of their reptiles. A potential limitation of this design opportunity would be the accuracy of the scan function to identify reptile species.

Key criteria addressed:

- 6.4.1.1
- 6.4.1.2
- 6.4.1.4
- 6.4.2.1
- 6.4.2.2
- 6.4.2.3
- 6.4.3.2



6.6 POTENTIAL IDEA 2

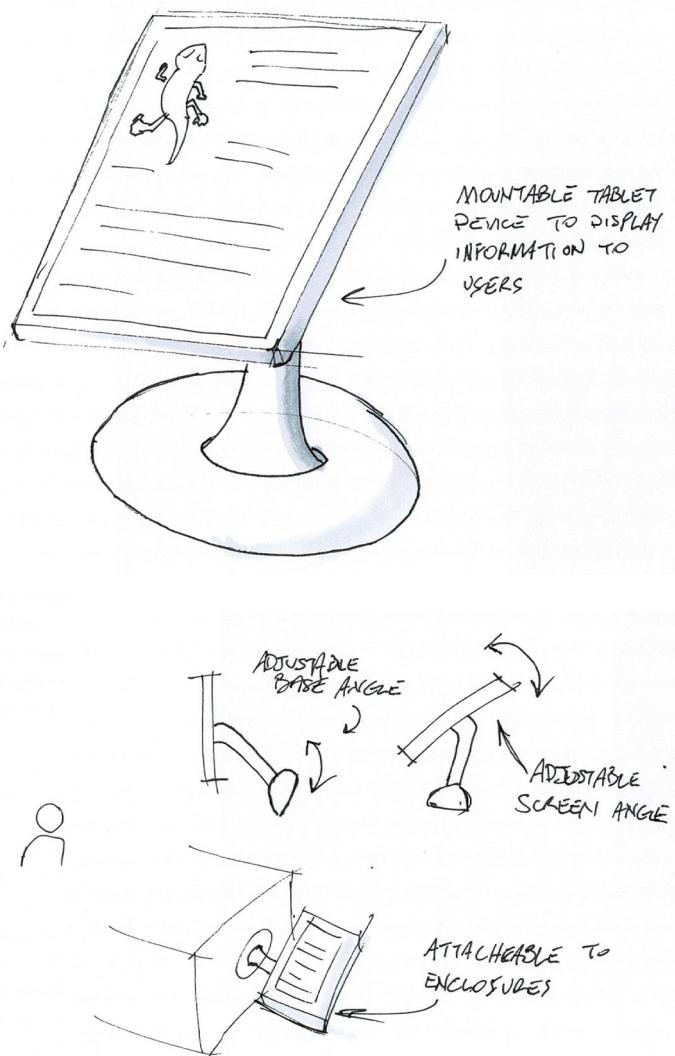
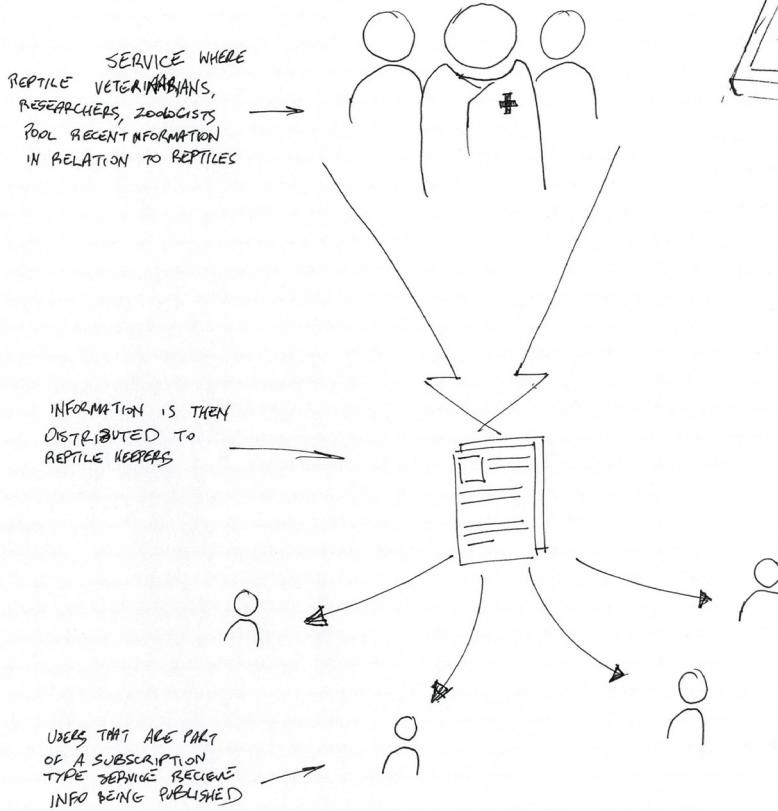
The second concept focuses on an information delivery system and service. Reptile veterinarians, researchers, zoologists, or other industry experts would pool relevant and rich information that would be beneficial for reptile keepers and distribute this information via a subscription service. The information distributed via this service can include new research being discovered within the industry, advised husbandry practices that may not be immediately apparent, or species-specific facts that could benefit their care in captivity. A potential product that could accompany this information service involves a mountable tablet device to display the information.

The cost of the service would be a key consideration as the value of the information provided would be quite high. The accompanying tablet device may also be of high cost depending on a number of variables such as manufacturing, materials, functionality, etc.

A limitation with this concept is the variety of experts contributing to the information pool. This will also limit the breadth of information provided to keepers which could limit the demographic that would benefit from this service.

Key criteria addressed:

- 6.4.1.1
- 6.4.1.2
- 6.4.1.3
- 6.4.1.4
- 6.4.2.2
- 6.4.3.1
- 6.4.3.3



6.7 POTENTIAL IDEA 3

The final concept focuses on information delivery through an online education course. The course would consist of a variety of informational videos on how to properly care for reptiles at home as well as how to set up an enclosure. Additional information resources that dive deeper into aspects such as reptile physiology, health issues in captivity, and common husbandry mistakes would be accessible through the course. The course would conclude through the completion of a quiz to solidify the new information and knowledge gained. An additional service provided through the course is the ability to have reptile keeper's enclosures reviewed and given feedback on. Photographs of the enclosures would be submitted by keepers and subsequently a review and areas of improvement would be provided by industry experts.

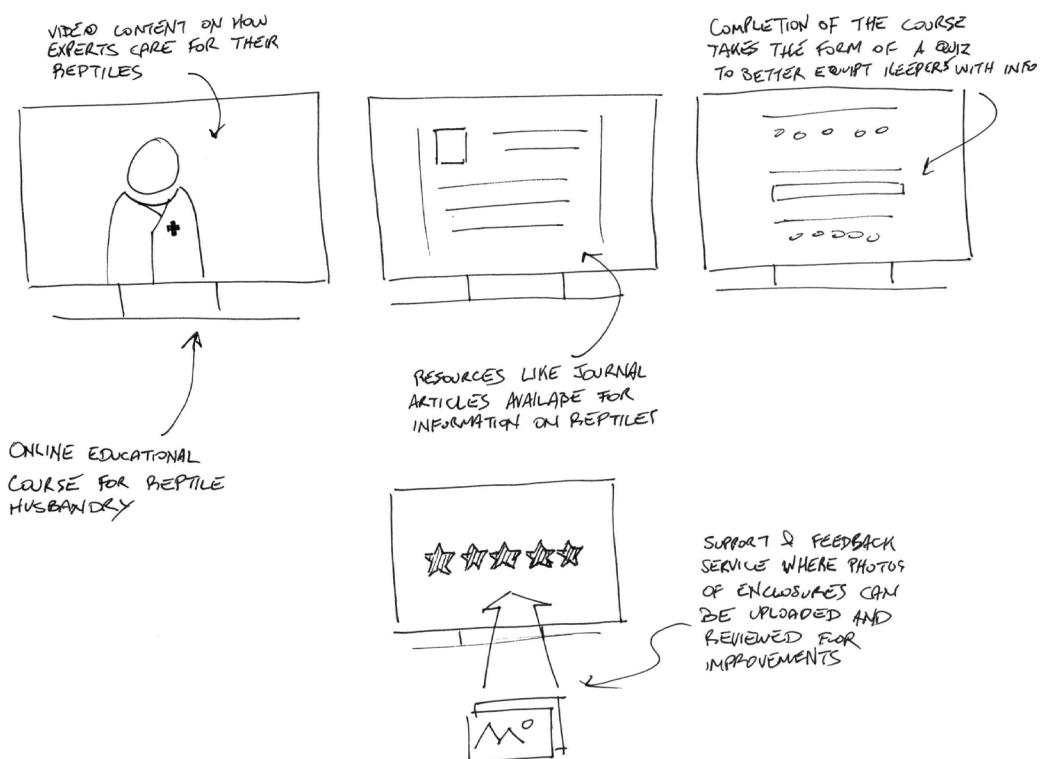
Key considerations for this include incentivising the uptake of the course and ensuring there is ample opportunity for access. Methods for promoting enrolment to the online course may include promotional material strategically placed at veterinarian clinics and with reptile traders.

A limitation of this concept is access for people who may not have exposure to information technology. Another potential limitation is access

to course information based on location that is, regional towns and remote locations.

Key criteria addressed:

- 6.4.1.1
- 6.4.1.2
- 6.4.1.3
- 6.4.2.2
- 6.4.3.2



6.8 PROPOSED DESIGN SCHEDULE



7.0 DESIGN JUSTIFICATION

7.1 INTRODUCTION

As established in the literature review and research stages of this project, it is evident that there is a general lack of information resulting in poor practice in caring for reptiles in captivity. As a result of this, the aim of the design solution is to increase the well-being of reptiles kept in captivity in the home context by providing carers with better knowledge and an ability to easily manage caring for reptiles. The design criteria established in section 6.4 (Key Criteria) of this report primarily focuses on the system solution as a whole, not necessarily the product solution. Nevertheless, the key criteria from section 6.4 implemented in the final design consists of (Appendix 3.0):

- 6.4.1.2
- 6.4.1.3
- 6.4.2.1
- 6.4.2.2
- 6.4.3.1
- 6.4.3.2
- 6.4.3.3

7.2 DESIGN CRITERIA

In addition to the above criteria, new design criteria were developed to better guide the design development of the physical product solution. These criteria are as follows:

7.2.1 FUNCTIONALITY

7.2.1.1 Must enable reptile keepers to set-up their desired enclosure

7.2.1.2 Must be able to alert users if problems arise within their reptile enclosure

7.2.1.3 Must be controllable by user inputs

7.2.1.4 Must be able to function autonomously after user inputs

7.2.2 USABILITY

7.2.2.1 Must be a simple design that is easy to use

7.2.2.2 Must be usable by reptile keeping novices and all other levels of experience

7.2.2.3 Access to power sockets and ports must be easy

7.2.2.4 Must be adaptable to variable environments

7.2.2.5 Must be easily assembled and disassembled

7.2.3 DATA

7.2.3.1 Data collected must be easily accessible to users

7.2.3.2 Data collected must be represented in a way that is easy to understand

7.2.3.3 Data collected must be easy to share

7.2.3.4 Information available to users must be easily accessible

The design justification will talk about the product solution ReptiZen, based on the above design criteria.

7.3 THE DESIGN

7.3.1 PRODUCT

ReptiZen is an all-in-one reptile enclosure monitoring and control product able to monitor and maintain temperature, humidity, and lighting conditions that can be implemented as custom settings by the user and can even mimic its surrounding environmental conditions (Figure 19). Additionally, users can choose from a range

of basic enclosure environment pre-sets for commonly kept species. This feature is specifically targeted for beginner and novice reptile keepers.

Reptile keepers can plug their heat lamps, heat mats, lighting, humidifiers, and other relevant equipment into the built-in power outlets (Figure 20). This enables ReptiZen to adapt the amount of temperature, lighting, or humidity set by the user whilst also controlling the amount of time each equipment item is powered. ReptiZen features multiple USB Type-C ports that serve as the sensor inputs for the control and data collection system, allowing users to plug in the necessary sensors and probes to set-up, control, and monitor their enclosure. The use of USB-C ports also enables users to use equipment such as infrared cameras to monitor their reptiles remotely.

ReptiZen offers an easy way to set-up and use the appropriate enclosure equipment benefiting all levels of users. The data collection and translation to usable information is predominantly geared to benefit the intermediate and advanced user. In addition, ReptiZen features an LED panel on the

base of the product which can be used as a light source for the enclosure.

7.3.2 DATA

A key feature of ReptiZen is that it collects and records data from all the enclosure equipment that is connected to it. The data collected can be inform the user on appropriate husbandry practices. For example, if a user has noticed a significant behavioural change in their reptile and is able to see their enclosure temperature data has not been within optimal ranges over the past week, adjustments can be made to equipment and their husbandry practices moving forward would be better informed.

An additional future feature is that the data collected may also be shared with industry experts such as reptile veterinarians, researchers, zoologists, etc. to provide them with insight on the husbandry practices within the reptile keeping community. This in turn will allow industry experts to inform reptile keepers within the ReptiZen system on



Figure 19. ReptiZen final design model in context.

appropriate husbandry practices based on the submitted data.

7.4 MANUFACTURING AND MATERIALS

7.3.3 SENSORS

The sensors and components that are compatible with ReptiZen are vast however, the key sensors that are included with the product are two temperature probes and one humidity probe. These are the basic requirements for creating an adequate reptile enclosure set-up.

7.3.4 APP

ReptiZen comes with an accompanying smartphone app allowing users to control the device and subsequently the sensors and other equipment within the enclosure (Figure 21). The app also enables users to view and share the data collected by ReptiZen and access information and data shared by industry experts as well as other users within the ReptiZen community.

The ReptiZen casing is manufactured from two injection moulded polypropylene (PP) parts. Injection moulding is a widely used manufacturing method and is ideal for the manufacture of the ReptiZen housing. Polypropylene is a strong and durable material that is easily recyclable which means the case can be made from recycled PP material. The internal components of ReptiZen consists of off-the-self components which include the power supply, USB-C ports, LCD display, LED panel, and ambient light, temperature, and humidity module. The surface of the product is a textured matte finish allowing for a sleek, fingerprint and dirt resistant aesthetic.

7.5 PACKAGING

The packaging of ReptiZen has a minimalistic and clean aesthetic that is in stark contrast to existing reptile keeping products on the market (Figure 22). The decision to keep the aesthetic minimal was to stand out amongst graphic heavy and highly saturated colours of competing brands. The packaging is made from 100% recycled paper and cardboard and the ink used in printing is made

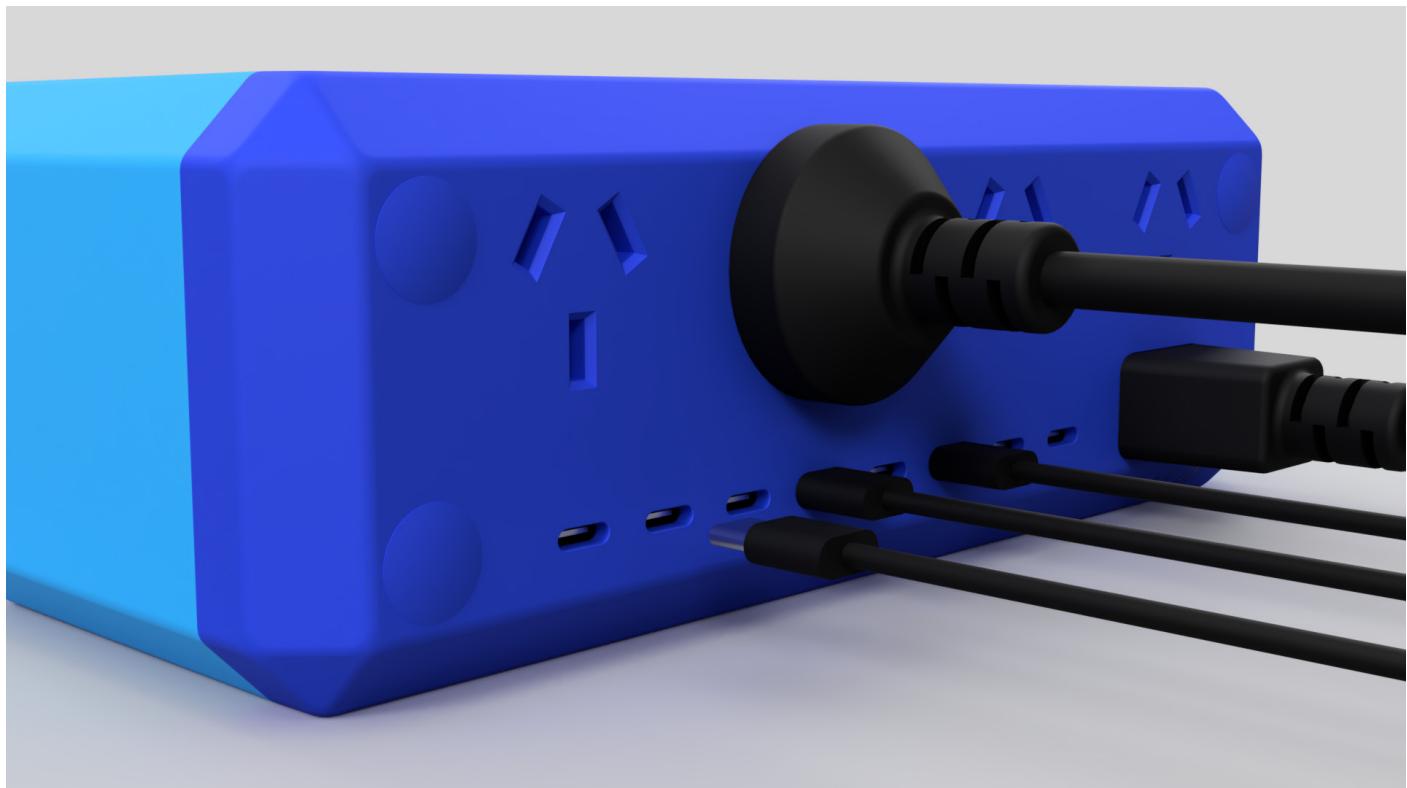


Figure 20. Sensors and powered equipment plug into the back of ReptiZen.

from algae. These materials were chosen as they allow for a highly sustainable packaging solution while still providing a premium design feel.

7.6 FURTHER RESEARCH

Extensive reptile keeping market research was undertaken prior commencing any design work. It was found that key competitors in the reptile keeping market space featured products that were similar in principle however they varied greatly in their functionality and features provided to users. Delivering appropriate and varied heating is arguably one of the most important considerations when keeping reptiles to enable proper and adequate thermoregulation. To achieve this, the most common equipment items used on the market are heat lamps. A thermostat often is accompanied by whatever heat source is chosen to be used within the enclosure as thermostats enable users to set their heating equipment to run within specific temperature ranges. Thermostats enable users to control the amount of heat their reptiles are exposed to and depending on the sophistication of the thermostat, can even have timed exposure to the heat source.

A thermostat features a temperature probe that is placed under or near the desired heat source. The heat source itself is plugged into the thermostat power outlet which enables it to control the intensity of the light or heat given off. Thermostats maintain the temperature set by users through reading the temperature input from the temperature probe and adjusting the intensity of the heat source plugged into the thermostat. Any deviations from the set temperature will

cause a rise or fall in intensity of the heat source to maintain an optimal thermal environment within the reptile enclosure. In a general sense, the functionality of reptile thermostats could arguably be the biggest competitor to ReptiZen as a result of how widely available they are in their most basic forms however, pale in comparison to ReptiZen's comprehensive functionality.

7.7 CONTEXT, SYSTEMS & SCENARIO

7.7.1 PEOPLE

The main users of this product are reptile enthusiast who keep reptiles at home as pets, for breeding, temporary rehabilitation, etc. There is no specific age group that ReptiZen is targeted for as it is intended for users with a broad spectrum of reptile keeping ability. The main users may vary from a beginner or novice level of reptile keeping ability, or a user who has an advanced level of knowledge. Secondary users of this product are those who keep reptiles within a more professional environment such as reptile veterinarians, researchers, zoologists, rehabilitation practitioners, etc.

7.7.2 ACTIVITIES

In terms of activities, the user would be predominantly interacting with the physical product during the initial set-up and when changing the sensors used based on user preference. These interactions include plugging in the power cable, enclosure heat sources or humidifiers, and the



Figure 21. ReptiZen app screen examples.

necessary sensors and probes for monitoring the various equipment within the enclosure. The rest of the interactions with ReptiZen is done via the accompanying app. The user controls their enclosure equipment settings and monitors the data readings within the app.

7.7.3 CONTEXT

The context in which the product is intended to be used is within the home environment of reptile keepers. As mentioned previously, it can also be used in a clinical or more professional setting as well. ReptiZen is suitable for both indoor and covered outdoor enclosures provided it is not exposed to the elements as it does not provide weatherproof protection in its current form. The product is able to be located wherever convenient however, the underside LED light panel makes the top of the reptile enclosure the ideal location.

7.7.4 TECHNOLOGY

There are various technological components featured within ReptiZen (Figure 23). The key internal components consist of a 4.2-inch RGB

LCD display; an ambient light, temperature, and humidity sensor; various LEDs and an LED light panel (Figure 24); a small motherboard with processor, Bluetooth, and Wi-Fi microchips; a power supply; and an array of USB Type-C ports. In terms of the technology that would plug into ReptiZen, this would consist of most equipment related to reptile keeping and enclosures. The equipment and technology that would be compatible through the various power outlet sockets would include heat lamps; heat mats; humidifiers or misting devices; standard or UV lighting; and small coolers or fans.

Smaller equipment items, sensors, or probes that are compatible with USB-C would plug into the dedicated ports. These may include thermometer and humidity probes; motion sensors; infrared thermometers; small monitoring cameras; microphones; ambient light sensors; and more. The accompanying app utilises smartphone Bluetooth and Wi-Fi capabilities to connect to ReptiZen remotely.

7.8 DESIGN PROCESS

The design process adopted for this project was

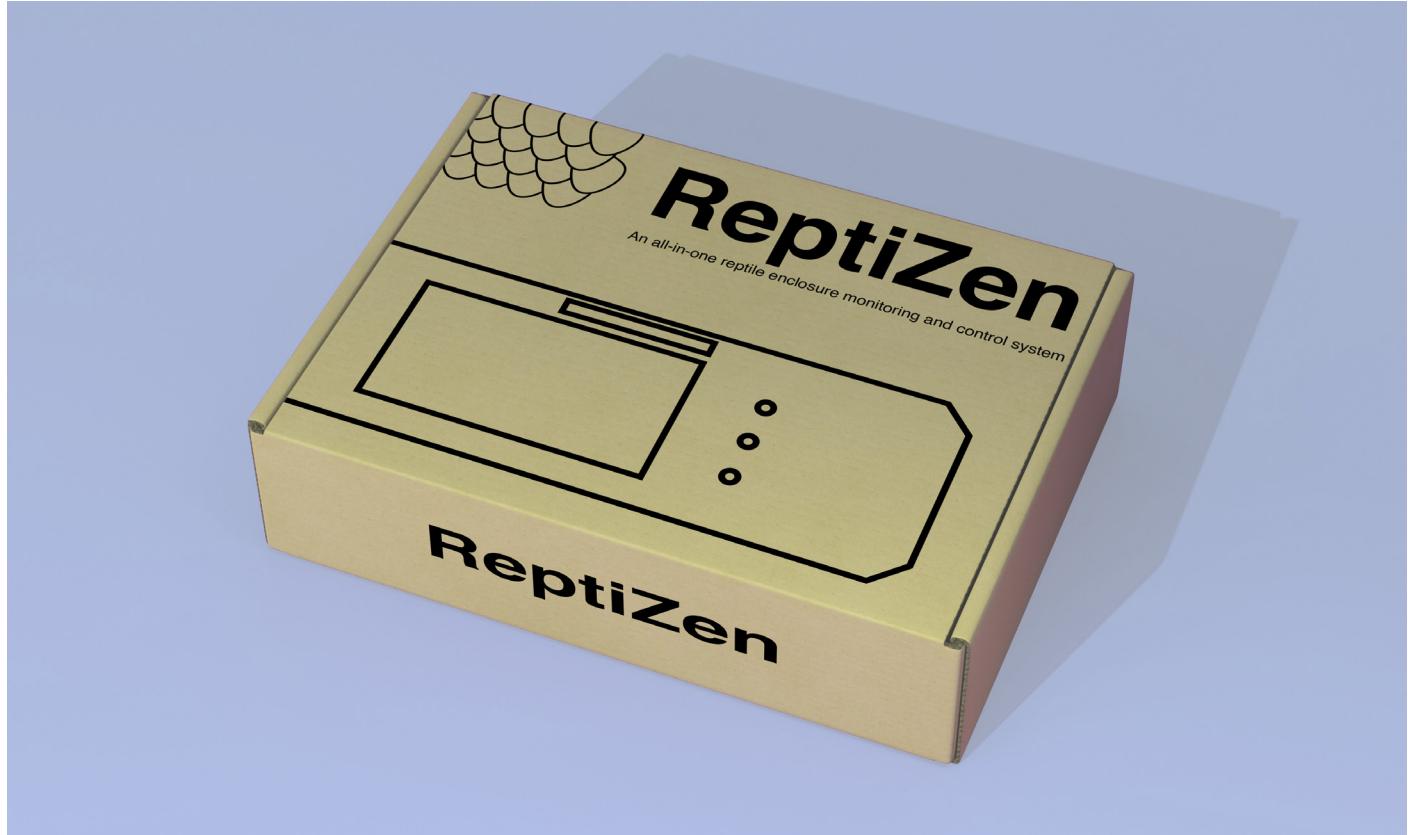


Figure 22. ReptiZen packaging design.

the double diamond method (Figure 25). The first diamond was undertaken during the research phase of this project and concluded with the definition of the problem statement. The second diamond encompassed the design and creation of a product solution to the identified problem.

The design phase of ReptiZen commenced with extensive market research and idea generation. Promising designs were developed through iterative sketching and further research. Prototypes were created to test various functions and aspects of the design. This process of generating ideas, developing concepts, conducting further research, and receiving feedback on the design progress was repeated numerous times before arriving at the final design. Towards the convergent end of the second diamond, 3D CAD models were made to better understand and communicate the design. Following this, final CAD renders and prototypes of the resolved solution were made to bring the design to life.

7.9 DESIGN VALIDATION

The design of ReptiZen was validated through prototyping and user, peer, and tutor feedback. Various prototypes were made that explored or

communicated certain aspects of the design. The intent of this was to ensure the design would be functional and feasible. User feedback was provided which helped to generate and narrow down concepts during the design process. Peer and tutor feedback was sought extensively throughout the design process of ReptiZen. The ability to gain additional insight from others allowed for the design to be simplified and developed into a resolved solution.

7.10 BUSINESS CASE

7.10.1 IMPLEMENTATION

There are two methods for users to purchase ReptiZen which include direct online purchasing or via pet stores. An online purchase would be dispatched and delivered directly to the users' home. ReptiZen would also be sold and distributed through various pet stores across Australia with the possibility of global expansion. Considering the compact size of the product, this would be easily achievable in future. The app is free with purchase and would be available on various smartphone app stores.

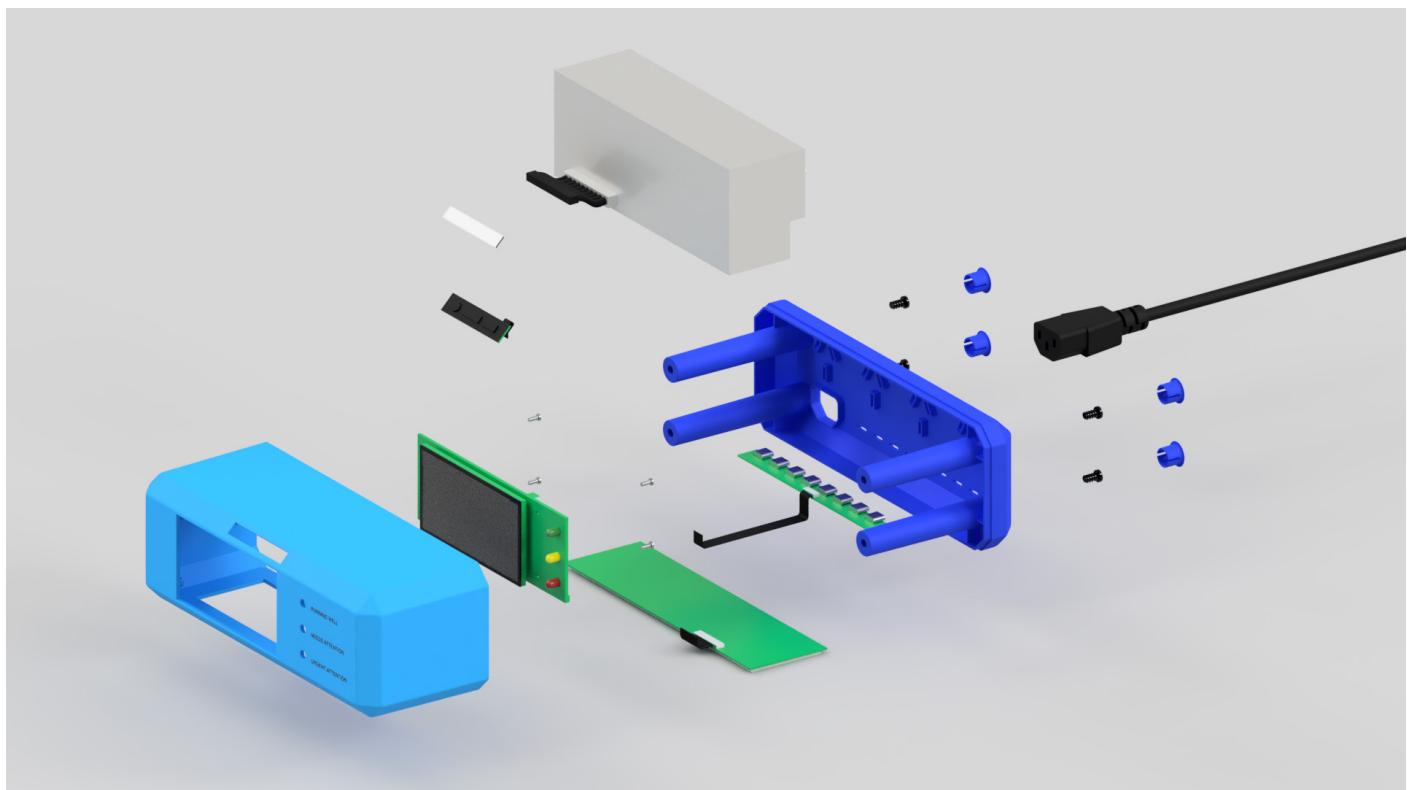


Figure 23. ReptiZen exploded view with all components.

7.10.2 VALUE PROPOSITION

ReptiZen offers reptile keepers a means of helping them increase their husbandry ability and reptile keeping knowledge. ReptiZen can be used in most reptile enclosures and is beneficial to the majority of reptile species. The product is compatible with many existing reptile enclosure thermoregulatory equipment, providing reptile keepers of all abilities with a means of collecting, monitoring, and recording environmental data within their reptile enclosures thus significantly benefit in informing their reptile husbandry decisions. Connecting the user's collected data with industry experts such as reptile veterinarians and the wider community will help to gather information on the current husbandry issues that are occurring in localised areas. Enabling a community platform where experts and users can interact and communicate creates rich information and data spreading that benefits the user but more importantly, reptiles in captivity.

7.10.3 BUSINESS MODEL

Since the early design stages of ReptiZen, the position it could assume in the market was considered in detail. To ensure a successful business model for ReptiZen, a target consumer cost of around \$100-\$200 AUD was decided to ensure it is affordable yet not compromise on technological features. This economic target

along with the uniqueness of the design and its features is a massive advantage over current reptile husbandry products in the same class.

7.10.3.1 CUSTOMER SEGMENTS

ReptiZen is targeted to reptile keepers of all abilities however, it may appeal more to novice, beginner, and intermediate reptile keepers. Its primary context is intended to be used within the home.

7.10.3.2 VALUE PROPOSITIONS

The two main products within the system solution are ReptiZen and its accompanying app. Both products work together to provide reptile keepers with the ability to increase their husbandry knowledge and ability.

7.10.3.3 KEY PARTNERS

Pet stores across Australia would be key partners of ReptiZen to ensure it can be accessibly to users.

7.10.3.4 KEY ACTIVITIES

The key activities involved consist of producing, marketing, and distributing ReptiZen as well as ensuring industry experts are active within the system and online platform.

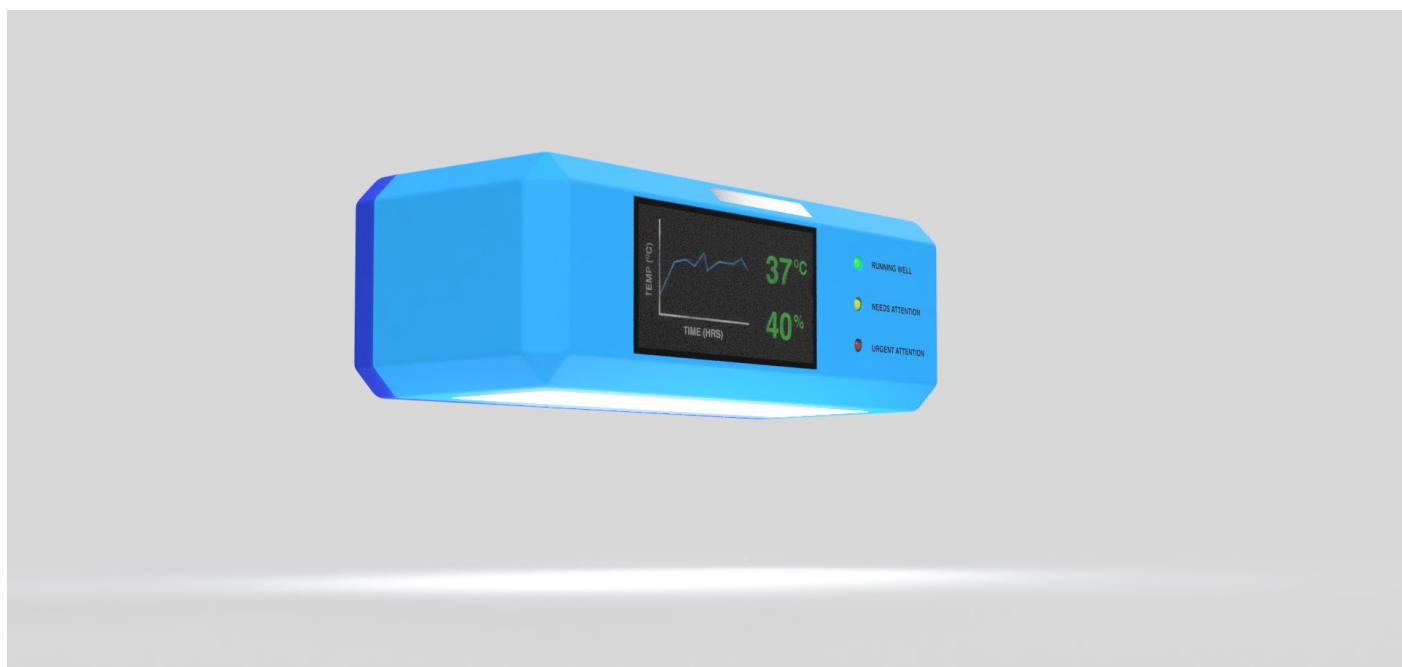


Figure 24. LED panel on the bottom of the product acts as a light for the enclosure.

7.10.3.5 KEY RESOURCES

The primary resources required consist of all the components needed to make the product itself followed by human resources to maintain the system solution.

7.10.3.6 CUSTOMER RELATIONSHIPS

The main customer relationships include distribution of the product, help services for troubleshooting, and maintaining an online community for data sharing and discussion.

7.10.3.7 CHANNELS

The primary channels that need to be implemented, aside from the product app, to engage with consumers include social media platforms and a website.

7.10.3.8 REVENUE STREAMS

The sales of ReptiZen to consumers directly and pet stores are the main revenue streams within this system.

7.10.3.9 COST STRUCTURE

The cost to manufacture ReptiZen, including materials and all necessary parts and components, is roughly \$114.22 AUD/unit at 5000 units. This allows for ReptiZen to be marketed at around

\$200 which falls within the initial target consumer cost bracket.

7.11 FINAL DESIGN DISCUSSION

This project's aim was met through the design and creation of ReptiZen. The importance of thermoregulation in reptiles is well documented and it is evident that reptiles are sensitive to variations in temperature and humidity within their environment. Providing users with the ability to inform their reptile husbandry decisions based on expert advice and their own real-time data will increase the level of care for reptiles in captivity. ReptiZen increases the ease of caring for reptiles by dealing with the technical aspects of the equipment used within enclosures meaning the user need only focus on monitoring and making occasional adjustments to the equipment. This not only makes reptile keeping user friendly, but it also increases the joy and user confidence of the activity as reptile keepers would avoid dealing with as many health issues or mortalities. As discussed previously, ReptiZen meets numerous design criteria that were established to guide the design development of the product and system.

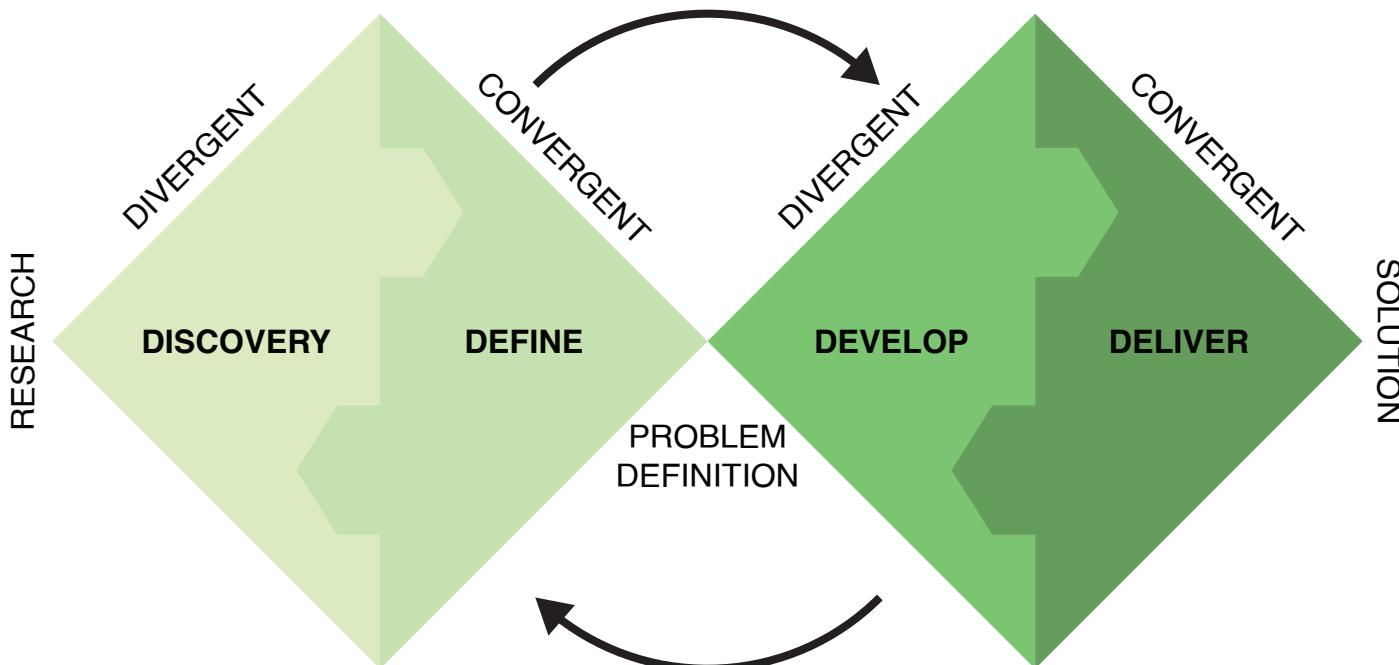


Figure 25. Double diamond design method.

7.11.1 INFORMATION AND DATA

The data collected by users is far richer than the level of information that is commonly accessed through online reptile forums and groups. Having reptile industry experts able to share relevant and current information directly to ReptiZen users will also increase their level of husbandry knowledge. The collected data is updated and displayed on the product display (Figure 26) and the smartphone app thus allowing for easy accessibility and viewing of the data. Through simple iconography, labels, and linework, the data is visually clear and easy to understand. Considering all information and data will be accessible through the app, reptile keepers should be able to locate relevant information to suit the situation at hand.

7.11.2 ACCESSIBILITY

Smartphones are widely used globally hence the smartphone app was created to utilise this market space. This allows the app and information delivery side of the ReptiZen system to be available to most users and would not require any specific industry or organisational privileges. The product itself would be available via pet stores which is utilising the industry standard for purchasing reptile keeping products.

7.11.3 ENCLOSURES

ReptiZen is made to be used with a variety of reptile enclosure shapes and sizes thanks to

its versatility in where it can be situated with an enclosure. The installation of ReptiZen is as simple as a plug-and-play product and does not require any specific installation equipment. ReptiZen is compatible with existing reptile enclosure equipment that are powered through a standard power plug meaning its application is not limited to any specific species. Featuring USB-C ports for sensor and other electronics input ensures that ReptiZen can be used with an array of different configurations for a wide range of reptile species.

7.11.4 FUNCTIONALITY

ReptiZen gives reptile keepers the choice of how they wish to set up their desired enclosure and is completely controllable by user inputs. The product will function autonomously after the user has set their desired parameters. However, if an issue arises within the enclosure or ReptiZen detects a significant deviation in the conditions set, the user will be alerted and notified via the app and LEDs on the product.

7.11.5 USABILITY

Although the product solution is not specifically targeted towards novice and reptile keepers, it is simple enough for these user groups to use and will definitely benefit in advancing and developing their reptile keeping ability. The user is only required to plug in various equipment items, sensors, and probes into the back of ReptiZen which makes the usability of the product very easy

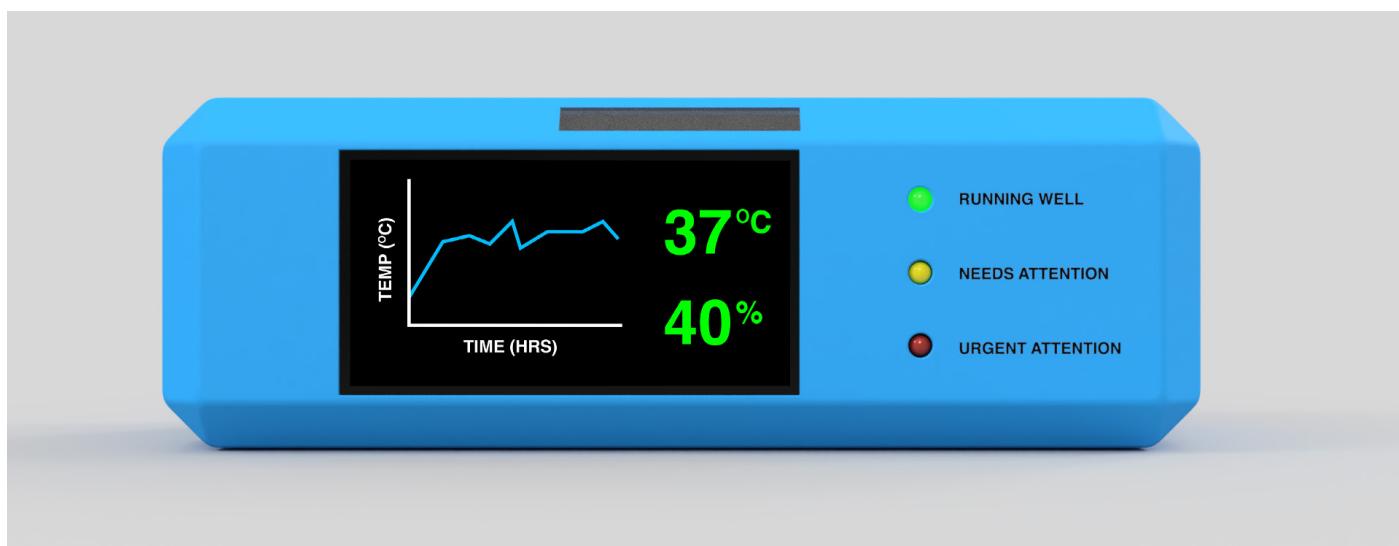


Figure 26. Data graph visible on the product display.

and streamlined (Figure 27). Considering this is the only physical interaction and input required by the user, as the rest is managed within the app, it is important that reptile keepers can easily access the back of the product if they wish to make any alterations to their enclosure set-up. Hence, there are no obstructing features that would inhibit the user from accessing this part of the product. The product is held together with screws meaning it can be easily disassembled if required for repair and disposal.

7.12 SUMMARY

In summary, ReptiZen achieves the aim of increasing the well-being of reptiles kept in captivity in the home context through providing owners with better knowledge and an ability to easily manage caring for reptiles. Providing users with the means of monitoring and collecting data of the equipment they use within their enclosure enables them to make valid and informed husbandry decisions. ReptiZen gives reptile keepers the option of implementing and using any reptile keeping equipment necessary or desired to ensure an appropriate living environment is created within their home enclosures.

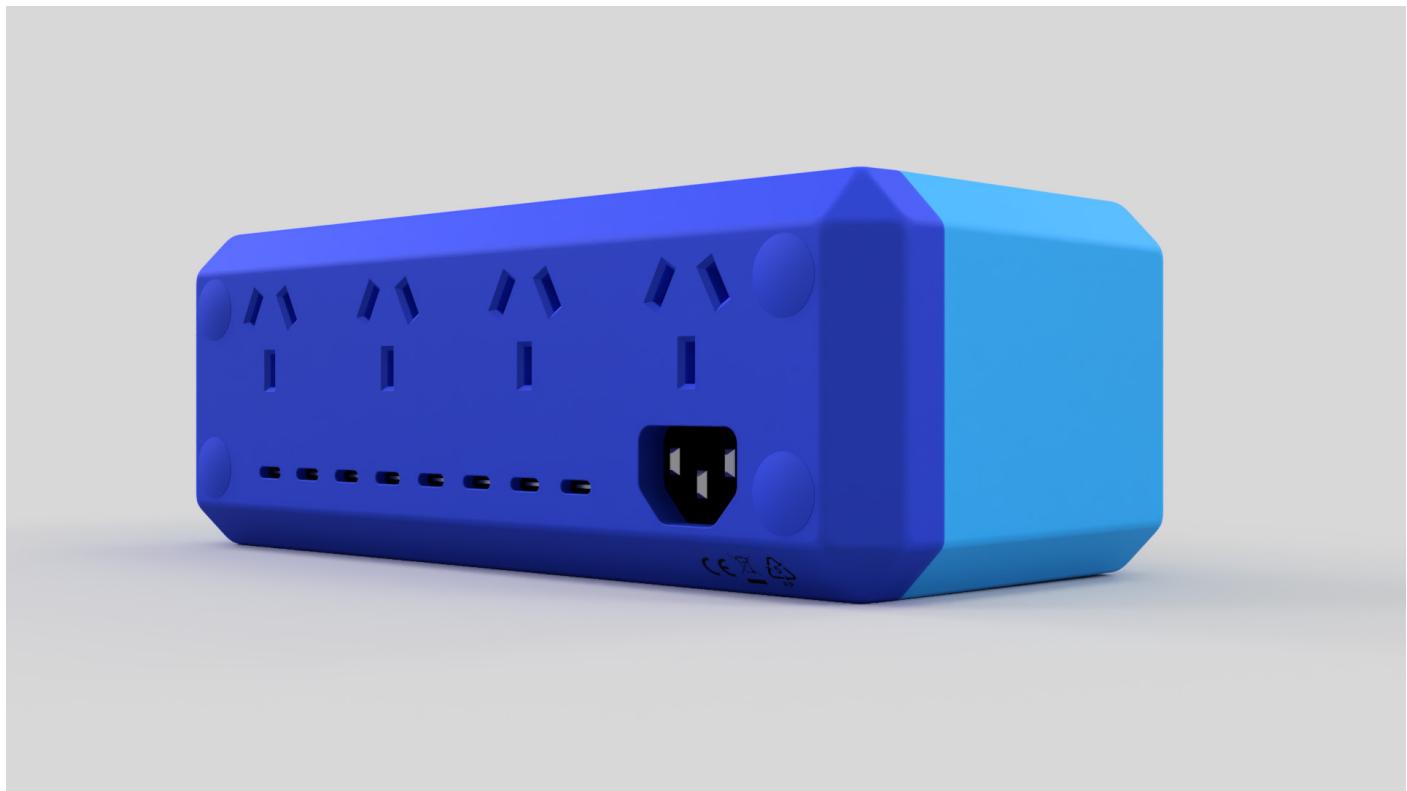


Figure 27. Back of the product where the user plugs in various equipment, sensors, and probes.

8.0 CONCLUSION

This research project found that thermoregulation in reptiles is vital to their well-being, especially in a captive environment. It was evident that the health issues seen in captive reptiles was largely attributable to poor husbandry practises. These findings led to an investigation on how the issues of thermoregulation in home reptile keeping affects the health of the reptiles.

To address this, a combination of expert interviews, an online survey, and a cultural probe were employed to gain insight into the various aspects of reptile keeping. The results from this study suggest thermoregulation and health issues present in captive reptiles stem from a lack of information and knowledge by keepers and owners. These findings suggest an improvement in the uptake and accessibility of information is needed to mitigate the issues presented by this study.

In response to these findings, a design solution, ReptiZen, was created that improves the delivery and access to quality information on reptile husbandry whilst also increasing the ease of caring for reptiles. ReptiZen achieves the aim of increasing the well-being of reptiles kept in captivity in the home context through providing carers with better knowledge and an ability to easily manage caring for reptiles. Ultimately, the ReptiZen system is a much-needed step towards improving the level of care for reptiles in captivity.



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APPENDICES

LEADERSHIP REFLECTION

The design leadership initiative I undertook this semester was being a member of the Design Pilots; a community of design students that host a range of creative events and provide peer learning and feedback to design students. This semester I hosted and co-hosted a number of *Design Sketching* events. The activities that take place during these sketching events include socialising amongst peers from various design disciplines, sharing ideas and discussing current design projects and work, and of course, sketching (analogue or digital) (Figure 27).

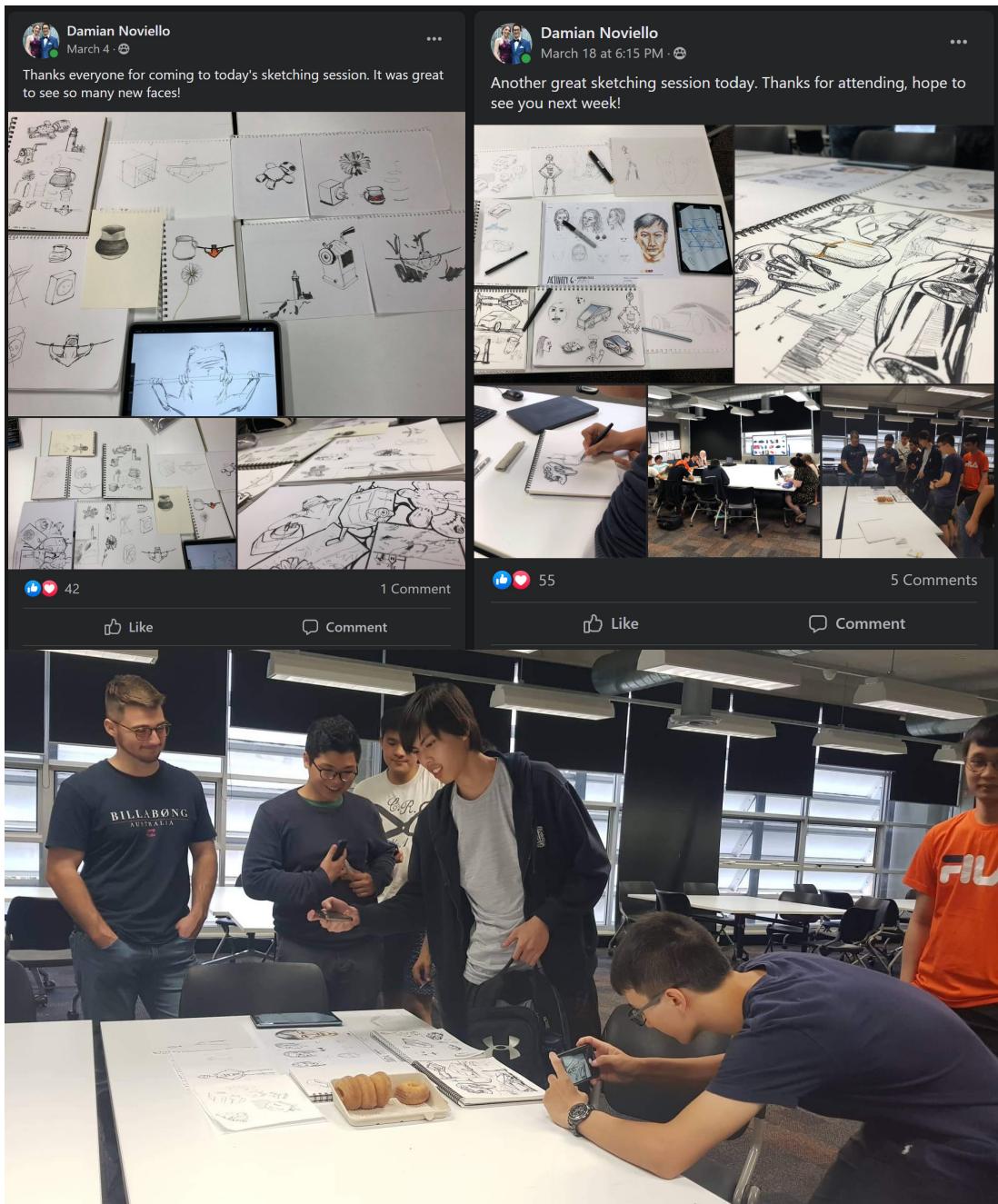


Figure 27. Photos of sketches posted to the Design Sketching Facebook group (myself pictured taking photos; bottom right).

Building my sketching skills is vital as a designer. I have used the skill of sketching, both analogue and digital, for all my design projects to date and I expect to continue to use these skills in future. Being a part of a community that meets on a weekly basis to socialise and sketch has greatly benefitted me in terms of skill development and networking. Providing tips and advice to other students, primarily those in earlier years of study, is very rewarding and comforting to know that my current knowledge and skills can be shared for the benefit of others. This also benefits me as I refresh my knowledge on sketching techniques and solidify them through practice. Socialising with like-minded peers has also greatly increased my networking ability as discussions around similar interests, projects or work experiences often take place.

Some initiatives I undertook in terms of project management this semester included regular weekly discussions and liaising with tutors, attending additional librarian help and information sessions, and completing two self-development and improvement online courses through LinkedIn Learning. Constant communication between tutors has given me immense guidance with my project thus far and I anticipate it will continue with the semester ahead.

The two online courses I completed were *Managing Self-Doubt to Tackle Bigger Challenges* and *How to Crush Self-Doubt and Build Self-Confidence* (Figure 28).



Figure 28. Certificates of completion for the LinkedIn Learning courses.

The first course spoke of self-doubt being a form of fight or flight response to difficult challenges. It was mentioned that practising mindfulness and progressing through these challenges, even though you might not feel completely confident in your abilities, is best practice for eliminating self-doubt.

The second course dived into building self-confidence and defined it as the genuine belief in one's ability to accomplish the task at hand. It taught that true confidence is attained through lots of repetition of a subject matter and positive affirmation. The use of physical gestures and cues to prompt focusing on the positives in the moment and produce constructive thoughts was also learnt.

I believe practising these skills could greatly benefit me when confronted with daunting tasks or situations like delivering a presentation. I will try to employ these techniques in future to help build my confidence and eliminate self-doubt. Moving forward in my career, I endeavour to continue to learn from other designers and creative minds to continuously better myself as a designer.

LEADERSHIP REFLECTION 2

The primary design leadership initiative I undertook continued from earlier this semester as being an active Design Pilots member. In Week 9 of the semester, I co-hosted a larger sketching event *Eat, Chat + Sketch* (May 6th) where the usual design sketching activities and idea sharing discourse took place but with the added bonus of snack foods and pizza (Figure 29). I assisted with organising the event and coordinating the food on the night. Considering pizza was mentioned to be present at the event, attendance was quite high and as a result, the event was very enjoyable.



Figure 29. Eat, Chat + Sketch event (myself pictured middle left; red shirt).

Another leadership initiative I took this semester was assisting in planning specific Design Pilot Adobe Sessions with unit coordinator Jeremy Kerr. These Adobe help sessions are much like the design sketching events however, focus on using the Adobe Creative Cloud suite. We contacted Jeremy directly via email as one of the Design Pilots knew of a two-week class break certain DVB units were partaking in (Figure 30). The purpose for contacting Jeremy during this time to promote the Adobe sessions was to create awareness of the Design Pilots program and incentivise attendance to future sessions. This also served to strengthen my communication, planning and organisational skills which I can apply at all stages in my design career.

Hi Damian,

This is exactly what I've been waiting for!! My DVB101 students would love to have the opportunity to come to these sessions. Have you been operating Design Pilots already this semester? I was under the impression it hadn't started.

I have 600 students in my unit and they are all being introduced to Illustrator, InDesign and Photoshop - and they are about to start Assessment 2 - so having you around doing this is perfect. Is it possible to have weekly sessions over this coming period? I will definitely advertise things in my next lecture (which I plan to record tomorrow). Can you send me details of where your sessions are at - do you have flyer? Also, I have around 150 online students - are any of your sessions blended - can students Zoom in & share screens etc?

best regards,

Jeremy

From: Damian Noviello <damian.noviello@connect.qut.edu.au>
Sent: 21 April 2021 16:46
To: Jeremy Kerr <jeremy.kerr@qut.edu.au>
Cc: Emily Boehmer <emily.boehmer@connect.qut.edu.au>; Bradley Stevens <b21.stevens@connect.qut.edu.au>
Subject: Design Pilot Promotion - DVB101

Dear Jeremy,

My name is Damian and I am a member of the Design Pilots.

It has come to our attention that there are no DVB101 classes over the next few weeks. We feel this is a perfect opportunity to incentivise student to attend our Adobe help sessions.

We run these sessions every second Wednesday from 4-5pm and were wondering if you would be interested in promoting these help sessions to the DVB101 cohort.

If there is enough interest in attending these sessions, we are happy to run them for both of those weeks.

These help sessions mainly consist of assisting students with Indesign, Illustrator and Photoshop. Many of the pilots have completed DVB101 and have substantial experience in the Adobe suite.

Hopefully by promoting these sessions we can encourage students to continue working over the coming weeks.

I look forward to hearing from you. Thank you for your consideration.

Kind regards,
Damian & Design Pilots

Figure 30. Emails exchanged with Jeremy.

An initiative I took that was more orientate towards my research project was attending a reptile information workshop, Basic Reptile Physiology and Lizard Care Worksop, through Reptile Rehabilitation Qld Inc (RRQi) (Figure 31). The purpose for my attendance at this workshop was primarily to network and socialise with expert reptile handlers with the hope to potentially interview them. I spoke with a few founding members that possessed an immense amount of knowledge on keeping reptiles however, I was unable to secure an interview with them despite my continuous contact efforts after the workshop. Although my efforts were not fruitful, my communication and interpersonal skills applied to network with people were heightened as a result of this.

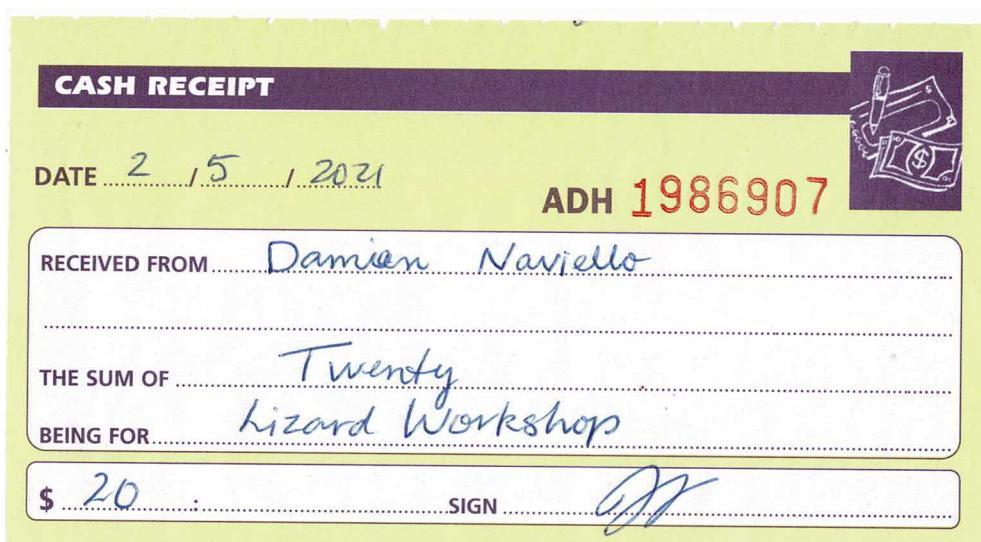


Figure 31. RRQi workshop receipt.

In terms of project management, the initiatives I continued throughout this semester consisted of weekly discussion and progress reporting with tutors and attending additional help and work sessions. The two additional help sessions that I attended this semester were run by some of my cohort peers and entailed concept idea brainstorming and rapid concept sketching (Figure 32). The first session primarily focused on generating concept ideas for myself and other peers that attended the session by swapping project topics and writing potential ideas on paper. The second session focused more on sketching and rapid concept development in the form of 'concept bombs'. Sharing ideas and collaborating with other peers despite not being apart of a group or team project is an important skill to practise as new insights and perspectives are gained that might not have been thought of by ourselves.



Figure 32. Concept sketching event (myself pictured right; brown jumper).

I believe the initiatives I pursued this semester have strengthened my skills as a designer and will benefit me as I progress with my design career. Continuing to build and advance these skills moving forward into next semester will allow me to solidify what I have learnt thus far.

APPENDIX 1.0: INTERVIEW QUESTIONS

1. Ask general questions about themselves as an introduction:
 - Do you mind telling me a bit about yourself in terms of your profession?
2. What is your experience with dealing with reptiles in your practice or business?
3. What have you found to be the most common health issues associated with reptile keeping?
4. In your experience, do recreational reptile keepers have appropriate knowledge for keeping reptiles at home?
5. Do you feel there is a lack of adequate knowledge available for reptile keeping and husbandry?
6. What do you see are the barriers to proper reptile husbandry practices at home?
7. How much do you feel a reptile's ability to properly thermoregulate affects its overall health?
8. Do you currently keep any reptiles yourself? If so, what type/species?
9. How have you monitored and controlled temperature and humidity in your enclosures?
10. What have you found to be the most successful way of enabling reptiles to properly thermoregulate within their enclosure?
11. Have you ever experienced instances where you would treat reptiles because of equipment failures? More specifically equipment that enabled them to thermoregulate.
12. What do you think are potential ways of improving the negatives mentioned?
13. One last question, would you be interested in participating in a cultural probe (if they keep reptiles)? Explain this.

APPENDIX 1.1: ONLINE SURVEY QUESTIONS

Reptiles in Captivity: Thermoregulation and Related Health Issues

This project is being undertaken as part of an Honours study for Damian Noviello. The purpose of this project is to investigate thermoregulation and associated health issues for reptiles in captivity with the intention of providing design opportunities to increase the health of reptiles kept at home.

You are invited to participate in this project because you are a licensed reptile owner, keeper or breeder and can provide valuable information about reptile keeping and husbandry. Participation will involve completing a 16 item anonymous survey with multiple choice, Likert scale, short and paragraph response questions that will take approximately 15 minutes of your time.

By completing and submitting this survey you are consenting to the use of your answers in this study. Your participation in this research project is entirely voluntary. All comments and responses are anonymous i.e. it will not be possible to identify you at any stage of the research.

Further information about this survey can be found using the link below:
<https://drive.google.com/file/d/196RcSkk-3ZW7mB4IGpJLV1FSXjDHkdfG/view?usp=sharing>

Please feel free to contact the researcher, Damian Noviello, if you have any questions, require further information, or if you are willing to participate more in this project by completing a cultural probe.

Email: damian.noviello@connect.qut.edu.au

This study has been approved by the QUT Human Research Ethics Committee (approval number 1800000355).

Thank you for helping with this research project. Your participation and responses are greatly appreciated!

1. What reptile or reptiles do you currently own or keep?

Please mention specific reptile name i.e. not just lizard or snake

Short answer text

2. What was the reason behind you wanting to own a reptile?

Long answer text

3. How would you rate the difficulty of caring for reptiles?

1

2

3

4

5

Not Difficult



Very Difficult

4. What are some of the difficulties in keeping your reptile/s?

Long answer text

5. Before you bought your reptile/s did you have any idea how to care for them?

- Yes, I knew a lot
- I knew enough
- I didn't know much
- No, I didn't know anything

6. Where do you currently obtain information about caring for your reptile/s?

Please select all that apply:

- Friends or family
- Pet shops
- Websites
- Online forum or group
- Veterinarians
- Other...

7. What do you understand/know about thermoregulation? Do you think thermoregulation is important for reptiles?

Long answer text

8. A reptile's environment affects its ability to thermoregulate (adjust its body temperature).

1 2 3 4 5

Strongly Disagree

Strongly Agree

9. Do you currently regulate the temperature of your reptile/s terrarium/enclosure?

Yes

No

10. How much time (in hours) do you allow your reptile/s to have access to heat sources during the day?

Please answer with a numerical value:

Short answer text

11. How much time (in hours) do you allow your reptile/s to have access to heat sources during the night?

Please answer with a numerical value:

Short answer text

12. What equipment or terrarium/enclosure features do you use to regulate your reptile/s temperature needs?

Please select all that apply and/or list all that are missing:

- Heat lamp
- Heat mat
- Basking rock underneath a heat lamp
- Electronically heated basking rock
- Thermometer
- Other _____

- Thermometer
- Specific substrate
- Other...

13. What equipment or terrarium/enclosure features do you use to regulate your reptile/s humidity needs?

Please select all that apply and/or list all that are missing:

- Humidifier
- Fogger
- Mister
- Spray bottle
- Water pool
- Specific substrate
- Other...

14. Do you know of any health issues experienced by reptiles with inappropriate heating or temperature control? Which of these have you experienced personally and how was this resolved?

Long answer text

15. How do you deal with your reptile/s if or when they show signs of illness?

Long answer text

16. Is there anything you would like to add that may have been missed in this survey?

Long answer text

If you are willing to participate in a cultural probe (sending photos of your reptile enclosure/s) for this project please enter your email below or contact Damian Noviello at
damian.noviello@connect.qut.edu.au

Participation in the cultural probe is completely optional and is not required to complete the survey

Short answer text

APPENDIX 1.2: CULTURAL PROBE TASKS AND QUESTIONS

- Please take 2-4 photographs of your entire reptile enclosure at different angles to show the enclosure's size and features.
 - Please take 2-3 up-close photographs of features that provide or manage the heating and temperature of your reptile enclosure.
 - At least 1 photograph should include an object of reference for scale purposes (e.g. a ruler or soft drink can).
1. What are some of the alterations or precautions made to your reptile enclosure if you are travelling or away from home?
 2. What are some of the alterations or precautions made to your reptile enclosure with weather or seasonal changes?

APPENDIX 2.0: INTERVIEW CODING SCHEME

Theme	Code	Abbreviation	Description
Thermoregulation	Behaviour	TB	Thermoregulation behaviour of reptile
	Physiological function	TPF	Physiological function depends on thermoregulation
	Ideal temperature	TIT	Temperature is ideal for reptile in question
	High temperature	THT	Temperature is too high for reptile in question
	Low temperature	TLT	Temperature is too low for reptile in question
	Low humidity	TLH	Humidity is too low for reptile in question
	Hot seasons	THS	Seasonal influence on thermoregulatory ability
	Cold seasons	TCS	Seasonal influence on thermoregulatory ability
Husbandry	Good practices	HGP	Mentions of good reptile keeping practices
	Poor practices	HPP	Mentions of poor reptile keeping practices
Knowledge	High knowledge levels	KHL	Owners have lots of knowledge on reptile keeping or husbandry
	Low knowledge levels	KLL	Owners have little knowledge on reptile keeping or husbandry
Information available	High amount	IHA	Lots of information on reptile keeping or husbandry
	Low amount	ILA	Little information on reptile keeping or husbandry
	Good sources	IGS	Good information sources available to public
	Poor sources	IPS	Poor information sources available to public
	High cost	IHC	Information available is costly
Health issues	Diet issues	HIDI	Improper diet leads to health issue
	Equipment failure	HIEF	Equipment failure leads to health issue
	Calcium deficiency	HIC	Health issue identified
	General infection	HIGI	Health issue identified
	Respiratory infection	HIRI	Health issue identified
	<u>Bacterimic</u>	HIB	Have bacteria in their bloodstream
	Burns	HIBU	Burns from heat source
	Disease	HID	Health issue identified
	Death	HIDE	Health issue identified
	Water quality	HIW	Poor water quality leads to health issues
	Dehydration	HIDY	Health issue identified
	Renal issues	HIRL	Health issue identified

Physiological functions	Immune system	PFIS	Requires heat to function
	Digestion	PFD	Requires heat to function
	Nutrition	PFN	Requires heat to function
	Metabolism	PFM	Requires heat to function
	Healing	PFH	Requires heat to function
	Day/night cycle	PFDN	Affected by enclosure lighting
	Calcium production	PFC	Affected by UV lighting
Enclosure	Thermostat	ET	Mentions of this enclosure feature or equipment
	Thermometer	ETR	Mentions of this enclosure feature or equipment
	Lighting	EL	Mentions of this enclosure feature or equipment
	UV lighting	EUV	Mentions of this enclosure feature or equipment
	Size	ES	Mentions of this enclosure feature or equipment
	Heat lamp/globe	EHL	Mentions of this enclosure feature or equipment
	Ceramic heat lamp/globe	ECH	Mentions of this enclosure feature or equipment
	Globe cage	EGC	Mentions of this enclosure feature or equipment
	IR lighting	EIR	Mentions of this enclosure feature or equipment
	Heat rock (electronic)	EHR	Mentions of this enclosure feature or equipment
	Heat mat	EHM	Mentions of this enclosure feature or equipment
	Radiant heat panel	ERH	Mentions of this enclosure feature or equipment
Opportunities	Design	OD	Identified design opportunities
	Regulation/legislation	ORL	Identified opportunities to change regulation/legislation
Reptile type	Snakes	SN	Conversation refers to snakes
	Lizards	LI	Conversation refers to lizards
	Turtles	TU	Conversation refers to turtles

APPENDIX 2.1: CULTURAL PROBE CODING SCHEME

Theme	Code	Abbreviation	Description
Enclosure	Thermostat	ET	Inclusion of this enclosure feature or equipment
	Thermometer	ETR	Inclusion of this enclosure feature or equipment
	Lighting	EL	Inclusion of this enclosure feature or equipment
	UV lighting	EUV	Inclusion of this enclosure feature or equipment
	Heat lamp/globe	EHL	Inclusion of this enclosure feature or equipment
	Ceramic heat lamp/globe	ECH	Inclusion of this enclosure feature or equipment
	Globe cage	EGC	Inclusion of this enclosure feature or equipment
	IR lighting	EIR	Inclusion of this enclosure feature or equipment
	Heat mat	EHM	Inclusion of this enclosure feature or equipment
	Basking rock	EBR	Inclusion of this enclosure feature or equipment
	Ventilation	EV	Inclusion of this enclosure feature or equipment
	Visible temperature reading	EVT	Inclusion of this enclosure feature or equipment
	Humidifier	EHU	Inclusion of this enclosure feature or equipment
	Size small	ESS	Small enclosure size
	Size medium	ESM	Medium enclosure size
	Size large	ESL	Large enclosure size
	Size very large	ESVL	Very large enclosure size
Away from home alterations	None	ANO	No alterations made to enclosure
	Lower temperature	ALT	Lowering temperature in enclosure
	Petsit	AP	Someone checks on reptile during away period
Seasonal alterations	None	SNO	No alterations made to enclosure
	Increase heat sources	SIHS	Increase heat source amount to achieve ideal temperatures
	Increase insulation	SII	Increase insulation to maintain heat in enclosure
	Reduced insulation	SRI	Reduce insulation to limit heat in enclosure
	Heat hours	SHH	Increase or decrease in time providing heat to reptile
	Reduce ventilation	SRV	Reduce ventilation to maintain heat in enclosure
	Increased ventilation	SIV	Increase ventilation to maintain heat in enclosure
	Lower temperature	SLT	Lowering temperature in enclosure
Opportunities	Design	OD	Identified design opportunities

APPENDIX 3.0: KEY CRITERIA JUSTIFICATION

Criteria Number	Criteria	Justification
6.4.1.1	Must provide current and reliable information regarding appropriate reptile husbandry	All interview participants and 26% of survey responses in Figure 8 highlighted that there is a lack of appropriate information for reptile husbandry.
6.4.1.2	Must provide a level of information that is deeper than current information available on online groups and forums.	All the interview participants suggested that online groups and forums are generally poor sources of information because of the amount of misinformation and opinionated husbandry practices they contain.
6.4.1.3	Should increase the level of husbandry knowledge of reptile keepers.	Figure 11 outlines the level of knowledge expressed by survey participant where only 15% of respondents were considered 'highly knowledgeable'. Comments by interview Participant 3 mentions some reptile owners completely lack knowledge.
6.4.1.4	Should provide regular information updates	Interview Participant 3 mentioned that a lot of books on reptiles are outdated and referred to the literature as good, current sources of information.
6.4.2.1	Must be widely accessible to reptile keepers and owners.	The survey indicated that the majority of participants obtained information through websites and online forums (Figure 10) which are widely accessible to the public.
6.4.2.2	Must be easily accessed without the need for specific industry or organisational privileges.	Interview Participant 3 spoke of current literature such as journal articles as good sources of information however, these articles and databases are rarely available to the public without a substantial cost or an industry or organisational account.
6.4.2.3	Cost of access to information should not be excessively high	Interview Participant 3 mentioned high costs of information as a barrier to people accessing quality information.
6.4.3.1	Must be suitable for a range of enclosure sizes.	The cultural probe results (Figure 16) indicates that a wide range of enclosure sizes are present with reptile keepers.
6.4.3.2	Must be applicable to a wide range of reptile species commonly kept.	Findings from all research methods indicated a vast range of reptile species are kept amongst owners.
6.4.3.3	Should be easy to install within reptile enclosures.	Interview Participant 2 mentioned that some injuries sustained by reptiles result from equipment failing or falling out of enclosures which resulted in issues such as improper heat regulation.