

Post-release Survival of Rehabilitated Brazilian Free-tailed Bats (*Tadarida brasiliensis cynocephala*)

MAENA C. VOIGT
DEPARTMENT OF WILDLIFE ECOLOGY AND CONSERVATION
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Abstract: Post-release studies of post-release behavior and survival are crucial to evaluate wildlife rehabilitation efficacy. Although large numbers of animals are admitted for rehabilitation across the country, few post-release survival studies have been conducted. Post-release studies are the only way to ascertain an individual's survival and a key variable in addressing the value of rehabilitation to wildlife populations. The goal of this study was to measure wildlife rehabilitation efficacy. One hypothesis is that capturing and handling stress negatively affects the survival of adult rehabilitated Brazilian free-tailed bats (*Tadarida brasiliensis cynocephala*). The second hypothesis is that injury negatively affects the survival of adult rehabilitated Brazilian free-tailed bats. In order to quantify the effects of capture, handling, and injury in rehabilitated bats the influences on survival, survival rates in three groups of bats were compared. Group one consisted of wild, healthy minimally handled bats; group two consisted of bats captive held and handled; and group three consisted of rehabilitated bats.

High transmitter loss, due to a number of factors, resulted in a small sample size. The results suggest that wildlife rehabilitation may in fact assist in the recovery, release, and survival of individual injured wildlife. There continues to be a need for carefully designed post-release studies with explicit objectives, especially for reintroductions of endangered species and/or captive bred animals.

Key words: Brazilian free-tailed bat, post-release, rehabilitation, stress, wildlife

INTRODUCTION

Wild animals are brought to wildlife rehabilitation centers in growing numbers due to concern for the well being of individual animals (Karesh 1995) with more than 440,000 wildlife cases handled each year by members of the National Wildlife Rehabilitators Association in addition to nearly one million telephone calls (Horton 1987). The objectives of wildlife rehabilitation include the rearing of young wild animals and the treatment of injured wildlife (Ludwig and Mikolajczak 1985). Many wildlife rehabilitation programs also provide training in the handling and care of injured wildlife to individuals, which can assist the training of those working with threatened or

endangered species or provide educational programs to the public (Karesh 1995). Wildlife rehabilitators cite the release of wildlife back into the wild as their main goal (Marion 1989). Two kinds of post-release studies exist. One group of studies involves captive reared animals or orphaned young. The other concerns injured wildlife. Although the groups of animals involved are markedly different, the rehabilitation processes that they undergo are similar.

Studies of Captive Reared and Orphaned Young Animals. Most post-release survival studies focus on captive reared animals or the placement of fostered young in the wild. Hand-raised grey-headed flying foxes (*Pteropus poliocephalus*) were released and monitored by radiotelemetry for twenty days (Augee and Ford 1999). The bats were found to have integrated into the colony at the release site and have long distance flights (Augee and Ford 1999). In Florida, captive reared and foster parent reared sandhill cranes (*Grus canadensis tabida*) were color banded and instrumented with solar powered leg-band transmitters before being released into the wild (Nesbitt and Carpenter 1993). Cranes that were captive raised were found to have higher first year survival rates than those raised by foster parents. Between 1988 and 1998, fifty captive manatees (*Trichechus manatus latirostris*) were released with radio tags as part of a post-release monitoring program in Florida. Twenty-four were either orphans or born in captivity (Bonde et al 2000). Twelve manatees died during the study period. Twenty-four were periodically captured for biomedical assessment in order to monitor their adjustment to the wild. Indices such as blubber thickness, weight, behavioral activity, and blood work were taken. Four captured manatees were eventually returned to captivity but two long-term captive females successfully gave birth to healthy calves following their release (Bonde et al 2000).

Maena C. Voigt holds a B.S. in Wildlife and Fisheries Conservation from the University of Massachusetts, Amherst, and a masters in Wildlife Ecology and Conservation from the University of Florida. She is currently interning as a Wildlife Biologist through the Environmental Careers Organization at the Bureau of Land Management in Jackson, MS.

Alt and Beecham (1984) reintroduced 84 orphaned black bear cubs (*Ursus americanus*) into the wild from 1973 to 1983. The adoptive mothers subsequently killed a quarter of them. Others had become habituated to humans and became nuisance animals needing recapture within four days of release. The total length of follow-up for each bear was not reported. In another study, transplanted red fox pups (*Vulpes vulpes*) were placed into occupied fox dens and the authors reported higher survival rates for the pups that were held in captivity for shorter periods (Andrews et al. 1973). Other fostering studies reported high post-release survival for raptors (Marti and Wagner 1980; Postupalsky and Holt 1975) and mixed results for songbirds (Brewer and Morris 1984).

Some of these studies indicate that some captive raised animals can survive in the wild. Other studies seem to indicate that the amount of time in captivity for animals that subsequently will be fostered in the wild may determine likelihood of success. None of the studies examined the stressors the animals are confronted with during these processes.

Post-release Survival of Injured Wildlife.

Post-release survival studies of injured wildlife focus mainly on oiled wildlife, not surprising considering the numbers of individuals affected at once and the money made available for clean up efforts. Estes (1998) estimated clean-up after the Exxon Valdez oil spill cost \$80,000 per individual sea otter released back into the wild, although another study (Jessup 1998) disputes these figures. The overall survival results are mixed. Anderson et al (1996) concluded from their study using color marking and radiotelemetry of oiled brown pelicans (*Pelecanus occidentalis californicus*), a recovering endangered species, that current rehabilitation efforts did not restore breeding condition nor did they achieve normal survival rates. A radiotelemetry study of oiled western gulls (*Larus occidentalis*) found that released gulls had the same survival as non-rehabilitated western gulls (Golightly et al 2002), while Sharp (1996) noted lower survivor rates for rehabilitated oiled seabirds in a review of ringing and recovery records of 3,200 marine birds. For example, oiled and cleaned guillemots (*Uria aalge*) had post-release life expectancies of 9.6 days, with long-term recovery rates of 10 to 20 percent of non-oiled bird rates. Freshwater turtles rehabilitated after an oil spill had no differences in survival or home ranges when compared to non-exposed turtles (Saba and Spotila 2003). The last recovery of transmitters occurred less than a year later, with one (out of twelve) oil exposed turtles being recovered. The study

had a small sample size of oiled turtles (twelve turtles amongst four species of freshwater turtles) and the authors cautioned that some effects of oil exposure on turtles may not be evident for years. A study on coastal river otters (*Lutra canadensis*) compared survivorship among three groups, some of which had been exposed to oil, others that had been held captive, and a control group of wild otters (Ben-David et al 2002). The authors found higher survivorship in the control group of wild otters. More rehabilitated river otters were preyed on, starved, or involved in accidents than wild river otters. Habituation to captivity may have been a leading cause of mortality in the rehabilitated otters. The rehabilitation of oiled wildlife may be a costly venture with no population level benefit.

Two recent studies of rehabilitated marine mammals suggest good survival for social marine mammals. Rehabilitated Pacific harbor seal pups (*Phoca vitulina richardsi*) were radio tracked for five months and the authors found no difference in survival between wild pups and the rehabilitated seal pups (Lander et al 2002). In another study, two rehabilitated stranded pilot whales (*Gobicephala melas*) were followed through satellite linked time-depth recorders for four months (Nawojchik et al 2003) and were noted to have moved great distances. Their close bond in captivity, along with healthy appetites and playful interactions may have made them good candidates for rehabilitation and reintroduction. The social aspect of these mammals may have been key to their survival.

A few post-release survival studies of rehabilitated raptors are available. Eighteen bald eagles (*Haliaeetus leucocephalus*) were successfully released in a study that used radiotelemetry to monitor their movements and survival. Two mortalities were recorded, neither was said to be associated with their previous injury or the rehabilitation process (one eagle was poisoned and the other euthanized after being caught in a leg hold trap) although no explanation was provided (Martell et al 1991). In another study, 16 bald eagles were radio tracked up to six months and appeared to engage in seasonally appropriate behavior. The authors state that the pre-release conditioning and suitable release site selection were some reasons for the eagles' success. Information on rehabilitated and released raptors from 1974 through 1979 included several cases of long-term survival for eight bald eagles that survived at least two years (Duke et al 1981). The authors of this study stated that rehabilitated raptors could become breeding members of a population and achieve expected longevity. One author asserted that post-release survivorship of a rehabilitated raptor is a reasonable expectation if strict guidelines are met

prior to release, despite the lack of large-scale follow-up of released raptors (Duke 1987). The presence of some large raptor research centers with stringent release criteria may be the reason for some of these successful releases.

Studies of post-release survival of injured terrestrial mammals, bats, or amphibians and reptiles are difficult to locate. One study of an emaciated wolf (*Canis lupus*) reported that it was found a long distance from its release site, which was used as a positive indicator of post-release survival (Mech et al 1984). Another study cited bears with wounded or amputated claws as having the same survival rates as normal cubs (Erickson 1959). One of the more recent papers on rehabilitated wildlife concerned koalas (*Phascolarctos cinereus*) after a wildfire (Lunney et al 2004). Survival and reproduction of sixteen rehabilitated koalas, and twenty-three unburnt koalas were compared. After following the koalas for up to three years, the authors concluded that there were no significant differences in survival and reproduction between the two groups. A study involving the treatment and release of a large number of amphibians (54) and reptiles (354) was done in Illinois (Hartup 1996). The major causes of injuries to these animals were automobile collisions, ingestion of fishing tackle, lawn and garden accidents, and pet collections. However, no post-release monitoring of these animals was done after they were released into local forest preserves.

Since there are few studies specifically addressing post-release survival of individuals, it is even more difficult to ascertain the effects of rehabilitation on a wildlife population. In order for a rehabilitated animal to have value to the population, it must not only live, but also breed. The rehabilitation and release of a relatively small number of individuals of a species may have little or no beneficial impact on a population. On the other hand, some people claim it could be detrimental, in instances such as disease transmission (Karesh 1995).

Fraser and Moss (1985) give three conditions by which rehabilitation could substantially alter the dynamics of a population: "the number of animals released must be a large fraction of the total population; the increased survival rate of treated animals must not be offset by increased mortality among the untreated part of the population; and any change in mortality rate caused by rehabilitation must not result in changes in natality, immigration, or emigration rates that compensate for the survival of rehabilitated animals." The authors state that these conditions are likely to be met only in small populations with low natural mortality rates. Even with endangered species,

there is no documentation of actual enhancement of populations by rehabilitation. The general public seems to give more attention and monetary support to wildlife rehabilitation (Jessup 1998), rather than become involved in issues where human interference has harmed whole populations (Forman and Alexander 1998).

The paucity of information regarding post-release survivorship has been attributed to a lack of money, and time and expertise (Lander et al 2002), along with the fact that many state regulatory agencies have not allowed banding of rehabilitated wildlife, particularly raptors (Steinhart 1990). Poor documentation of releases and follow-up or the lack of dissemination of information to the public or scientific community are the same difficulties that have arisen in many of the carnivore reintroduction programs in the US and abroad. These programs are notorious for their poor post-release monitoring and obscure or lacking documentation (Breitenmoser et al 2001). Furthermore, many of the post-release studies that are available pertain to major events such as oil spills. The problem with the studies is that the researchers are generally funded by the producer of the event, the majority of the animals affected will not be found (Estes 1998), and, most importantly, the studies describe a particular type of rehabilitation that most rehabilitators do not undertake in their daily operations. Typical injuries to wildlife and their post-release outcomes need to be assessed, documented, and shared by wildlife rehabilitators.

OBJECTIVE

The objective of this study was to evaluate wildlife rehabilitation's efficacy with bats. In order to do that the effects of stress and injury on survival in animals were separated, tested, and compared to the effects of rehabilitation. The first hypothesis was that capturing and handling stress affects the survival of adult rehabilitated Brazilian free-tailed bats. The second hypothesis was that injury affects the survival of adult rehabilitated Brazilian free-tailed bats. If capture stress was the dominant influence on bat survival, then rehabilitated and captive held bats would have lower survival rates. If injury were the dominant influence on survival, then there would be lower survival rates in the rehabilitated and injured bats than the captive held and wild bats. Differences in age and gender were assumed not to affect bat survival during the study duration as were any interferences from the process of radiotelemetry (additional weight, and human presence at roost), as routine guidelines were adhered to for radiotelemetry (Aldridge and Brigham 1988).

If the combination of injury and stress has the largest influence, then rehabilitated bats would have lower survival rates than the captive held and wild bats. It was anticipated that the results of this study would elucidate whether wildlife rehabilitation assists in the recovery, release, and survival of injured wildlife, as well as add to the body of work regarding post-release survival in wild animals.

MATERIALS AND METHODS

This study took place during the summer of 2004 in Gainesville, FL, using bats from a local bat rehabilitator at the West End Animal Hospital and bats from the University of Florida (UF) bat house. The majority of the bats in the bat house are Brazilian free-tailed bats, a common insectivorous bat used for this study. Brazilian free-tailed bats are relatively long-lived and may have improved reproductive success up to age eight (Altringham 1999). The bat house is thought to contain a number of bat species, including evening bats (*Nycticeius humeralis*) and southeastern bats (*Myotis austroriparius*). The main causes of mortality in adult insectivorous bats include pesticides, predation, and maternal stress.

Wild Healthy Minimally Handled Bats.

Twenty bats were captured at the University of Florida bat house. Ten of these bats were fitted with transmitters (Holohil Systems, Ontario, Canada) that were glued on using Skin-Bond Cement[®] (Smith and Nephew, London, UK), and released within twenty-four hours. Telemetry was conducted using a Telonics (Telonics, Inc., Mesa, AZ) receiver and a hand-held Yagi-Uda antenna.

Captive Held and Handled Bats. The remaining 10 bats were brought to the United States Department of Agriculture (USDA) National Wildlife Research Center, Gainesville, FL. These bats experienced a mock treatment to simulate rehabilitation. The regime replicated the process bats undergo at the West End Animal Hospital during actual rehabilitation. The bats were held for three days and technicians handled the bats two times per day. Bats were housed in a mesh cage with a heating pad to one side and a dark blanket covering the cage. Water and mealworms sprayed with Repti-Vite Carnivore Spray[®] (Fortitude Valley, Queensland), a nutritional supplement, were provided continuously. The bats were fed 2 cc of 'bat glop' twice a day. Bat glop is a mixture of mealworms, baby food, and nutritional supplements that is commonly used for Brazilian free-tailed bat rehabilitation.

Dr. Cottrell's Bat Glop

Mix until very smooth in blender:

- Five 71-gm jars of turkey baby food
- One 71-gm jar of banana baby food
- 1 cup mealworms
- 2 tbsp Vionate[®] Powder (ARC Laboratories, Atlanta, GA)
- 2 tbsp Missing Link[®] Feline Formula (Designing Health, Inc., Valencia, CA)
- 4 inches Nutrical[®] (EVSCO Pharmaceuticals, Buena, NJ)

When the bats were receptive to eating mealworms, each bat was given between five and fifteen mealworms twice a day with careful attention to the bats stomach to watch for any distention (which would indicate overfeeding). Dr. Cottrell advises using Harrison's Baby Bird Mash (HBD International, Delray Beach, FL) as primary substrate (medium) for the mealworms, and sliced sweet potatoes in the substrate to provide hydration and a few extra nutrients. Prior to serving worms in a bowl, she advises spraying worms with Carnivore Vitamin Spray (Energy Savers Unlimited, Inc.) and dusting with Missing Link Feline Formula. After three days the bats were fitted with transmitters using the same gluing procedure described earlier and released back at the bat house.

Rehabilitated Bats. Ten bats were rehabilitated at the West End Animal Hospital by an experienced and licensed bat rehabilitator using standard procedure for rehabilitation (modified from Lollar and Schmidt-French 1998). When the bats were deemed ready for release by the rehabilitator, transmitters were attached using the same gluing procedure noted above and the bats were released into the bat house.

RESULTS

Survival of all three groups of bats was monitored by radiotelemetry for the duration of the radio transmitter's life, approximately 20 days. Figure 1 compares the survival between the groups. All bats involved in the study had typical morphological measurements taken (weight, length, forearm length, and tail) (Figures 2 and 3). There appeared to be no substantial difference in any of the morphological measurements between the groups.

Wild Bats. Three of the 10 wild-caught bats survived for at least 12 days. These bats were at unknown locations for two days until they were found at an underpass in the town of Alachua outside of Gainesville, FL. One bat survived for at least two

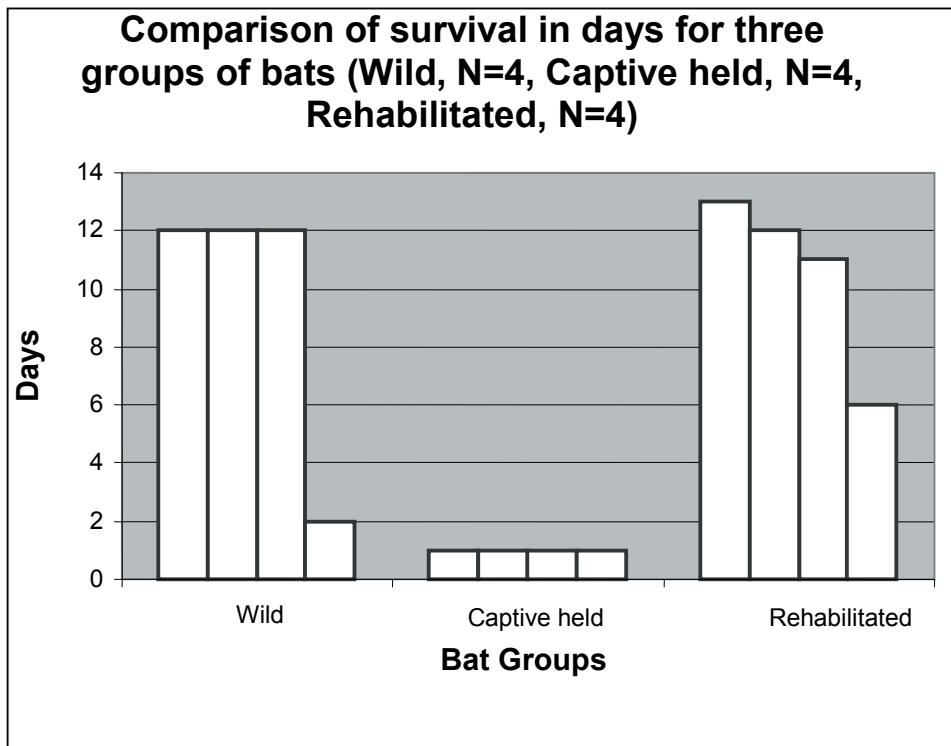


Figure 1. Survival in days of the three groups of Brazilian free-tailed bats (total N=12).

days near an organic garden in Gainesville. On the third day, the bat was located in a pine tree, where it remained for the duration of the transmitter's life. Two of the transmitters never left the bat house. The transmitter signal indicated that the transmitter was somewhere within the bat house. However, this does not mean that the bat itself stayed in the bat house. Four bats left the bat house the night they were released and were never relocated with telemetry.

Captive Held Bats. In the captive held bat group, four bats survived for at least one day and then left the bat house but were never located again. Three of the transmitters never left the bat house. Three bats left the bat house immediately and were never relocated.

Rehabilitated Bats. There were nine bats (out of the original ten rehabilitated) in the rehabilitated bat group due to one transmitter failure during attachment. Of the nine, four bats survived for a minimum of six days. The number of days survived were 13, 12, 11, and 6. One transmitter never left the bat house. The remaining four bats left the bat house immediately and were not relocated.

DISCUSSION

Although high transmitter loss resulted in a very small sample size and made any statistical meaningful comparisons between the study groups impossible, the

study did yield some new information. The underpass used by the wild bat group was a recently discovered colony of Brazilian free-tailed bats, but it was unknown that bats from the UF bat house used this roost area. The bats were found to be using the underpass roost during the day and then flying immediately back to the UF bat house after emergence for the first two days after locating them at the underpass roost site. While the UF bat house was made specifically for housing the bats, constructed of wood and roofed with sheet metal, the additional roost found is made of concrete. Another difference is that the UF bat house is located in a field

across from Lake Alice, which provides hydration and foraging opportunities, while the underpass roost is located on a busy county road near rural housing and railroad tracks. Additionally, the capacity of the underpass roost is much lower than the estimated capacity of the UF bat house. Any information regarding the habits of the Brazilian free-tailed bats at the UF bat house is valuable since the UF bats have never been studied before this project. It is difficult to track movements of Brazilian free-tailed bats due to their fast and high altitude flight. Future projects will now have an alternate roost site for the bats.

The poor response of the captive held bats, a total of seven gone from the bat house by the second day, could indicate a low stress threshold for the Brazilian free-tailed bat. The rehabilitated bats survival and movement indicate that they were in fact able to fly and feed after rehabilitation.

Additionally, for at least six days, four rehabilitated bats were healthy enough to be able to do some level of predator avoidance. Common birds seen roosting and/or hunting near the bat house include: red-shoulder hawk (*Buteo lineatus*), red-tailed hawk (*Buteo jamaicensis*), American crow (*Corvus brachyrhynchos*), loggerhead shrikes (*Lanius ludovicianus*), ospreys (*Pandion haliaetus*) and the great horned owl (*Bubo virginianus*). The red-tailed hawk and great horned owl are well known predators of Brazilian free-tailed bats (Wilkins 1989).

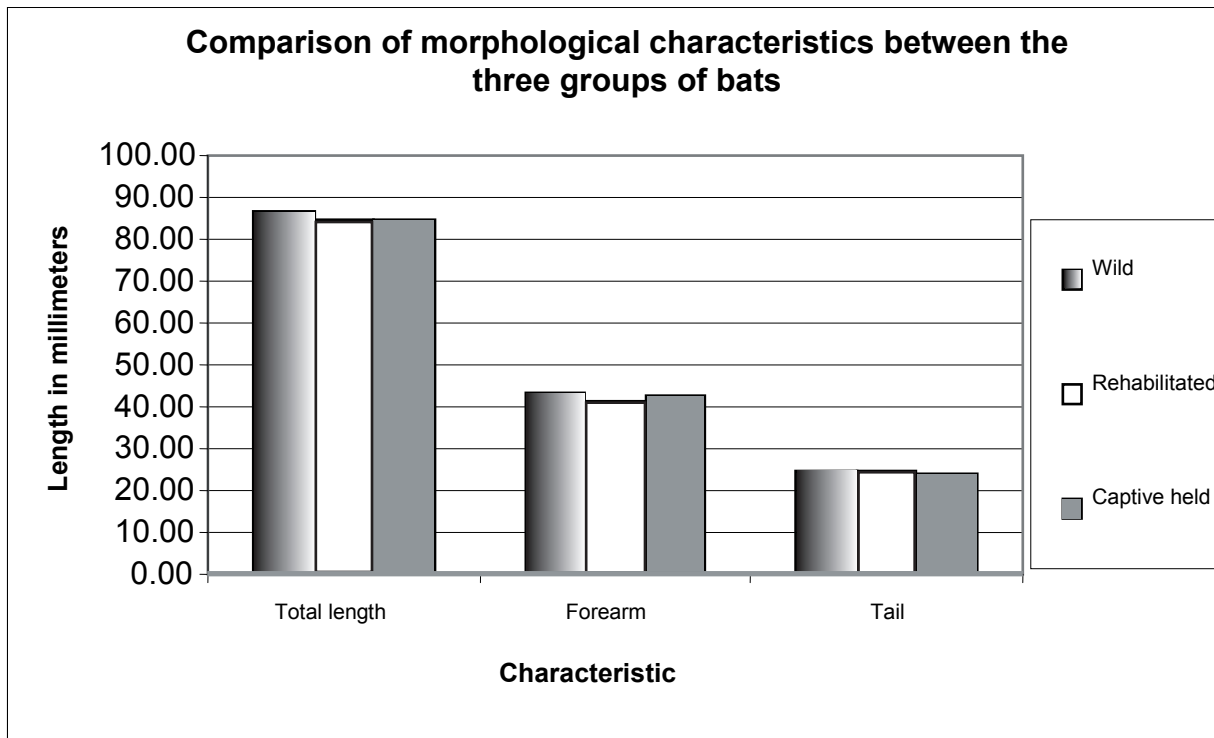


Figure 2. Comparison of morphological features of three groups of Brazilian free-tailed bats (total N=30, 10 from each group). Each column equals the average of that group.

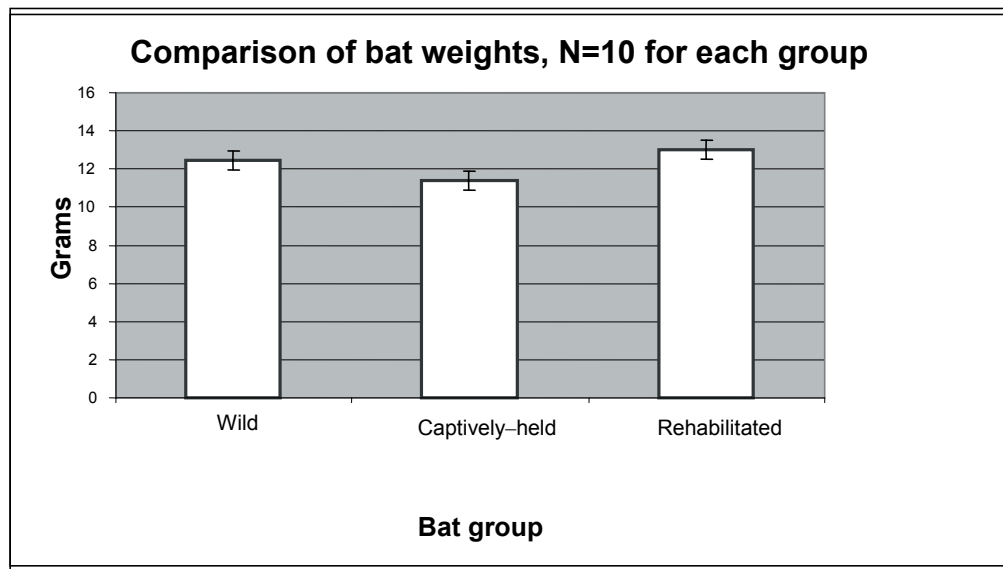


Figure 3. Comparison of weights of three groups of Brazilian free-tailed bats (total N=30, 10 from each group). Each column equals the average of that group.

Two other known predators of bats are found at the bat house. The most common mammalian species near the bat house was raccoon (*Procyon lotor*) that could often be seen and detected by the presence of scat at least once per week inside the gates of the bat house. The other known predator, the opossum (*Didelphis virginiana*), was detected by footprints.

Although some researchers believe that radio-telemetry has been useful in obtaining information

regarding individual bats and will likely play a key role in bat conservation as bat numbers continue to decline (Fenton 2003), the use of telemetry to gather information on bats, specifically Brazilian free-tailed bats, is fraught with pitfalls. In this study, there are two possible explanations why a total of six bats in the three groups did not seem to leave the bat house. First, after entering the bat house, bats may have been able to successfully scratch

or pull off the transmitter. Second, bats may have entered the bat house and after some period of time died without leaving the bat house.

The 11 bats (total of all three groups) that left the bat house immediately and could not be relocated may have scratched off the transmitter in another area before returning to the bat house. Alternatively, the bats may have died shortly thereafter, or may not have lost the transmitter and flown to an alternate roost.

However, based upon this experience with transmitters, the most plausible scenario for both instances is that bats were able to dislodge the transmitters. Brazilian free-tailed bats did not tolerate the transmitter on their backs and commenced scratching immediately after they were out of the researchers' hands. Brazilian free-tailed bats are also a host to a number of ectoparasites (chiggers, mites, fleas, etc.) (Wilkins 1989). Based upon an infrared camera placed within the slats, the bats spend a good deal of time grooming, especially right before emergence each evening.

The glue used to attach transmitters to bats was not particularly strong. The stronger glues available would have caused skin irritation or toxicity. The humid climate in Florida undoubtedly played a role in the success of the glue adhering. Severe weather during the study also affected the ability of the receiver to receive signals and prohibited telemetry during rain. It appears that researchers will experience a high level of transmitter loss. This is further complicated by the fact that this species is a colonial species and that it roosts in man-made roosts. Even without the large amount of scratching done by the individual bat with the transmitter, the cloistering behavior of bats could result in further transmitter loss. Unfortunately, the physical characteristics of man-made roosts, (such as the bat house on the UF campus), make retrieval of displaced transmitters virtually impossible. All attempts to retrieve transmitters in the house were unsuccessful. Therefore, continued attempts to use radio transmitters for survival studies are an unwise expenditure with Brazilian free-tailed bats until improvements are made.

CONCLUSION

This study hoped to clarify whether rehabilitation assists in wildlife survival. Due to high transmitter loss, this study was unable to make any reliable comparisons regarding survival among the three groups. Using data obtained from this project to accomplish a longer, larger project would assist in examining the role of bat rehabilitation. Different transmitter attachment techniques, such as harnesses and implants, should be tested in a controlled setting that mimics natural or man-made Brazilian free-tailed bat roosts in order to learn more regarding this species.

It is clear that some rehabilitated bats were able to survive past three-day post-release, suggesting the bats were able to fly, eat, and engage in predator avoidance. The bat house environment has a strong predator guild present, especially during the breeding season. However, the small numbers of Brazilian free-tailed bats that are rehabilitated in this area may make any

population level considerations negligible. Since it is widely known that most bat species are at risk due to habitat loss, the focus of wildlife rehabilitation should emphasize the educational aspect of wildlife rehabilitation and encourage thoughtful conservation of bats by preventative measures.

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