Evaluation of Enrichment for Reptiles in Zoos

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Table of Contents

Summary iii

Introduction 1

Methods 4

Table 1. Environmental enrichment category definitions as appeared in survey 5

Data Analysis 5

Results 6

Table 2. Accreditation status of zoos 6

Table 3. Number of individual reptiles per group 6

Table 4. Percentage of reptiles in each group receiving different enrichment forms and chi-square test results 7

Table 5. Reason for providing reptiles with enrichment 9

Table 6. How enrichment is assessed for effectiveness 10

Table 7. Sources of information for reptile environmental enrichment ideas 11

Discussion 12

Respondents 12

Reptiles and Environmental Enrichment Differences 12

Assessment and Information 14

Policy Implications 15

Conclusion 17

References 18

Summary

Studies on environmental enrichment for reptiles are lacking in the scientific literature. While the literature reflects a limited take on reptile enrichment in the zoological community, this may not be the case in reality as enrichment is generally considered an important aspect of captive animal care. This project investigated the current state of reptile enrichment as it is being used in zoos. Although respondents were disproportionately Association of Zoos and Aquariums accredited, results showed many forms of enrichment being used for reptiles in zoos and happening at much greater levels than what is suggested by the scientific literature. There were significant differences between (1) reptile groups for each form of enrichment, and (2) enrichment forms within each reptile group, except for with the use of natural enrichment devices and structural/habitat design, which did not differ across all reptile groups. Enrichment goals, assessment methods and sources of information for reptile enrichment used by zoos suggest the need for more scientific publications in order for facilities to make evidence-based decisions to improve the welfare of captive reptiles.

Keywords: Reptiles, Environmental Enrichment, Animal Welfare, Zoos

Introduction

Reptile behavior largely originates from a genetic component that does not require social learning; these are a type natural behavior referred to as innate (Warwick, 1990a). In this way, when reptiles are born, they are perfectly adept to survive in the environment they have been genetically sculpted for. When reptiles are then removed from their natural environment, and not provided with appropriate stimuli, their innate behaviors are unable to function properly.

Stereotypies and abnormal behaviors in captivity are often a result of natural behaviors unable to be fully realized (Mason, 1991) and are often indicators of stress (Cowen, 1980). Reptile stress indicators can be generalized into two different categories: hyperactivity (which can be described as trying to remove oneself from an aversive situation), or hypoactivity (which can be described as trying to “wait out” an aversive situation) (Warwick, 1990b).

In captivity where biological needs are readily met even a reptile’s slower metabolism may produce enough energy for play behavior. Occurrences of play behavior for several reptilian species are documented by Burghardt, Ward and Rosscoe (1996), and in Burghardt (2013). This excess energy, if not properly directed, has the potential to develop into abnormal behaviors (Burghardt et al., 1996).

Caution must be taken not to equate the presence of innate behaviors with simple cognitive function. An accumulating number of studies are showing the complex cognitive abilities of reptiles (Burghardt, 2013; Kis, Huber & Wilkinson, 2014; Leal & Powell, 2012; Manrod, Hartdegen & Burghardt, 2008).

Observation of qualities such as abnormal behaviors, complex cognitive abilities, and play behavior often suggest the need to provide a stimulating environment. Environmental enrichment is a common tool used to “enhance the quality of captive care by identifying and providing environmental stimuli necessary for optimal psychological and physiological wellbeing” (Swaisgood & Shepherdson, 2005, pg. 500).

While the discussion of environmental enrichment for reptiles is growing, the number of studies is still limited. De Azevedo, Cipreste, and Young (2007) searched for peer-reviewed environmental enrichment papers between 1985-2004. They report that 0.57% of enrichment studies were for reptiles while 92.2% for mammals and 8.24% for birds. Melfi’s (2009) review considered knowledge gaps in regards to zoo animal welfare. In Melfi’s search for British and Irish Association of Zoos and Aquariums (BIAZA) research projects between 1998-2008, 1.8% of projects featured reptiles, compared to 89% mammals and 8% birds. Most recently, Alligood and Leighty’s (2015) search for peer-reviewed zoo environmental enrichment articles from 2002-2014 found 7% relating to reptiles and amphibians, while primates had the largest percentage at 36%. Felines had 21%, and bears had 13% for comparison. The scarcity of enrichment studies for reptiles’ offers little evidence-based guidance on how to provide reptiles with an appropriately stimulating environment in order to promote individual well-being.

While the literature reflects a limited take on reptile enrichment in the zoological community, this may not be the case in reality as enrichment is generally considered an important aspect of captive animal care. This project will give an assessment for the current state of reptile enrichment as it is being used in zoos, exposing where more

research, education and/or facility resources may be directed. In order to accomplish this objective, this study aims to answer five primary questions:

1. To what extent is environmental enrichment being used for reptiles in zoos?
2. Are there differences between reptile groups in with regard to the different forms of environmental enrichment?
3. Within each reptile group, are there environmental enrichment techniques that are used more than others?
4. Is the environmental enrichment provided being assessed for effectiveness?
5. Where are zookeepers getting environmental enrichment ideas for their reptiles?

Methods

An online survey was used to collect responses on facility practices in regards to reptile enrichment over the months of July and August 2015. The survey platform Qualtrics provided by Tufts University was used to create, distribute and collect the survey. A list of active licensed exhibitors in the United States (n=2,578) was obtained from the United States Department of Agriculture. General public contact information, including email or website contact forms, were collected for 206 zoos and used to distribute the survey.

For the purposes of this study, reptiles have been divided into seven groups: (1) non-venomous snakes, (2) venomous snakes, (3) turtles, (4) crocodilians, (5) tortoises, (6) monitor lizards (of the genus *Varanus*), and (7) non-monitor lizards. Non-venomous and venomous snakes were divided due to differences in husbandry and management techniques. Monitor and non-monitor lizards were divided due to differences in size, husbandry technique, and perceived cognitive complexity (Manrod et al., 2008).

Table 1 outlines the different environmental enrichment categories presented as options to participants of the survey. The categories were adapted from the Association of Zoos & Aquariums' (AZA) webpage on forms of enrichment (AZA, 2014). The definitions here were provided during the survey before respondents were asked to identify which environmental enrichment forms were being utilized.

Table 1. Environmental enrichment category definitions as appeared in survey.

Category	Definition
Food	Novel food presentations (fresh, frozen, live, different textures), the use of puzzle boxes, having food hidden or scattered throughout the enclosure, etc.
Olfactory	Application (artificial or natural) of pheromones, predator or prey scents, or novel scents (spices or perfumes), etc.
Training/ Behavior Modification	Training for standard husbandry and/or medical procedures, training for public presentations, etc.
Natural Enrichment Devices	Branches, leaves, rocks, flowers, hay, etc.
Man-Made Enrichment Devices	"Toys", man-made items added for novelty.
Social	Members for the same species housed together to mimic natural social groupings or mixed species groupings that provide complementary behaviors between species, etc..
Structural/ Habitat Design	Variety of substrates, terrestrial and aquatic considerations, elevated platforms, climbing structures, nesting areas, space considerations, etc..
Other	Any other practices by this facility considered to be enrichment.

Notes. Categories and definitions were modeled after AZA categories and definitions for enrichment (AZA, 2014).

Data Analysis

Chi-square tests were used to determine if significant differences exist between (1) reptile groups for each from of enrichment, and (2) enrichment forms within each reptile group. The 'other' enrichment forms category was not included in chi-square tests, expected values for this category were too low and write-ins came from the same few zoos with the same responses for each reptile group, therefore not offering any valuable insight into the data. All other data was analyzed using descriptive statistics.

Results

The survey had a 37% response rate (n=76); AZA-accredited zoos were disproportionately represented among respondents (Table 2). 95% of zoos (n=54) reported using environmental enrichment with their reptiles, with a high percentage of all reptile groups receiving enrichment (Table 3).

Table 2. Accreditation status of zoos.

Accreditation	Number of Surveys Sent Out	Percent Responded
AZA	121	44%
ZAA	16	25%
None	69	20%

Table 3. Number of individual reptiles per group.

Number of Zoos with:	Enriched	Not Enriched
Non-Venomous Snakes	72	3
Venomous Snakes	41	0
Turtles	65	3
Crocodilians	54	2
Tortoises	63	4
Monitor Lizards (Genus *Varanus*)	39	1
Non-Monitor Lizards	63	4

Notes. Total number of zoos that provide reptiles with enrichment, n=72.Total number of zoos that do not provide reptiles with enrichment, n=4.

Table 4. Percentage of reptiles in each group receiving different environmental enrichment forms and chi-square tests results.

	Food	Olfactory	Training/ Behavior Modification	Natural Enrichment Devices	Man-Made Enrichment Devices	Social	Structural/ Habitat Design	Other	Chi-Square test results: Differences between enrichment forms within each reptile group.
Non-Venomous Snakes	60% (43)	63% (45)	21% (15)	85% (61)	58% (42)	35% (25)	88% (63)	4% (3)	x^2=104.6 P=2.79x10^{-20}
Venomous Snakes	54% (22)	46% (19)	27% (11)	85% (35)	39% (16)	37% (15)	85% (35)	5% (2)	x^2=54.2 P=7.0x10^{-10}
Turtles	91% (59)	38% (25)	38% (25)	83% (54)	63% (41)	55% (36)	89% (58)	3% (2)	x^2=90.3 P=2.61x10^{-17}
Crocodilians	87% (47)	22% (12)	74% (40)	70% (38)	33% (18)	28% (15)	76% (41)	4% (2)	x^2=95.1 P=2.60x10^{-18}
Tortoises	92% (58)	43% (27)	54% (34)	86% (54)	68% (43)	56% (35)	84% (53)	3% (2)	x^2=62.7 P=1.28x10^{-11}
Monitor Lizards	100% (39)	67% (26)	79% (31)	85% (33)	62% (24)	36% (14)	92% (36)	3% (1)	x^2=57.6 P=1.41x10^{-10}
Non-Monitor Lizards	89% (56)	52% (33)	38% (24)	84% (53)	70% (44)	35% (22)	89% (56)	3% (2)	x^2=92.3 P=1.03x10^{-17}
Chi-square test results: Differences between reptile groups using…	x^2=64.6 P=5.15x10^{-12}	x^2=29.4 P=5.16x10^{-5}	x^2=63.9 P=7.15x10^{-12}	x^2=6.72 ***P*=0.348**	x^2=26.6 P=1.69x10^{-4}	x^2=17.9 P=6.52x10^{-3}	x^2=7.23 ***P*=0.300**		

Notes. Numbers in parentheses are raw number of respondents. Total number of individuals for each reptile group may be found in Table 3. The 'other' category is not included in chi-square tests. Bold p-values are not significant at α=0.05.

Structural/habitat design and natural enrichment devices are widely used across all reptile groups, both showing no significant differences between reptile groups (Table 4). The correlation between these two forms of enrichment (r^2=0.64) may be explained by the common usage of natural enrichment devices to create the structural aspects of habitat design (i.e. branches and rocks)(Almli & Burghardt, 2006; Cardiff, 1996; Rose et al., 2014; Rosier & Langkilde, 2011). Differences between all other forms of enrichment across and with in all reptile groups were found to be significant (Table 4).

Food is the most commonly used form of enrichment for all reptile groups except for snakes (venomous and non-venomous). Both venomous and non-venomous snakes are most likely to receive structural/habitat design and natural devices and are both least likely to receive training. The differences between venomous and non-venomous snakes can be seen in the use of olfactory enrichment where non-venomous snakes receive 17% more, and with man-made enrichment devices where non-venomous snakes receive 19% more (Table 4).

Turtles and tortoises are also similar in the amounts of enrichment they receive, and both are the most likely groups to receive social enrichment. The most apparent differences between these groups is tortoise receiving 16% more training/behavior modification than turtles (Table 4).

While there are similarities between venomous and non-venomous snakes and between turtles and tortoises, the same cannot be said for monitor lizards and non-monitor lizards. Monitor lizards are most likely to receive food enrichment and the most likely reptile group to receive food, training/behavior modification, and olfactory

enrichment. Non-monitor lizards are most likely to receive food or structural enrichment and are the most likely group to receive man-made enrichment devices. There are several apparent differences between these groups: monitor lizards receive 41% more training, 15% more olfactory, and 11% more food enrichment (Table 4).

While crocodilians are not the most likely group to receive any form of enrichment, they are the least likely to receive olfactory, man-made enrichment devices and social enrichment (Table 4).

Write-ins for the 'other' category included misting, temperature variations, auditory (playing music or species specific sounds), and outdoor exposure.

Participants were asked if a schedule was used to track provision of enrichment to reptiles, 38% of participants responded yes, and 63% no. Of those that do use a schedule, 93% track how often and 100% track what kind of enrichment was provided. Participants were also asked about their reasons for providing enrichment (Table 5) as well as how any assessments of the enrichment were made (Table 6).

Table 5. Reasons for providing reptiles with enrichment.

Reasons:	**Percentage:**	**Primary Reason:**	**Percentage:**
Promote Natural/ Species Specific Behaviors	99%	Promote Natural/ Species Specific Behaviors	83%
Behavioral Conditioning	61%	Behavioral Conditioning	4%
Reduce Stereotypies/ Abnormal Behaviors	53%	Public Education	4%
Public Education	49%	Other Primary Reason	4%
Aesthetics	42%	Aesthetics	3%
Other Reasons	17%	Reduce Stereotypies/ Abnormal Behaviors	1%

Notes. Percentages calculated out of zoo total (n=72) that provide enrichment to their reptiles.

Table 6.
How Enrichment for Reptiles is Assessed for Effectiveness.

Assessment Method	Percentage
Use of Provided Enrichment by the Reptiles	78%
Increase in Desired Behavior	58%
Reduction of Undesired Behavior	35%
Biological Growth Measurements (i.e. growth, weight, shedding)	25%
Reptile Stress Indicators are Monitored	24%
No Formal Assessments are Made	14%
Corticosterone (CORT) Levels are Analyzed	0%
Other	0%

Notes. Percentages calculated out of the zoo total (n=72) that provide enrichment to their reptiles.

Overwhelmingly, the most important reason given for enrichment was to "Promote Natural/Species Specific Behaviors" (Table 5). Responses for “other reasons” included general promotion of wellbeing (50% of the 17%), exercise, and protocol. Write-ins for “other primary reason” all center on a general promotion of wellbeing.

Most respondents used behavioral measurements to assess enrichment, including use of the enrichment and increases or decreases of desired and undesired behaviors (Table 6). A relatively small proportion used biological measurements; 14% did not use any assessment at all.

Participants are primarily relaying upon word-of-mouth for information on enrichment ideas for reptiles. 64% of all primary sources are un-reviewed hearsay sources (word-of-mouth and the internet). Whereas only 31% of participants used sources that might be considered highly credible (primary sources, peer reviewed

articles, and zoo accreditation-related networking). Write-ins for “other sources” generalized to original ideas (57% of the 10%), and professional guidance (43% of the 10%). Responses for “other primary source” also included original ideas and professional guidance (Table 7).

Table 7. Sources of information for reptile environmental enrichment ideas.

Sources:	**Percentage:**	**Primary Source:**	**Percentage:**
Zookeepers (word of mouth)	96%	Zookeepers (word of mouth)	53%
Internet	78%	Zoo Accreditation Supplied Networking	17%
Peer-reviewed Published Journal Articles	64%	Internet	13%
Zoo Accreditation Supplied Networking	60%	Peer-reviewed Published Journal Articles	11%
Herpetology Magazine	56%	Other Primary Source	4%
Other Sources	10%	Herpetology Magazines	1%

Notes. Percentages calculated out of the zoo total, (n=72) that provide enrichment to their reptiles.

Discussion

Respondents

It is unclear whether the 37% response rate can be extrapolated to all zoological facilities. One potential bias with this study is zoos that do provide environmental enrichment to their reptiles may have disproportionately responded to the survey. On the other hand, several of the larger, well-known, major city zoos' automated responses indicated they could not participate due to the volume of requests they receive. Because these are large, AZA-accredited zoos with more resources than smaller zoos it is probable that they are using environmental enrichment with their reptiles, suggesting that the number of zoos that do use environmental enrichment with their reptiles might be larger than is suggested by this survey.

What this study does show is what is being done at zoos that do use environmental enrichment with their reptiles. Most importantly, even if this study may not be an accurate depiction of the entire zoological field, the number of responses collected does indicate that the use of environmental enrichment with reptiles is more prevalent than what is depicted in the scientific literature.

Reptiles and Environmental Enrichment Differences

This study indicates there are many forms of environmental enrichment being used for reptiles in zoos, as well as statistically significant differences between reptile groups per form of enrichment (Table 4). The provision of complex and stimulating environments increases desired behaviors (Almli & Burghardt, 2006; Burghardt et al., 1996; Cardiff, 1996; Case, Lewbart & Doerr, 2005; Phillips et al., 2011; Rose et al., 2014) and

improves cognitive function as observed by increases in problem solving abilities (Almli & Burghardt, 2006; Manrod et al., 2008; Noble, Cazaro & Whiting, 2012)

Each form of enrichment stimulates different aspects of the senses necessitating all forms of enrichment to be provided (Bloomsmith, Brent & Schapiro, 1991). Food enrichment allows for reptiles, who are natural hunters/browsers, to participate in active food searches (Warwick, 1990b). Structural/habitat design, man-made and natural enrichment devices may be used to facilitate natural environmental interactions, allowing natural social interactions, which may allow for reproductive behaviors (Rose et al., 2014). Many reptiles explore their environments using an olfactory component or additional senses beyond our perception (Clark & King, 2008). Training/behavior modification allows for complex cognitive function to be exercised (Kis et al., 2014; Manrod et al., 2008) and may provide improved safety and husbandry protocols for zookeepers (Augustine & Baumer, 2012; Augustine, Titus & Foster, 2013). Rather than varying the use of these enrichment forms per species, species-specific variation should be happening within all forms of enrichment.

Because these enrichment forms will require modulation for different species, scientific literature would be useful in guiding choices of enrichment. The data collected by this study allows us to see a correlation between field usage and scientific publications. The study by de Azevedo et al. (2007) found structural enrichment to be the most commonly studied form of enrichment in the scientific literature. This is encouraging, since the current study shows the common usage and even distribution of structural/habitat design and natural enrichment devices across all reptiles groups. Publication of more studies on varying forms of enrichment across many different

species might also be reflected in the field. For enrichment practices that are already happening, scientific publications may help those forms develop standardized norms.

One area particularly lacking in scientific study is olfactory enrichment. While many reptiles explore their environment using an olfactory component and this form of stimulation is recommended for use with reptiles (AZA, 2014), very little is understood about reptile perception of it (Clark & King, 2008). Something to consider for future studies may be the monitoring of CORT levels in conjunction with the provision of olfactory enrichment, particularly in the case of presenting predator scents. Questions such as are CORT levels being raised, if so for how long, and do the animals habituate to the scents over time should be answered.

Assessment and Information

Completing assessment on enrichment is important because perceptions of preferences may not always be accurate (Gaalema, Perdue & Kelling, 2011; Mehrkam & Dorey, 2015; Morgan, Line & Markowitz, 1998). A recent study by Mehrkam and Dorey (2015) found that while zookeepers are able to predict what animals will not like, they are not accurate in predicting an animal's preferred enrichment stimuli. Furthermore, they were least accurate at predicting preferred enrichment for reptiles, with only a 5.8% accuracy. Fortunately, paired-stimulus preferences assessments measured using time-budgets are time and cost effective as well as an accurate tool for evaluating enrichment preferences, even taking into account individual preferences (Hoy et al., 2010; Mehrkam & Dorey, 2015, pg. 10).

While this study's data shows that a variety of assessment methods are being used (Table 7), results also indicate that the majority of zoos are not using a schedule to track their provision of enrichment to reptiles. The provision of stimuli cannot technically be considered enrichment without goals and assessment (Alligood & Leighty, 2015; Hoy et al., 2010).

When considering all species, Alligood and Leighty (2015) found the primary enrichment goal in zoos to be for decreasing stereotypies. Contrary to the findings of Alligood and Leighty, this study has found that when considering only reptiles, the primary enrichment goal is to increase natural behaviors. In fact, decreasing stereotypies is the least likely goal (Table 5). While these results may seem like progress, to be promoting natural behaviors so stereotypies do not manifest, this is much more likely because of the difficulty in identifying abnormal behaviors in reptiles.

Policy Implications

The data collected by this study shows that the most common sources of information for zookeepers on enrichment ideas for reptiles, comes from other zookeepers (Table 8). It is also suggested by the 'other sources' write-ins that these are original ideas being shared. These findings are concerning given the results of Mehrkam and Dorey (2015) and Gaalema et al. (2011) discussed above.

Therefore, one of the hopes for this study is to encourage zookeepers to research forms of enrichment and monitor for effectiveness to ensure appropriate forms of enrichment are being provided. Setting up enrichment monitoring/schedules for reptile enrichment and protocols for implementing new forms of enrichment may help

guide zookeepers through the enrichment process (Alligood & Leighty, 2015). These protocols may also help to facilitate discussion between researchers, management and animal caretakers (Melfi, 2009). Dialogue between these three groups is key for ensuring effective implementation while considering time and budget constrains as well as animal welfare concerns.

Another hope of this study is to encourage zoos to perform and publish environmental enrichment papers on reptiles for different forms of enrichment. Swaisgood and Shepherdson (2005) point out that the most useful information on the topic of enrichment will come from multi-institutional studies using large sample sizes. While it may be unrealistic to ask for all this data from one study, published works from many institutions with the populations they have will start to give a better understanding on reptile enrichment.

The final hope for this study is to help facilitate getting information about reptile enrichment to zookeepers. While the study indicates that the primary source for information is from other zookeepers, the data also shows that zookeepers are looking at all sources for information.

Conclusion

This study suggests that environmental enrichment for reptiles is happening at much greater levels in zoos than is suggested by the scientific literature. While this study limited its scope to zoological facilities, reptiles may be kept in other educational facilities (i.e. schools or museums) where results may be different. The data from this study did show differences between and within reptile groups in regard to the use of different enrichment forms. These differences seem to be a reflection of our current perceptions towards reptile cognition and behavior. These perceptions however, may not be well grounded in a complete understanding of the topic.

While there is assessment happening in zoos, the data suggests that it is limited and unsystematic. Promoting assessment and publications within the zoological community in regards to reptile enrichment may encourage zookeepers to assess and publish original ideas as well as utilize reputable sources of information for other enrichment ideas. Overall, additional scientific publications on reptile enrichment are needed in order to promote assessment and implementation of protocols to improve the welfare of reptiles in captivity.

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