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8 THE MALAYSIAN BAT CONSERVATION RESEARCH UNIT: RESEARCH,
9 CAPACITY BUILDING AND EDUCATION IN AN OLD WORLD BIODIVERSITY
10 HOTSPOT
11

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33 CAPACITY BUILDING AND EDUCATION IN AN OLD WORLD BIODIVERSITY
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35

36 **ABSTRACT**

37 The Malaysian Bat Conservation Research Unit (MBCRU) was established in 2001 to
38 promote the conservation of Malaysia's unique bat diversity. Activities centre on
39 conservation research, capacity building and environmental education. Our research focuses
40 on the patterns and processes affecting diversity in insectivorous bat communities in
41 undisturbed rainforest in the Krau Wildlife Reserve and aims to predict relative extinction
42 risk of species within these inherently vulnerable assemblages. Capacity building is
43 implemented through a combination of local student support and technical and educational
44 workshops, and we hope to develop the MBCRU at Krau Wildlife Reserve as a regional
45 centre of excellence through a programme of regional internships. The mission of our
46 education programme is to raise awareness of the diversity of bats in Malaysia and to
47 generate concern for their conservation that can be directed to support changes in both
48 public attitudes and administrative policy. Here we present preliminary results and
49 summary of outreach activities of the MBCRU for the period 2002-2004.

50

51 Unit pemuliharaan dan penyelidikan kelawar Malaysia (MBCRU) telah ditubuhkan pada
52 tahun 2001 dengan objektif untuk meningkatkan usaha-usaha memulihara kepelbagaian
53 kelawar di Malaysia yang dianggap unik. Unit ini memberi penekanan kepada kajian
54 pemuliharaan, menambah sumber manusia yang terlatih dan pendidikan. Kajian kami
55 memberi penumpuan kepada corak dan proses yang mempengaruhi kepelbagaian
56 komuniti kelawar dalam hutan tropika tidak terganggu di Rezab Hidupan Liar Krau dan

57 cuba mengecam spesies kelawar yang mudah diancam kepupusan. Sumber manusia terlatih
58 ditingkatkan melalui pembiayaan pelajar-pelajar diperingkat sarjana/kedoktoran dan juga
59 melalui bengkel-bengkel pendidikan dan teknikal. Adalah diharapkan melalui program-
60 program ini Rezab Hidupan Liar Krau akan diakui sebagai satu pusat kecemerlangan
61 serantau. Tujuan program pendidikan ialah untuk meningkatkan kesedaran dikalangan
62 masyarakat dan penggubal polisi mengenai mengapa pentingnya kelawar perlu dilindungi.
63 Di sini, kami ingin bentangkan hasil awal aktiviti-aktiviti yang telah dijalankan oleh
64 MBCRU dari tahun 2002-2004.

65

66 **INTRODUCTION**

67 Bats are a vital component of global biodiversity: with 1111 species worldwide (Simmons,
68 in press) they constitute nearly one-fifth of all mammal species, yet throughout the world
69 populations are declining, ranges contracting and eight species have already become extinct
70 (Hutson *et al.*, 2001; Mickleburgh, 1992). Malaysia is a critical country for international bat
71 conservation; it is at the centre of Old World bat diversity (Findley, 1993), with 118 species
72 (Simmons, in press) accounting for 10% of the world's bat fauna. Bats constitute over 40%
73 of Malaysia's mammal fauna, and in rainforest ecosystems this rises to 50%. Tragically, 34
74 species, more than a quarter of all Malaysian bat species are red-listed by The World
75 Conservation Union (IUCN). This is a great tragedy – not only is Malaysia's bat heritage
76 unique in a global context, but many species play a key role in the country's ecology and
77 economy. At least 31 Malaysian plant species rely on bats for pollination, including
78 favourites such as durian, petai, mango, banana, guava, jackfruit and papaya. The durian
79 (*Durio* spp.) trade in South East Asia was valued at US \$120 million in the mid-1980s
80 (Myers, 1985), and sales of petai in the just Klang Valley generate approximately US \$2.8
81 million annually (Cheun *et al.*, 1998). Old World fruit bats also play an essential ecological

82 and commercial role as seed dispersers (Marshall, 1985; Fujita & Tuttle, 1991; Shilton *et*
83 *al.*, 1999), particularly as they frequently move the seeds away from the parent plant where
84 seed predation is high. The insect-eating bats are just as important. Each night, an
85 insectivorous bat consumes at least half its body weight in insects, and large colonies can
86 consume over 2000 tonnes of insects per year.

87

88 Within Malaysia, the bat fauna of Krau Wildlife Reserve (KWR) has been the subject of at
89 least nine published surveys dating from Medway & Wells (1971) to Kingston *et al.* (2003).
90 Not only is it the best known bat fauna in the Palaeotropics, but KWR supports the highest
91 diversity of insectivorous bats for a single site in the world, with more than 50 insectivorous
92 species known from only a 3 km² area (Kingston *et al.*, 2003). Of particular conservation
93 concern are the insectivorous bats of the rainforest interior. They are an exceptionally
94 diverse group in Malaysia and as consequence are of intrinsic conservation value and
95 ecological importance; more than thirty species are known from KWR alone (Kingston *et*
96 *al.*, 2003). Specializations of wing morphology and echolocation signal design that equip
97 bats of the forest interior to forage in the dense clutter of the forest understory, greatly
98 constrain their ecological flexibility (Kingston *et al.*, 2003), and they are ill-suited to detect
99 and capture prey in the more open habitats that tend to arise from disturbance events such as
100 forest fragmentation and degradation. Thus, they are highly dependent on intact expanses of
101 forest, and are likely to experience a severe decline in diversity as forest habitats are lost
102 and fragmented (Meijaard *et al.*, 2005).

103

104 The Malaysian Bat Conservation Research Unit (MBCRU) was established to promote
105 research and conservation education of Malaysia's unique bat fauna. It was founded by
106 scientists from the USA (Boston University), Malaysia (Universiti Kebangsaan Malaysia

107 (UKM) and the Department of Wildlife and National Parks (DWNP) with further
108 collaborations with Queen Mary University of London and University of Bristol, UK, the
109 Malaysian Nature Society, Earthwatch Institute, the Organization for Bat Conservation
110 (OCB) and the Bat Taxon Advisory Group (Bat TAG) of the American Zoo and Aquarium
111 Association. The MBCRU was launched by the Director General of the Department of
112 Wildlife & National Parks in his opening address to the 12th International Bat Research
113 Conference in Kuala Lumpur, 5th August 2001. The primary objectives of the unit are: long-
114 term research on bat diversity and conservation; capacity building; and environmental
115 education. Below we outline the primary activities and achievements of the MBCRU in the
116 first three years (2002-2004) with particular reference to these objectives.

117

118

119 **A. LONG-TERM RESEARCH ON BAT DIVERSITY AND CONSERVATION:**
120 **ECOLOGICAL DETERMINANTS OF EXTINCTION RISK.**

121

122 **BACKGROUND**

123 The primary research objective is to develop a predictive framework to determine which
124 forest interior bat species are at greatest risk of local extinction, so that preventative
125 measures can be implemented before populations decline. Current methods of evaluating
126 risk are rarely suitable for identifying vulnerable species in intact, diverse local
127 communities, particularly those for which there are few ecological and demographic data.
128 For example, on a global scale, small geographic range and low wing aspect ratios are the
129 only significant independent predictors of extinction risk and explain 48% of the variance in
130 the IUCN assessment of threat to bats (Jones *et al.*, 2003). But such global predictors do not
131 have the power to discriminate at the local level as all members of the interior guild in the

132 present study are characterized by low aspect ratios. Similarly, landscape-level post-hoc
133 explanatory or experimental studies (e.g. Davies *et al.* 2000; Gorresen and Willig, 2004;
134 Medellín *et al.*, 2000; Schulze *et al.*, 2000; and see Henle *et al.* 2004 for review) typically
135 provide insights into systems that are already disturbed and are rarely predictive in nature,
136 and population viability analyses, which do model the future status of individual species
137 (Boyce, 1992; Brook *et al.*, 2000 for review) require extensive and reliable demographic
138 data and often decades-long time series (as many as 12 generation times) to ensure that risk
139 predictions are accurate (Coulson *et al.*, 2001; Reed *et al.*, 2003). The time, money and data
140 are simply not available to apply these analyses to most diverse tropical systems.

141

142 In this study we aim to synthesize theoretical principals, basic knowledge of bat ecology,
143 and empirical evidence derived from studies of other taxa and meta analyses to predict risk
144 in local diverse bat communities. Ecological determinants of extinction risk such as
145 abundance, spatial distribution, roost selectivity, reproductive phenology, home range,
146 longevity and population turnover rates, and landscape and temporal population variability,
147 are derived from a simple but standardized, spatially-referenced harp-trapping protocol and
148 from an extensive radio-tracking program. The evaluations of these ecological correlates are
149 then combined to develop vulnerability profiles for each species that can be used to suggest
150 priority species for conservation action and inform management plans. In a separate project,
151 the profiles will be tested against actual species representation in fragmented and degraded
152 habitats. Here we report the first two years of research, during which time efforts have
153 focused on establishing the new study sites, investigating the landscape-level variability in
154 species abundance and community assemblage, and generating preliminary extinction risk
155 profiles.

156

157 **METHODS**

158 In order to derive the landscape-level predictors of extinction risk, the first stage of the
159 project focused on the selection and establishment of four new study plots, to complement
160 the original site established by Chivers (1980) for primate studies at Kuala Lompat. The
161 plots (Kuala Gandah, Kuala Serloh, Lubuk Baung, Jenderak Selatan) are a minimum of 7
162 km apart and 1 km from the forest edge, and all < 300 m above sea level. Each plot
163 comprises a 1 km x 1 km grid with cross trails every 100 m (22 km of trails per grid).

164

165 The grids are sampled on a rotational basis. Up to 15 four-bank harp traps (Francis, 1989)
166 are set during the day, spaced approximately 50 m apart (ca. 435 trap positions per grid per
167 sample, with an offset suite of 435 positions used in alternate years). The traps are checked
168 for bats at 2000 h and then left open over night and rechecked at dawn (following the peaks
169 in bat activity at dusk and dawn). Captured bats are held individually in cloth bags and
170 identified, sexed, weighed, measured and banded with unique wing bands and released at
171 the capture point within 12 hours. All harp trap positions for each grid are mapped and
172 imported into a GIS where they are linked to the capture data (e.g. species, sex, reproductive
173 condition, wing-band number).

174

175 Individualized capture data generates measures of relative abundance, community
176 composition, longevity, reproductive phenology/seasonality, number of breeding season per
177 year (which combine to influence intrinsic rate of increase), whereas spatially-referencing
178 the records enables us to derive species distribution patterns and home range indices.

179 Repeated sampling across the landscape provides a measure of population fluctuations and
180 the extent to which they are spatially autocorrelated and synchronous. In 2003 we began an

181 extensive radio-tracking program to determine the impact of roost choice and availability on
182 population processes and extinction risk (Christine Fletcher – Ph.D. dissertation research).

183

184 **RESULTS**

185 Between March 2002 and October 2004 each of the five study grids was sampled twice,
186 generating over 12,500 captures of 42 species (34 Microchiroptera and 8 Megachiroptera
187 (Table 1)). Additional species captured using other methods (primarily mist nets set over
188 rivers and at roosts in buildings or caves) included *Cheiromeles torquatus*, *Mops mops*,
189 *Chaerephon johorensis*, *Miniopterus schreibersii*, *Scotophilus kuhlii*, *Myotis horsfieldii*, *M.*
190 *hasseltii*, *Hipposideros armiger*. Three species were added to the reserve list reported in
191 Kingston et al. (2003), including *Miniopterus schreibersii* captured over the Lompat River
192 at Lubuk Baung (Tony Wood, unpub. data), *Harpiocephalus mordax* captured at Jenderak
193 Selatan and Kuala Serloh, and *Coelops robinsoni* captured at Kuala Lompat, Kuala Serloh
194 and Lubuk Baung (Senawi, 2004; the present study). Our work also confirms previous
195 records reported for KWR but not captured by Kingston et al. (2003): *Hipposideros*
196 *armiger*, *Scotophilus kuhlii*, *Tylonycteris robustula*, *Tylonycteris pachypus*. This brings the
197 total number of insectivorous bats to 54 species.

198

199 Preliminary compilation of extinction risk profiles suggest that some species conform to the
200 extreme expectations. For example, *Hipposideros ridleyi* (an IUCN Vulnerable species) is
201 typical of a high-risk species profile, abundance is low at all sites (rarely constituting more
202 than 2% of captures – Table 1), it roosts in small social groups in large, fallen tree cavities
203 with DBH > 240 cm (C. D. Fletcher, unpub. data) which may both limit the population and
204 impose a clustered distribution susceptible to passive sampling effects. Conversely, the
205 ecology of *Kerivoula intermedia* suggests a much lower-risk species: it is consistently one

206 of the three most abundant bats at each of the five study sites within KWR, comprising from
207 12-14% of all captures, and appears to be randomly distributed within the plots, indicating
208 less specialized roosting habits and smaller home range. These profiles represent the
209 extremes of a continuum in which high-risk factors may be offset by low-risk factors, and
210 one of the long-term aims of the project is to determine the relative importance of different
211 predictors.

212

213 **DISCUSSION**

214 The present study brings the list of insectivorous bat species at KWR to 54 species, and
215 when the 11 species of Megachiroptera known for the reserve are added, the reserve total
216 reaches 65 species. Thus, KWR supports the highest known diversity of bats in the Old
217 World, 12 of which are red listed by IUCN, and hence the Reserve is one of the most
218 important sites for international bat conservation in the world. Because of their ecological
219 and taxonomic diversity, bats are often viewed as an important and sensitive indicator taxon
220 (Fenton, 2003; Medellín *et al.*, 2000; Safi and Kerth, 2004). Consequently, the diversity of
221 species at Krau Wildlife Reserve is likely indicative of high species-richness of other
222 poorly-known taxa and suggests that the ecological health of the KWR ecosystems is to be
223 envied throughout South East Asia.

224

225

226 **B) CAPACITY BUILDING AND ENVIRONMENTAL EDUCATION**

227 **PROGRAMME**

228

229 **BACKGROUND**

230 Although Malaysia is a critical country for international bat conservation, our understanding
231 of the distribution and ecology of Malaysian bat species remains poor. Some of the most
232 important tools for biodiversity conservation are field guides and systematic keys, but the
233 last field guide to the bats of peninsular Malaysia was published in 1983 (Medway, 1983).
234 Since that time approximately 27 species have been added for Malaysia (Simmons, in press;
235 T. Kingston, pers. obs). Thus, without a comprehensive guide, efforts to describe and
236 protect Malaysia's unique bat fauna are severely hampered at a time when accurate surveys
237 are urgently needed. Moreover, new techniques for capturing or monitoring bat assemblages
238 (primarily the use of harp traps and acoustic monitoring) can strongly influence the
239 characterization of local bat faunas and the dissemination of these techniques, along with
240 appropriate handling and identification skills is urgently needed.

241

242 Not only is there a shortfall of technical expertise, but public awareness of the ecological
243 diversity and economic value of bats remain poorly known. The most common perception is
244 that there are two kinds -- 'big bats' and 'little bats'. Only two species of *Pteropus* are
245 protected by legislation in Peninsular Malaysia, and hunting is still permitted under licence.
246 In a talk at the 12th International Symposium on Bat Research, held in Malaysia in 2001, C.
247 A. Yeap of the Malaysian Nature Society stated that raising public awareness (especially
248 eliminating misconceptions) was the major challenge facing the conservation of Malaysian
249 bats. Although Malaysia is a global hotspot for bat biodiversity, bat conservation has been
250 neglected in comparison with the conservation of other mammals and birds.

251

252 Following the recommendations of Fien *et al.* (2001), the strategy of the MBCRU has been
253 as follows:

- 254 I) determine the baseline awareness of the diversity and importance of bats; design
 255 outreach materials that address the key knowledge gaps identified in the survey;
 256 evaluate the efficacy of the materials;
- 257 II) design and disseminate outreach materials for educators;
- 258 III) design and disseminate technical materials to build capacity for accurate surveys;
- 259 IV) provide local and regional student support to foster academic research in bat
 260 ecology.

261

262 I) Awareness & Materials

263 METHODS

264 To determine the baseline awareness of the diversity of bats and their ecological and
 265 economic importance in Malaysia, and to highlight the key misconceptions that should be
 266 addressed in the development of subsequent materials, the MBCRU conducted 108
 267 interviews of visitors to the Elephant Conservation Centre at Krau Wildlife Reserve in 2003
 268 (January – March). The questionnaire was designed to determine the following:

- 269 • Level of awareness of bat biology, and diversity in Malaysia and the world
 270 (Questions: what is a bat? Where do you think they live? What do you think they
 271 eat? How many different species of bat do you *think* there are in the
 272 world/Malaysia?).
- 273 • Level of awareness of the utility of bats as pollinators, seed dispersers, and as agents
 274 of insect pest control (Questions: what else do you know about bats? What do you
 275 think they eat?).
- 276 • Extent of empathy towards bats (Question: How do you feel about bats?).
- 277 • Extent of misconceptions about bats (myths) (Questions: what else do you know
 278 about bats? What do you think they eat?).

279 In response to the findings of the survey, a simple leaflet and poster were produced. The
280 leaflet was developed to highlight the diversity of bats in Krau Wildlife Reserve and
281 Malaysia; their ecological and economic importance to the country; to dispel key myths and
282 misconceptions. It was distributed to over 8,000 high school students (mailed with
283 Malaysian Nature Society publication ‘Tapir’), and dispensed at large posters sites in the
284 three Interpretive Centres in the Krau Wildlife Reserve at Kuala Gandah, Bukit Rengit and
285 Jenderak Selatan. A second series of 100 interviews was conducted at the Elephant
286 Conservation Centre at Krau Wildlife Reserve in 2004 (March - April) to evaluate the
287 effectiveness of the materials. No attempt was made to discriminate between visitors that
288 had read the bat poster and those who had not, so the re-survey results incorporate the extent
289 to which visitors were attracted to the outreach materials.

290

291 **RESULTS**

292 More than 32% of respondents in 2003 believed there were fewer than 10 bat species in
293 Malaysia (Fig. 1a), with 19% reporting less than 10 species in the world (Fig 1b). As a
294 consequence, the diversity of bats was the primary focus of the poster developed in 2003.
295 This appears to have been relatively effective, as these percentages had dropped to 11% and
296 3% in 2004, and there was a significant association between year and number of Malaysian
297 bat species estimated ($\chi^2 = 17.16$, $\chi^2_{0.05, 8} = 15.507$ $p < 0.05$) that appeared to be driven by
298 the changes in the < 5 category (as the association was no longer significant when this
299 category was excluded from the analysis). There was also a 5% increase in the number of
300 visitors correctly estimating between 100 and 150 species in Malaysia. Nonetheless, a large
301 proportion of respondents still fell into the ‘do not know’ category.

302

303 The poster also highlighted the fact that bats are mammals and interviewee awareness of
304 this increased from 53% in 2003 to 75% in 2004, although 12% and 5% of respondents
305 thought bats were some kind of flying rodent (Fig. 2a). There was a significant effect of
306 year on the allocation of bats to animal type ($\chi^2 = 16.32$, $\chi^2_{0.005, 4} = 14.860$ $p < 0.005$). As
307 the frequency of allocations to mammal appeared to show the greatest difference across
308 years, the contingency table was subdivided so that mammals were excluded from a second
309 analysis, and then compared against all other allocations pooled in a third analysis. Since
310 the second analysis resulted in a nonsignificant χ^2 and the third a significant value ($\chi^2 =$
311 15.81 , $\chi^2_{0.005, 4} = 14.860$ $p < 0.005$), it is likely that difference across years was driven by
312 changes in the frequency with which bats were identified as mammals.

313

314 The number of people reporting that they do not like bats actually rose from 32% in 2003 to
315 49% in 2004 (Fig. 2b); and there was a significant association between year and attitude (χ^2
316 $= 13.62$, $\chi^2_{0.005, 3} = 12.383$ $p < 0.005$). Subsequent division of contingency tables
317 suggested that there was both an increase in the number of people disliking bats as well as a
318 decrease in those liking bats. Of the emotive associations with bats held by those
319 interviewed, 76% were negative and 24% positive (Table 2). Nearly 17% of people found
320 bats scary or frightening, and few knew of the role of bats as pollinators or seed dispersers
321 (2.4%), agents of pest control (4.3%) or as producers of guano for fertilizer (3.4%). Other
322 negative associations stemmed from the mythical connection of bats with vampires and
323 ghosts, and many people believed bats to be dirty, smelly, pests of fruit-crops and likely get
324 tangled in your hair.

325

326 There was a broad understanding of bat diets, with the majority of respondents aware of the
327 contribution of insects and fruit to bat diets (Fig. 3). Interestingly, few people (4.7 & 1.0%
328 in 2003, 2004) were aware of the dependence of some species on nectar, suggesting that the
329 importance of bats as pollinators in Malaysia is poorly known.

330

331 **DISCUSSION**

332 Baseline awareness of the diversity and importance of bats was low, but it appeared that
333 response to the materials developed was high, particularly as visitors to the interpretive
334 centre were not anticipating material on bats. Awareness of the diversity of bats and the fact
335 that they are mammals increased, but the large bat photographs in the poster may have
336 contributed to the increase in fear and dislike of bats; it was suggested by some visitors that
337 an indication of scale may be needed to allay people's fears. Although the utility of bats (as
338 pollinators, seed dispersers, pest control, etc.) is featured in the leaflet that accompanies the
339 poster, this information was not reaching the target audience. Difficulties have been
340 encountered maintaining the supply of leaflets at the interpretive centres, additional posters
341 highlighting the role of bats as pollinators, dispersers, and as agents of pest control may
342 prove to be a more effective and efficient means of conveying this message.

343

344 **II) Outreach materials for educators**

345 A half-day 'bat party' (workshop) for children was developed and run for 22 children
346 between the ages of 7-12 from Kuala Gandah in March 2003. The activities included
347 inviting children to compare themselves to a bat (both children and bats were weighed and
348 measured), participate in a puppet show ("Betty the Bat" who saves the rainforest from
349 loggers) and join in games that illustrate key biological aspects such as echolocation and

350 mother-pup interactions. A final quiz proved the efficacy of this approach as the children
351 answered all the questions correctly.

352

353 A ‘Children’s Party Pack’ was developed in 2004 to enable the children’s workshop format
354 to be accessible to outreach workers and officers from wildlife interpretive centres,
355 including those that do not have access to live bats for their programmes. The pack
356 includes photos, templates for puppets and a bat costume, detailed instructions and
357 interpretations of the games, quiz questions; all the materials and information needed to
358 enable outreach workers to host a children’s workshop of their own. The Pack was launched
359 at a workshop for educators at Bukit Rengit in May 2004, and a second workshop is
360 scheduled for June 2005 at Ulu Gombak.

361

362 **III) Technical materials and capacity building**

363 The MBCRU has developed a key to the bats of Peninsular Malaysia, as well as a technical
364 manual covering handling and identification skills. A fully illustrated Field Guide to the
365 Bats of Krau Wildlife Reserve has been produced, and we expect to expand this guide to
366 encompass all species on the peninsular in the coming years. These materials are
367 distributed to all participants at the annual 3-5 day capacity-building workshops “Bat
368 Identification and Survey Techniques” (March 2002, February 2003, April 2004). Over 40
369 participants have come from DWNP, Malaysian Universities and Institutes, and Singapore
370 NPB. The workshop includes a lecture series covering the diversity and identification of
371 bats, survey techniques, data collection and sampling design, and bat conservation and
372 education. Practical sessions cover the use of harp traps, mist nets, radio-telemetry, acoustic
373 monitoring, handling, identification and data collection, and specimen preparation.

374

375 **IV) Student support and internships**

376 The MBCRU has supported 3 Malaysian (2 masters 1 Ph.D.) and one Indonesian student
377 (masters) to complete their graduate degrees at Universiti Kebangsaan Malaysia. In
378 addition, in 2003 we sponsored a Ph.D. student from Myanmar for a one-month training
379 visit, and accommodate similar short-term interns from local NGOs or those wishing to join
380 the research team to obtain further exposure to survey techniques and skills. In 2004 we
381 were joined by a staff member from WCS (Sarawak), and in 2005 we will be sponsoring
382 interns from Indonesia and India and the Philippines. Logistical/in kind support has been
383 provided for graduate and undergraduate students from UK (University of Bristol,
384 University of East Anglia, Queen Mary University of London), USA (Boston University),
385 and France (L'Institut national agronomique Paris-Grignon (INAPG)). It is hoped that this
386 programme of international exchange will enable us to establish the MBCRU at KWR as a
387 regional centre of excellence for bat research and outreach.

388

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404

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486

487 **TABLES**

488 Table 1. Bats captured using harp traps in Krau Wildlife Reserve during two rounds of
489 sampling between 2002-2004 at five study plots. I = number of individuals; R = recaptures.

490 All species names follow Simmons, in press.

491

492 Table 2. Bat associations reported by 208 visitors interviewed at Kuala Gandah Interpretive
493 Centre in 2003 and 2004.

494

495 **FIGURES**

496 Figure 1. Visitor perception of the number of bat species a) in the world; b) in Malaysia
497 before (2003) and after (2004) outreach materials had been placed in Kuala Gandah
498 Interpretive Centre. Exploded black pie indicates the correct category.

499

500 Figure 2. Visitor response to the questions: a) “what is a bat?” to determine public
501 perception of the taxonomic affiliation of bats; b) “how do you feel about bats?” to
502 determine empathy towards bats, before (2003) and after (2004) outreach materials had
503 been placed in Kuala Gandah Interpretive Centre. Exploded black pie indicates the correct
504 category.

505

506 Figure 3. Visitor response to the question “what do bats eat?” in 2003 and 2004. Visitors
507 were able to give multiple answers, so the results are displayed as the percentage of
508 respondents identifying each of the dietary items.

Table 1. Bats captured using harp traps in Krau Wildlife Reserve during two rounds of sampling between 2002-2004 at five study plots. I = number of individuals; R = recaptures. All species names follow Simmons, in press.

Species	Jenderak		Kuala		Kuala		Kuala		Lubuk		All study sites		
	Selatan		Gandah		Lompat		Serloh		Baung		pooled		
	I	R	I	R	I	R	I	R	I	R	I	R	Total
Pteropodidae													
<i>Balionycteris maculata</i> (Thomas, 1893)	26	0	12	1	36	0	21	0	32	0	127	1	128
<i>Chironax melanocephalus</i> (Temminck, 1825)	0	0	0	0	4	0	0	0	0	0	4	0	4
<i>Cynopterus brachyotis</i> (Müller, 1838)	0	0	6	0	4	0	2	0	1	0	13	0	13
<i>Cynopterus horsfieldii</i> Gray, 1843	0	0	0	0	0	0	1	0	0	0	1	0	1
<i>Eonycteris spelaea</i> (Dobson, 1871)	0	0	0	0	1	0	0	0	0	0	1	0	1
<i>Macroglossus minimus</i> (E. Geoffroy, 1810)	0	0	0	0	0	0	1	0	0	0	1	0	1
<i>Megaerops ecuadatus</i> (Temminck, 1837)	0	0	0	0	3	0	0	0	0	0	3	0	3
<i>Penthetor lucasi</i> (Dobson, 1880)	0	0	1	0	0	0	0	0	0	0	1	0	1
Emballonuridae													
<i>Emballonura monticola</i> Temminck, 1838	1	0	8	0	7	0	13	0	3	0	32	0	32
Megadermatidae													
<i>Megaderma spasma</i> (Linnaeus, 1758)	7	0	5	0	11	1	2	1	3	1	28	3	31
Nycteridae													
<i>Nycteris tragata</i> (K. Andersen, 1912)	17	4	11	2	8	2	6	0	16	1	58	9	67
Rhinolophidae													
<i>Rhinolophus affinis</i> Horsfield, 1823	3	0	5	0	5	1	14	5	0	0	27	6	33
<i>Rhinolophus lepidus</i> Blyth, 1844	4	0	103	11	135	37	40	6	474	57	756	111	867
<i>Rhinolophus luctus</i> Temminck, 1834	4	0	3	1	4	0	7	0	1	0	19	1	20

Species	Jenderak		Kuala		Kuala		Kuala		Lubuk		All study sites		
	Selatan		Gandah		Lompat		Serloh		Baung		pooled		
	I	R	I	R	I	R	I	R	I	R	I	R	Total
<i>Rhinolophus robinsoni</i> K. Andersen, 1918	7	0	0	0	0	0	7	0	1	0	15	0	15
<i>Rhinolophus sedulus</i> K. Andersen, 1905	35	11	59	20	11	3	26	2	26	3	157	39	196
<i>Rhinolophus stheno</i> K. Andersen, 1905	58	12	179	23	186	38	149	24	287	31	859	128	987
<i>Rhinolophus trifolius</i> Temminck, 1834	139	15	123	34	110	27	87	18	93	11	552	105	657
Hipposideridae													
<i>Coelops robinsoni</i> Bonhote, 1908	0	0	2	0	2	0	1	0	0	0	5	0	5
<i>Hipposideros bicolor</i> - 142 kHz*	117	20	16	3	24	5	5	0	171	31	333	59	392
<i>Hipposideros bicolor</i> - 131 kHz	262	14	85	28	36	3	20	2	27	5	430	52	482
<i>Hipposideros bicolor</i> sp	262	101	39	29	26	7	7	0	268	34	602	171	773
<i>Hipposideros cervinus</i> (Gould, 1854)	1252	489	535	64	142	44	135	12	207	38	2271	647	2918
<i>Hipposideros cineraceus</i> Blyth, 1853	1	0	3	0	0	0	2	0	2	0	8	0	8
<i>Hipposideros diadema</i> (E. Geoffroy, 1813)	16	1	12	7	45	11	20	3	23	1	116	23	139
<i>Hipposideros larvatus</i> (Horsfield, 1823)	0	0	0	0	3	0	0	0	25	0	28	0	28
<i>Hipposideros ridleyi</i> Robinson and Kloss, 1911	3	0	25	9	30	9	30	16	37	10	125	44	169
<i>Hipposideros doriae</i> (Peters, 1871) †	6	2	8	1	5	2	2	0	3	0	24	5	29
Vespertilionidae													
<i>Kerivoula intermedia</i> Hill and Francis, 1984	308	106	338	131	219	92	260	95	348	91	1473	515	1988
<i>Kerivoula papillosa</i> (Temminck, 1840)	157	97	136	121	135	105	124	110	101	108	653	541	1194
<i>Kerivoula pellucida</i> (Waterhouse, 1845)	172	2	80	1	173	11	116	5	109	6	650	25	675
<i>Kerivoula</i> sp.**	4	0	4	1	9	2	13	2	3	0	33	5	38
<i>Phoniscus atrox</i> Miller, 1905	12	6	15	3	20	13	16	5	16	4	79	31	110
<i>Phoniscus jagorii</i> (Peters, 1866)	0	0	0	0	2	0	0	0	0	0	2	0	2
<i>Harpiocephalus mordax</i> Thomas, 1923	1	0	0	0	0	0	1	0	0	0	2	0	2
<i>Murina aenea</i> Hill, 1964	5	0	6	1	3	1	5	0	2	1	21	3	24

Species	Jenderak		Kuala		Kuala		Kuala		Lubuk		Total		
	Selatan		Gandah		Lompat		Serloh		Baung		Total		
	I	R	I	R	I	R	I	R	I	R	I	R	Total
<i>Murina cyclotis</i> Dobson, 1872	34	6	19	4	30	12	14	0	46	6	143	28	171
<i>Murina rozendaali</i> Hill and Francis, 1984	1	0	3	0	0	0	3	0	1	0	8	0	8
<i>Murina suilla</i> (Temminck, 1840)	45	4	40	6	74	10	30	7	36	4	225	31	256
<i>Myotis ater</i> (Peters, 1866)	0	0	0	0	5	1	4	0	0	0	9	1	10
<i>Myotis muricola</i> (Gray, 1846)	0	0	0	0	1	0	0	0	1	0	2	0	2
<i>Myotis ater/muricola</i>	0	0	0	0	1	0	0	0	1	0	2	0	2
<i>Myotis ridleyi</i> Thomas, 1898	1	0	13	0	25	1	5	0	8	0	52	1	53
<i>Tylonycteris robustula</i> Thomas, 1915	0	0	0	0	0	0	1	0	0	0	1	0	1
Total	2960	890	1894	501	1535	438	1190	313	2372	443	9951	2585	12536
Number of species	29		30	`	24		35		31		42		

*Individuals identified externally as *Hipposideros* 'bicolor' comprised two phonic types. These morphologically cryptic but acoustically divergent species are differ genetically and in echolocation call frequencies (mean values a Krau Wildlife Reserve 131 kHz and 142 kHz) (Kingston *et al.*, 2001), but overlap morphologically. Individuals with FA < 43 mm and/or tibia < 19 mm could be assigned to *H. bicolor* 142 kHz, and those with FA > 45 mm and tibia > 20 mm to *H. bicolor* 131 kHz, but individuals with FA 43 – 45 mm and tibia 19 – 20 mm for which there were no echolocation recordings were assigned to *bicolor* sp. pending genetic confirmation.

** *Kerivoula* sp. represents an undescribed species. (Francis *et al.* in prep)

† *Hipposideros doriae* synonymous with *H. sabanus*.

Table 2. Bat associations reported by 208 visitors interviewed at Kuala Gandah Interpretive Centre in 2003 and 2004.

Association	Percentage of people interviewed making the association (2003, 2004 pooled)
Positive associations	
Unspecified ecosystem services	2.4
Seed dispersal or pollination (particularly of Durian)	2.4
Pest control (insect eating)	4.3
Guano (for use as fertilizer)	3.4
Anticoagulant (medical application of anticoagulant in vampire bat saliva)	0.5
Folk medicine (particularly as cure for asthma). NB. This is a negative association for conservation purposes.	1.4
Negative associations	
Scary/frightening	16.9
Spread disease/dirty	7.7
Smelly	6.3
Bite	1.4
Bad reputation (vampire associations, ghosts)	8.7
Fruit crop pests	3.4
Caught in hair/clothes	1.4

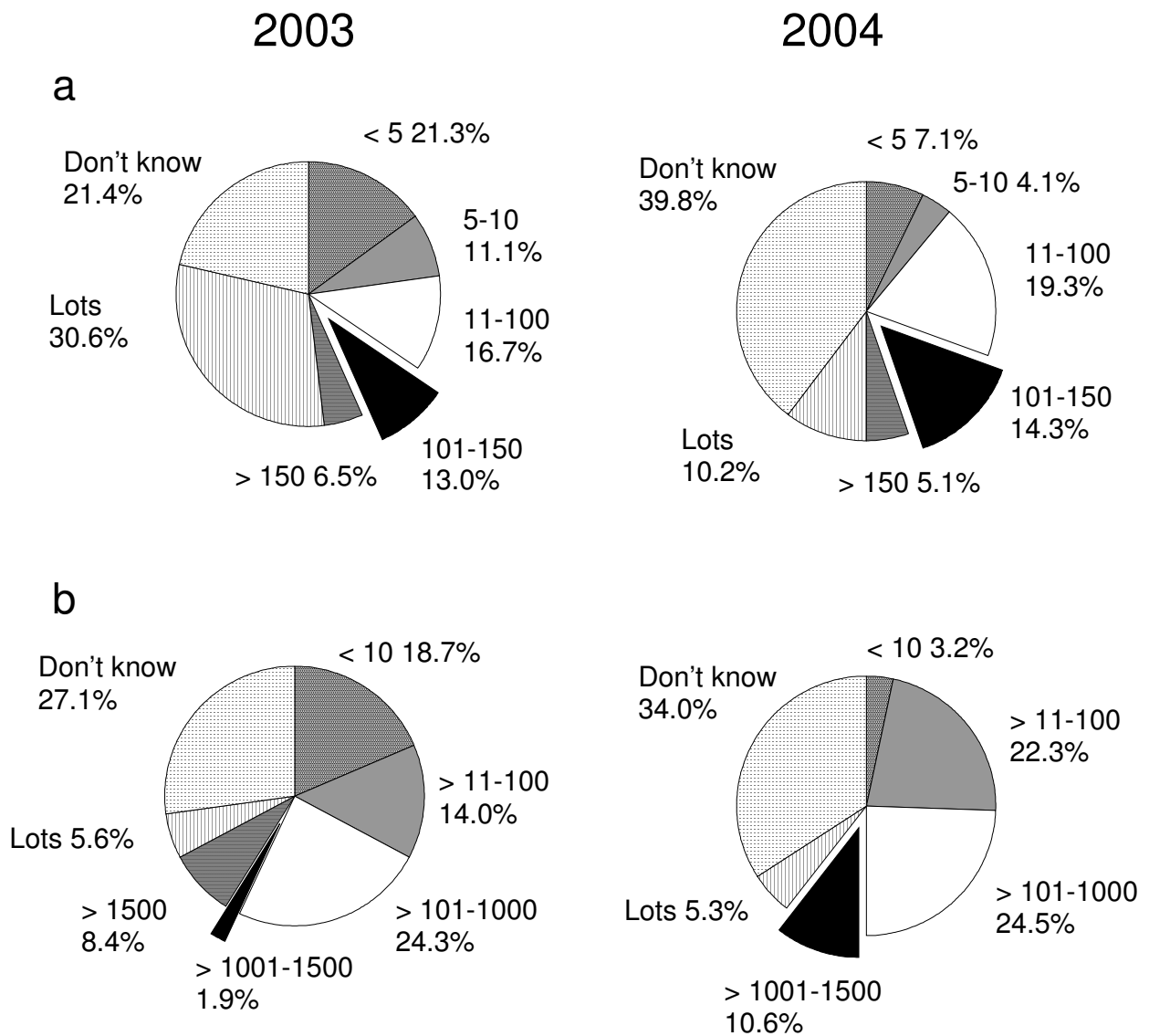


FIGURE 1.

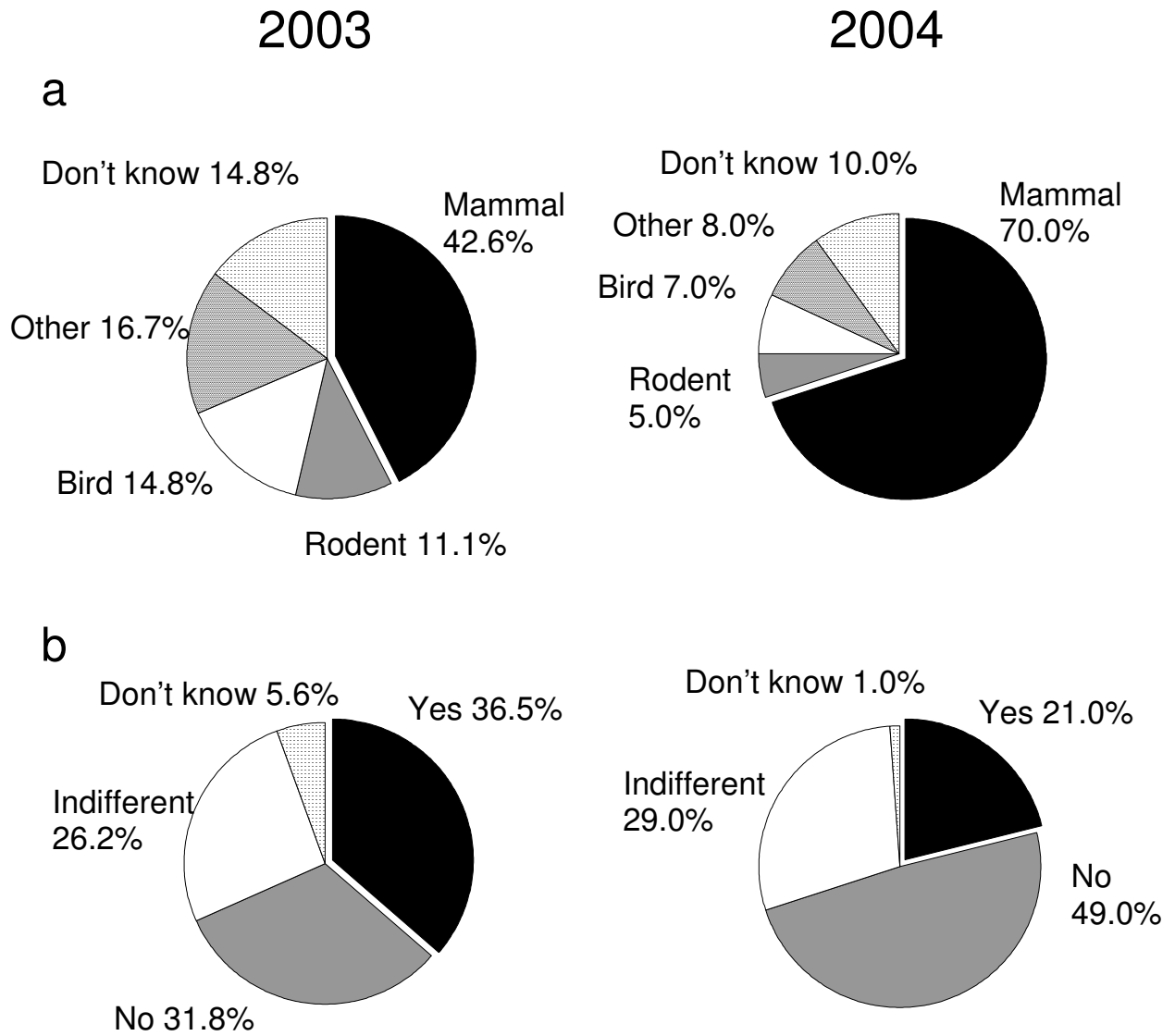


FIGURE 2.

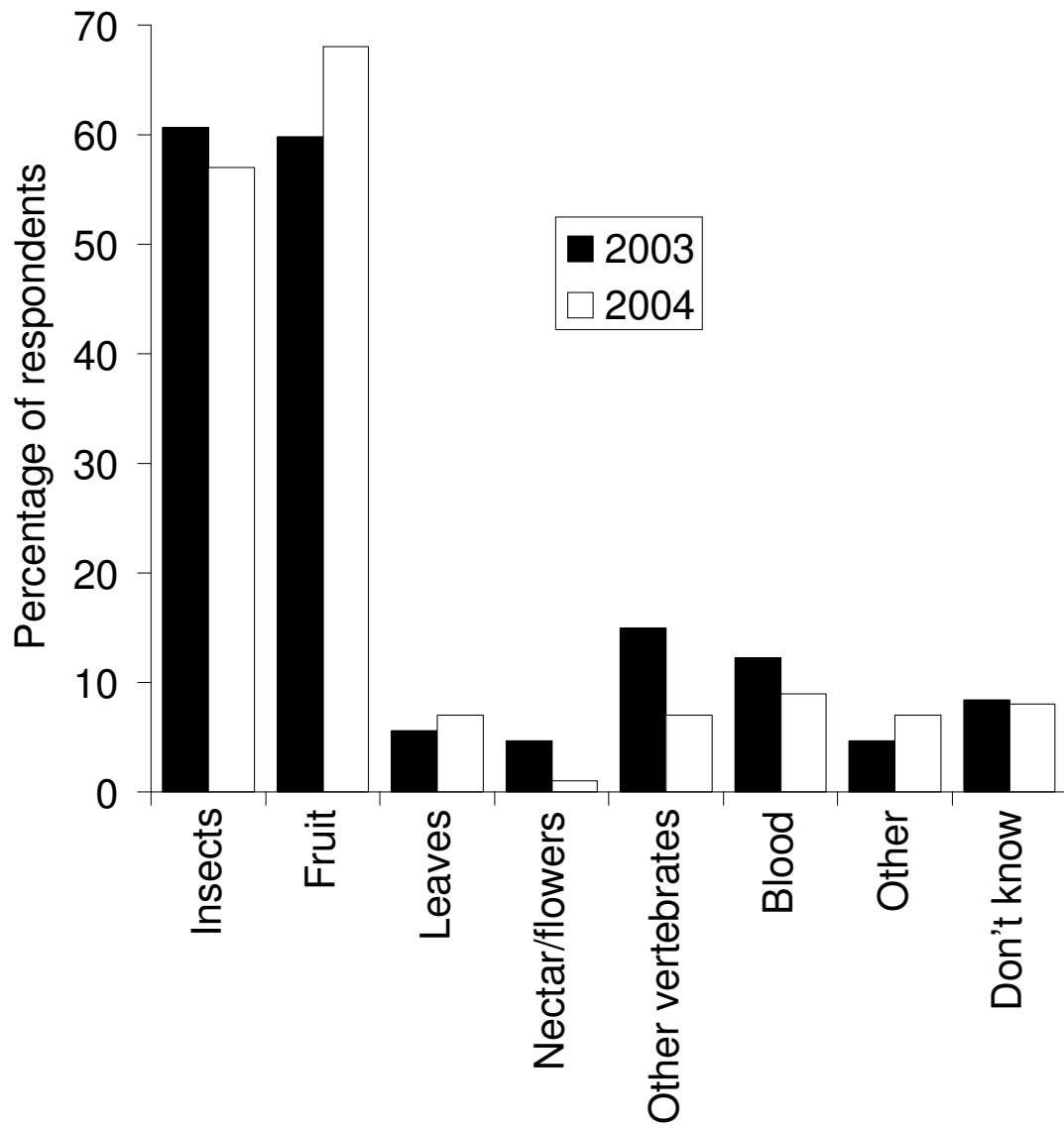


FIGURE 3.