Morbidity of Fiji Banded Iguanas (*Brachylophus bulabula*) in the San Diego Zoo Collection from 2000–2010

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Abstract: Medical records of 63 Fiji banded iguanas (*Brachylophus bulabula*) examined by veterinarians at the San Diego Zoo from January 2000 to May 2010 were reviewed to identify age, sex, presenting complaint, final diagnosis, and outcome. A total of 154 presentations were recorded, which included 63 individual animals. Females outnumbered the males, both in number of presentations and in mean presentations per individual. Trauma was the most frequent diagnosis (39%) and, of those cases, conspecific inflicted trauma was more common than trauma from environmental elements. In addition, the majority of conspecific trauma presentations were female (86%). Additional causes of morbidity included reproductive, idiopathic, infectious, congenital, inflammatory, and neoplastic conditions. All reproductive presentations were female. In hatchlings, congenital issues made up the majority of presentations. The majority of cases improved (84%), 8% were euthanized, 4% died, and 3% remained static but stable. The overall mortality rate during the 125 month study period was 20%.

Key Words: *Brachylophus bulabula*, Fiji banded iguana, morbidity, reproductive, trauma.

Introduction

The genus *Brachylophus*, comprising three species, represents the most geographically isolated iguanid species in the world (Gibbons, 1981, 1984). All three species of *Brachylophus* are listed as endangered on the International Union for Conservation of Nature and Natural Resources (IUCN, 2012) Red List of Threatened Species, ranging from endangered to critically endangered, and have decreasing population trends (www.iucnredlist.org). The most recently identified species, *Brachylophus bulabula* (Fiji banded iguana), was previously grouped with the other species of Fiji banded iguana, *Brachylophus fasciatus* (Lau banded iguana) (Keogh *et al*., 2008). These species are striking in their sexual dimorphism (Fig. 1). The San Diego Zoo (SDZ) houses the largest population of Fiji banded iguanas outside Fiji (Kinkaid, 2003) and has had a successful breeding colony since 1987 (Stacy *et al.*, 2008). Their husbandry and health management in captivity is vital to the well being of the species for future conservation efforts.

Morbidity, the incidence of disease in a specific community, is an important area of research in captive breeding programs of endangered species. The purpose of this study was to identify problems that occur commonly, reveal general trends and patterns, and potentially identify areas of improvement in husbandry, diagnostic procedures, or treatment of diseases in Fiji banded iguanas. To the authors' knowledge, morbidity studies on captive populations of Fiji banded iguanas have not been previously published.

Materials and Methods

Husbandry: Individuals or breeding pairs were housed in 1.5 m × 1.5 m × 1.8 m (4.9 ft × 4.9 ft × 5.9 ft) screen enclosures with dark mesh covering the sides to prevent visual contact between animals in adjacent enclosures. Enclosures contained branches with foliage for climbing. Animals had access to direct sunlight every third day and ultraviolet light daily. The main diet fed consisted of a green vegetables mixture with approximately 15% mixed fruit. Animals were fed a variety of insects 3 days a week and were fasted 1 day a week. Water was misted on the leaves in the enclosure as well as provided in bowls. Animals were visually monitored by keepers each day, and if an animal appeared to require veterinary attention, the veterinary staff was notified.

Medical record review: The medical records of all Fiji banded iguanas in the SDZ collection from January 2000 to May 2010 were reviewed and data were recorded for each presentation to veterinary staff. For this study, one presentation was defined as any time an animal was seen by a veterinarian for any reason, excluding preshipment exam or data collection for scientific study. Follow-up examinations for the same condition were not counted as a separate presentation. Specific information collected included age, sex, presenting complaint, final diagnosis, and outcome. After data collection was complete, the data were evaluated and grouped based on several different parameters to reveal patterns and trends. Evaluation included the number of presentations by females vs. males, the type of diseases on presenting complaint and final diagnosis, and the types of diseases in relation to age. The total number of individuals in the SDZ collection between January 2000 and May 2010 (94 individuals) was tallied using the studbook (Kinkaid, 2009).

Case categorization: The presenting complaints of animals presenting to veterinary staff were divided into six categories: appearance, trauma, behavior, congenital, reproductive, and other. An animal was placed in the appearance category if the presenting complaint was that the animal

Figure 1. Striking sexual dimorphism representative of Fiji banded iguanas; males (*left*) have broad vertical blue bands while females (*right*) do not.

had an abnormality that could be seen externally (e.g., mass, wound, distended abdomen). Appearance differed from the trauma category by the reporting of a health condition in which the keeper did not witness the cause/origin of the injury. The behavior category included animals that presented for inappropriate behavior per the keeper (e.g., lethargy, inappetance).

The final diagnosis was divided into eight categories: traumatic, reproductive, infectious, congenital, idiopathic, inflammatory, neoplasia, and other. Trauma cases were further divided according to the cause (either conspecific or environment). These were classified as such only if the keeper observed either cagemate aggression or interaction with environmental elements. All other cases were classified as "unknown." The outcome was divided into four categories: resolved, euthanized, died, and static. In one presentation there was no notation of the outcome.

The age of the animals at presentation was recorded and categorized into groups: hatchling (less than 1 month), juvenile (between 1 month and 1 yr), subadult (between 1 yr and 1.5 yr) and adult (greater than 1.5 yr). The age groups were based on major changes in their life history. Due to the scarcity of presentations in both the juvenile and subadult age groups, the groups were combined when analyzing results.

Table 1. Age and sex of Fiji banded iguana presentations (n = 154) at the San Diego Zoo between January 2000 and May 2010.

Age group	Total number	Male	Female	Unknown
Hatchling	18	6	12	0
Juvenile/subadult	9	2	7	0
Adult	127	33	92	2
Total	154	41	111	2

Statistical analysis: Pearson's chi-square test was used to determine statistical significance between the total number of female and male presentations. The mean presentations per sex were determined using a weighted average for the number of presentations per individual. After the means were calculated for each sex, the difference of means was calculated using a two-tailed t-test to evaluate statistical significance. The P-value was set at <0.05 for both statistical analyses.

Results

Sex: From January 2000 to May 2010, Fiji banded iguanas were presented to the veterinary staff at the SDZ 154 times for various health reasons. These presentations comprised 127 adults, 9 subadults–juveniles, and 18 hatchlings (Table 1). Females consisted of 111 (72%) of these presentations while 41 (27%) were males. Two presentations were of animals of unknown sex. These 154 presentations were made up of 63 individual animals; 38 (60%) were female, 23 (37%) were male, and two (3%) were of unknown sex (data not shown). Thirty-eight individuals, 27 (71%) female and 11 (29%) male, presented more than once in the 125 month period of the study. The range of the number of presentations in repeat patients was two to seven. The census of Fiji banded iguanas in the SDZ collection from January 2000 to May 2010 consisted of 52% females and 48% males.

Overall, females were significantly more likely to present to the SDZ veterinary staff than were males ($\chi^2 = 26.923$, $P < 0.0001$). Female iguanas were also significantly ($P = 0.00046$) more likely to present to the SDZ veterinary staff when accounting for the weighted mean number of presentations (2.28) when compared with males (0.95).

Presenting complaint: The results for presenting complaint are presented in Figure 2. The most-common presenting complaint was that for appearance (36%), followed closely by trauma (34%). Behavior comprised a lesser portion (17%), with congenital following (9%). Reproductive and other made up the least number of presentations (3% and 1%, respectively).

Final diagnosis and age: Final diagnoses were broken down according to category and then subdivided by age (Fig. 3).

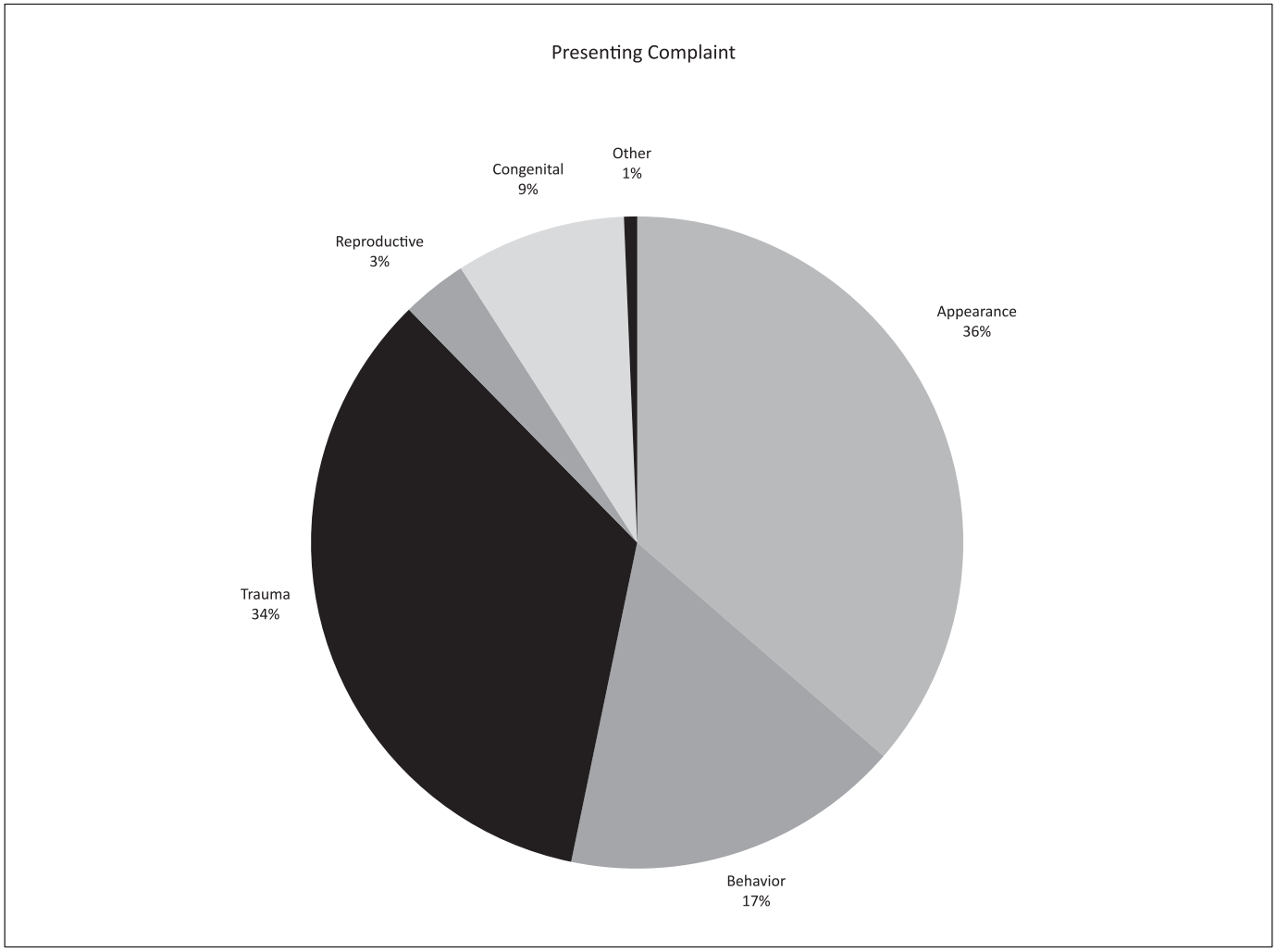

Figure 2. Presenting complaint of Fiji banded iguanas (n = 154) differentiated by category.

Trauma was the most-common diagnosis in the adult and subadult/juvenile age groups (43% and 56%, respectively), while congenital was most common in hatchlings (72%). In adults, the next most-common diagnosis was reproductive (20%), and all reproductive presentations were female. Infectious (12%) and idiopathic (11%) presentations comprised the next most-common diagnoses in adults (11% and 10%, respectively), followed by inflammatory (6%), neoplasia (5%) and other (5%). In subadults/juveniles, idiopathic and other diagnoses were equally common (22%) with two presentations each. In hatchlings, idiopathic diagnoses were second-most common with 3 presentations (16%) followed by one presentation each of trauma and other (6%).

Overall, trauma was the most-frequent diagnosis (39%). Trauma was further divided into conspecific, environmental, or unknown causes (Table 2). Conspecific trauma made up almost half (48%) of the total trauma presentations and was more than double the number of environmental trauma presentations (22%). Eighty-six percent (86%) of conspecific trauma presentations were female while the majority of environmental trauma presentations were male (62%).

Outcome: The outcomes are summarized and categorized by final diagnosis (Table 3). The majority of presentations improved (84%). Three percent of presentations remained static, 8% were euthanized, and 4% died. One presentation (1%) did not have the outcome noted in the medical record. The individuals that were euthanized were diagnosed most commonly with reproductive issues (46%) followed by neoplasia (31%), other (15%), and congenital (7%). The individuals that died were diagnosed with reproductive disease (33%), idiopathic (33%), congenital (17%), and other (17%). The total mortality over the 125 month study period was 19 individuals (94 individuals in the population during study period). The mortality rate over the study period was 20%. Mortality rate for the period of study was determined as follows:

$$\frac{\text{Number of individual deaths during study period}}{\text{Number of total individuals in the collection}} \times 100.$$

Discussion

This study reviewed and categorized the various illnesses and injuries of Fiji banded iguanas that presented to veterinarians at the SDZ in relation to age and sex. A morbidity study of a population of an endangered species can provide

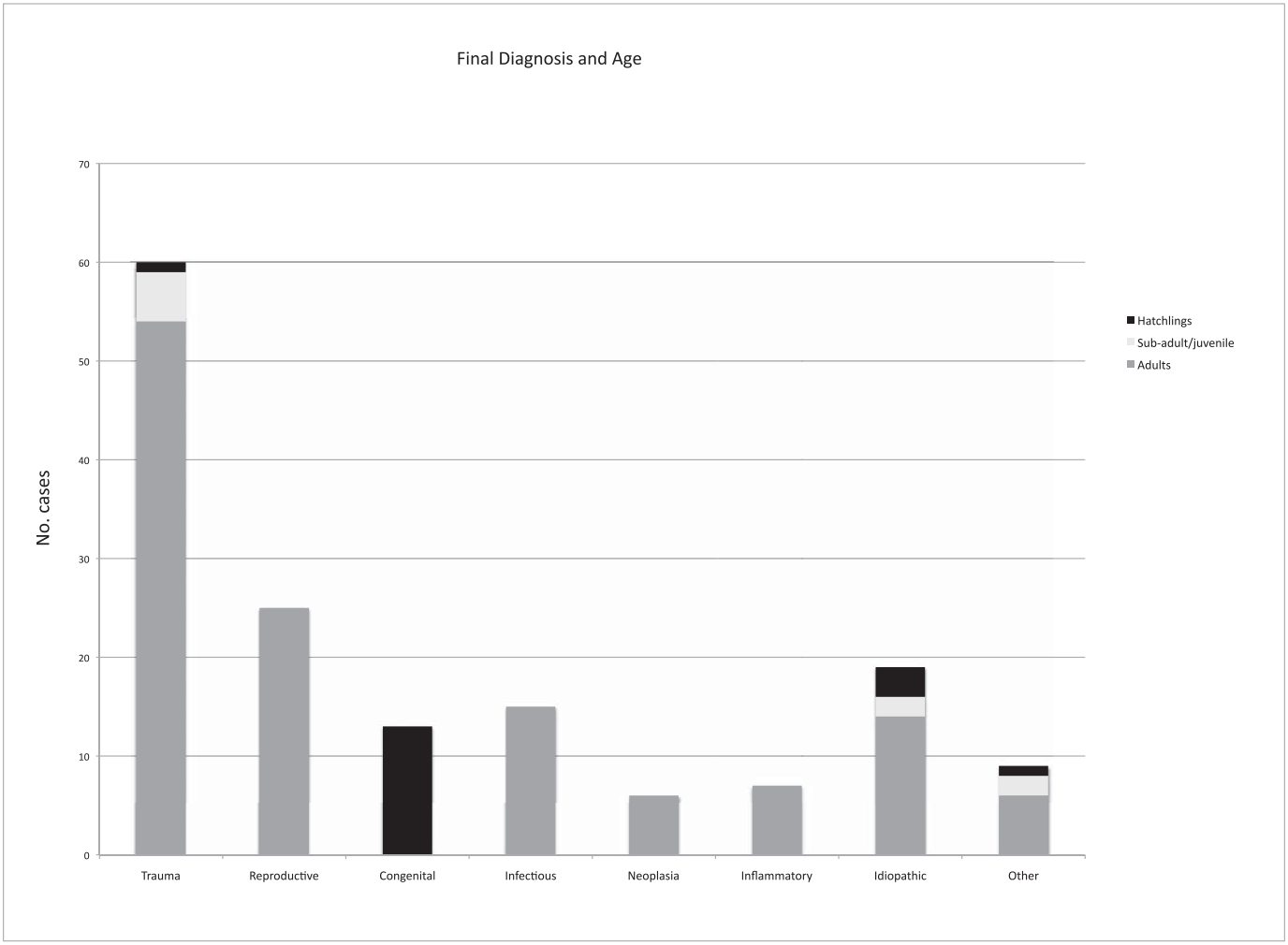

Figure 3. Presentations of Fiji banded iguanas (n = 154) differentiated by final diagnosis and age group.

valuable information about how that species adapts to living in captivity. This information is important for maintaining and improving the care of this species. A previous mortality study in captive reptilian species revealed 36.6% of deaths were caused by microbial agents, 12% by parasites, 11.5% by trauma, and 9.3% by nutritional deficiencies (Kaneene *et al*., 1985), which differs from the results in the present study.

Trauma was the most-common diagnosis for presentation to veterinary staff in this study population during the time period examined. The majority of these presentations were female, and conspecific trauma was the most-common cause. Because only breeding pairs are housed together, it seems that conspecific aggression between breeding pairs is a major problem. Aggressive behavior has been previously reported in this species (Carpenter and Murphy, 1978); however, the aggression was seen only in male–male displays for territorial dominance. This aggressive male behavior in Fiji banded iguanas at the SDZ previously prompted a change in husbandry such that green mesh was added on the sides of enclosures to prevent visual contact between males in adjacent enclosures. While this resolved the problem of male–male aggression, problems with aggression between breeding pairs still remains an issue. Anecdotally, conspecific aggression between breeding pairs at the SDZ has declined since steps have been taken to co-house breeding pairs early in life rather than after reaching sexual maturity. More research is needed to determine whether the incidence of aggression has indeed decreased since this change has been implemented. In wild iguanid lizards, aggression serves to establish social structure and is used to defend territory against intruders of the same species, especially in males (Carpenter, 1967). The results of the present study suggest that more behavioral studies are needed to determine what initiates conspecific aggression in a captive setting and, in turn, what management practices could be utilized to decrease injury without decreasing breeding success.

Table 2. Trauma presentations of Fiji banded iguanas (n = 60) differentiated by cause and sex.

Trauma type	Total number	Male (%)	Female (%)
Conspecific	29	14	86
Environment	13	62	38
Unknown	18	28	72
Total	60	28	72

Table 3. Outcome of all presentations of Fiji banded iguanas (n = 154) categorized by final diagnosis.

Outcome	Improved	Euthanized	Died	Static	Not Noted	Total
Trauma	60					60
Reproductive	17	6	2			25
Congenital	11	1	1			13
Infectious	15					15
Neoplasia	2	4				6
Inflammatory	7					7
Idiopathic	9		2	2	1	14
Other	1	2	1	2		6
Total	130	13	6	4	1	154

Females were more commonly seen than males by veterinary staff during the study period. Furthermore, the difference in average number of male and female presentations was statistically significant. The authors can postulate that the reasons for this are 2-fold: conspecific trauma and reproductive disease. In this study population, only females presented with reproductive disease. Yolk coelomitis is a major cause of death in adult female Fiji banded iguanas (Stacy *et al.*, 2008); this conclusion is supported by the present study. Yolk coelomitis has also been reported in Komodo dragons (*Varanus komodoensis*) (Spellman, 2002), white-throated monitors (*Varanus albigularis*) (Gardner and Barrows, 2010), and captive chelonians (Sykes, 2010). This disease is thought to be multi-factorial and a condition of captivity (Gardner and Barrows, 2010). Further studies are needed to understand this disease process in order to diagnose and implement management solutions.

An encouraging finding from the present study is that a majority of presentations later improved, indicating that this species is amenable to treatment, especially in the case of traumatic injury. All presentations that were diagnosed with trauma improved.

Future morbidity studies should be performed using data from an earlier time period (e.g., 1990–1999). Those results could then be compared with the results of this study to reveal trends over longer periods of time. Another related study would be a mortality study for the same time period (2000–2010), which would reveal more-detailed information about other causes of death besides reproductive issues. A mortality study could also look at the mortality rate compared with birth rate to evaluate the overall growth of the captive population.

Acknowledgments: We thank the San Diego Zoo reptile staff for their help with this project. We also thank Steve Culver, RVT, for the photograph of the female iguana in Figure 1.

Literature Cited

Carpenter CC. 1967. Aggression and social structure in Iguanid lizards. *In* Milstead WW (ed): Lizard Ecology: A Symposium. University of Missouri Press, Columbia, MO: 87–105.

Carpenter CC, Murphy JB. 1978. Aggressive behavior in the Fiji Island lizard *Brachylophus fasciatus* (Reptilia, Lacertilia, Iguanidae). J Herp, 12(2):251–252.

Gardner BR, Barrows MG. 2010. Yolk coelomitis in a white-throated monitor lizard (*Varanus albigularis*). J S Afr Vet Assoc, 81(2):121–122.

Gibbons J. 1981. The biogeography of *Brachylophus* (Iguanidae) including the description of a new species, *B. vitensis*, from Fiji. J Herp, 15(3):255–273.

Gibbons J. 1984. Iguanas of the South Pacific. Oryx, 18(2):82–91.

[IUCN] International Union for Conservation of Nature and Natural Resources. The IUCN Red List of Threatened Species [Internet]. 2012. Available from: www.iucnredlist.org. Accessed October 2012.

Kaneene JB, Taylor RF, Sikarskie JG, Meyer TJ, Richter NA. 1985. Disease patterns in the Detroit zoo: a study of reptilian and amphibian populations from 1973 through 1983. J Am Vet Med Assoc, 187(11):1132–1133.

Kinkaid J. 2003. The history of banded iguanas in United States collections. Iguana, 10:108–110.

Kinkaid J. 2009. AZA North American regional studbook on *Brachylophus fasciatus*, San Diego Zoo, San Diego, CA.

Keogh JS, Edwards DL, Fisher RN, Harlow PS. Molecular and morphological analysis of the critically endangered Fijian iguanas reveals cryptic diversity and a complex biogeographic history. Phil Trans Royal Soc Biol Sci, 363 (1508):3413–3426.

Spellman LH. 2002. Medical Management. *In:* Murphy JB, Ciofi C, de la Panouse C, Walsh T (eds.). Komodo Dragons: Biology and Conservation. Smithsonian Press, Washington, DC: 208–210.

Stacy BA, Howard L, Kinkaid J, Vidal JD, Papendick R. 2008. Yolk coelomitis in Fiji Island banded iguanas (*Brachylophus fasciatus*). J Zoo Wild Med, 39(2):161–169.

Sykes JM. 2010. Updates and practical approaches to reproductive disorders in reptiles. Vet Clin Exot Anim, 13(3): 349–373.