Obstacle avoidance by hand-raised, wild-caught, and captive-raised big brown bats

Holly Gibbs and David L. Johnson

School of Natural Resources
The Ohio State University

Introduction

Bat populations are declining at an alarming rate; nearly 50% of all species are currently listed as endangered (Kunz, 1988). Widespread use of toxic chemicals, channelization of waterways, as well as habitat destruction and deliberate human persecution have all led to this decline (Kunz, 1988). Insectivorous bats can consume their body weight in insects nightly and are the major predators of night-flying insects (Kurta and Baker, 1990). Specifically, big brown bats (*Eptesicus fuscus*) play an important role in controlling populations of agricultural pests such as stinkbugs (Pentatomidae), leafhoppers (Cicaellidae), scarab beetles (Scarabaeidae), and spotted cucumber beetles (Chrysomelidae) (Whitaker, 1995). Bats play a critical role in the function of ecosystems all over the world and are in need of intensive conservation efforts.

Big brown bats are generalists, foraging for insects over water and land and roosting in a variety of natural and human-made structures (Kurta and Baker, 1990). These widespread bats can serve as a model for studying endangered and threatened species by allowing experimental information to be gathered and technique to be improved.

Inseminated in the fall, female big brown bats store sperm for use in the spring after hibernation (Phillips, 1966). In Ohio, big brown bats birth May through June, with the majority of infants born in the first two weeks of June (unpublished data, The Ohio Wildlife Center). Big brown bats often have twins in the eastern half of the United States and single pups in the western half (Kurta and Baker, 1990).

Each summer brings controversy and an influx of orphaned bats into wildlife rehabilitation centers around the country; the issue centers around what to do with an infant or juvenile bat that is at risk or orphaned. Wildlife professionals have proposed a variety of solutions, including relocation and not interfering, but hand-raising orphaned bats with the intent of re-release is the predominant practice. Hand-raising involves intensively caring for the bats in captivity so they may eventually be returned to their natural habitat.

Many rehabilitators profess that hand-raised bats are not able to survive in the wild but offer little substantive evidence to support the claim (Barnard, 1989, Belwood, 1998). It is often assumed that hand-raised bats cannot feed themselves despite the complete lack of confirming evidence (Barnard, 1988). Thus, the ethics of releasing hand-raised bats have been debated for many years. Many rehabilitators opt to keep bats in captivity when faced with the alternatives of euthanization or blind release. As a long-term solution, captivity may be both inhumane and unrealistic. The few studies that have been completed are informal and use extremely small sample sizes and rarely published peer-reviewed literature.

Recent studies have stated that hand-raised bats were able to feed themselves on native insect species but the assumptions are based on bodyweight gain. (Dicke, 1994; Fry, 1994; Winters, 1993; Adkins and Wasserman, 1992). Insectivorous bats use torpor, a state of lowered metabolic rate and decreased body temperature, to conserve energy on a daily basis and to control weight loss under stressful conditions such as food deprivation. Short-term weight maintenance may simply indicate that hand-raised bats are able to enter torpor, thus surviving the release initially but possibly later starving.

Adkins and Wasserman (1993) used radio telemetry and a bat detector to observe one hand-raised big brown bat after release. The bat was behaviorally normal and demonstrated typical flight patterns. Based on feeding buzz responses from a bat detector, Adkins and Wasserman assumed that the bat was feeding on flying insects. Although this demonstrates the bats' ability to recognize and attempt to capture appropriate prey, it does not indicate that hand-raised bats are able to feed enough to survive after release.

While hunting insects, a bat performs a variety of acrobatics and often consumes its prey while in flight. To feed itself enough to survive, a bat must have fully developed flight abilities. It is not clear what flight capacity hand-raised bats have. In order to determine if hand-raised big brown bats are able to survive release, a quantitative study needs to be performed assessing the bats' flying capabilities.

The purpose of this study is to compare obstacle avoidance by bats raised by humans to those raised by natural mothers. By examining obstacle avoidance it will be possible to estimate flight ability and thereby make inferences about the post-release survivability of hand-raised bats. With the decline in bat populations, knowledge of how to rescue at-risk juveniles and infants and successfully reintroduce them will be key to species survival.

Materials and Methods

All persons handling bats involved in the study were administered pre-exposure rabies vaccines, used appropriate safety equipment, and received training prior to exposure.

Orphaned bats were obtained from community members who brought infant bats to The Ohio Wildlife Center (OWC), located at 2661 Billingsley Road in Columbus, Ohio. All attempts to reunite infants with their mothers were made and only those bats that would have otherwise died were included in the study. Hand-raised bats were fed a milk-replacement and vitamin supplements by the staff and volunteers of OWC according to the guidelines in Barnard (1995). All orphaned bats used in the study were between one and three days old when brought to OWC and their health was periodically monitored by veterinarians. All other bats, captive-raised and wild-caught, were obtained through a bat research laboratory located on The Ohio State University campus at 1735 Neil Avenue in Columbus, Ohio.

The wild-caught bats were born and raised in the wild while the captive-raised bats were born in captivity and raised by their natural mothers. Hand-raised bats were born in the wild but raised by humans in captivity. Captive-raised bats were housed with their mothers until four weeks of age, at which point they were separated but housed nearby. Hand-raised bats were exposed, visually and auditorily, to other hand-raised bats only, while the captive-raised and wild-caught bats were housed in close proximity to each other.

The weaned hand-raised bats, captive-raised bats, and wild-caught bats were fed mealworms (*Tenebrio molitar*) and vitamin-enriched water, *ad libitum*. The hand-raised bats were housed collectively in wood cages measuring 3 x 1.5 x 2 ft and covered with plastic-coated mesh. The captive-raised and wild-caught bats were housed individually in wood and mesh cages measuring 2 x 0.75 x 1.3 ft. The hand-raised bats' fur was trimmed with scissors into different patterns to aid in distinguishing the bats from each other.

The trials took place at The Olentangy River Wetlands Research Park, located at 352 Dodridge Road in Columbus, Ohio. Obstacles were set up in the middle of a 32 x 16 x 10 ft canvas tent. The large size of the tent was necessary to give the relatively large big brown bats room to maneuver. Dicke (1994) found a room of 10 ft in length too small for big brown bats and Griffin (1958) recommended an area of 33 x 12 x 7 ft for obstacle avoidance experiments. A 4 x 4 ft wooden frame held four galvanized steel bars that were placed vertically 7 in apart. The frame was secured to a 3-ft high metal cart and surrounded by sheets. The cart extended 2.5 in around all edges of the obstacle frame. The obstacles bisected the tent longitudinally and were surrounded by a wall of sheets that was suspended from the ceiling. A 6-ft-long fabric tunnel was used to encourage the bats to pass through the obstacles. A 5.5-ft stack of cinder blocks, located opposite the obstacle and at the end of the tunnel, was used as a take-off platform. One small fluorescent light was used along with four red lights suspended from the ceiling to illuminate the tent.

Bats were not fed before a trial and individual bat weights were maintained between 17.5-22.5 g throughout the trial. All bats were flown at least once a week for the duration of the trials. The captive-raised and wild-caught bats were flown inside a 10 x 10 ft room, usually once a week for approximately 10 minutes. The hand-raised bats were flown as a group in outside flight enclosures measuring 16 x 8 x 8 ft and 10 x 16 x 32 ft. The hand-raised bats were flown for 2-3 hours 5 times per week from 11 to 15 weeks of age and for 1-2 hours 2-3 times per week until the study's end. The trials began on October 19, 1998 and ended on November 22, 1998.

One bat was removed from the trial due to sudden weight loss and others never completed any trials because of refusal to fly. A bat was considered to be refusing flight if after release it did not flap its wings but simply glided straight down. These bats were tried on different occasions in attempts to include them in the study; bats that participated initially but then refused to fly were still included in the study.

The bats would not fly through the obstacles independently so a method of assisted flight was used. Each bat was held with its wings pulled back, a forefinger between its shoulder blades and its feet left free. They were released at the end of a soft forward motion. The entire procedure occurred at the level of the cinder blocks, between 5.6-5.8 ft above the bottom of the tent. Prior to a trial, the bats were allowed ample time to warm up and adjust to their surroundings. Vocalization, coupled with side-to-side head motions, was used to indicate a bat's state of readiness. Each bat was flown through the tunnel without the metal obstacles 3 times before the start of the trials.

The bats rested facing the obstacles, either on top of the cinder blocks or in hand, for 45 seconds before each trial. Performance was rated by one of four categories (miss, touch, hit, or crash) as outlined by Griffin (1958). Visual and auditory clues were used to rate individual trials and results were either recorded or written. A miss was defined as no visible contact made with the bars and often a swooshing sound. A touch was defined as contact with the bars made below the elbow that did not affect ensuing flight pattern and usually was accompanied by a slight contact noise. A hit was also defined as contact with the bars but was distinguished from a touch by an alteration of subsequent flight pattern and contact made above the elbow. A distinctive contact sound often accompanied a hit. A crash was defined as a strong impact with the obstacles that halted flight and resulted in the bat on the obstacle, on the cart or within the confines of the tunnel.

If the bat passed through the obstacle to the other side of the tent, it would proceed to circle or land. Once the bat had stopped flying, it either attempted to hide or remained in the open, thus time lapses between trials varied. The bat was then returned to the landing platform and the 45 s waiting period was observed.

Results

The data were not distributed normally, therefore non-parametric tests were used. Chi-square tests were used to determine whether significant differences existed between the type of bat (hand-raised, captive-raised, and wild-caught) and subsequent obstacle avoidance. Two chi-square tests were run, one comparing the type of bat to the four result categories (miss, touch, hit or crash) and one to categories designated as successful and unsuccessful. Successful was defined to be a touch or a miss since by definitions given by Griffin (1958), neither category affected flight pattern. Unsuccessful was defined as an affected flight pattern and thus included hit and crash.

Significant differences were found (p=0.0001) between the type of bat and both the four category and successful versus unsuccessful comparison. There was no significant difference between the performance of the wild-caught and captive-raised bats. There was a significant difference in the performance of the hand-raised versus the wild-caught and captive-raised bats. Based on Figure 1, hand-raised bats were slightly more likely to be unsuccessful while the wild-caught and captive-raised bats were twice as likely to be successful. Wild-caught and captive-raised bats had slight performance improvement over time but there were no definite trends in the performance over time for hand-raised bats.

Discussion

Hand-raised bats do not have the same overall obstacle avoidance ability as bats that have been raised by their mothers and therefore should not be re-released until scientific studies demonstrate post-release survival. Inappropriate release of hand-raised bats poses a threat to bat conservation as a whole. As noted by Taylor et al. (1974) and observed during this study, hand-raised bats are more docile than wild bats and are thus less likely to bite in self-defense. Hand-raised bats are more likely to come into contact with humans and create public health concerns that could ultimately harm bat conservation and therefore should not be re-released under current rehabilitation practices.

The trials lasted longer than anticipated because of technical difficulties. As the weather grew colder some of the bats objected to being flown; in particular, the wild-caught bats began to refuse to fly and consequently were removed from the study. The captive- and hand-raised bats seemed to be unaffected by the changing seasons, possibly because they have not been exposed to outdoor weather patterns. This lack of effect of seasonal change on captive- and hand-raised big brown bats has been noted by Dr. W. M. Masters and Dr. J. J. Belwood (*pers. com*., 1998).

Comparisons involving wild-caught bats are problematic because of the small number that completed the study and the effect of decreasing temperature on those that did finish the trials. Essentially, this study compares bats that were raised by humans and bats that were raised by natural mothers. Possible explanations for the significant differences in obstacle avoidance by hand-raised big brown bats could include age, timing and conditions of first flight, maternal exposure, exercise and diet.

All wild-caught bats and captive-raised bats were greater than one year of age while participating in the study. The hand-raised bats were under one year of age but were of full adult size and were observed copulating on multiple occasions.

Wild insectivorous bats have been noted by many to have equal foraging capacity as an adult 10 days after the first foraging excursion (Buchler 1980). Thus the age difference between the groups of bats most likely does not play a role.

The age at first flight attempt may be an important part in determining bat obstacle avoidance. Captive-raised bats were first flown at approximately three weeks of age. They were flown in isolation and thus were not taught to fly by their natural mothers. The conditions of early flight by the wild-caught bats is not known but are assumed to be similar to that observed and recorded by other researchers (Buchler, 1979, 1980; Moss et al., 1997, Powers et al., 1991). Kunz (1974) observed wild big brown bats to be foraging by four

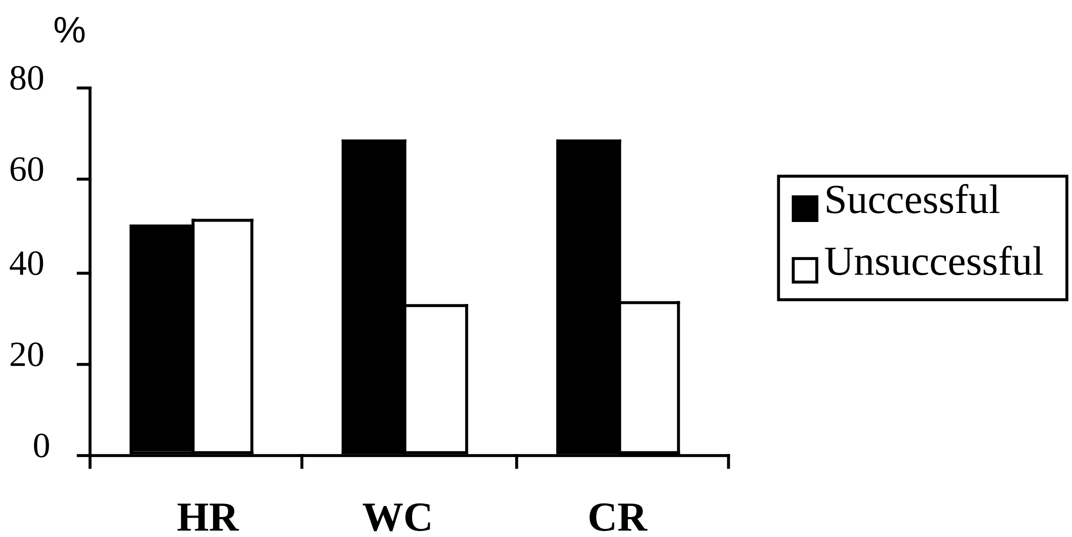

Figure 1. The percent of combined total obstacle attempts resulting in a successful or unsuccessful outcome for hand-raised (HR), wild-caught (WC) and captive-raised bats (CR).

weeks of age. Taylor et al. (1974) found that hand-raised big brown bats' first flight at 34 days old was much later than the typical age of 21-23 days. The hand-raised bats in this study may have missed their opportunity to learn to fly since they were not permitted access to suitable flying conditions until after the age of first flight attempts made by bats in the wild. The hand-raised bats were not able to practice flight until 11 weeks of age, when flight was regularly encouraged.

Conditions of flight ontogeny in wild insectivorous bats are controversial. Brigham and Brigham (1989) note that *Eptesicus fuscus* forages with conspecifics at an early age. Through radio-tracking, they observed a mother and offspring pair foraging together 76.5% of the time. Conversely, Buchler (1980) proposes that little brown bats (*Myotis lucifigus*) forage independently to avoid any confusion caused by noise from other echolocating bats. The association between mother and young is partially confirmed by Gaudet and Fenton's (1984) study on observational learning. They demonstrated that *Eptesicus fuscus* does learn through observation, which would partially explain the importance of maternal interaction for developing bats. Studies of observational learning in other mammals are well established (Weigl and Hanson, 1980).

Flight conditioning does not explain observed obstacle avoidance differences because the hand-raised bats had more frequent and longer exercise sessions than the wild-caught and captive-raised bats. As noted previously, bats in the wild successfully fly as early as 3 weeks of age and have clearly not had physical flight conditioning before first flight attempt.

The composition of bat milk varies species to species as well as during lactation (Kurta and Baker, 1990) and access to it may play a role in flight ontogeny and overall development. The hand-raised bats were fed a combination of milk-replacer and vitamin supplements and this diet most likely did not provide adequate nutrition. Buchler (1979) noted that captive-raised little brown bats grew more slowly than wild little browns. Perhaps the physiological development is stunted or delayed in hand-raised bats, preventing them from flying with the obstacle avoidance ability of the captive-raised or wild-caught bats.

A study similar to that performed by Moss et al. (1997) would be an excellent confirmation of these obstacle avoidance results. Moss et al. (1997) dropped young bats from a platform onto a soft pad and observed for signs of flight and where they landed on the pad. The behavior of the bat was scored by wing-flapping response. Additional research assessing the echolocation patterns of hand-raised bats would be useful in evaluating the effectiveness of their echolocation. Recordings of the echolocation of hand-raised bats could be compared to the patterns of captive-raised and wild-caught bats of similar ages established by Masters et al. (1995). Echolocation comparison could potentially confirm the observed differences in the behavior and flight performance of hand-raised bats.

References

Adams, D. B. and G. M. Baer. 1966. Cesarian section and artificial feeding device for suckling bats. J. Mammalogy 47: 524-525.

Adkins, B. and J. Wasserman. 1992. Suitability of captive-reared bats for release: a post-release study of a captive-reared big brown bat (*Eptesicus fuscus*). J. Wildlife Rehabilitation 15: 119-126.

Barnard, S. M. 1995. Bats in Captivity. Wild Ones Animal Books, Springville, California.

Brigham, R. M. and A. L. Brigham. 1989. Evidence for association between a mother bat and its young during and after foraging. Am. Mid. Nat. 121: 205-207.

Buchler, E. R. 1979. The development of flight, foraging, and echolocation in the little brown bat (*Myotis lucifigus*). Beh. Ecol. Soc. 6: 211-218.

Christensen, J. E. 1990. Principal components-like procedures for cross-tabulated recreation data: an illustration from search activity related to park choices. Leisure Sciences 12: 281-288.

Dicke, C. 1994. A post-release study of a juvenile pallid bat. J. Wildlife Rehabiltiation 17(2): 3-5.

Fry, M. 1994. Infant insectivorous bat rehabilitation. The National Wildlife Rehabilitatorsí Association Quarterly, Winter 1994:1-5.

Gates, W. H. 1966. Raising the young of red bats on an artificial diet. J. Mammalogy 47(3): 461.

Gaudet, C. L. and M. B. Fenton. 1984. Observational learning in three species of insectivorous bats (Chiroptera). Animal Behavior 32: 385-388.

Kunz, T. H. 1974. Reproduction, growth, and mortality of the vespertilinoid bat, *Eptesicus fuscus*, in Kansas. J. Mammalogy, 55(1):1-13.

Kunz, T. H. 1988. Ecological and Behavioral Methods for the Study of Bats. Smithsonian Institution, Washington, D. C.

Kurta, A. and R. H. Baker. 1990. *Eptesicus fuscus*. Mammalian Species 356:1-10.

Moss, C. F., Reddish, D., Gouden, C. and T. H. Kunz. 1997. Ontongeny of vocal signals in the little brown bat, Myotis lucifigus. Animal Behavior 54:131-141.

Powers, L.. V., Kandarian, S. C. and T. H. Kunz. 1991. Ontongeny of flight in the little brown bat, Myoits lucifigus: behavior, morphology, and muscle histochemistry. J. Comparative Physiology 168:675-685.

Rosleth, S. L., Koehler, C. E., and R. M. R. Barclay. 1994. Difference in the diets of juvenile and adult hoary bats, *Lasiurus cinereus*. J. Mammalogy 75(2):394-398.

Taylor, H., Gould, E., Frank, A. and N. Woolf. 1974.

Successful hand-raising of one week old bats, *Eptesicus* and *Antrozous*, by stomach catheter. J. Mammalogy 55: 229-231.

Thomas, D. W., Fenton, M. B., and R. M. R. Barclay. 1979. Social Behavior of the little brown bat, Myotis lucifigus. Beh Ecol Sociobio. 6: 129-136.

Weigl, P. D. and E. V. Hanson. 1980. Observational learning and the feeding behavior of the red squirrel *Tamiasciurus hudsonicus*: the ontogeny of optimization. Ecology 61: 213-218.

Whitaker, J. O. 1995. Food of the big brown bat Eptesicus fuscus from maternity colonies in Indiana and Illinois . Am. Midland Naturalist 134: 346-360.

Winters, P. 1993. A release study of 15 *Myotis yumanensis* hand-raised orphans. California Bat Conservation fund 4: 4-14.