

FROM RESEARCH TO OUTREACH: ENVIRONMENTAL EDUCATION MATERIALS FOR THE BATS OF MALAYSIA

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ABSTRACT

Despite their contribution to global and national biodiversity, their ecological and economic importance, and their imperiled status, public awareness of the conservation and economic value of bats in Malaysia is extremely low and myths and prejudice abound. Established in 2001, the Malaysian Bat Conservation Research Unit (MBCRU) takes a multidisciplinary approach to the conservation of Malaysia's bat fauna, combining long-term conservation research with local capacity building and an environmental education programme (EEP). Here we detail the development of the MBCRU's EEP for the bats of Malaysia which follows a three-point strategy: i) To focus on core issues that are both of immediate conservation relevance and likely to enhance public empathy for bats (Malaysian bat diversity; the ecological and economic importance of bats; major threats and vulnerability); ii) To use research findings to guide the development of materials; and iii) To design materials and activities in line with more recent advances in learning theory. We illustrate this strategy with detailed examples of some of the materials developed by the MBCRU in the last three years. Bats are by no means the only uncharismatic and overlooked group in need of public concern and we believe that much of our approach is broadly applicable to other diverse but poorly-known taxa.

INTRODUCTION

Malaysia is a critical country for international bat conservation; it is at the centre of Old World bat diversity (Findley 1993), with at least 125 species, yet as a consequence of habitat loss and hunting, more than a quarter of Malaysian species are listed as at some risk of extinction by the World Conservation Union (IUCN) (red-listed species) (Mickleburgh *et al.* 1992, Hutson *et al.* 2001). There is a clear need to prioritize the conservation of Malaysia's bat fauna, and this led in 2001 to the establishment of the Malaysian Bat Conservation Research Unit (MBCRU). The MBCRU is an international collaboration among scientists from Boston University (USA), University Kebangsaan Malaysia, and the Department of Wildlife and National Parks (see Kingston *et al.* in press a, b for details), and takes a

multidisciplinary approach to the conservation of Malaysia's bat fauna. Long-term conservation research and local capacity building are combined with the development of an environmental education programme (EEP) for bats. Such an integrative approach has proven successful elsewhere (Trehwella et al. 2005) and provides the opportunity to use the technical knowledge of the Unit's scientists and its research findings as a basis for outreach materials. Such a foundation enhances the relevance and immediacy of the materials for the Malaysian public.

Compared to popular, charismatic megafauna such as the tiger, elephant, rhinoceros and panda, bats are something of a conservation and outreach "hard sell". The nocturnal, volant habits of bats mean that few people personally encounter them, and worldwide they tend to be feared and disliked, and surrounded by myth and prejudice. Interviews of visitors to Kuala Gandah Interpretive Centre (Krau Wildlife Reserve) revealed just how misunderstood and poorly-known bats are in Malaysia: 32% of people did not like bats with nearly 17% of people finding them scary or frightening and 76% of emotive associations were negative (stemming from mythical connection of bats with vampires and ghosts, and misconceptions that bats are blind, dirty, smelly, pests of fruit-crops and likely to get tangled in your hair). Less than 50% of people were aware that bats are mammals (Kingston *et al.* in press a). This lack of empathy is a major hindrance to raising public awareness and furthering conservation efforts. As the American naturalist John Burroughs aptly put it "Knowledge without love will not stick. But if love comes first, knowledge is sure to follow".

Conservation biologists and naturalists generally recognize the existence value (*sensu* McNeely *et al.* 1990) of any species, but the 'right to exist' argument generally holds little sway with much of the general public and even less with policy makers. To reach such target audiences, it is often necessary to highlight the contribution that the focal group (bats in this case) makes to the nation's social and economic development (the direct and indirect use values (McNeely 1988, McNeely *et al.* 1990)). Fortunately, bats play a key role in ecosystem and ecological services. The Megachiroptera (Old World fruit bats) provide essential ecosystem services as pollinators (Whittaker & Jones 1994) and seed dispersers (Shilton *et al.* 1999) of tropical plant species, including many of economic importance, and play a key role in structuring and regenerating forest communities (Marshall 1985, Cox *et al.* 1991, Fujita & Tuttle 1991, Rainey *et al.* 1995, Gumal 2001). In Malaysia, the majority of species are in the other sub-order of bats, the Microchiroptera. With a few carnivorous exceptions, the Old World Microchiroptera are insectivorous and are the primary predators of nocturnal insects. Typically, an individual needs to consume at least half its body weight in insects every night, and as a consequence, insectivorous bats are a vital component of the army of natural pest control agents. It has been estimated that natural enemies reduce crop losses worldwide by in excess of \$100 billion (Pimentel *et al.* 1997).

Similarly, legislative and policy changes are unlikely if there is little awareness of the threats and risks to the target group. Worldwide approximately a quarter of all bat species are threatened by extinction, that is they fall within the IUCN categories that indicate threat (critically endangered, endangered or vulnerable) (IUCN 1996). In Malaysia, 31 Microchiroptera and 3 Megachiroptera are red-listed by the IUCN (which includes the least-concern categories as well as the threatened species) (IUCN 2002).

The strategy of the MBCRU bat EEP has thus been to emphasize three elements of bat ecology and conservation in Malaysia: the diversity of bats in Malaysia; the ecological and economic role of bats; and the vulnerability of bats to habitat loss and hunting. The materials

are designed to not only inform the public of the pertinent facts and knowledge, but to raise public empathy and liking for bats, primarily through familiarization and by correcting misconceptions and myths. Below we give details of some of the outreach materials developed by the MBCRU in accordance with these priorities. For each of the three issues, we start with a brief summary of the current state of knowledge and relevant research findings that we have used to provide the foundation for material development. To determine the amount of that knowledge that needs to be conveyed, and to identify the most appropriate means by which to do so, public perception of the issues was assessed by interviewing visitors to Kuala Gandah Interpretive Centre (Krau Wildlife Reserve). Examples are then given of some of the materials used to convey the environmental message. The selection of materials presented is intended to illustrate the range of different approaches used by the MBCRU in terms of target age group and type of material. Many of the principles behind the materials are applicable to other diverse taxa, so we try to review the materials critically and make recommendations for those developing similar EEPs. All materials can be obtained by contacting the first author (T. Kingston –IS THERE A FRIM WEBSITE I COULD MAKE THESE AVAILABLE FOR DOWNLOAD FROM? ANYTHING ASSOCIATED WITH THIS CONFERENCE OR MORE GENERALLY?).

1: BAT DIVERSITY IN MALAYSIA

Knowledge/research base: Bat species constitute more than a fifth of all mammals worldwide, second in diversity only to rodents. With 125 species, Malaysia supports the highest density of bat species anywhere in the Old World, and accounts for over 10% of the world's 1111 species. Approximately 40% of all Malaysian mammal species are bats and 50% of those in rain forest habitats. MBCRU research has demonstrated that in excess of 60 species can co-exist at a single locality (Kuala Lompat, Krau Wildlife Reserve, the primary study site of the MBCRU), and that this represents the highest diversity of insectivorous bat in the world (Kingston *et al.* 2003). For so many insectivorous species to co-exist, they exhibit differences in size, wing morphology and echolocation signal design that enable them to forage for insects in different microhabitats and using different foraging strategies (Kingston *et al.* 2000)

Awareness and perceptions: More than 32% of respondents in the interviews believed there were fewer than 10 bat species in Malaysia, with 19% reporting less than 10 species in the world.

Materials:

a) Poster

To raise awareness of the importance of bats to global biodiversity, and to engender pride in the unique contribution that Malaysia makes to bat diversity, a simple poster was designed detailing the number of species worldwide, in Malaysia and in Krau Wildlife Reserve. The poster featured large pictures of the faces of over 20 bat species, to both familiarize people with the appearance of bats and to illustrate the extreme morphological diversity that they exhibit. The poster was displayed in the interpretative centres around Krau Wildlife Reserve. A second round of interviews conducted by the MBCRU indicated that the poster was effective in raising awareness of bat diversity (Kingston *et al.* in press a). However, the poster did not lead to a greater liking or empathy of bats, and it is possible that the large-than-life photographs intimidated visitors.

b) Compare yourself to a bat

One of the problems that many outreach workers may encounter is that the species of interest may not be physically available, reducing opportunities for children or students to interact directly. The MBCRU has the experience and expertise to use live bats as part of its outreach programme, but this is unlikely to be an option for many outreach workers, as training is required to both capture and handle these fragile animals. Consequently, the “Compare yourself to a bat” activity was designed to familiarize children (ages 8-12 years) with the size, shape and appearance of bats when live animals are not available. Each child (or a pair of children) is allocated a bat species, one that the MBCRU research has demonstrated occurs as part of the bat community at Krau Wildlife Reserve. The first task is to put together a jigsaw puzzle of the face of the bat. Because few people will have seen a bat up close, this is an opportunity to both familiarize children with their appearance, and by selecting species from different families, to appreciate the physical diversity of bats. The children are then required to reconstruct a life-size silhouette of the wing and body of their bat, one that was drawn by tracing around the wings of the actual species. Again, the species are selected to show the diversity of sizes of bats that can occur together, and this is complemented by having the children create a bat body by filling a section of ladies’ stocking with rice, to the exact weight of the species. The children then use a paragraph of information about “their bat” to fill in a table that compares the biology and ecology of the bat to their own life. The table has a column for the bat and one for themselves and includes two conceptual categories that the children are unaware of. First, there are aspects that are similar between people and bats to build empathy (we are all mammals, and have five fingers, we have a formal (equivalent to the scientific) name and a common name). Second, there are ecological details that differ from us, but most importantly differ among the selected species, providing an opportunity to illustrate the ecological diversity of bats (where they live, who they live with (social structure), what they eat). For example, some species live alone and just roost under leaves, others live in colonies of a million in caves, yet they can all be found in the same forest. When all the activities are completed, each child presents their bat to the rest of the group, and the facilitator draws attention to the similarities between bats and people, and the physical and ecological diversity of the bats themselves.

2. ECOLOGICAL AND ECONOMIC IMPORTANCE OF BATS

Knowledge/research base: Over 300 palaeotropical plant species from more than 200 genera depend upon the plant-visiting family Pteropodidae for pollination and/or seed dispersal (Marshall 1983, Fujita & Tuttle 1991). In excess of 500 economically important products are derived from these plants (Fujita & Tuttle 1991), in Malaysia at least 31 commercially important species are bat-dependent including favourites such as durian, petai, mango, banana, guava, jackfruit and papaya. The economic impact of these services is clear: the value of the durian industry world wide is estimated to be US\$1.5 billion (Lim 1998), and sales of petai in the just Klang Valley generate approximately US \$2.8 million annually (Chuen *et al.* 1998).

The insectivorous Microchiroptera, which make up over 85% of Malaysia’s bat species are just as ecologically and economically important. They are the primary predator of nocturnal insects, and in the US studies have demonstrated that a large part of their diet includes many of the most damaging agricultural and forestry pests, including cucumber, potato and snout beetles; corn-earworm, cotton-bollworm, and grain moths; leaf hoppers; and mosquitoes (reviewed in Ducummon 2001). Moreover, some colonies of Mexican free-tailed bats

(*Tadarida brasiliensis*) may consume over 2,450 metric tons of insects in a six month period, and researchers are taking a cross-disciplinary approach to assign a financial value to the services that these bats provide as agents of pest control. Although there is not yet equivalent research in Malaysia, a recent study in Thailand clearly illustrates that related species in South East Asia are having a similar impact. A single colony of 2.6 million wrinkle-lipped free-tailed bats (*Tadarida plicata*) is estimated to consume at least 17.5 tons of insects per night and dietary analysis revealed that at least a quarter of all insects eaten by the colony (over 4 tons per night) were white-backed planthoppers (*Sogatella* sp., Delphacidae), the major pest of rice crops in the area (Leelapaibul et al. 2005).

Although little-exploited in Malaysia, guano from bat faeces is widely used in other parts of South East Asia as an organic fertilizer as it is high in nitrogen, phosphorous and beneficial bacteria and fungi. In Myanmar for example, over 260,000 kg per year are extracted, primarily for domestic use as a natural and inexpensive fertilizer (Khin Maung Lwin 1995), and guano collection from the Khao Chong Pran Cave in Thailand generates an annual income for local villagers of US\$135,000 (Leelapaibul et al. 2005).

Awareness and perceptions: Only 2.4% of people knew of the role of bats as pollinators or seed dispersers, or agents of pest control (4.3%) or as producers of guano for fertilizer (3.4%). Interestingly, when asked to describe the feeding habits of bats, only 4% of people were aware that several species took nectar, further indicating that the importance of bats for pollination is poorly-known.

Materials:

a) Bat fruit salad.

The objective of this simple activity is to demonstrate how important bats are in the daily lives of many Malaysians. It is suitable for all ages, and can provide an educational break mid-way through a workshop, as it simply requires putting together a fruit salad using fruits that are dependent upon bats for pollination or seed dispersal. The fruits available will obviously depend on the time of year but any of the following could be selected: durian, mango, papaya, jambu, rambutan, banana, jack fruit, guava, petai. If younger children are involved, then a rather messy but informative activity is to “eat like a fruit bat”. Because of the high fiber content of many fruits, fruit bats thoroughly chew their selected fruit, but then only swallow the juices. The fiber and seeds are spat out as rejecta pellets. As the bat often takes the fruit some distance from the parent tree, this is an important part of their role as seed dispersers. Children can be encouraged to chew up large mouthfuls of fruit, swallow the juices and spit out the remainder. In more open areas, having children disperse from the source of the fruit before they spit out the seeds further helps to illustrate this point.

b) Bat maths: A natural pesticide.

This activity is for secondary or tertiary students. It illustrates the impact that large colonies of bats can have on local insect populations. Students are told that there are over 1.8 million individuals of the wrinkle-lipped bat (*Tadarida plicata*) in Deer Cave at Mulu, Sarawak. They are informed of the average weight of a bat and told that typically a single bat needs to eat at least half its body weight every night. Based on a colony of 1 million bats, the students are ultimately asked to calculate how many tons of insects are eaten by the colony per year (answer: 2,920 tons). The weight can be converted into numbers of insects to gain a better appreciation of what this means in terms of pest populations (equates to 11,680 million moth-sized insects (0.25 g each), or 29200 million smaller insects (0.10 g each). A final thought experiment asks what this level of insect control might require in terms of litres of pesticide.

There are is no absolute answer to this (as such figures are not available). We have found some participants simply say that “lots” of pesticides would need to be used, others have made assumptions of the number of insects killed per litre of pesticide and generated more specific answers. Many of these large colonies occur in limestone karst systems (Mulu in Sarawak, Gomantong in Sabah, and Batu Caves in Peninsular Malaysia), and this provides the opportunity to present another threat to bats, that of disturbance at caves (for limestone extraction, tourism, vandalism).

3. VULNERABILITY OF BATS

Knowledge/research base: Due to rapid changes in land-use and excessive hunting, the main declines in bat populations in Malaysia are experienced by the large flying foxes and the insectivorous bats of the rain forest interior. The large flying fox, *Pteropus vampyrus*, is the largest bat in the world, but hunting and habitat loss in Malaysia have resulted in a dramatic decline in populations throughout the country. 40% of sites that historically supported large colonies no longer do so, and remaining populations are rapidly declining and largely restricted to remote areas (Mohd.-Azlan *et al.* 2001). Insectivorous bats of the rainforest interior can comprise communities in excess of 35 species in Malaysia. Specializations of wing morphology and echolocation signal design equip these bats to forage in the dense clutter of the forest understory, but as a consequence they are much less efficient at hunting for prey in the more open habitats created by forest disturbance and fragmentation (Kingston *et al.* 2003). Thus, they are highly dependent on intact expanses of forest, and are likely to experience a severe decline in diversity as forest habitats are lost and fragmented (Meijaard *et al.* 2005). For example, extensive urbanization in Singapore has resulted in an estimated loss of over 70% of microchiropteran species and c. 60% of the Megachiroptera (Lane *et al.* submitted), and it is the forest-dependent species that have been most adversely affected by the land-use changes of the last 150 years.

Bat maths: life statistics

Bats are particularly vulnerable to disturbance and hunting because many of their life history traits represent adaptations for life in stable, predictable habitats, and where populations are maintained close to the carrying capacity of the environment (Kunz & Pierson 1994, Purvis *et al.* 2000). The combination of low fecundity, prolonged maternal care, slow development and long life-spans means that many species are extremely slow to recover their populations following disturbance.

The life statistics bat maths activity specifically addresses this issue, and is suitable for secondary or tertiary students, and adults. Aside from illustrating how the natural history of bats makes them particularly vulnerable to disturbance, it also introduces two of the major threats to bats – habitat loss and pesticide use. It contrasts the reproductive strategies of bats with people and rats and the implications of this for species recovery rates; the student is given a table of the basic reproductive characteristics for bats and rats and required to complete the table with data for people, based on their own life. Through the activity, the student discovers that bats are more like people than rats; typically just one young is born at a time, and in many cases the bats just breed once per year. In contrast, rats may have up to 12 litters per year, with each litter comprising something in the order of 8 young. Not only does this prepare the student for the second part of the maths questions, but it is also an attempt to build empathy; people are often more comfortable with species with biology similar to their own. In the second part of the activity, we introduce two of the key conservation challenges

facing bats – deforestation (habitat loss) and pesticide use. A hypothetical scenario is described in which a forested area housing 1000 rats and 100 bats is largely cleared for agricultural, reducing populations dramatically. Thereafter the new plantation is aggressively sprayed with pesticides, reducing populations of both species still further until there are just 2 bats and 2 rats (one male and one female for each species). The student is then asked to assume that populations were allowed to recover, and to use the life-history data from the first part of the activity to calculate the maximum number of rats and bats that would be present after two years (1250 rats and only 4 or 5 bats (depending if the young of the first year was male or female)), and to discuss the implications of these findings for species recovery. Although some of the calculations are simplified for clarity (in fact there would be more rats, as sexual maturity is reached within four months in females, but we have assumed that reproduction is delayed until the second year), the differences between the two species clearly indicate the vulnerability of bats compared to rats.

DISCUSSION

The MBCRU EEP for Malaysian bats draws heavily on biological principles and research findings, but we have also tried to design materials in line with more recent advances in learning theory. Much of the material has a constructivist and/or collaborative element to it. Constructivist learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge (Bruner 1990). Rather than telling students why bats are so important, they discover it for themselves in the course of the activity, with the facilitator there as a guide. Both the “Compare yourself to a bat” activity and the “Bat Maths” problems were designed with this approach in mind – from a few basic facts (or materials) given at the start of the activity (current knowledge), the learner is able to construct knowledge of bat natural history and key environmental issues. Collaborative learning is that effected through the exchange and sharing of information and opinions among a peer group. For example, the “Compare yourself to bat” activity requires input from all children (each with their own bat) to illustrate the diversity of morphology, social structure and roost choice that makes bats so unique.

We have also found it useful to restrict the program to core issues that are both of immediate conservation relevance and likely to enhance public empathy. In the case of the MBCRU EEP, emphasis on the extraordinary diversity of bat species in the country can engender national pride and concern for the bat fauna; highlighting the ecological and economic importance of bats demonstrates the relevance of their conservation to the general public; and explaining and illustrating the threats they face both raises concern and challenges the public to take an active involvement in their preservation. Bats are by no means the only uncharismatic and overlooked group in need of public concern and we believe that much of our approach (core issues; research-based materials; inclusion of learning theory) is broadly applicable to other groups (e.g. amphibians and reptiles, invertebrates, fish).

The focus of this paper has been the development of the materials, but of course a critical component of any EEP is the actual implementation of the programme and use of materials. Generally, the MBCRU takes a “train the teachers” approach, by conducting workshops for educators and outreach workers that familiarize them with all the materials. The materials have been designed to provide EE practitioners with options – a single activity might be incorporated into an ongoing awareness programme, or educators may wish to follow the format of a three-hour children’s workshop (for which a full educator’s pack is available). At

the end of each of these three-day educators' workshops, the participants conduct a children's workshop of their own. This provides practical experience of running the activities that builds confidence, particularly as the MBCRU facilitators are on hand to answer queries and reinforce relevant concepts. This has been a highly successful approach. Since attending a workshop in 2005, participants from Singapore have held two Children's Workshops, and are currently planning a bigger programme creating bat-friendly gardens in schools. In addition, workshop participants from the Department of Wildlife and National Parks, Malaysia, are currently integrating some of the bat activities into their ongoing outreach programmes.

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