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Editorial Note

This special issue on biodiversity comes in response to the urgent need to document our biological resources and to understand them better before they disappear. Very interesting and useful information is given here on a wide array of organisms including bats, deer, wild pigs, whales and dolphins, and mangroves. Two articles deal with freshwater ecosystems and the resources found therein. Extinction of plants after the eruption of Mt. Pinatubo is also documented. In most of these articles, management strategies are suggested. Finally, a good bibliography on mammals is contributed.

We hope the readers will enjoy this issue. The Editorial Board wishes to apologize for the delay in its appearance.

H.P. Calumpong

Notice to Authors

The **Silliman Journal** welcomes contributions in all fields from both Philippine and foreign scholars, but papers should normally have some relevance to the Philippines, Asia, or the Pacific. All submissions are refereed.

Articles should be products of research, taken in its broadest sense; a scientific paper should make an original contribution to its field. Authors are advised to keep in mind that SJ aims at a general international audience, and to structure their papers accordingly.

SJ also welcomes submissions, such as "Notes," which generally are briefer and more tentative than full-length articles. Reports on work in progress, queries, updates, reports of impressions rather than of research, responses to the work of others, even reminiscences are appropriate here. Book reviews and review articles will also be considered for publication.

Manuscripts should conform to the conventions of format and style exemplified in this issue of SJ. Whenever possible, citations should appear in the body of the paper, holding footnotes to a minimum. Pictures will be accepted only when absolutely necessary. If possible, scientific papers should be accompanied by an abstract. All authors must submit their manuscripts in duplicate, typewritten double-spaced on good quality bond paper.

The Editorial Board will endeavor to acknowledge all submissions, consider them promptly, and notify authors of its decision as soon as possible. Each author of an article is entitled to twenty-five free offprints. More may be had by arrangement with the Editor before the issue goes to press.

THE NATURAL HISTORY OF BATS ON MT. MAKILING, LUZON ISLAND, PHILIPPINES

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ABSTRACT. Over 1500 bats representing 20 species were captured in lowland forest on Mt. Makiling, Luzon Island, from January to August 1989. The two most commonly captured species, the fruit bats *Ptenochirus jagori* and *Cynopterus brachyotis*, were found to reproduce seasonally with two birth periods per year. Although microchiropterans comprised only 8% of all captures, they represented 14 species. Species accounts presented here include information on reproduction, habitat use, and other aspects of natural history.

INTRODUCTION

The Philippine bat fauna is very diverse, with 70 species recorded, of which at least 20 are endemic (Heaney *et al.*, 1987; Ingle and Heaney, 1992; Koopman, 1989). However, the ecology and distribution of most species are very poorly known. This is particularly true for microchiropterans, which are much more rarely caught in mist nets than megachiropterans, or fruit bats.

Heaney *et al.* (1987) reviewed information on the occurrence, distribution, and conservation status of bats of the Philippines. They noted large gaps in our knowledge of the taxonomy and distribution of Philippine bats, dramatically illustrated by identification of five new species since 1969. Studies on the population biology (Heideman and Heaney, 1989), reproductive ecology (Heideman, 1987, 1988, 1989), and foraging ecology (Utzurrum, 1984; Utzurrum and Heideman, 1991) of fruit bats on Negros Island comprise the bulk of the work conducted on the ecology of Philippine bats. The taxonomy and biogeography of Philippine fruit bats were reviewed by Heaney (1991). Reports of recent mammal surveys (Heaney *et al.*, 1981, 1989; Mudar and Allen, 1986) included information on the ecology of the bats captured, particularly on their habitat and reproduction.

This paper provides information on the natural history of bats captured in lowland forest on Mt. Makiling during a seven-month field study. Along with the work conducted on Negros Island, this is one of the few studies on Philippine bats in-

volving intensive netting and collection of seasonal reproductive data. Species accounts for the 20 species captured include information on their habitat, reproduction, and other aspects of their natural history.

Mt. Makiling is a dormant volcano in central Luzon about 60 km south southeast of Manila. Its protected status as a forest reserve and its proximity to the capital and to the University of the Philippines at Los Baños (UPLB), situated at the base of Mt. Makiling, make it attractive for long-term research. Previous reports on the bats on Mt. Makiling include notes on eight species of bats netted on the UPLB campus and in forest on Mt. Makiling (Catibog-Sinha, 1982, 1987), and studies on the foraging ecology of *Megaderma spasma* within the Makiling forest (Balete, 1988) and of *Scotophilus kuhlii* on the UPLB campus (Rubio, 1977). The latter study included a list of bat species netted at sites along the access road up Mt. Makiling.

STUDY AREA

The study was conducted within a 330-ha area of second growth forest ($14^{o}09$'N longitude, $121^{o}13$'E latitude) within Makiling Forest Reserve, Luzon Island, Philippines. The study area is located on the northeastern face of Mt. Makiling, a dormant volcano with an elevation of 1143 m at the peak. Elevation within the study area ranges from 200 to 500 m. The topography is characterized by ridges and valleys, with few flat areas. Four major creeks drain the study area. Despite variation in the annual pattern of rainfall on Mt. Makiling, in most years a wet season and a dry season can be identified. In 1989 the annual rainfall on the UPLB campus (elevation ca. 50 m) was 2055 mm. The wettest months were from May to October, when the monthly rainfall always exceeded 200 mm (mean monthly rainfall = 284 mm; Fig. 1). The six other months of the year received less than 120 mm of rain (mean monthly rainfall = 59 mm). Mean monthly temperature ranged from 25^{o}C to 29^{o}C.

The forest canopy is about 25 m high in valleys and on slopes and is slightly lower on the tops of ridges. Dominant tree species include *Nephilium mutabile* Blume (Sapindaceae), *Celtis luzonica* Warburg (Ulmaceae), *Parashorea malaanonan* (Blanco) Merrill (Dipterocarpaceae), *Diplodiscus paniculatus* Turczaninow (Dilliaceae), *Ficus variegata* Blume (Moraceae), *Palaquium foxworthyi* Merrill (Sapotaceae), *Chisocheton pentandrus* (Blanco) Merrill (Meliaceae), *Bischofia javanica* Blume (Euphorbiaceae), *Alstonia macrophylla* Wallich *ex* De Candolle (Apocynaceae), and *Shorea contorta* Vidal (Dipterocarpaceae) (Quimbo *et al.* 1980). Palms and rattans are common in the understory.

METHODS

Between 11 January and 10 August 1989, bats were netted with 35 mm mesh monofilament mist nets 6- or 12-m long at 20 sites within the study area. Each site was sampled once for a period of one to four consecutive nights. In the first seven sites only ground-level nets were set. At subsequent sites, nets were set 3-16 m above the ground using a pulley system (for details see Ingle, 1990).

Nets were usually open from 1800-0530 h but were closed during periods of rain. Nets were checked at 30-min to 2-h intervals throughout the night. Each bat captured was identified to species, sexed and weighed to the nearest 0.1 or 0.5 g with a 50- or 300-g Pesola spring balance and its forearm was measured to the nearest 0.1 mm with dial calipers. Bats were classified into age classes based on the presence or absence of cartilaginous metacarpal and phalangeal epiphyseal plates, determined by transilluminating the metacarpal-phalangeal joints with a flashlight (Anthony, 1988). Juveniles were defined as those bats with both phalangeal and metacarpal plates visible, subadults as bats with only one plate visible, and adults as bats with no plates visible. Reproductive condition was not a criterion for classifying individuals into age classes. In females, pregnancy was determined by palpation and the lengths of embryos were estimated and recorded (see Heideman, 1988, for an estimate of the accuracy and precision that can be obtained using this technique). For female *Ptenochirus jagori* and *Cynopterus brachyotis*, only embryos at least 20 mm long were recorded before 24 May. After this date, females with embryos estimated by palpation to measure 3 mm or more were scored as pregnant. The criteria for determining pregnancy changed because of increased ability to detect embryos by palpation. Lactation was determined by squeezing the nipples to express milk.

Most bats captured were released immediately after processing at the site of capture. Before release, bats with adult weights of at least 20 g were marked with a numbered aluminum band (Gey Band and Tag Co., Norristown, PA) on a stainless steel ball-chain necklace (Ball Chain Manufacturing Co., Mt Vernon, NY).

Some bats were collected as voucher specimens. These were fixed in 10% formalin solution for three days and then transferred to 70% ethanol. Standard specimen measurements were taken (Handley, 1988). Specimens are deposited in the American Museum of Natural History, Cornell University Vertebrate Collection, Field Museum of Natural History and the Philippine National Museum.

For the analysis of pregnancy and lactation in *Ptenochirus jagori* and *Cynopterus brachyotis*, adult females were grouped by trapping period. Sites with $n < 5$ were excluded. Condition of pregnancy was divided into four categories: not palpably preg-

nant; embryo < 2 cm long; embryo ≥ 20 mm long; and either not palpably pregnant or with an embryo < 20 mm long.

The distributions of weight and of forearm length of juvenile *Ptenochirus jagori* and *Cynopterus brachyotis* netted in each trapping period were examined with histograms. Means of weight and forearm length were calculated for each site. Mean weight and mean forearm length were regressed separately against trapping date (the middle of the trapping period when it comprised more than one night of netting). For juvenile *P. jagori* recaptured at least 10 days after they were necklaced, mean daily changes in forearm length and in weight were calculated.

Numbers of adult and juvenile *Ptenochirus jagori* and *Cynopterus brachyotis* netted at each site were summed; for each species, the hypothesis that proportions of juveniles and adults were homogeneous among trapping periods was tested using contingency tables. Subadults were excluded from this analysis because they represented only 64 of 1059 *P. jagori* captures and four out of 217 *C. brachyotis* captures. For both juveniles and adults of each species, the sex composition was tested for homogeneity with a contingency table. In contingency tables for *P. jagori* the x^2 statistic was calculated using the statistical computer package Minitab (Ryan *et al.*, 1985). In contingency tables for *C. brachyotis* sample sizes were small so Monte-Carlo approximations of the *P*-value were computed using StatXact (CYTEL Software Corp., 1989). If no significant difference in sex composition was detected between trapping periods then all trapping periods were pooled. A binomial test was performed to test if the overall sex ratio was significantly different from 1:1.

The population size of the *Ptenochirus jagori* colony was estimated by the Lincoln-Petersen method using a 95% confidence interval of the Chapman estimate (Pollock *et al.*, 1990). For *P. jagori*, differences in both weight and forearm length between various pairs of groups defined by sex and whether they were netted in the forest or at the roost were tested for statistical significance with t-tests.

For all statistical analyses $p < 0.05$ was deemed statistically significant. All statistical analyses other than contingency tables were performed using SAS (SAS Institute, Inc., 1985).

RESULTS AND DISCUSSION

A total of 1548 bats representing 20 species were captured (Table 1). Many of the species captured in the study had not been reported from Mt. Makiling. Standard external measurements of adults are given in Table 2. Species names follow Heaney *et al.* (1987).

***Cynopterus brachyotis* (Muller)**

Cynopterus brachyotis is found throughout Southeast Asia (Hill, 1983; Koopman, 1989); it occurs throughout the Philippines (Heaney *et al.*, 1987). (Kitchener and Maharadatunkamsi (1990) split *C. brachyotis* into several species assigning Philippine records to *C. luzoniensis.* However, as this proposed revision has not yet been evaluated by other workers, the previously accepted taxonomy is followed here.) The species had been previously reported from Mt. Makiling by Catibog-Sinha (1982, 1987) and Rubio (1977).

Cynopterus brachyotis was the second most commonly captured bat in this study, accounting for 15% (231 individuals) of all captures (Table 1). The age class composition of *C. brachyotis* varied significantly between trapping periods (Fig. 2; contingency table with Monte-Carlo approximation of p-value computed using statistical package StatXact due to low sample size, p 0.05; subadults were excluded from this analysis as they represented less than 2% of all captures). The sex ratio of adults also varied significantly between trapping periods (Fig. 3; StatXact contingency table, $p < 0.01$). Sex ratios of juveniles, however, were homogeneous (StatXact contingency table, $p > 0.20$) and not significantly different from 1:1 (binomial test, $p = 0.19$)

Temporal variation in age class composition and sex composition of adults were also detected in the most commonly captured species, the fruit bat *Ptenochirus jagori*. For this species these patterns appeared to be linked to seasonal reproductive patterns. It is likely that this was also the case for *Cynopterus brachyotis*, but sample sizes were too small to infer such a relationship.

In *Cynopterus brachyotis*, patterns of lactation indicate a birth period sometime between mid-March and mid-May. A more precise estimate of the timing of the birth period from either this or the pregnancy data is not possible because of the lack of samples. Four out of five adult females captured in early June carrying embryos <20 mm were lactating, suggesting post-partum estrus. Three *C. brachyotis* females were captured carrying young on April 16 and 17, and on July 23. The first and last such females netted were captured more than three months apart. The umbillicus was still attached to the neonate captured on 17 April, indicating that it was born utmost a few days previously.

The distributions of both forearm length and weight of juvenile *Cynopterus brachyotis* netted in each trapping period were unimodal when sample sizes were $\geq$ 15, as would be expected if the juveniles belonged to a cohort that had been born at roughly the same time. Mean forearm length of juveniles netted within a trapping period increased from 59 mm to 64 mm from late May to mid-June, and was strongly

correlated with trapping date (r^2 = 0.97, slope = 0.0565 mm/day). Mean weight showed a similar strong correlation (Fig. 4; r^2 = 0.93, slope = 0.111 g/day, *S.E.* = 0.01). The cohort sampled was represented in juvenile captures from late May to early August.

In the 30-g African pteropodid *Micropteropus pusillus*, weight increases of a cohort of free-flying juveniles about 2-6 months old were 0.116 g/day and those for the 120-150 g *Epomops beutikkoferi* were 0.276 g/day (Thomas and Marshall, 1984). Rates of increase in mean weight of a cohort will represent growth rates if catchability and mortality of equal-aged individuals do not differ with weight. The increases in mean weight of cohorts of *C. brachyotis*, *M. pusillus*, and *E. beutikkoferi* are low compared to the growth rates of other similarly sized mammals. Thomas and Marshall (1984) attributed the apparently slow growth rates of pteropodids to the low-protein quality of their fruit diets.

***Eonycteris spelaea* Miller**

Eonycteris spelaea is widely distributed in South and Southeast Asia, occurring from India to Timor, and is found throughout the Philippines (Heaney *et al.*, 1987; Koopman, 1989). The species is strongly associated with agricultural areas (Heideman and Heaney, 1989; Heaney *et al.*, 1989) feeding on pollen and nectar (Start, 1974). *E. spelaea* was previously reported from Mt. Makiling (Catibog-Sinha, 1987; Rubio, 1977).

Of the six individuals netted (Table 1), a female with unfused epiphyses that was captured on 10 May was pregnant. Populations of *Eonycteris spelaea* in central India (Bhat *et al.*, 1980) and in Selangor, Malaysia (Start, 1974), appear to breed aseasonally (with births occurring throughout the year) and with a post-partum estrus. On Negros Island the reproductive status of ten adult females captured over one year was consistent with births occurring throughout the year (Heideman, 1987).

***Haplonycteris fischeri* Lawrence**

Haplonycteris fischeri is endemic to the Philippines. It occurs throughout the country, possibly excluding Palawan and associated islands (Heaney *et al.*, 1987) and was previously reported from Mt. Makiling (Rubio, 1977). Fourteen individuals were netted in this study (Table 1). Although *H. fischeri* was not common in the study area on Mt. Makiling, it was the most commonly netted bat species in submontane dipterocarp rainforest on Negros Island (830-1000 m elevation); it accounted for a third of all captures and was estimated to occur at a density of 3.7 individuals/ha (Heideman and Heaney, 1989).

Two adult females caught on 28 May and 4 June carried embryos that were judged to be near-term based on palpation, and two adult females caught on 2 and 3 July were lactating. Heideman (1988, 1989) described the reproductive ecology of *Haplonycteris fischeri* on Negros Island. Parturition occurred in June, after an 11.5-month gestation period including an 8-month delay in embryonic development following implantation.

***Macroglossus minimus* (E. Geoffroy)**

Macroglossus minimus is found from Thailand to Australia and throughout the Philippines (Heaney *et al.*, 1987; Koopman, 1989). This species was previously netted on Mt. Makiling (Catibog-Sinha, 1982, 1987; Rubio, 1977). In the present study, 32 individuals were netted, of which two were kept as voucher specimens (Table 1). The species is strongly associated with agricultural areas and is uncommon in forest, but when found in forest it is most common in clearings (Heideman and Heaney, 1987). *M. minimus* feeds on nectar and pollen (Start, 1974).

Pregnant females were caught on 16 July (n = 1) and 25 July (n = 2). Four lactating females were caught on 5, 11, and 26 May. *Macroglossus minimus* breeds aseasonally on Negros Island (Heideman, 1987) and in Selangor, Malaysia (Start, 1974). This species has been demonstrated to undergo post-partum estrus (Start, 1974).

***Ptenochirus jagori* (Peters)**

Ptenochirus jagori is found throughout the Philippines, except the Palawan region (Heaney *et al.*, 1987). This endemic species was known to occur on Mt. Makiling (Catibog-Sinha, 1982, 1987; Rubio, 1977). In this study 1143 individuals were netted, accounting for 74% of all bats captured (Table 1).

The proportion that juveniles comprised of all *Ptenochirus jagori* captures varied significantly between trapping periods (Fig. 5; x^2 = 222, $d.f.$ = 11, p <<0.005; subadults were excluded from this analysis as they represented only 6% of all captures). From April through mid-June, adults outnumbered juveniles. In late June juveniles and adults were captured in roughly equal numbers, and in July through mid-August juveniles constituted about 80% of the netted population. The increase in the proportion of juveniles was due partly to the addition of free-flying juveniles from a seasonal birth period, which was also indicated by the patterns of pregnancy and lactation (discussed below). It was due also to greater catchability of juveniles relative to adults, which is evident if one considers that in July and August juveniles greatly outnumbered adult females, even though each adult female gives birth to only one young at a time.

The sex ratio of juveniles did not differ significantly between trapping periods ($x^2 = 13.5, d.f. = 11, p > 0.25$). When all trapping periods were combined, the overall sex ratio did not differ significantly from 1:1 (binomial test, $p = 0.76$).

Among adults, however, the sex ratio was not consistent between trapping periods (Fig. 6; $x^2 = 24.8, d.f. = 11, p < 0.01$). Females constituted about 75% of adults captured at all sites trapped in May and June (Fig. 6). At the sites trapped before and after this period, however, the females constituted about 50% of all captures. It should be noted, however, that for some of these sites samples sizes were small.

Temporal variation in the age class and adult sex composition of captured *Ptenochirus jagori* was probably caused by seasonal reproductive patterns. The patterns of lactation and pregnancy (Fig. 7) in adult female *P. jagori* indicate that a birth period occurred sometime from the second half of April to the first week of May. Sixty per cent of adult females captured in 25-29 May in early stages of pregnancy (embryo cm; $n = 30$) were lactating, suggesting that post-partum estrus occurred after parturition during the April-May birth period. After the April-May birth period most females were palpably pregnant by late May. From monthly samples of *P. jagori* on Negros Island, Heideman (1987) estimated gestation to last about four months. With this estimate of gestation length, a second birth period for the Mt. Makiling population is predicted to occur around September.

Of 240 lactating females captured in May and June only four were carrying young. This suggests that females are leaving their young at a roost while they forage. In May and June, sex ratios for adult *Ptenochirus jagori* were strongly female-biased (Fig. 6). Females may have an increased likelihood of capture during lactation if they spend more time flying to forage to meet their increased energetic demands, and possibly to return periodically throughout the night to feed their young. Females with young were also caught on 16 April ($n = 1$) and 3 July ($n = 1$).

Captured juveniles fell into two size classes by body weight and forearm length. These size classes were inferred to represent cohorts of approximately equal-aged individuals. Members of cohort A were netted from March, when the first sites were trapped, to mid-June, after which they became subadults or adults because their epiphyseal plates had closed. Members of cohort B overlapped with members of cohort A and were first trapped in late May. For sites at which > 25 juvenile *Ptenochirus jagori* were netted, the distributions of weight and forearm length were distinctly unimodal except for the sites trapped from late May to mid-June when both cohorts were netted. At the three sites netted during this period the distributions of weight were sharply bimodal. As the ranges in weight for the two peaks did not overlap there was no ambiguity is separating juveniles caught in each of the three sites

into the two cohorts. However, in the period in which both cohorts were netted, their ranges of forearm length overlapped.

For both cohorts, mean weight of juveniles netted at a site was positively correlated with trapping date (cohort A, $r^2 = 0.95$; cohort B, $r^2 = 0.96$; Fig. 8). For cohort A, mean weight ranged from 60 to 71 g, and increased by an average of 0.12 g/day (*S.E.* = 0.01). For cohort B, mean weight ranged from 45 to 62 g and increased by 0.26 g/day (*S.E.* = 0.02). Rates of weight gain differed significantly between the two cohorts ($p = 0.0001$). This difference is probably because at the time that they were captured, members of the two cohorts differed in weight, and therefore presumably in age; rates of weight gain tend to decline with increasing age.

Mean forearm length of members of a cohort trapped at a site and trapping date was also positively correlated with trapping date (cohort A, $r^2 = 0.53$; cohort B, $r^2 = 0.99$), but this relationship was not as consistent as the relationship between mean weight and trapping date. For cohort A, mean forearm length ranged from 76 to 78 mm and increased by 0.02 mm/day. For cohort B, mean forearm length ranged from 74 to 76 mm and increased by 0.03 mm/day. Unlike rates of increase in mean weight, rates of increase in mean forearm length did not differ significantly between cohorts ($p = 0.37$). The weaker relationship of netting date with mean forearm length compared to the relationship with mean weight is probably due to greater measurement error. The range in mean forearm length was 2-3 mm, whereas the range in mean weight was 20 g; thus measurement errors would have a stronger effect on forearm measurements. In further such studies, careful measurement of forearm length with calipers is important.

Rates of increase in body weight were obtained from 19 marked juveniles recaptured 10-59 days after initial capture. Recaptures came from both cohorts. Mean increase in weight was 0.12 g/day (*S.E.* = 0.03). Rates of increase in forearm length were similarly obtained. Mean increase in forearm length was 0.03 mm/day (*S.E.* = 0.005). These rates of increase of recaptured juveniles are comparable to those obtained for the two cohorts netted during the study. As noted in the section on *Cynopterus brachyotis*, pteropodids appear to have slow growth rates compared to other similarly-sized mammals.

A colony of *Ptenochirus jagori* roosted in a cave located just beyond the northeast edge of the Makiling forest. The cave was about 15 m from a road, between the Jamboree Swimming Pool and the Jamboree Center. The area near the cave was called "Grotto" because two religious statues had been placed nearby. The cave was about 6 m off the ground in a 15-m high vertical rock face. It measured about 2 m wide, 1 m high, and 2 m deep. People came within 10 m of the cave almost daily to visit the statues, and flourescent lights illuminated the area in the early part of the

night. However, as the cave itself was not easily accessible, it probably was not subjected to frequent direct human disturbance.

The cave was visited on 11 occasions from 7 February to 23 May 1989. On four nights a net was set outside the roost; captured individuals were marked and processed in the same way as those caught in the forest. Twenty *Ptenochirus jagori* were netted at least once; some were captured on more than one night. Nineteen were adults; one female was not aged. The sex ratio among adults was 2.8 males per female (n = 19). Lincoln-Petersen point estimates of the population size (Pollock *et al.*, 1990) ranged from 20 to 54. This author estimated that 20-30 bats flew out of the cave when she first visited the roost on 7 February. Two adult females captured on 6 April were pregnant with embryos at least 2 cm long. Two juvenile female and one juvenile male *Macroglossus minimus* were caught outside the cave in the same net in which *P. jagori* were caught.

Although in the large sample of bats netted in the forest no sexual dimorphism in forearm lengths of adults was detected (males: $\bar{x}$ = 78.2 mm, n = 128; females: $\bar{x}$ = 78.2 mm, n = 339; t-test, p = 0.89), among adults captured at the cave roost, males had significantly longer forearms than females (males: $\bar{x}$ = 80.1 mm, n = 14; females: $\bar{x}$ = 76.6 mm, n = 5; t-test, p = 0.002). This and the longer forearm length of males netted at the roost over those netted in the forest (t-test, p = 0.001) suggest that males netted at the roost are on average larger than males from the general population. This pattern might be expected from a species with a harem roosting system, but the male-biased sex ratio of individuals netted at the roost would not be consistent with this social system if all individuals that were netted were roost inhabitants.

Fecal material, and pellets of fruit fiber and seeds that bats had spat out after squeezing out the fruit juices, were found on the cave floor below the roost.

Few bats were observed at the roost on 16 May, and no bats were seen there on 18 and 23 May. The reason why the roost was abandoned was not clear, but could have been due to human disturbance.

***Rousettus amplexicaudatus* (E. Geoffroy)**

Rousettus amplexicaudatus is widely distributed in Southeast Asia, occurring from Thailand to the Solomon Islands; the species is found throughout the Philippines (Heaney *et al.*, 1987). *R. amplexicaudatus* was previously reported from Mt. Makiling (Catibog-Sinha, 1987; Rubio, 1977). Four individuals were netted (Table 1); both adult females captured were netted on 14 May and were lactating. The species is found primarily in or adjacent to agricultural areas (Heaney *et al.*, 1989;

Heideman and Heaney, 1989); both sites in which it was captured, although in secondary forest, were within 300 - 400 m of agricultural areas. On Negros Island, *R. amplexicaudatus* has two annual birth periods, the first in March through April and the second in July through early September (Heideman, 1987).

***Emballonura alecto* (Eydoux and Gervais)**

Emballonura alecto is found throughout the Philippines, and in Borneo and Sulawesi (Heaney *et al.*, 1987).

Of the eighteen individuals netted at the entrances of three roosts (Table 1) three individuals were collected. Roost 1 consisted of a rock shelter about 8 m long and 3-5 m wide was formed by two large boulders leaning against each other. Smaller boulders contributed to the sides of the shelter. Several openings were formed by gaps between the boulders; bats were netted in front of the largest opening (ca. 2 m by 1.5 m). The roost was at 180 m elevation, 5 m from a 3-5 m wide creek lined with boulders. Five adult males and six adult females were netted outside Roost 1 on 14 April. This author estimated that the total roosting group consisted of 15-20 individuals.

Roost 2 was formed by a large boulder, supported at a 45^{o} angle by smaller rocks. Like Roost 1, Roost 2 was dimly lit. It was located at 260 m elevation, on a slope leading down to a creek. Three adult males, one juvenile male, and two adult females were netted outside Roost 2 on 13 June. The total number of individuals inhabiting the roost was not estimated.

Roost 3 was a shelter under a boulder located about 20 m from Roost 2, and contained about five roosting bats, of which an adult female was captured. The roosting group was discovered 3 hours after roost 2 had been netted, and therefore possibly consisted of bats disturbed from Roost 2. Shelters formed by other boulders in the area around Roosts 2 and 3 were inspected but no other bats were found.

All six females caught on 14 April were pregnant. One of the three adult females caught on 13 June carried a fetus that was judged to be near-term. The female and fetus together weighed 9.4 g (non-pregnant female weight = 7.2-7.7 g). Of the two other females captured on 13 June, one was lactating and the other was neither pregnant nor lactating.

***Megaderma spasma* (Linnaeus)**

Megaderma spasma is found from India through Indonesia and throughout the Philippines (Heaney *et al.*, 1987). The species was previously netted on Mt. Makiling (Catibog-Sinha, 1987; Rubio, 1977). Eight individuals were captured in this study (Table 1). Seven were captured in mist nets set 0-3 m above the ground. One female was netted at a roost.

Megaderma spasma is known to roost in caves and hollow trees (Payne *et al.*, 1985) and under the eaves of houses (Phillips, 1922). In this study, six *M. spasma* roosts were located and one of two roosts within the study area that had been discovered by Balete (1988) was visited. All seven roosts were cavities in large (diameter = 1.2-1.6 m) living trees, with one to four openings (usually one) either on the ground (n = 5) or within 1.5 m above it (n = 2). Except in Roost 7, the openings measured about 1 m at the widest part and 0.5 m at the tallest part, and the cavities extended 2.5-7.0 m above the ground and were 0.6-1.2 m in diameter. In two of these roosts the cavity also had an opening at the top (diameter $\geq$ 0.7 m). In Roost 7 the opening was a high arch extending from the base of the tree, where it was 1 m wide to 5 m above the ground. The top of the cavity in this roost could not be seen in the weak light of a flashlight. Balete (1988) described a small cave in which *M. spasma* roosted. The cave was located on the bank of a creek and was about 7.5 m wide, 1 m high, and 4.5 m deep.

Roosting groups consisted of one to seven individuals. As roosting *Megaderma spasma* are easily identified by their large joined ears, pale underparts, and relatively large size, nets were only set at Roost 2. Two roosts were visited twice. Seven bats were seen in Roost 4 on visits four days apart. On the first visit to Roost 3, four or five bats were seen, but only one bat was seen two days later. The number of roosting bats in the roosts Balete (1988) visited fluctuated from three to seven in the tree hollow and from none to six in the cave during regular visits over a one-year period.

Parts of exoskeletons of large insects were found on the floor of most roosts. Balete (1988) collected culled insect parts below two roosts on Mt. Makiling over a one-year period. Most of the insects represented were relatively large and were sound-producing, and spend most of their time on the substrate. These characteristics of the insect prey suggest that the insects were gleaned from the ground and from low foliage (Balete, 1988). The fact that in the present study *Megaderma spasma* was only captured in low nets is consistent with the hypothesis that the species gleans its prey from low-level foliage and the ground. In India, *M. spasma* were observed flying very low, almost touching the ground (Brosset, 1962; Phillips, 1922). In the laboratory, *M. spasma* was shown to have two foraging strategies: surface gleaning,

and flycatcher-style foraging, in which prey are captured in short sallies from a perch (Tyrell, 1987, 1988).

The female caught on 30 March at Roost 2 was pregnant. Balete (1988) observed a female with young in the cave roost on 8 June 1986. On 31 May 1987 he observed a female with young at both the cave roost and the tree roost. The above observations are consistent with a seasonal birth period in April-May, but further work is necessary for confirmation. *Megaderma spasma* has been reported to breed seasonally in west India (Brosset, 1962) and in Thailand (Phillips, 1922).

***Hipposideros diadema* (E. Geoffroy)**

Hipposideros diadema occurs from Burma to the Solomon Islands and is found throughout the Philippines (Heaney *et al.*, 1987). The species was previously recorded from Mt. Makiling (Catibog-Sinha, 1987; Rubio, 1977). Of the 14 individuals netted (Table 1), one escaped before its sex was determined. The other 13 captured were all males (10 adults, three juveniles). Four individuals were collected. *H. diadema* showed a strong association with creeks. Twelve *H. diadema* were netted either over a creek (n = 7) or on creek banks 10-15 m from the creek (n = 6). The other two *H. diadema* were caught more than 20 m from a creek.

Two adult males captured on 31 May did not fly immediately after they were released onto a twig of a small sapling, but hung from the twig turning their heads from side to side, noseleaves and ears twitching. Similar scanning behavior has been described for *Hipposideros commersoni*, a 120-g congener that hunts by making repeated sallies from a perch (Vaughan, 1977). Observations of *H. diadema* by Brown and Berry (1983) and Goodwin (1979) indicate that this species has the same "flycatcher" hunting behavior.

***Hipposideros obscurus* (Peters)**

Hipposideros obscurus is endemic to the Philippines; specimens have been collected from Dinagat, Luzon, and Mindanao (Heaney *et al.*, 1987). Two juveniles were netted on 25 and 29 July and kept as voucher specimens (Table 1).

***Rhinolophus arcuatus* Peters**

Rhinolophus arcuatus is found in Indonesia, Borneo, the Philippines, and Papua New Guinea. It occurs throughout the Philippines, possibly excluding Palawan and associated islands (Heaney *et al.*, 1987).

Twelve individuals were caught; seven were retained as voucher specimens (Table 1). A female collected on 11 May carried a 23-mm long embryo. All three adult females caught on 4 and 6 July were lactating. Of six *Rhinolophus arcuatus* captured on 4-6 July, all were adults, except one male with incompletely fused epiphyses. The fur of the three males was much darker than that of the females, which was more orange. The brighter fur of females may have been caused by bleaching from ammonia in roosts. One possible explanation for the color difference between the sexes is that females do not molt at the same time as do males. Alternatively, males and females may roost separately and be bleached to different degrees because of different roosting environments. It is also possible that the fur of males is naturally lighter than that of females.

***Rhinolophus macrotis* Blyth**

Bats assigned to *Rhinolophus macrotis* have been captured from southern China, Nepal, Indochina, Thailand, Sumatra, and the Philippines (Lekagul and McNeely, 1977). Specimens from the Philippines, however, appear to differ in noseleaf structure and overall size from those captured elsewhere in Asia, and may represent a distinct species (Ingle and Heaney, 1992); further work will be necessary to document this. Two adult males were caught on 21 May; both were retained as voucher specimens.

***Rhinolophus rufus* Eydoux and Gervais**

Rhinolophus rufus is endemic to the Philippines; specimens have been taken from Luzon, Mindanao, Bohol, and Mindoro (Heaney *et al.*, 1987). One nonpregnant adult female was caught on 25 June and retained as a voucher specimen.

***Rhinolophus subrufus* Andersen**

Rhinolophus subrufus is endemic to the Philippines (Heaney *et al.*, 1987). Twenty-seven individuals were captured (Table 1). Eight were retained as vouchers. Of 13 adult females captured on 3-5 July, nine were definitely lactating and three showed signs of either lactation or recent lactation (i.e. hairless ring around nipples, swollen mammary tissue). As with *R. arcuatus*, two distinct pelage colors were observed in *R. subrufus*. Subadults of both sexes were considerably darker than adults, which were all female. Observed color differences were perhaps due to a difference in the initial pelage color of subadults and adults, to differences in the duration since molt, or to different roosting environments.

***Rhinolophus virgo* Andersen**

Rhinolophus virgo is endemic to the Philippines, where it is widespread and common (Heaney *et al.*, 1987). One adult male was captured on 14 June and kept as a voucher specimen.

***Myotis horsfieldii* (Temminck)**

Myotis horsfieldii occurs from southeast China to the Malay Peninsula, Bali, and Sulawesi. In the Philippines it has been recorded from Luzon, Mindanao, Negros, and Palawan (Heaney *et al.*, 1987). A juvenile male netted on 25 June was kept as a voucher.

***Myotis muricola* (Gray)**

Myotis muricola is found throughout Southeast Asia (Koopman, 1989). It is widespread in the Philippines, common in both agricultural and forested areas (Heaney *et al.*, 1987). Eleven individuals were caught (Table 1) of which three were kept as voucher specimens. *M. muricola* appeared to be associated with riparian habitat because, out of the 11 individuals captured, seven were netted over creeks. Two adult females caught on 25 May were lactating. The only other adult female caught, netted on 26 July, was neither pregnant nor lactating.

***Philetor brachypterus* (Temminck)**

Philetor brachypterus occurs in Indonesia, Borneo, Papua New Guinea, and the Philippines, where it has been recorded from Mindanao and Negros (Heaney *et al.*, 1987). A male and female with incompletely fused epiphyses were caught on 4 and 6 July and were kept as voucher specimens.

***Pipistrellus javanicus* (Gray)**

Pipistrellus javanicus is found from Korea to Java and the Philippines. It is found throughout the Philippines where it is common in forest (Heaney *et al.*, 1987). Fourteen individuals were caught (Table 1); 12 were kept as vouchers. Six individuals were caught either over a creek (n = 1) or within 15 m of one (n = 5), two were caught within the UPLB campus, and the remaining six were caught in forest sites at least 20 m from creeks. Two females caught on 18 April within the UPLB campus were pregnant. One, which at 10.8 g weighed twice non-pregnant body weight (see Table 2), was dissected and found to have two embryos. The other adult weighed 10.2

g, and was released. A female caught on 3 June weighed 11.2 g and had a single embryo 19 mm long.

***Scotophilus kuhlii* Leach**

Scotophilus kuhlii is found from Pakistan to Taiwan and Bali; it occurs throughout the Philippines, where it is abundant in urban and agricultural areas (Heaney *et al.*, 1987). The species was previously reported for Mt. Makiling (Catibog-Sinha, 1987; Rubio, 1977). Five adults were caught on 18 April outside a house within the UPLB campus (Table 1). They were roosting under the eaves. *S. kuhlii* has been reported to roost under modified fan palm fronds which drooped down to form "tents" because of cuts near the base of the leaf blades (Rickart *et al.*, 1989).

All three females that were captured were pregnant. Working also on the UPLB campus, Rubio (1977) collected pregnant females in April and June, and lactating females in June through August. Thus, in the UPLB population, parturition appears to occur in June. *Scotophilus kuhlii* is also known to reproduce seasonally in Vietnam (Topal, 1974).

CONCLUSIONS

Microchiropterans constituted only 8% of all captures, but represented more than two-thirds of all species netted. These species are harder to capture in mist nets than megachiropterans because of their ability to echolocate. The fact that many of the microchiropteran species captured in this study were represented by only a few individuals suggests that the list of microchiropteran species is incomplete. The list of megachiropteran species is also incomplete. Although never netted, large flying foxes (*Pteropus* or *Acerodon* spp.) were observed flying over the canopy and were reported by local hunters. *Otopteropus cartilagonodus,* a fruit bat endemic to Luzon, may be present on Mt. Makiling. This species is apparently confined to high elevations, making its capture unlikely at the low elevation (300-500 m) netting sites. To obtain a complete list of all the bats on Mt. Makiling, intensive field efforts, and methods of capturing bats other than netting, will be required.

Despite the importance of bats in the ecology of Philippine forests, particularly as pollinators and seed dispersers, very little is known about their distribution and ecology. Further studies on this group are greatly needed.

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Table 1. List of species and number of bats netted on Mt. Makiling, Luzon Island, Philippines, from January to August, 1989. Bats were assigned to age classes according to degree of epiphyseal closure as described in text. For some species, totals are greater than the sum of all sex and age classes because some individuals were not aged or sexed.

Species	Adults		Subadults		Juveniles		Total
	M	F	M	F	M	F	
Pteropodidae							
Cynopterus brachyotis	28	69	1	3	52	62	231
Eonycteris spelaea	1	0	0	0	3	2	6
Haplonycteris fischeri	3	7	0	1	1	1	14
Macroglossus minimus	8	6	0	0	6	9	32
Ptenochirus jagori	145	350	29	34	250	245	1143
Rousettus amplexicaudatus	0	2	0	0	1	1	4
Emballonuridae							
Emballonura alecto	8	9	0	0	1	0	18
Megadermatidae							
Megaderma spasma	3	1	0	0	0	0	8
Rhinolophidae							
Hipposideros diadema	10	0	0	0	3	0	14
Hipposideros obscurus	0	0	0	0	1	1	2
Rhinolophus arcuatus	4	5	2	0	0	0	12
Rhinolophus macrotis	2	0	0	0	0	0	2
Rhinolophus rufus	0	1	0	0	0	0	1
Rhinolophus subrufus	0	15	4	7	1	0	27
Rhinolophus virgo	1	0	0	0	0	0	1
Vespertilionidae							
Myotis horsfieldii	0	0	1	0	0	0	1
Myotis muricola	7	3	0	0	1	0	11
Philetor brachypterus	0	0	0	0	1	1	2
Pipistrellus javanicus	5	5	0	0	3	1	14
Scotophilus kuhlii	2	3	0	0	0	0	5

Table 2. Ranges of measurements of adults bats caught on Mt. Makiling, Luzon Island, Philippines, from January through August, 1989. Sample sizes are given in parenthesis. Weights for females are from individuals that were not palpably pregnant.

Species	Sex	Weight (g)	Forearm (mm)	Total length (mm)	Tail (mm)	Hindfoot (mm)	Ear (mm)
Cynopterus brachychiotis	M	(28) 31.6-47.0	(28) 60.3-67.6	-	-	-	-
	F	(21) 32.5-44.5	(70) 60.0-67.3	-	-	-	-
Eonycteris spelaea	M	(1) 92.5	(1) 73.9	-	-	-	-
Haplonycteris fischeri	M	(3) 17.8-19.7	(3) 46.7-48.7	-	-	-	-
	F	(5) 19.9-21.9	(7) 46.5-50.7	-	-	-	-
Macroglossus minimus	M	(8) 15.9-18.1	(8) 39.3-41.7	-	-	-	-
	F	(3) 16.0-16.5	(7) 40.2-41.5	-	-	-	-
Ptenochirus jagori	M	(151) 60.0-88.0	(157) 70.9-84.9	(2) 115-117	(2) 9-10	(2) 20-21	(2) 18-19
	F	(99) 57.5-87.0	(359) 69.5-84.5	(1) 118	(1) 9	(1) 19	(1) 18
Rousettus amplexicaudatus	F	(2) 85.5-88.0	(2) 81.6-85.6	-	-	-	-
Emballonura alecto	M	(8) 4.9-6.5	(8) 45.1-48.5	(2) 63-65	(2) 11	(2) 7	-
	F	(2) 7.2-7.7	(9) 45.4-47.7	(2) 66-68	(2) 12-13	(2) 7-9	-
Megaderma spasma	M	(3) 24.0-24.8	(3) 56.7-59.4	-	-	-	-
Hipposideros diadema	M	(10) 41.5-59.0	(10) 78.2-84.9	(2) 124-132	(2) 42-44	(2) 16-17	-
Rhinolophus arcuatus	M	(3) 7.5-8.9	(4) 43.2-46.3	(3) 67-74	(3) 17-18	(3) 10-11	(2) 19-20
	F	(2) 7.7	(4) 44.0-47.0	(3) 61-69	(3) 16-17	(3) 10-11	(2) 18-23
Rhinolophus macrotis	M	(2) 8.2-8.6	(2) 44.3-45.2	(2) 75-79	(2) 26	(2) 9	-
Rhinolophus rufus	F	(1) 34.3	(1) 65.0	(1) 118	(1) 31	(1) 19	(1) 31
Rhinolophus subrufus	F	(14) 15.2-19.5	(14) 53.9-56.6	(5) 78-91	(2) 22-25	(5) 12-15	(4) 24-25
Rhinolophus virgo	M	(1) 6	(1) 37.8	(1) 68	(1) 21	(1) 8	(1) 15
Myotis muricola	M	(7) 3.4-5.5	(7) 30.3-31.7	(2) 72-73	(2) 34-37	(2) 7	-
	F	(1) 4.2	(3) 30.9-32.0	-	-	-	-
Pipistrellus javanicus	M	(5) 4.5-6.4	(5) 31.5-33.2	(5) 71-80	(5) 30-34	(5) 7	(2) 10-11
	F	(2) 5.6-6.4	(5) 32.9-35.5	(3) 76-84	(3) 27-32	(3) 7-8	(1) 10
Scotophilus kuhlii	M	(2) 18.6-18.8	(2) 47.5-51.5	-	-	-	-
	F	-	(3) 48.7-52.1	-	-	-	-

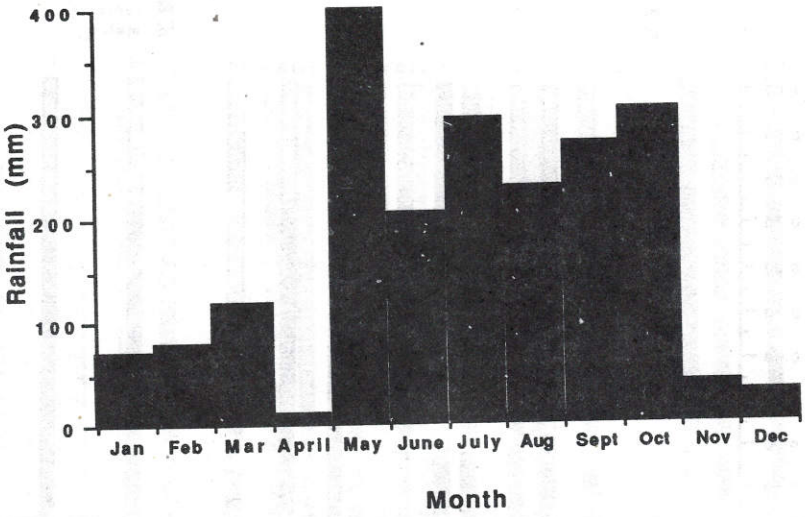

Figure 1. Monthly total rainfall for 1989 on the campus of the University of the Philippines at Los Baños, Luzon Island. Source: University of the Philippines at Los Baños Meterological Station.

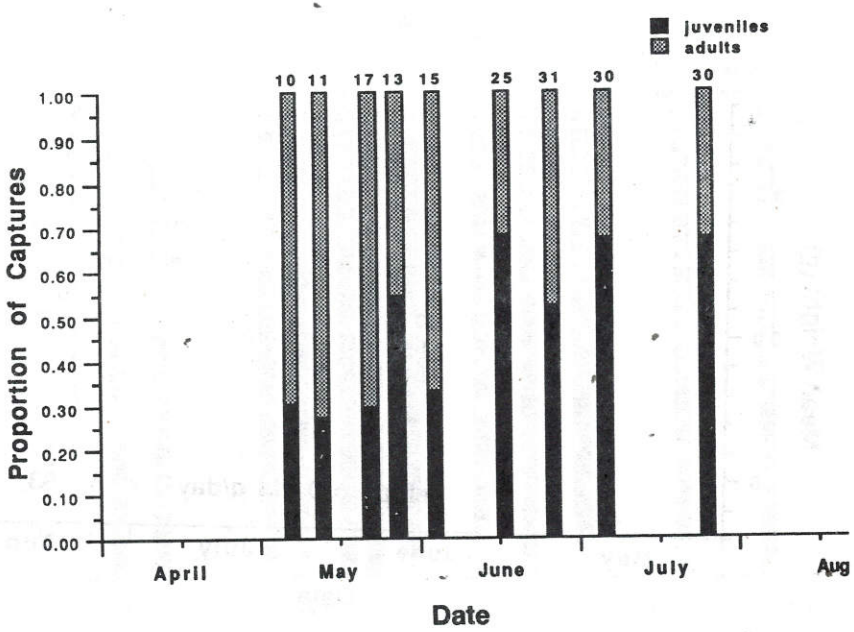

Figure 2. Age class composition of *Cynoptera brachyotis* at each sampling period. Sample sizes are indicated above bars. Only periods where $n \geq 5$ are included.

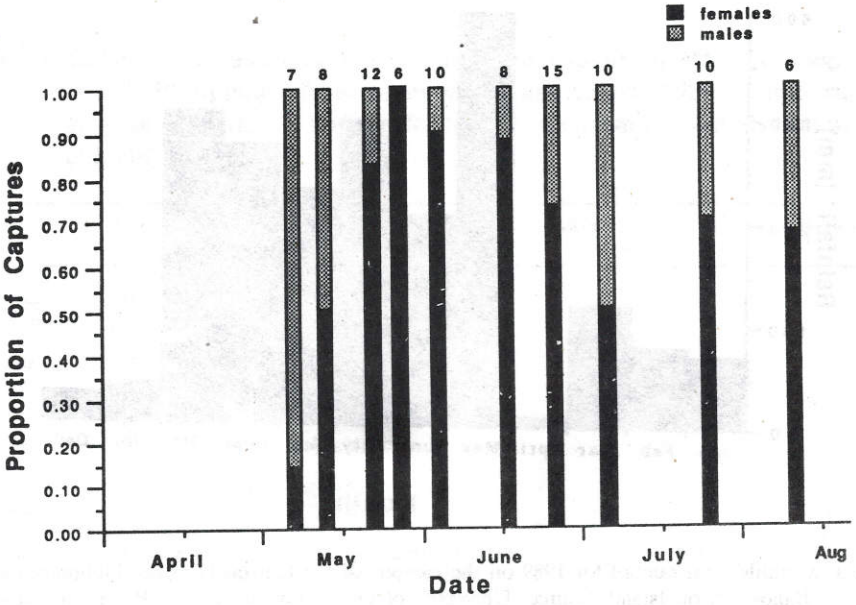

Figure 3. Sex composition of adult *Cynopterus brachyotis* at each sampling period. Sample sizes are indicated bars. Only periods where $n \geq 5$ are included.

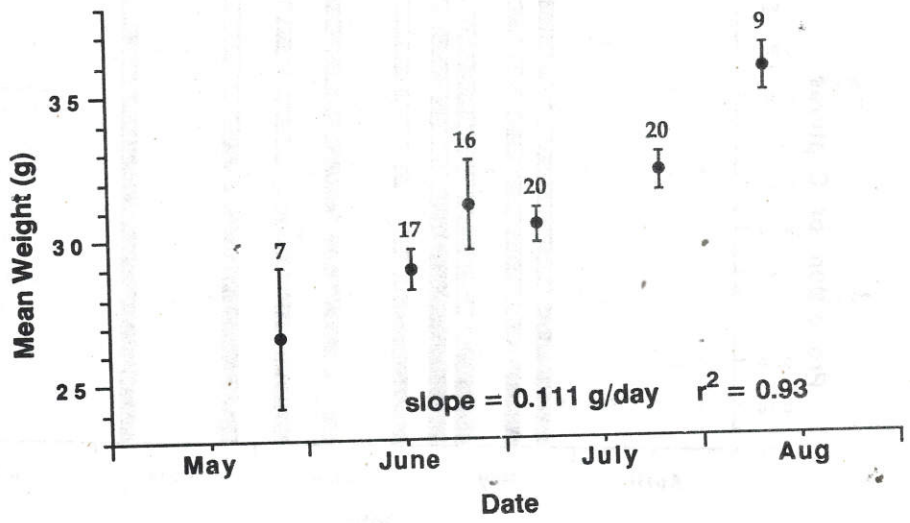

Figure 4. Mean weight of juvenile *Cynoptera brachyotis* at each sampling period. Bars around means represent standard errors. Sample sizes are indicated above points.

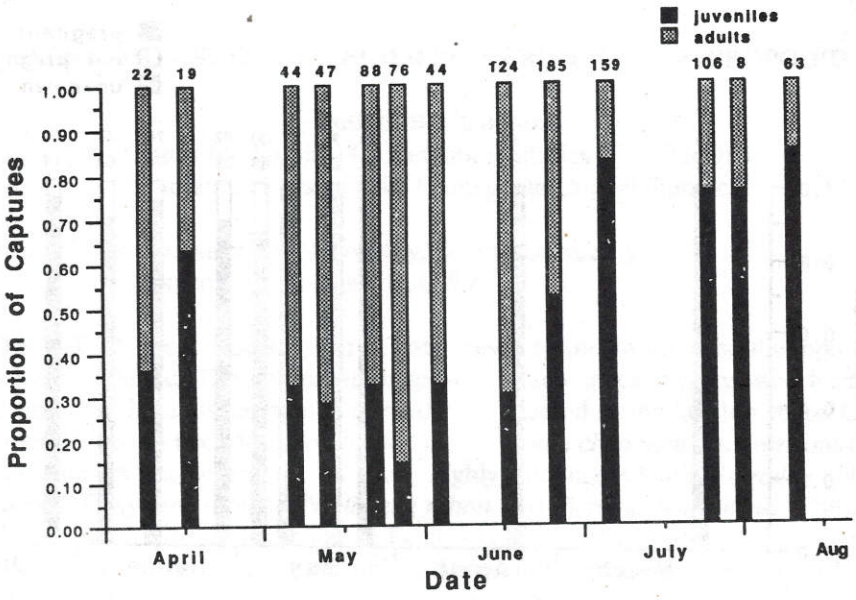

Figure 5. Age class composition of *Ptenochirus jagori* at each sampling period. Sample sizes are indicated above bars. Only periods where $n \geq 5$ are included.

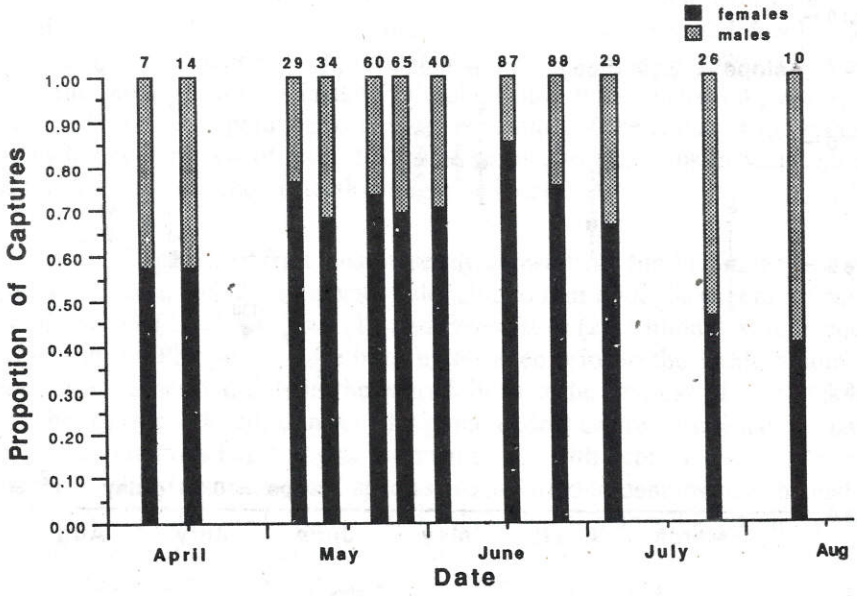

Figure 6. Sex composition of adult *Ptenochirus jagori* at each sampling period. Sample sizes are indicated above bars. Only periods where $n \geq 5$ are included.

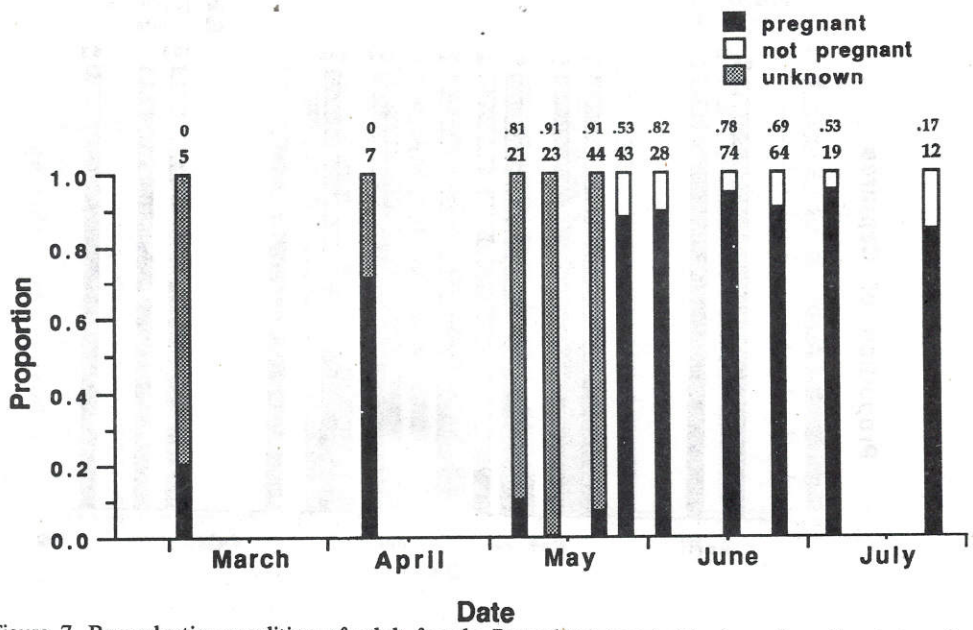

Figure 7. Reproductive condition of adult female *Ptenochirus jagori*. The bars show the status of pregnancy, the numbers directly above the bars are the sample sizes, and the smaller numbers above these represent the proportion of individuals that were lactating. Only periods where $n \geq 5$ are included.

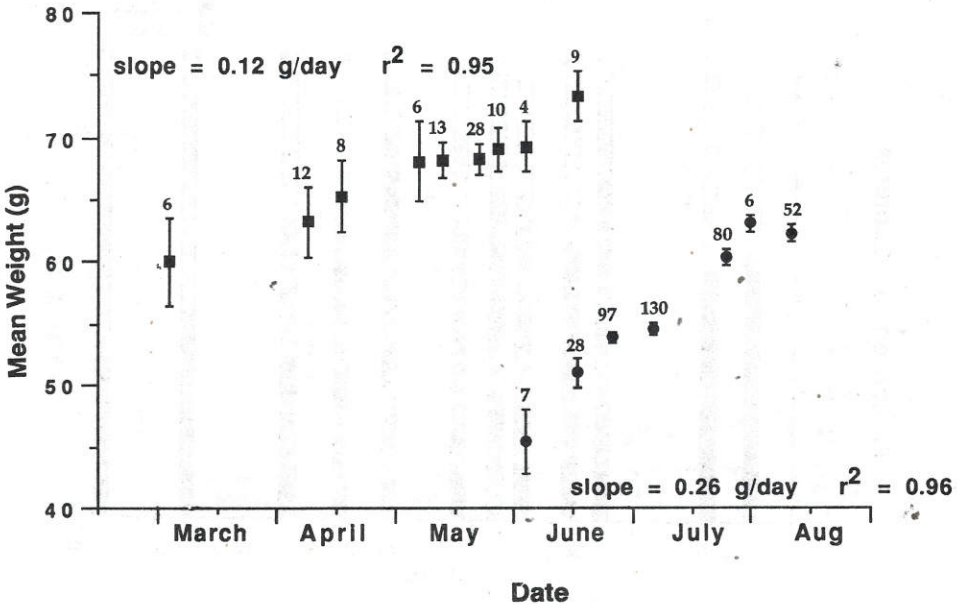

Figure 8. Mean weight of juvenile *Ptenochirus jagori* at each sampling period. Cohort A is represented by squares, cohort B by circles. Bars around means represent standard errors. Sample sizes are indicated above points.

CONSERVATION STATUS OF PHILIPPINE FRUIT BATS (PTEROPODIDAE)

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ABSTRACT. Of the 25 species of fruit bats presently known from the Philippines, 15 (60%) are endemic. The conservation status of each species is reviewed based on published and unpublished results of studies conducted in the last ten years. Of the 15 endemic species two, *Acerodon lucifer* and *Dobsonia chapmani* are now considered extinct. Species recognized to be most highly endangered are *Acerodon jubatus*, *A. leucotis*, *Eonycteris robusta*, *Nyctimene rabori* and *Pteropus leucopterus*. These five species are part of the endemic fauna. Factors considered to contribute to population declines are discussed, including habitat destruction and geographical distribution. The discussion focuses on strategies for conservation.

INTRODUCTION

Information on the ecology and distribution of Philippine fruit bats increasingly points to a strong association between endemic species and forest habitats (Heaney *et al.*, 1981; Heaney *et al.*, 1989; Heideman and Heaney, 1989). Considering the high rate at which forests in the Philippines have been destroyed (Myers, 1988; Kummer, 1990), it is imperative to initiate evaluation of the status of the remaining fauna, including a review of published information, so that gaps in knowledge and needs for further study and protection might be identified.

Of the 25 species of fruit bats presently known from the Philippines, 15 (60%) are endemic. These include six species belonging to four endemic genera, *Alionycteris* (1), *Haplonycteris* (2), *Otopteropus* (1), and *Ptenochirus* (2). Although several zoological surveys in the Philippines have been undertaken prior to the 1900s, a number of endemics were described only in the years following the first use of mist nets in the 1960s. The historical descriptions of Philippine endemics are chronicled in Figure 1, using 10 year intervals beginning at the turn of the 19th century; the species names are listed in Table 1. Non-endemic species are included to demonstrate the historical importance of species discoveries. Years when the non-endemic species were described are not directly indicative of their actual discoveries in the Philippines (since very few were described from this country); however, descriptions of endemic species show temporal progress of systematic work on the pteropodids. *Acerodon jubatus* was the first endemic species to be described in 1831. The list of endemic species contin-

ues to grow with the discovery of a possible new species of *Haplonycteris* in 1989 on Sibuyan Island (S. Goodman and L. Heaney, pers. comm.). Most striking is the fact that from 1931 to the present, seven of eight species which have been documented in the Philippines for the first time are endemic (Fig. 1). The single non-endemic added to the species list is *Pteropus dasymallus*, whose identity was only recently recognized (Ingle and Heaney, in press) although specimens of this species have apparently been in collections (in the Philippine National Museum) from as early as 1948 .

The list presented here represents a first approximation of the conservation status of the various bat species known from the Philippines. Sources of information include published literature, field studies from 1981 to the present, and unpublished observations of colleagues who have worked with and still are actively involved in studies on various aspects of Philippine fruit bat biology. A listing of each species with comments on habitats and distribution may be found in an annotated checklist of Philippine land mammals by Heaney, Gonzales, and Alcala (1987). An identification key to Philippine bats (both mega- and microchiropterans) is currently in press (Ingle and Heaney, in press). Likewise, a number of pertinent publications on fruit bat ecology and biogeography have been published in the last decade (e.g., Heaney, 1991; Heaney *et al.*, 1989; Heideman, 1989; Heideman and Heaney, 1989), some of which are reviewed in this volume (Balete *et al.*).

CATEGORICAL LISTING OF SPECIES AND THEIR PROTECTION NEEDS

The functional categories used here are patterned after those used in a more general review of the conservation status of Philippine land mammals (Heaney and Utzurrum, 1991). Categories have been modified and expanded to improve descriptions of the state of knowledge of each species. The annotations are focused on biological information that may be useful in the assessment of the protection needs of the various species. The list itself is not intended to replace official listings, such as those by Convention on International Trade of Endangered Species and International Union for Conservation of Nature. Rather, it is to provide a baseline for future research and conservation activities by focusing on currently available ecological and biogeographical knowledge.

Category 1. Species thought to be extinct; status critically in need of investigation.

Under this category are two species of Philippine fruit bats recently reported as extinct by Heaney and Heideman (1987). Both were endemic species limited in distribution to the Pleistocene Negros-Panay faunal region (sensu Heaney, 1986).

1. *Acerodon lucifer* Elliot- Panay Flying fox

This endemic species is currently represented in museums only by the type series collected by J. B. Steere near Concepcion, Iloilo on Panay Island in January and April 1888, and two additional specimens taken in 1893 also near Concepcion (specimens in Bell Museum of Natural History, University of Minnesota; Timm and Birney, 1980). *Pteropus vampyrus* were taken by Steere at the same location in 1888, but *Acerodon jubatus* has never been reported from Panay (Steere, 1890; Heaney, unpubl. data). No other sightings of *A. lucifer* have been reported since that time despite several surveys conducted over the last 10 years. A recent examination of the type series suggests the need for a critical re-evaluation of its taxonomic status (L. Heaney, pers. comm.). Cranial measurements of *A. lucifer* all fall within the range exhibited by its congener, *A. jubatus* (Ingle and Heaney, in press).

2. *Dobsonia chapmani* Rabor- Philippine Naked-backed Fruit Bat

Named a new species by D. S. Rabor (1952), this fruit bat was believed to be relatively common when last recorded in 1964. Noted as roosting principally in caves with associated patches of lowland forest, its disappearance from known localities on southern Negros Island may be attributed to disturbance by guano miners, the rampant harvest of bats from caves for food, and the extensive removal of forest cover in the lowlands. Skeletal remains consisting of one mandible and a few leg bones of a long-dead individual found by Heaney and Heideman in 1981 (Heaney and Utzurrum, 1991), were the last indications of the species' occurrence despite surveys in the last 10 years of previously documented localities on Negros (Heaney, Heideman, and Utzurrum, unpubl. data). It is doubtful whether the species persists on southern Cebu Island, where the one specimen from outside of Negros was taken, as since the 1960's the island has been severely denuded.

Given the Pleistocene connection between Negros and Panay Islands (Heaney, 1986), there is a possibility that *D. chapmani* may occur on Panay in lowland areas with associated limestone caves in or near forest. Survey of such caves reported to hold populations of fruit bats should be made a priority for future inventory work.

Category 2. Species known to be seriously threatened by habitat destruction; vulnerability exacerbated by limited distribution.

1. *Nyctimene rabori* Heaney and Peterson- Philippine Tube-nosed Fruit Bat

The first specimens of this fruit bat were obtained in the 1960s but the species was not described until 1984 (Heaney and Peterson, 1984). It is restricted to Negros where it is closely associated with low- to mid-elevation primary forests. Extensive netting and mark-and-recapture studies on southern Negros indicate the species is uncommon (Heaney *et al.*, 1989; Utzurrum, unpubl. data). Heideman and Heaney (1989) estimated densities at two to three individuals per 10 hectares in primary lowland forest surrounding Lake Balinsasayao, Negros Oriental. It appears to depend largely on figs (*Ficus* spp.) for food (Utzurrum, 1984). Although its roosting habits are unknown, studies suggest a requirement for forest habitats. It has never been found in caves, and only a few individuals were captured in disturbed habitats all of which were within a 1 km-radius from the edge of an adjoining forest (Heaney *et al.*, 1981; Heideman and Heaney, 1989; Utzurrum, unpubl. data).

Category 3. Species with populations known to have declined substantially in recent years and to be in need of protection, but status uncertain due to inadequate information.

1. *Acerodon jubatus* Eschscholtz- Golden-crowned Flying Fox

Considered by some as the largest bat in the world by weight, this endemic species was once reported to occur in large mixed species colonies (with *Pteropus vampyrus*) of 100,000 or more individuals on all major islands (Taylor, 1934 in Nowak and Paradiso, 1983) except the Palawan faunal region. This species is closely associated with forests (Heideman and Heaney, 1989), and feeds principally on wild figs and other forest fruits (Utzurrum, 1984). Because of its large size, it is often hunted with guns, modified fish nets, and aerial fish hook lines (locally known as "salabay" or "surambao"; Utzurrum, unpubl. data). Exportation to Guam as a food delicacy during the late 1980's may have contributed to the decline of these populations (W. Rainey and G. Stiles, pers. comm.). It now appears to be absent in most parts of its known range (Heaney and Heideman, 1987). Colonies located since 1981 (e.g., on Maripipi Island) numbered no more than 5,000 individuals, and often were in the low hundreds (Rickart *et al.*, in prep.; Heideman and Heaney, unpubl. obs.). Body size of this species is geographically variable, perhaps indicating several genetically distinct forms (Heaney and Heideman, unpubl. data).

2. *Eonycteris robusta* Miller- Philippine Nectar Bat

This endemic species is widespread in the Philippines (excluding Palawan) but appears to be uncommon throughout its range. It has been captured most often in slightly degraded habitats associated with patches of *Musa* spp. in proximity to for-

ests. Unlike its congener, *E. spelaea*, it has never been reported from heavily disturbed areas, agricultural lands, or urban orchards. On Negros, where its occurrence has been previously recorded, it has not been netted since 1987 despite regular intensive surveys. On Leyte, where it was abundant in the 1960s, a few were found in 1984 and 1987 (Rickart *et al.*, in prep.). Its roosting habits are unknown. While *E. spelaea* has been found regularly in caves, the existence of *E. robusta* colonies in such sites is unknown.

3. *Pteropus leucopterus* Temminck- Philippine White-winged Flying Fox

Originally described in 1853 from specimens from Luzon (Heaney *et al.*, 1987), this endemic species remains poorly represented in collections worldwide. It is, thus, presumed to be rare in the wild. Recent surveys on Catanduanes Island have led to the capture of several individuals: two in 1988 in a "kaingin" area at 200 m elevation adjacent to a large tract of primary forest, and three more in 1991 at 600 m elevation in montane forest within that tract (Heaney *et al.*, 1991; Heaney *et al.*, unpubl. data). They are now known to occur throughout northeastern Luzon and on the islands of Catanduanes and Dinagat (Heaney *et al.*, 1987; Heaney et al., 1991; Heaney and Rabor, 1982). Two live individuals (male and female) are now in captivity at Silliman University as a founding pair for a captive breeding program. The female gave birth to the first captive-bred pup in March 1992.

Category 4. Potentially vulnerable due to a limited distribution, but status uncertain due to inadequate information.

1. *Acerodon leucotis* Sanborn- Palawan Flying Fox

Described in 1950, this endemic species is restricted to the Palawan faunal region where it appears to replace *A. jubatus* (Heaney *et al.*, 1987). There are two subspecies reported, one occurring on Palawan and the Balabac islands, and a second confined to Busuanga. These poorly-defined taxa require critical review. Large colonies of flying foxes on small islands off northern Palawan and in Honda Bay east of Puerto Princesa, Palawan (L. Dolar and E. Solis, pers. comm.) could be *A. leucotis*. This species may be moderately common in forests of mainland Palawan, but little current information is available.

2. *Haplonycteris* sp. - (undescribed pygmy fruit bat)

Substantially larger than *Haplonycteris fischeri*, individuals of this putative species of the endemic genus *Haplonycteris* were first collected in 1989 from Sibuyan Island (Goodman and Heaney, unpubl. data). All specimens were taken in primary

forest habitat. Preliminary genetic analyses indicate substantial differences from populations of *H. fischeri* (Peterson and Heaney, in press).

3. *Pteropus dasymallus* Temminck- Wooly Flying Fox

P. dasymallus was previously known to range from southern-most Japan to Taiwan; it was described by Temminck (1825) on the basis of specimens from the Liukiu Islands (near Okinawa). Its occurrence in the Philippines has recently been verified by L. R. Heaney (pers. comm.) and recognized by Ingle and Heaney (in press) from specimens taken in the late 1980s from the Babuyan and Batanes Islands off northern Luzon. Specimens taken in the 1940s (in the research collection at the Philippine National Museum) were initially identified as *P. hypomelanus*. These specimens, however, show a distinct cranial morphology and long, dense pelage characteristic of *P. dasymallus*. No observations on habitat use or estimates of population size are currently available.

Category 5. Species for which little or no current information is available; status unknown.

1. *Alionycteris paucidentata* Koch- Least Pygmy Fruit Bat

Since its description in 1969 (Kock, 1969a), this smallest of Philippine fruit bats was known only from the type series collected on Mt. Kitanglad in Mindanao. A recent (1992) survey on Mt. Kitanglad produced the first few specimens outside of the type series (Heaney *et al.*, unpubl. data). A preliminary re-evaluation of the type series suggests that this endemic monotypic genus is very closely related to the endemic genus *Haplonycteris* (L. R. Heaney, pers. comm.). Given the virtual absence of any information on the species, efforts to the study the species in the immediate future are in order.

2. *Dyacopterus spadiceus* Thomas- Dayak Fruit Bat

This species is known from Borneo, Sumatra, the Malay Peninsula, and the Philippines (Heaney *et al.*, 1987). In the Philippines, it is only known from two specimens, one from Mindanao and another from Luzon. Nothing is known about its status locally, but populations are probably stable in the species' range outside of the Philippines. Specimens in collections show three discrete size classes throughout its range, a small-sized population in Borneo, medium-sized from Sumatra, and large-sized from the Philippines, suggesting the possibility of three genetically distinct populations (L. R. Heaney, pers. comm.).

3. *Megaerops wetmorei* Taylor- White-collared Fruit Bat

Until recently, this species was considered a Philippine endemic (Heaney *et al.*, 1987), but is now also known from Borneo and the Sunda Shelf islands (Payne *et al.*, 1985). Its distribution in the Philippines is restricted to Mindanao and may be confined largely to primary forest habitats, or on disturbed areas right at the fringes of forest tracts (Heaney et al., 1987; Heaney *et al.*, unpubl. data). As with the two other fruit bats listed in this category, there is virtually no information on this species in the Philippines.

Category 6. Species with populations known to have declined substantially in recent years, but are geographically-widespread and/or under some protection.

This category includes three non-endemic species of *Pteropus* whose distribution ranges outside the Philippines. As with the aforementioned *Acerodon jubatus*, these species were once reported in colonies of thousands of individuals at various localities, often in mixed-species aggregations. However, their visibility in tree roosts and their large sizes have made the species vulnerable to hunting pressure. Unlike the endemic flying foxes mentioned in other sections here, all three species listed below regularly forage in agricultural areas and orchards well removed from tracts of forests. This habit increases their exposure to hunters using more sophisticated equipment. Populations appear to have declined and they are now absent from extensive forest-associated lowland areas where they were reported to be abundant in the 1960s.

1. *Pteropus hypomelanus* Temminck- Island Flying Fox

This is probably the least endangered of the flying foxes in the Philippines and occurs throughout the islands except in the Palawan faunal region. Outside of the Philippines, its range extends from Australia to Thailand (Heaney *et al.*, 1987). A colony of about 2000 individuals was recently (1991) recorded at the Sampunong Bolo Bird Sanctuary in Sara, Iloilo, and is tentatively identified as *P. hypomelanus* (Utzurrum, unpubl. report). This particular colony is presently protected indirectly as part of a purple heron (*Nycticorax caledonicus* Vigors) conservation program at the sanctuary.

2. *Pteropus speciosus* Andersen- Sulu Flying Fox

This species is currently documented only from two small island groups in the Java Sea (Indonesia) and the southernmost parts of the Philippines (Heaney *et al.*, 1987). Although largely centered in the Sulu Archipelago, it has also been recorded

from Basilan and extreme southwestern Mindanao (Heaney and Utzurrum, 1991). Previous reports of this species from Cebu and Negros appear to have been based on misidentified *P. hypomelanus* (Heaney, unpubl. data). Voucher specimens from the late 1980s (Smithsonian Institution) indicate its persistence despite the extensive removal of forests in Sulu. Religious taboos on meat consumption may reduce hunting pressure on the animals in this largely Muslim region. However, extensive collection in the 1980s for exportation to Guam may have offset this advantage. Taxonomic review of the species is needed since some evidence indicates a close relationship with *P. griseus,* a species widespread in Wallacea (Klingener and Creighton, 1984; L. Heaney, pers. comm.).

3. *Pteropus vampyrus* Linnaeus- Giant Flying Fox

This geographically widespread species ranges in distribution from Indochina to the Lesser Sunda Islands and occurs throughout the Philippines (Heaney *et al.*, 1987). It now appears to be uncommon in the Philippines where it was previously reported in large numbers (see Category 3 on *A. jubatus*). Of the three species in this category, this may be the most threatened.

Category 7. Endemic species currently believed to have relatively stable populations, but vulnerable to habitat destruction.

Surveys of fruit bats conducted since 1981 indicate the relative stability of populations of six endemic species of Philippine fruit bats. All six are, however, consistently found in close association with forests (Heaney *et al.*, 1989; Heideman and Heaney, 1989; Utzurrum, unpubl. data). Hence, they may be seriously threatened by continued deforestation in the Philippines.

1. *Haplonycteris fischeri* Lawrence- Fischer's Pygmy Fruit Bat

The species is widespread in the Philippines (probably excluding the Palawan faunal region; Heaney *et al.*, 1987; Heaney, 1991). Its association with primary forest from low to high elevations is well-documented. It is locally common in primary forests (Heideman and Heaney, 1989) where it appears to specialize on fruits of *Ficus* spp. and *Piper* spp. (Heideman, 1987; Utzurrum, 1984). It is uncommon in secondary forest, rare in adjoining degraded habitats, and absent in areas more than 0.5 km from forest (Heideman and Heaney, 1989; Utzurrum, unpubl. data). Heideman (1988, 1989) has published a thorough study of its reproductive biology and ecology. Of all the Philippine fruit bats, it is, perhaps, the species for which the most comprehensive information is available.

2. *Harpyionycteris whiteheadi* Thomas- Harpy Fruit Bat

Although long known from Mindanao, Negros, and Mindoro, its occurrence on Luzon was first documented in 1988 by Heaney *et al.* (unpubl. data; Heaney, 1991). Estimated densities of this species are low (Heideman and Heaney, 1989; Utzurrum, unpubl. data). Typically absent outside of forest, it is uncommon in lowland primary forest but is moderately common in mid- to high elevations where it appears to specialize on both the flowers and fruits of pandan (*Freycinetia* spp.) (Heaney *et al.*, 1989; Utzurrum, unpubl. data).

3. *Otopteropus cartilagonodus* Loch- Luzon Pygmy Fruit Bat

Described in 1969 (Koch, 1969b), this member of the monotypic endemic genus *Otopteropus* is restricted to Luzon. It is reportedly common in primary and mature secondary forest throughout its range. Moderate numbers were recently (1992) captured in the forests of Zambales by a survey team from the Philippine National Museum and the Cinncinati Museum of Natural History (P. Gonzales, pers. comm.). However, the size of local populations throughout its range on Luzon Island appears to be highly variable. For example, only low densities were recorded during an intensive survey of Mt. Isarog, southern Luzon in 1988 (Heaney, Rickart and Utzurrum, unpubl. data). None of the individuals taken in the 1988 survey were captured outside of forest; thus, forest denudation may seriously threaten the survival of this species. Preliminary analysis of its reproductive pattern showed evidence of delayed development of embryos (Heideman *et al.*, in press). The only other fruit bat in the Philippines for which such a pattern has been established is the endemic *Haplonycteris fischeri* (Heideman, 1989).

4. *Ptenochirus jagori* (Peters)- Philippine Bear-faced Fruit Bat

The species occurs throughout the Philippines except in the Palawan region (Heaney *et al.*, 1987). Although occasionally netted in disturbed and agricultural habitats, it is typically absent in areas more than 1 km from forests (Heideman and Heaney, 1989; Rickart *et al.*, in prep.; Utzurrum, unpubl. data). It is common in lowland primary forest but uncommon at higher elevations or in secondary forest. Its dependence on wild fig fruits as food in forests and its role as a major seed dispersal agent are well-documented (Utzurrum, 1984; Utzurrum and Heideman, 1991).

5. *Ptenochirus minor* Yoshiyuki- Lesser Bear-faced Fruit Bat

This species appears to be restricted to the Mindanao faunal region; a single report of its occurrence on Palawan needs verification (Heaney *et al.*, 1987; Heaney,

1991). It is locally abundant in primary forest, especially at low elevations, but is uncommon in secondary forest, and rare to absent outside of these habitats (Heaney *et al.*, 1989; Rickart *et al.*, in prep.). In contrast to its congener, *P. jagori*, little is known of its ecology.

6. *Pteropus pumilus* Miller- Little Golden-mantled Flying Fox

This species is the smallest member of the genus *Pteropus* and is widespread in the Philippines, except in the Palawan faunal region (Heaney *et al.*, 1987). Unlike its non-endemic congeners, it is rare in degraded and cultivated areas exceeding 1 km from tracts of forest. It may be locally common or uncommon in primary forest and is typically uncommon in secondary forest. Its close affiliation with low to mid-elevation primary forest habitats has been repeatedly noted in numerous surveys conducted since 1981 in various forests on Negros, Leyte, and Maripipi (Heaney *et al.*, 1989; Heideman and Heaney, 1989; Rickart *et al.*, in prep.). Unlike the larger species of flying foxes, it is regularly captured in nets set below forest canopies (Utzurrum, unpubl. data). Although this may be the least threatened of the endemic flying foxes, it appears to be under increasing pressure from hunting. An ongoing study (Utzurrum, unpubl. data) of the fruit bat community on Mt. Talinis, Negros Oriental has documented several instances of serious injuries resulting from gun shots and fish hooks, including extensive wing tear, tissue injuries from hooks, and hind limb amputations . With the increasing rarity of the larger flying foxes, hunting pressure on this species is likely to intensify. Its apparent requirement for forest trees as roosts and sources of food will exacerbate its vulnerability to local extinction as lowland forests continue to decline.

Category 8. Species with populations known to be stable or increasing, and are geographically widespread.

This category includes four species of fruit bats widespread both within and outside of the Philippines. All species are associated with disturbed, agricultural, and/or urban habitats where they are usually abundant (Heaney *et al.*, 1989; Heideman and Heaney, 1989; Rickart *et al.*, in prep.; Utzurrum, unpubl. data). They are known from primary and secondary forests where they typically have low to moderate abundance. Occurrence in high-elevation forests is often associated with the proximity of cultivated and/or disturbed patches.

1. *Cynopterus brachyotis* (Muller)- Short-nosed Fruit Bat

This species is widespread in Southeast Asia and throughout the Philippines (Heaney *et al.*, 1987). It is most abundant in lowland cultivated areas and ranges up to montane forest habitats. In forests, it appears to rely mostly on wild figs for food

(Utzurrum, 1984, unpubl. data). In disturbed and cultivated habitats, it is regularly netted in large numbers around orchards and patches of bananas (*Musa* spp.). It is one of a few species commonly associated with urban centers. (A cluster of four individuals was found roosting under a palm leaf (*Livistona* sp.) in 1991 at a zoo in downtown Manila; Utzurrum, unpubl. obs.). Fecal analysis indicate its consumption of fruits of *Melastoma* spp., shrubs common in secondary growth and disturbed habitats (Utzurrum and Heideman, unpubl. data). The species may be an important contributor to seed exchange between forests and altered habitats and may be valuable to natural regeneration of degraded habitats.

2. *Eonycteris spelaea* (Dobson)- Cave-roosting Nectar bat

This species ranges from India to Timor and is widespread in the Philippines (Heaney *et al.*, 1987). It is most common in agricultural and disturbed habitats with patches of banana and abaca (*Musa* spp.) (Heaney *et al.*, 1981; Heideman and Heaney, 1989; Utzurrum, unpubl. data). Information on its food habits throughout its geographical range strongly indicate its specialization on nectar and pollen; the species may be an important pollinator of commercial trees such as durian (*Durio zibethicus* Murr.) and kapok (*Ceiba pentandra* (L.) Gaertn.) and of mangrove trees such as *Sonneratia* spp. (e.g., Start and Marshall, 1976). In the Philippines, this bat typically roosts in caves where it may occur in groups of less than 10 individuals to huge colonies of a few thousand individuals (Utzurrum and Heaney, in prep.; Utzurrum, unpubl. data). Although populations appear stable, its habit of roosting in caves exposes the species to indiscriminate harvesting for local food consumption. A recent (1991) visit to caves at the Bulabog-Putian National Park in Dingle, Iloilo (Panay Island), yielded considerable evidence of poaching in caves occupied by this and other fruit bats (Utzurrum, unpubl. project report). Implements used for such collections found within and outside the caves included empty rice sacks, sections of old fish gill nets, large wood frames (for the nets), long bamboo poles, and kerosene torches.

3. *Macroglossus minimus* (E. Geoffroy)- Dagger-toothed Flower Bat

Found throughout the Philippines, the species is abundant in agricultural areas, but also occurs uncommonly in secondary and primary forests over a broad elevational range (Heaney *et al.*, 1989; Utzurrum, unpubl. data). As with *E. spelaea*, the species is often associated with patches of *Musa* spp. but may not be as strictly nectarivorous. Outside of the Philippines, its range extends from Thailand to Australia (Heaney *et al.*, 1987).

4. *Rousettus amplexicaudatus* (E. Geoffroy)- Common Rousette

The species is geographically widespread from Thailand to the Solomon Islands, and occurs throughout the Philippines (Heaney *et al.*, 1987). It is most common in disturbed and agricultural areas. As with *E. spelaea*, it is most vulnerable to hunting in its cave roosts. It is uncommon in forests (Heideman and Heaney, 1989), but increases in abundance in association with disturbed habitat (Utzurrum, unpubl. data).

DISCUSSION

Recent studies of mammals other than fruit bats demonstrate a strong and consistent correlation between endemism and diversity on one hand and the extent of primary forest habitats on the other (Heaney and Rickart, 1990; Heaney *et al.*, 1989; Rickart *et al.*, 1991). This is compelling evidence for the importance of habitat preservation as a basic requirement for species conservation in the Philippines. However, it is becoming equally evident that habitat protection alone cannot guarantee the survival of many species, especially those whose natural populations have been pushed to the brink of extinction. In the face of diminishing forest habitat, such factors as unregulated local hunting and commercial trade can push threatened species towards extinction and imperil those species maintaining stable but precarious populations. Thus, there is a need for concerted efforts towards developing flexible and multidimensional programs to address problems of species conservation. In line with the problems that are discussed in this preliminary review, a five-point strategy is suggested under which programs should be developed. These strategies are:

1) **Habitat Protection** - Priority should be given to the designation of protected areas that will provide for the ecological needs of fruit bats and other valuable Philippine fauna and flora. If properly implemented, the recently-developed Integrated Protected Areas System (I.P.A.S.) is an important step in this direction. Species-specific habitat protection is needed for those bat species that typically form large aggregations, including the foliage-roosting flying foxes and cave-dwelling species. Critical sites supporting large colonies should be identified and completely protected against all forms of perturbation (e.g., small off-shore islands in Palawan reported to support large colonies of flying foxes). Foremost, they should be protected at roost sites where they are most vulnerable to collectors and where such vital biological activities as breeding and rearing of young occur.

2) **Captive Breeding** - A direct and aggressive approach is warranted in the case of those species whose populations in the wild have greatly declined. This is especially critical for those species whose roosting habits preclude direct protection through reserves or sanctuaries (i.e., as in those that may roost in small, discrete

groups). Captive breeding may be the principal means of ensuring that species survive if wild populations become so decimated that they drop below levels critical for successful reproduction. Species that should be accorded priority in captive breeding programs are those listed in Categories 1 to 3 (assuming the possibility of re-discovering wild populations of the currently presumed extinct species, *Acerodon lucifer* and *Dobsonia chapmani*).

3) **Ecological and Biogeographic Studies** - It is clear from this review that there are many species for which biological information is inadequate or absent (especially species under Categories 4 and 5). This problem is not peculiar to fruit bats and is one that limits our ability to formulate programs and regulations suited for the conservation of target species. Given the rate at which natural habitats are being destroyed, inventories and ecological surveys focusing on food and habitat requirements are needed. The recent discovery of a potentially new species of *Haplonycteris* from Sibuyan Island demonstrates the need for inventory work in poorly surveyed areas of the Philippines. New institutional collaborations are encouraged between academic, private, and governmental agencies, both national and foreign, to establish programs designed to accomplish goals outlined in this paper.

4) **Taxonomic Review** - Establishing the distinctiveness of species is sometimes viewed as an arcane exercise and thus is often accorded low priority in conservation work. A systematic knowledge of the validity of species is crucial when establishing priorities for species-specific action plans and captive breeding programs. The recognition of the genetic distinctiveness of populations from various geographical locations is vital for the management of captive populations. In combination with information from biogeographical and ecological studies, systematic analysis can provide insights into and better understanding of patterns of extinction and speciation as well as possible proximal and historical factors that may influence such processes. Among the fruit bats in this list, those that deserve immediate taxonomic study are: *Acerodon jubatus, A. leucotis, A. lucifer, Alionycteris paucidentata, Dyacopterus spadiceus, Haplonycteris* and *Pteropus speciosus*.

5) **Public Education** - The public's image of and attitude towards bats need to be improved. Negative views, reinforced by years of folk horror stories and contemporary vampire movies, must be reversed. Unwarranted fear of rabies and other negative popular perceptions can be negated through public education programs that emphasize the important contributions of bats as agents of seed dispersal, pollination, control of insect populations, and in the production of guano fertilizer. Notions that populations in the wild are infinite can only be revised through an aggressive educational program that stresses the value of maintaining wild populations and seeks to recruit local human populations as partners in a stewardship and conservation program by imparting information of the species' needs for food, habitat and

successful reproduction. While public education programs are often difficult to undertake, they are most essential for the long-term success of other conservation programs that require the cooperation of local communities.

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Table 1. Chronological list of fruit bats known to occur in the Philippines. Endemic species are distinguished from the non-endemic. The year of description of a non-endemic species does not necessarily reflect its actual year of discovery in the Philippines.

Species Name	Year Described	Endemic Species	Non-Endemic Species
Pteropus vampyrus	1758		X
Macroglossus minimus	1810		X
Rousettus amplexicaudatus	1810		X
Acerodon jubatus	1831	X	
Cynopterus brachyotis	1838		X
Pteropus hypomelanus	1853		X
Pteropus leucopterus	1853	X	
Ptenochirus jagori	1861	X	
Eonycteris spelaea	1871		X
Dyacopterus spadiceus	1890		X
Acerodon lucifer	1896	X	
Harpyionycteris whiteheadi	1896	X	
Pteropus speciosus	1908		X
Pteropus pumilus	1910	X	
Eonycteris robusta	1913	X	
Megaerops wetmorei	1934		X
Haplonycteris fischeri	1939	X	
Acerodon leucotis	1950	X	
Dobsonia chapmani	1952	X	
Alionycteris paucidentata	1969	X	
Otopteropus cartilagonodus	1969	X	
Ptenochirus minor	1979	X	
Nyctimene rabori	1984	X	
Pteropus dasymallus	1825 (1992)		X
Haplonycteris sp.	(undescribed)	X	

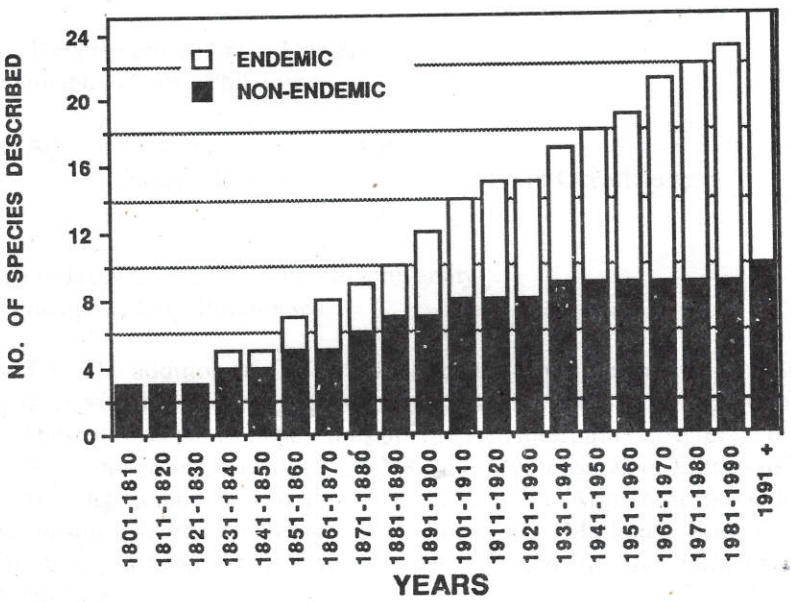

Figure 1. Number of Philippine fruit bat species described by ten-year intervals. Endemic species are distinguished from the non-endemic. With the exception of *Pteropus dasymallus*, whose occurence in the Philippines has only been recently recognized, all other non-endemic species are included under intervals embracing their actual year of description and not the year of their discovery in the Philippines.

THE PHILIPPINE SPOTTED DEER, *CERVUS ALFREDI* SCLATER, CONSERVATION PROGRAM

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ABSTRACT. The addition of *Cervus alfredi* Sclater to the taxonomic grouping of the Philippine cervids has spurred efforts to study and conserve this highly threatened species. These efforts led to the establishment of an international agreement between the Philippine government through DENR, and Mulhouse Zoo, France to maintain captive breeding facilities within and out of the country. At present, three deer facilities: two *in-situ* (Negros and Panay) and one *ex-situ* (Mulhouse Zoo, France) are operating under a captive breeding program managed by three Filipino and three foreign members.

INTRODUCTION

Until quite recently, the Philippine Spotted or Prince Alfred's deer, *Cervus alfredi* Sclater, remained extremely poorly known. Indeed, it was effectively lost as a recognized form by being classified as a regional variant of the widespread and diverse group of sambar deer, *C. unicolor* , which also included the Philippine rusa, *C. mariannus* Desmarest. However, in their recent review of the taxonomy of the Philippine deer, Grubb and Groves (1983) recognized *C. mariannus* and *C. alfredi* as separate species; the former having at least four subspecies endemic to the islands of Luzon, Mindoro, Mindanao, and associated smaller islands in the east Philippines, and the latter a highly distinct, monotypic form, endemic to the Visayan Islands, central Philippines.

The survival of both of these deer, and that of the third endemic species, the Calamian deer, *Cervus calamianensis*, which is found only on a few of the larger islands of the Calamian group, is threatened by profligate deforestation and, despite

full legal protection, intense hunting pressure. Thus, the Calamian deer is recognized both nationally and internationally as a seriously threatened form, and has been accorded "vulnerable status" on the International Red List of Threatened Animals (IUCN, 1992) since the late 1970's (Oliver and Villamore, in prep.). *C. mariannus* is not yet considered seriously threatened throughout its range, and is not included on the IUCN Red List. However, it is certain that at least one subspecies, *C. m. barandanus* Grubb and Groves, is at some risk over its restricted range in Mindoro, and the present status of some other forms, such as *C. m. nigricans* Grubb amd Groves, from lowland Mindanao, needs to investigated.

By comparison, the spotted deer is unquestionably highly threatened, because it has already been extirpated over most of its known former range on the larger islands of the Negros Faunal Region of the central Philippines, which comprises the larger, western section of the Visayas geopolitical region (Figure 1).

THE PRESENT STATUS OF *C. ALFREDI*

The extent of the decline of the Philippine spotted deer was not fully appreciated until 1985, when a three-month field status survey was conducted by Cox (1985, 1987a). This survey revealed that the species was already extinct over most of its former range, including all of Cebu, Bohol, Siquijor and Guimaras, and that it survived in only one small area of western Panay (namely: Mt. Baloy/Mt. Madja-as) and in a few scattered fragments of remaining forest on Negros. It is likely that the species is also extinct on Masbate, which has been almost completely deforested, though this area was not visited during the 1985 survey. Deer are also now extinct on Bohol, though it remains unclear whether *Cervus alfredi* or *C. marianus* formerly occurred there because this island actually forms part of the Mindanao Faunal Region, as defined by Heaney (1986) on the basis of the 120-m bathymetric line (Fig. 1). Reports of deer occurring on the larger, neighboring islands of Samar and Leyte were also assumed to refer to *C. alfredi*, rather than *C. marianus*, during the 1985 survey (Cox, 1985, 1987a), although these islands also form part of the Mindanao Faunal Region. Moreover, as *C. marianus* is known to occur on both of these islands, it now seems likely that *C. alfredi* is absent, at least as a native or pure-bred form. As a result, the species is believed to have been extirpated over at least 95% of its former range, and to survive only as a series of small, discrete and highly vulnerable populations on no more than two islands, Panay and Negros.

Commensurate with the findings and recommendations of the 1985 survey, the species was included for the first time on the Red List of Threatened Animals (IUCN, 1988), when it was accorded "endangered status", thereby denoting the probability of its extinction in the near future if the causal factors, habitat attrition and hunting pressure, continued to operate. In a recent worldwide review of conservation

priorities, the IUCN Deer Specialist Group (in litt.) concluded that *Cervus alfredi* was one of the most seriously threatened of all species of deer.

PROTOCOL FOR THE CONSERVATION PROGRAM

In the interim, the findings of the 1985 field survey were presented to the relevant authority in the Philippines, the Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR). As a result, two priority recommendations for immediate conservation action were agreed upon. These were: 1) that a new national park be created to protect the sole remaining (and single largest) wild population of spotted deer in the Mt. Baloy/Mt. Madja-as area of west Panay; and 2) that a properly structured, international cooperative captive breeding programme be established. In order to execute and finance these projects, the first formal International Agreement for a species conservation programme in the Philippines was drafted and signed by DENR and the Mulhouse Zoo, France, in April 1987. Under the terms and conditions of this agreement (which was modified in May 1990 in accordance with the development of a new breeding-loan policy by DENR, the Philippine Wildlife Loan Agreement or PWLA, which now applies to all threatened species of wildlife legally exported from the Philippines), it was recognized that the DENR had insufficient resources for the implementation of the proposed conservation strategy and that much of the necessary funding would have to be obtained from outside agencies. To this end, the West Berlin Zoological Society provided funding for a survey and development of a new management plan for the proposed new national park on Panay. This project, which was conducted over a four-month period in 1986/1987 by a team of Filipino and foreign scientists, resulted in plans for the development of a 40,000 hectare area of forest as the new Panay Mountains National Park (Cox, 1987b). Further work on this proposal is currently being undertaken by the relevant regional authorities of DENR (C. Magno, pers. comm.), but it is hoped that the new Park will be established by Presidential Decree and officially gazetted in the near future (W. Dee, pers. comm).

In the interim, efforts were being made to raise the necessary funds for the development of the captive breeding programme. Under the terms of the Memorandum of Agreement (MOA) with the Mulhouse Zoo, it was proposed that this include the establishment of both local and international breeding stocks under the aegis of similar loan agreements between all participating institutions and the DENR. All of the animals acquired for this program (the "founders") would therefore be "loaned" to the project by the Government of the Philippines and managed cooperatively as a basis for the establishment of a "World Herd". The title of all ensuing captive-bred progeny would also remain with the Government and People of the Philippines under the terms of this MOA, thereby enabling the future management

the establishment of the local breeding centers is that these may also be used to accommodate and accumulate any additional specimens of Negros or Panay origin as may become available in the future by donation, purchase or confiscation. Any such animals will be added to the "World Herd" thereby enabling the number of founder individuals to be increased at intervals. As previously mentioned, a total of seven individuals, comprising two (both males) from Panay and five (two males, three females) from Negros have been acquired by the project following the export of the Mulhouse animals, all but one of which were donated by their owners. In addition, a total of eight (five males, three females) births have been recorded (two at Bitu Farm, two at Silliman and four in Mulhouse) to date under the aegis of this program, all but one of which (a male at Bitu Farm), have been reared successfully.

As soon as is practicable, it is intended to establish a second "Spotted Deer Breeding and Rescue Center" in Negros Occidental to extend the breeding program by the distribution of breeding stocks of least-related, captive-bred individuals to other reputable breeding centers, both in the Philippines and elswhere. All such extensions would be made under breeding loan agreements, and the title of those animals would remain with the Government of the Philippines. Whenever possible, the Spotted Deer Conservation Committee will also negotiate the donation of funds from the recipient institutions for specific, related conservation projects in the Visayan region (which should eventually include *Cervus alfredi* reintroduction projects); thereby involving those institutions in the local, as well as the international, conservation effort.

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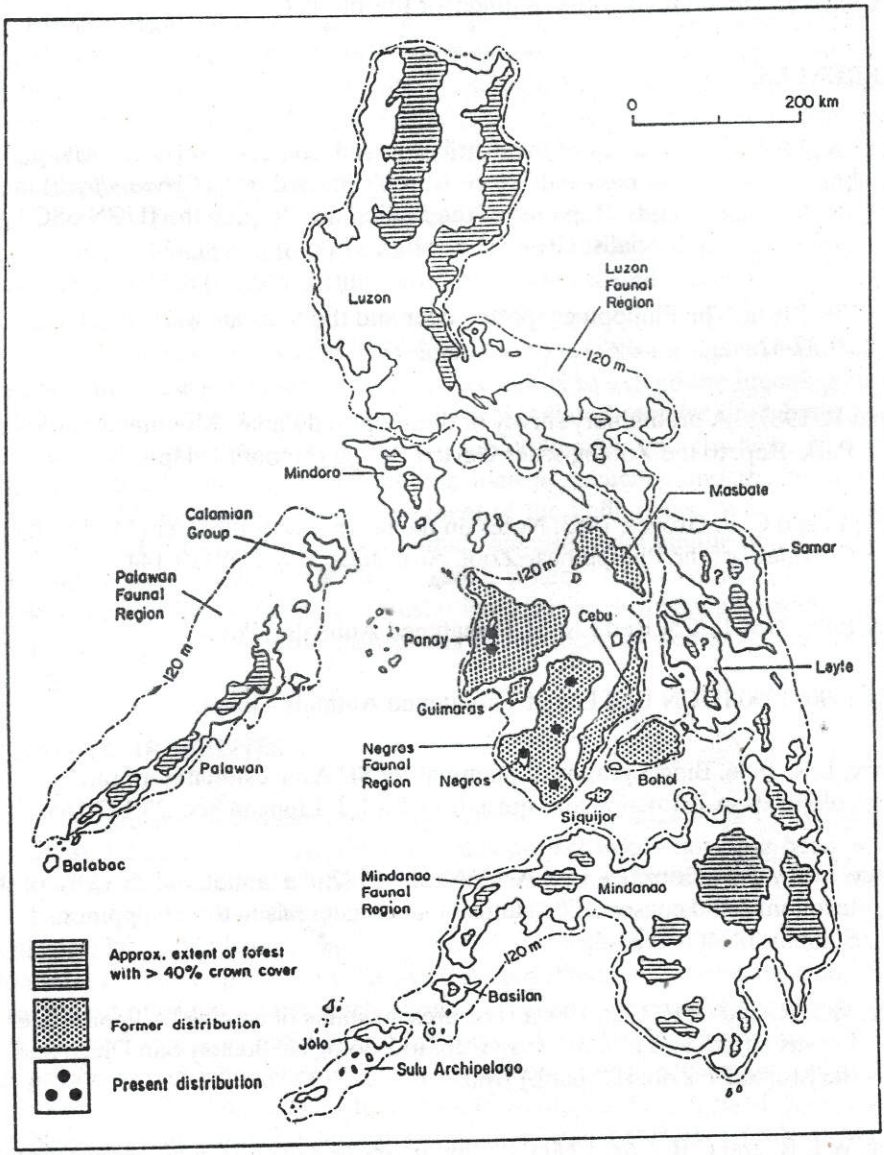

Figure 1. Approximate former and present distribution of the Philippine Spotted Deer, *Cervus alfredi*. Forest cover data is modified after Revilla (1986), and the division of the archipelago into separate faunal regions, as indicated by the 120m bathymetric line, follows Heaney (1986). See text for further explanation.

THE TAXONOMY, DISTRIBUTION, AND STATUS OF PHILIPPINE WILD PIGS

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ABSTRACT. Recent taxonomic reviews have revealed that there are three species and at least two subspecies of wild pigs in the Philippines, of which two species and one subspecies are endemic. This is a larger number of endemic suid taxa than any other country, with the exception of Indonesia. Unfortunately, however, the generally extreme levels of deforestation on most islands on which they occur, coupled with intense hunting pressure, inadequate legal protection, and the poor enforcement of existing legislation even within protected areas, have resulted in the systematic decline of all Philippine populations of these animals. These factors are especially apparent in the Visayan region, where the endemic warty pig, *S. cebifrons*, is probably the second most endangered of the world's suids. This species is now extinct or close to extinction in five (Masbate, Guimaras, Cebu, Siquijor and Bohol) of the seven islands in which it is known or believed to have occurred, and now survives only in a few small, isolated areas of Negros and Panay, where all remaining populations are declining as a result of continued habitat destruction and intense hunting pressure. By comparison, the other two species of Philippine pigs -- *S. philippensis* of Luzon, Samar, Leyte, Mindanao and associated smaller islands, and *S. barbatus* Muller of Balabac, Palawan, the Calamian Islands (*S. b. ahoenobarbus*) and Tawi-tawi and Sibutu (*S. b. barbatus*) remain rather more widely distributed throughout their ranges at the present time.

TAXONOMY AND DISTRIBUTION OF THE WILD PIGS

Following Sanborn (1952), the wild pigs of the Philippines have generally been attributed to two more widely distributed species, the bearded pig, *Sus barbatus*, and the Sulawesi warty or crested pig, *S. celebensis*. Thus, the wild pigs of the western Philippine islands of Balabac, Palawan, and the Calamian Group, which form part of the Sunda Shelf, are most closely related to the bearded pigs of Borneo, Sumatra, and the Malaysian Peninsula, while those of the west-central Visayas Islands and eastern Philippines (Luzon, Mindanao, and associated islands), which form part of the Wallacean Region, were lumped with the Sulawesi pig.

In a major review of the genus *Sus,* Groves (1981) confirmed the close relatedness of the west Philippine pigs with *S. barbatus*, though he recognized that these were sufficiently distinct to warrant separation as an endemic subspecies, i.e., *S. b. ahoenobarbus*. However, Groves also showed that the affinity of the central and eastern Philippine pigs with *S. celebensis* was largely superficial, and that these

populations were also more closely allied to *S. barbatus*, a view later endorsed by Mudar, 1986). Groves (1981) also suggested that the central and eastern Philippines populations were not only distinct from those of the western Philippines, but that these were also distinct from each other. He therefore, provisionally referred the pigs of these two regions to two separate subspecies of *S. barbatus*, i. e., *S. b. cebifrons* from the central Visayan region islands of Cebu and (probably) Negros, and *S. b. philippensis* from the eastern Philippine islands of Luzon, Mindanao and Jolo. Even so, Groves stressed that these were tentative assignations because the shortage of museum specimens particularly from the Visayan region (where only two skulls were available for examination from Cebu, only one from Negros and none from the other Visayan islands of Guimaras, Panay, and Masbate) and the complete absence of any comparative cytogenetic data, precluded a definitive assessment of the systematic relationships of these populations.

To a large extent this situation still obtains, though there have been some important developments in our understanding of the systematic relationships and genetic diversity of the Philippine suids in recent years. These developments include the acquisition of a series of skulls and mandibles from Negros (*cebifrons*) and Samar (*philippenensis*) which, together with the first photographs revealing the external characters of the Visayan animals, have not only led Groves (1991 and in litt.) to reaffirm his (1981) assertion that the central and eastern Philippine pigs are more closely allied to *barbatus* than to *celebensis*, but also to suggest that these are sufficiently different from *barbatus* and from each other to warrant separation as distinct species; i. e., *Sus cebifrons* and *S. philippensis*, respectively. Both of these taxa are currently regarded as monotypic, but Groves and Grubb (in press) acknowledge that *S. philippensis* appears to be regionally variable in some characters and may ultimately prove polytypic.

The first studies of karyotypes and banding patterns of Philippine wildpigs also yielded important new information. In 1992, blood samples were collected from seven individuals of known origin (including two F_1 captive-bred hybrids), representing five islands -- Palawan, Culion, Mindoro, Luzon and Mindanao-- and the results compared with those from similar studies of other species of *Sus* which have also been undertaken in recent years. The diploid chromosome number of the domestic pig and Asian and South-East Asian populations of the Eurasian wild pig (*Sus scrofa*) is invariably 38. The same number has been found for *S. barbatus*, *S. celebensis*, *S. verrucosus* (the Javan warty pig), and *S. salvanius* (the pygmy hog). The preliminary results from the Philippine pigs are therefore of considerable interest. Of the seven-pig sample, three pigs (a boar from Luzon and two sows from Mindanao) had 2n=36, with a centric fusion between chromosomes 13 and 16 in the homozygous condition, and two pigs (both sows, one each from Culion and Mindoro) showed 2n=38 chromosomes, with chromosomes 13 and 16 separately present. This type of translocation is new, both to the domestic pig and to the wild species of *Sus* karyo-

types so far. The remaining two (hybrid) pigs (one from each of the latter sows but both sired by the Luzon boar), each showed 2n=37, with the same centric fusion of chromosomes 13 and 16 in the heterozygous condition (for details see: Bosma *et al.*, in press).

These results strongly support Groves' (1991) suggestion that *Sus philippensis* is a valid speciesm endemic to Luzon, Mindanao and associated islands. They also refute the assertions of earlier workers that the Philippine wild pigs east of Wallace's Line should be attributed to *S. celebensis*, which also has 2n=38 chromosomes. Owing to the absence of comparative museum specimens, the systematic relationships of the wild pigs from Mindoro have not been studied before, but these results indicate that the Mindoro population is closely allied with the bearded pig of Palawan and associated islands (including Culion), i.e., *S. b. ahoenobarbus*, rather than *S. philippensis* from neighboring Luzon. This conclusion, which is also borne out by the animal's external morphology, is interesting in that most of the non-endemic mammal fauna of Mindoro is allied to the neighboring, larger island of Luzon, although Palawan faunal elements are present in smaller numbers (S. Goodwin, pers. comm.).

In any event, the recognition of at least three taxa of wild pigs means that the Philippines has a larger number of endemic suids than other country with the exception of Indonesia, which has at least five species and eight subspecies, of which three species and five subspecies are endemic. The inclusion of pigs from Jolo in the Sulu Archipelago with *S. philippensis* in Groves' (1981) review is some further interest in this context, since it implies the westward colonization of these islands by wild pigs from Mindanao, rather than eastwards from the Bornean mainland (Sabah). However, there is no doubt that typical bearded pigs *S. barbatus* ssp., also occur in the south-westernmost islands of Sibutu and Tawi-tawi of the Sulu chain. Indeed, there are numerous, apparently reliable, accounts of wild pigs crossing the channel between Sabah and Sibutu, where they have sometimes been killed by fishermen. On one occasion, a large number of swimming animals are reputed to have been used for target practice by a U. S. Navy battleship, which encountered them while on patrol (R. Hilado, pers. comm.). It therefore seems likely that a fourth non-endemic taxon of wild pig, the Bornean *S.b. barbatus*, should be added to the Philippine list, and that the Sulu Archipelago has been colonized by immigrant groups of these animals from the southwest, Sabah, as well as the northeast, Mindanao.

PRESENT DISTRIBUTION AND CONSERVATION STATUS

Wild pigs are known or reported from all of the larger, and many of the smaller, offshore islands in the Philippines. As previously indicated, their distribution may be broadly divided into the major biogeographical regions west (Sundaic) and east (Wallacean) of Wallace's Line, each of these being divided into two sub-re-

gions, i. e., Palawan (including Balabac and the Calamianes Group) and Tawi-tawi and Sibutu, and the west-central Visayas Islands, comprising Negros, Cebu, Masbate, Panay and Guimaras, and the larger, eastern islands of Luzon, Samar, Leyte, Mindanao and associated smaller islands. Wild pigs are known to occur or to have occurred until recently, on all of these islands and many of the smaller, offshore islands and island groups (e. g., Mindoro, Sibuyan, Siquijor and the Sulu Archipelago), though the affinities of some of these populations are not yet known (Table 1).

As indicated in Table 1, recent data on the wild pig populations on many islands, particularly the smaller islands, are lacking, and their present status can only be inferred from the extent of remaining forest over their known ranges. Thus, *Sus b. ahoenobarbus* is probably the most threatened subspecies of *S. barbatus* (Caldecott *et al.*, in press) because it has by far the smallest range and because the smaller, insular populations on the islands of Balabac and the Calamian Islands (Oliver, in prep.) are unlikely to remain securely established. This subspecies is thought to be still relatively widely distributed on Palawan, where it may even be locally common in some areas, but it is intensively hunted (McGowan, 1987 and pers. comm.) and the surviving forests on Palawan are being rapidly depleted by uncontrolled logging and agricultural enroachment (Quinnell and Balmford, 1988).

By comparison, *Sus philippensis* has almost certainly been extirpated over a much greater proportion of its former range than *S. b. ahoenobarbus*, but this range is also considerably larger and includes some still relatively extensive tracts of forest on the larger islands of Luzon, Samar, Leyte and Mindanao. On all of these islands, the species is reported to remain quite widely distributed wherever significant amounts of forest remain. Far less forest remains on Mindoro, though wild pigs are said to be locally common in some areas (Rabor, 1986: Cox, unpubl.), on Catanduanes (Heaney *et al.*, 1991), and on Biliran (see below) where, by 1985, the species was reported to declined to the point that viable populations were unlikely to survive for much longer. The species is known from Jolo and it is presumed to occur, or to have occurred formerly, on Basilan and on some of the other smaller islands in the Mindanao and Luzon faunal regions, but recent data from these areas are lacking.

The distribution and status of wild pigs on Samar, Leyte and Biliran were investigated during a field survey in the central Philippines in 1985. This was primarily intended to assess the status and future management needs of *Sus cebifrons* and the Philippine spotted deer (*Cervus alfredi* Sclater), which were assumed to occur on these islands (Cox, 1985, 1987a). However, although Samar, Leyte, and Biliran comprise the eastern part of the Visayas geopolitical region, they actually represent a northward extension of the Mindanao Faunal Region, as defined by Heaney (1986) on the basis of the 120 m bathymetric line (Fig. 1). Thus, although Cox's survey revealed that Samar and to a lesser extent, Leyte continued to support the largest

populations of wild pigs in the Visayan Islands, these populations are undoubtedly *S. philippensis*, rather than *S. cebifrons*, as was assumed at the time.

Conversely, the recognition that *Sus cebifrons* is confined to the west-central Visayan Islands of Cebu, Negros, Guimaras, Panay and Masbate, profoundly influences any assessment of its conservation status. This taxon is undoubtedly more gravely threatened than previously supposed, or indicated by its current designation on the IUCN Red List of Threatened Animals (IUCN, 1990), where it was listed as "vulnerable" on the assumption that the aforementioned Samar, Leyte and Biliran populations belonged to this taxon. As it is, the species is certainly "Endangered" according to the terms of these status categories, and perhaps more so than other wild suid with the exception of the pygmy hog, *S. salvanius* (Oliver, 1991).

The reasons for this are based on Cox's (1985, 1987a) revelations that these animals are extinct on Guimaras and Cebu, and absent or extinct on Siquijor, all of which islands have been virtually deforested. A similar situation obtains on Masbate, which was not visited during the 1985 survey, and on Bohol, where the last surviving population of wild pigs is thought to be close to extinction in the Raja Sikatuna National Park (A. Alcala, pers. comm.; D. Kho, pers. comm.). However, it is known whether the pigs on Bohol are allied to *S. cebifrons* or *S. philippensis*, since this island is closest to Cebu but it forms part of the Mindanao Faunal Region. In either event, potentially viable populations of *S. cebifrons* are confined to the last remaining area of forest in west Panay, and the few small, fragments of remaining forest on Negros. This range is essentially identical to that of the critically endangered Philippine spotted deer, *Cervus alfredi* (Cox, 1985, 1987a; Oliver *et al.*, this vol.) and, in common with the latter species, all of the few remaining pig populations are declining as a result of continued habitat loss, hunting pressure and other forms of disturbance.

The survival prospects of these pigs are therefore intimately linked with the efforts now being made to conserve the spotted deer, which has been adopted as a "flagship" species for conservation action in the Negros-Panay Faunal Region. To this end, a new (40,000-ha) national park, the Panay Mountains National Park, has been proposed for the Mt. Madja-as/Mt. Baloy area of west Panay, to protect the single largest and most important tract of forest remaining in the region and, hence, the largest and most important surviving populations of these and diverse other Visayan endemic species. A preliminary management plan has been drafted and submitted to the relevant authorities (Cox, 1987b) and it is hoped that this park will be officially gazetted in the near future (W. Dee, pers. comm.).

On Negros, wild pigs are known to occur in the Northern Negros Reserve Forest (i.e., Mt. Silay and the Mangdalangan Mountains) and Mt. Canlaon National Park in the north (L. Cayayan, pers. comm.), and in scattered forest in the south, in-

cluding the environs of Mt. Talinis and Lake Balinsasayao, near Dumaguete City. However, in all of these areas wild pigs are still subject to intense hunting pressure as well as the continued attrition of their remaining habitat through illegal logging activities. However, precise data on the extent of these threats are lacking owing to the remoteness of most of these areas and or the presence of the New People's Army both of which factors effectively negate their regulation or control.

This situation is excerbated by the attitudes of local people towards these animals. Wild pigs are most frequently encountered when they are hunted in the forest fragments or when they emerge from the shelter of those fragments to forage for vegetable or fallen fruits in neighboring cultivation areas or "kaingin". In some areas farmers build bamboo fences to protect their crops or even go to the trouble of surrounding whole clearings with sharpened staves planted obliquely outwards to prevent the entry of wild pigs (Rabor, 1977). Nonetheless, the damage caused to agricultural smallholdings can be severe. For this reason, no special conservation measures have been introduced to protect these animals, which are generally regarded as pests, and therefore a legitimate target for control or reprisal. Some government officials from the former Bureau of Forest Development (BFD), who should certainly have known better, even suggested that wild pigs should be hunted down and killed wherever possible (Cox, 1987a).

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Table 1. Present known distribution and status of wild pigs (*Sus* spp.) in the Philippines.

Taxon	Status	Distribution
S. b. ahoenobarbus (endemic spp.)	Rare and declining	Balabac*, Palawan and Calamians (Busuanga, Calauit, Culion and Coron Is.)
S. b. barbatus (non-endemic spp.)	Locally rare but widespread in Borneo	Sibutu and Tawi-tawi
S. cebifrons (endemic spp.)	Endangered	Panay, Guimaras (extinct) Negros, Cebu (extinct) Masbate*
S. philippensis (endemic spp.)	Rare and declining	Luzon, Marinduque (extinct) Catanduanes,Samar,Leyte, Biliran,Mindanao,Basilan*, Jolo*, and other islands
Sus spp.	Rare and extinct	Mindoro (rare), Sibuyan (vulnerable), Bohol (endangered), Siquijor (extinct)

Key: * - no recent data. N. B. The suggested status categories adopted above broadly follow those of IUCN as defined in the IUCN Red List of Threatened Animals (IUCN, 1992).

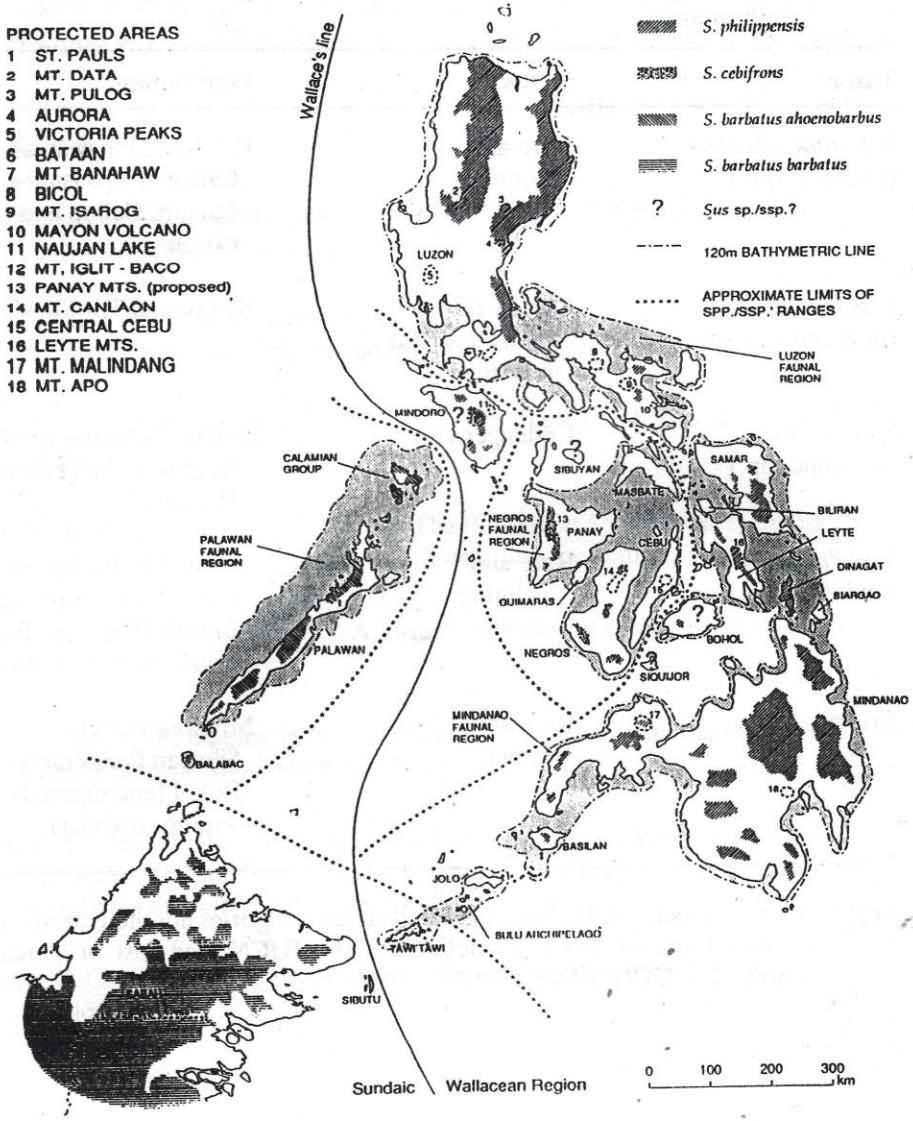

Figure 1. Presumed former and present known distribution of wild pigs in the Philippines (modified after Groves, 1981; Groves and Grubb, in press; Cox, 1985; Heaney, 1986; and Forest Management Bureau, 1988).

MARINE MAMMAL SPECIES CONFIRMED FROM PHILIPPINE WATERS

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ABSTRACT. In 1990, the authors began compiling information (from strandings, interviews, trained observers aboard fishing vessels, unpublished sources, examination of specimens taken in fisheries, and surveys) on marine mammal presence, relative abundance, and involvement in fisheries in Philippine waters. Through September 1992, the Philippine marine mammal fauna had been confirmed to include 17 species. At least those indicated are involved in directed fisheries (+) or are taken incidental to gillnetting or seining operations (*): Risso's (+*), bottlenose (+*), rough-toothed (*), pantropical spotted (+*), long-snouted spinner (+*), and Fraser's (+*) dolphins, melon-headed (+*), pygmy-killer, short-finned pilot (+*), Blainville's beaked (+), sperm (+), pygmy sperm (+), dwarf-sperm, humpback (+), minke and Bryde's (+) whales, and dugongs (+*). Eight other species for which yet unconfirmed reports exist are: striped, common and Indo-Pacific humpbacked dolphins, and blue, bottlenose, goosebeaked, killer, and false killer whales. There is evidence

that incidental takes in fishing operations have given rise to directed fisheries for small cetaceans as human populations have burgeoned and traditionally harvested marine species have declined.

INTRODUCTION

There are few published reports on marine mammals occurring in Philippine waters. Townsend (1935) plotted locations of kills of sperm whales between 1821 and 1899; these included records within the current Extended Economic Zone (EEZ) of the Philippines. Herre (1925) reported the stranding of a 33-foot whale near Bacoor, Cavite Province, on 3 January 1925. He identified the specimen as a minke whale; however, his failure to describe diagnostic features for this species and the reported size and coloration of the specimen lend doubts as to the validity of the identification. Slijper *et al.* (1964), who plotted and analyzed distribution of rorquals seen from Dutch ships, showed sightings of humpback whales off southwestern Palawan, in the South China Sea northwest of Luzon, and off Mindanao in the southern Sulu and northwestern Celebes Seas. From the seasonal distribution of records from Indonesia, they concluded that both northern and southern hemisphere humpback whales visited that area and suggested that the Philippines may be a migration corridor for the northern hemisphere animals. Hammond and Leatherwood (1984) reported on observations and collections of cetaceans off southeastern Cebu (the Camotes Sea and Cebu Strait) by representatives of Ocean Park, Hong Kong, April 1974 through July 1975. Collectors observed a sperm whale, Risso's, pantropical spotted, spinner, and Fraser's dolphins, and melon-headed whales, and captured specimens of these last three species. Alcala (1986) reported on surveys to determine the distribution, movements and status of dugongs and the condition of seagrass beds in the Palawan and the Calamianes areas of the Sulu Sea. Aragones (1990, 1992) reported on the distribution, status, and feeding ecology of dugongs at Calauit Island, Busuanga.

In 1990, the authors began a collaborative research program on marine mammals of the Philippines (Figure 1A). The major goals of the program were (1) to document the distribution and relative abundance of marine mammal species occurring in waters of the Philippine EEZ; (2) to document the nature and extent of fisheries which take marine mammals, either as primary targets or accidentally/ incidentally in the course of fishing operations; (3) to study economic, political, and legal aspects of cetacean exploitation and conservation; (4) to initiate studies on the life history and ecology of selected species; and (5) to conduct activities designed to increase awareness in the Philippine general public, academic community, and resource management agencies about marine mammals and their conservation and management. The research program was recently expanded to include placement of observers aboard Philippine purse-seiners fishing in the Sulu and Celebes Seas

(Dolar and Leatherwood, 1992) and intensified collection of data and specimens from fish-landing sites.

Some results of these efforts have already been reported in scientific meetings and published. Dolar (1992) presented information on incidental takes of small cetaceans in fisheries in Palawan, the central Visayas and Northern Mindanao. She confirmed that the six major fisheries in these regions account for deaths of at least Risso's, bottlenose, pantropical spotted, spinner and Fraser's dolphins and suggested that many more species are involved. Dolar *et al.* (1991a, 1991b) confirmed that directed fisheries for cetaceans in these regions also take specimens of the above five species plus melon-headed, short-finned pilot, Blainville's beaked, sperm and Bryde's whales.

This paper presents an annotated checklist of all species of marine mammals confirmed from Philippine waters through September 1992. It expands and updates the brief listing of Aragones *et al.* (1991) which included results of the various sighting surveys, mostly of the central Visayas, through 1992. Presentation includes scientific names, common and vernacular names, and the author(s) and year of the original description, followed by records of sightings, strandings, directed takes, and incidental/accidental takes in fisheries. Classification above the generic level follows Honacki *et al.* (1982), Barnes *et al.* (1985), Mitchell (1989) and Perrin (1990). Common names follow Leatherwood and Reeves (1983) and Reeves *et al.* (1992).

MATERIALS AND METHODS

Literature on marine mammals of the Philippines and immediately adjacent areas was reviewed. Files of the Smithsonian Institution, which contain listings of marine mammal holdings of 68 institutions, were queried and appropriate records extracted. Interviews were conducted with scientists who were working or had worked in the Philippines. A series of investigations were also undertaken by the authors, as described below. Locations of some places referred to in the text and areas of coverage are shown in Figures 1A to 1D.

Vessel Surveys (see Fig. 1B)

Batangas Bay, Verde Island Passage and Sibuyan Sea. From June through September 1988, four surveys a month were conducted from the scheduled ferrys (*M/V Puerto Galera III* and *IV*), connecting Batangas City, Luzon, with Puerto Galera, Oriental Mindoro (Figure 1 inset). On 5 May 1992, a single survey was conducted aboard the *M/V Sugbu*, a ferry between Manila Bay and Romblon Islands. Searches were made from a platform on the bridge, at an eye level of about 8m and 15m respectively. Binoculars were used to aid in locating and identifying dolphins.

Almost all species seen approached the vessel, at least occasionally. Thus, identifications were easily confirmed.

Bohol Sea, Cebu Strait and Sulu Sea. Surveys for cetaceans were conducted during the following cruises: 1-2 April 1991 and 3-5 April 1991 aboard the 18m *M/V San Antonio* - Dumaguete to Pamilacan Island to Siquijor to Dumaguete; 8-9 April 1991 aboard the 24 m *R/V Melaena* - Apo Island to Selinog Island to northern Mindanao to Selinog Island to Apo Island to Dumaguete; 1-10 May 1991 aboard the R/V *Melaena* - Dumaguete to Tubbataha Reef and around the islands of Cavili and Cagayancillo to Dumaguete; 13-15 May 1991 aboard the 7m *F/V Regis* and *F/V Christina*- off Brooke's Point, Palawan; 21 May 1991 aboard an unnamed pumpboat - in Ulugan Bay, Masarascas, Palawan; 19 May 1991 aboard an unnamed 8m pumpboat - off Puerto Princessa, Palawan; 13-15 May 1992 aboard the *M/V San Antonio* - Dumaguete to Siquijor to Selinog to Apo to Dumaguete; 11 and 29 June 1992 aboard the 10m *M/V Prima I* and *Prima II*, respectively, the ferrys between Dumaguete and Siquijor; 24-26 May 1992 aboard an unnamed pumpboat - off San Francisco, Negros; 28 May to 1 June 1992 aboard the 21m *M/V Flying Fish II* - Dumaguete to Pamilacan Island to Camiguin to Siquijor to Dumaguete; 12-14 June 1992 aboard the 10m *R/V Oikos III* - Dumaguete to Siquijor to Dumaguete; 16 June 1992 aboard the 50m *M/V Georich*, the ferry between Dumaguete and Dapitan, Mindanao; 2 July 1992 aboard the 125m *M/V Don Virginia*, the ferry between Dumaguete and Naso Point, Panay; 8-9 July 1992 aboard the *F/V Accord* - off Siaton, Negros; 28-29 July 1992 aboard *R/V Melaena* - Mactan Island to Balicasag Island to Dumaguete; 9-10 August 1992 aboard the *R/V Melaena* - Dumaguete to Pamilacan Island to Dumaguete; 5-6 September 1992 aboard the *M/V Flying Fish II* - Dumaguete to Apo Island to Dumaguete.

Except for the surveys conducted from scheduled ferry services, watches for cetaceans were maintained at all times by two or more observers. Whenever possible, the vessel was diverted to approach the animals, and photographs and videos were taken. Groups were followed and observed for 10 minutes to 2 hours, during which time group size, diving times and respirations rates, moving directions and speeds were noted in detail. These information will be reported elsewhere. Sightings also were logged incidentally during various cruises by Aragones around Palawan, Calauit Island and off Occidental and Oriental Mindoro, 1989-1991.

Tañon Stait, Visayan Sea and Camotes Sea. The following surveys were conducted in these areas: 18 and 23 June 1992 aboard the 12m *M/V ABC*, the ferry between Tampi, Negros, and Bato, Cebu; 20-21 June 1992 aboard the *M/V Flying Fish II* - Dumaguete to Moalboal to Dumaguete; 27-28 June and 29-30 September 1992 aboard the *M/V Oikos* - Dumaguete to Moalboal to Dumaguete; 11-12 July aboard the *M/V San Antonio* - Dumaguete to Basak, northern Negros, to Bantayan Islands to Boao, northern Cebu, to Mactan Island. All cetaceans seen were closely approached

and their positions estimated with compass references to identifiable land masses, photographs and video footage were taken, behavioral characteristics were noted, and group numbers were estimated. Survey height was between 4 and 9m; speed was 7-9 knots.

Site Visits

Information was also gathered during site visits as follows: to all major fish landing sites between Honda Bay Pier, Tagburos, and Rio Tuba, on the east coast of Palawan, and to Quezon, on the West Coast of Palawan, 28 March - 1 April 1991; to Caletegas, Narra, Brooke's Point, and Puerto Princessa, Palawan, 13-18 May 1991; to Pamilacan Island, April and July 1990, 5 and 6 April 1991, and 20 and 23 May 1991 and 28 May and 9 August 1992; to Selinog Island 14 and 15 February 1991, 8 and 9 April 1991, and 13 and 14 May 1992; and to San Francisco, Negros, 15 June 1991 and 24-26 May 1992; to Brooke's Point 3-7 August 1991; to Lila, Bohol, 29 May and 10 August 1992; to Sagay, Camiguin, 30 May 1992; and to Siaton, Negros, 2-3 April 1991 and 8-9 July 1992. Local contacts in several of these villages/towns were enlisted to collect data on fishing effort and number and species of animals taken. They were given aids to identification, measurement forms, and a camera and print film to photograph animals landed. These photographs were used to verify species identifications (Dolar *et al.*, 1991a, 1991b).

Sightings made during vessel surveys of the Central Visayas through 18 May 1992 are shown in Figure 1C; those made during concentrated surveys of a smaller area of Tañon Strait, Cebu Strait and the Bohol Sea 19 May-30 September 1992 are shown in Figure 1D. Information on marine mammals species confirmed during these vessel surveys and all other activities is summarized below by species.

For all specimens and photographs, species was determined by reference to keys and other identification aids in Leatherwood and Reeves (1983), Leatherwood *et al.* (1988), Baker (1983) and Jefferson *et al.* (1992). To confirm identifications of some difficult specimens, particularly skulls and loose bones and baleen, photographs and measurements were provided to various experts and their opinions solicited. Voucher specimens are deposited in the Silliman University Marine Laboratory (SUML) or Biology Department (SUBD) or the Museum of Natural History at the University of the Philippines at Los Baños (UPLB).

CHECKLIST

Order Cetacea Brisson, 1762 (Whales, dolphins and porpoises)
Suborder Odontoceti Flower, 1867
Superfamily Delphinoidea (Gray, 1821), Flower, 1864

Family Delphinidae Gray, 1821. Dolphins; *lomod* (most of the Visayas) and *lumba-lumba* (Tagalog region and some of the Visayas)
Subfamily Delphininae (Gray, 1821), Flower, 1867

Grampus griseus (G. Cuvier, 1812) - Risso's dolphin; pakatang (Visayas) and *kabang* (= uneven coloration) (Figures 2a, 2b)

Sightings: repeated encounters with a small pod off the northwest tip of Cebu Island, April 1974 - July 1975 (Hammond and Leatherwood, 1984); frequent sightings, usually in the company of Fraser's dolphins, off southeastern Negros, between Dumaguete and Siaton, and off northern and southeastern Siquijor, April 1991 - May 1992 (Dolar *et al.* 1991a, b; this study); off San Francisco, Ormoc, Leyte, Camiguin, Siquijor, and the tips of southern and northern Cebu, around Sumilon, Pamilacan, Balicasag Islands, between Camiguin and Siquijor, and in Batangas Bay, May - September 1992. Directed takes: by harpoon off Brooke's Point, Palawan, 22 June 1991 (Dolar *et al.*, 1991a, 1991b); Incidental takes: in gillnets throughout the central Visayas (Dolar *et al.*, 1991a, 1991b).

Tursiops truncatus (Montagu, 1821) - Bottlenose dolphin; *lomod* (Figure 2c)

Sightings: Occasional, in groups of up to 200, off Coron, Lincapacan, Busuanga, Culion, Calauit Islands, El Nido and Taytay, Palawan, San Jose, Occidental Mindoro, - 1989 - 1991; Batangas Bay and Verde Island Passage - 19 June (10 individuals, 5), 29 July (15 individuals), 14 August (20 individuals), 19 August (five individuals), 21 August (11 individuals), 9 September (two individuals), 10 September (25 individuals), 16 September (four individuals), 17 September (eight individuals) and 1 October (three individuals), 1988; Balicasag Island - 5 April 1991 (200 individuals); Ulugan Bay, Mascarascas, Palawan, 21 May 1991; off Brooke's Point, Palawan 18 May 1991; around Pamilacan 28 and 29 May 1992, and Camiguin Islands, 30 May 1992, and repeated encounters between the southern tip of Cebu and Negros, June - September 1992. Directed takes: by harpoon off Brook's Point, Palawan, 18 May 1991 (173 cm), 15 July 1991 (150 cm), and 27 July (150 cm) 1991 (Dolar *et al.*, 1991a, 1991b); Incidental takes: widely in the Central Visayas (Dolar *et al.*, 1991a, 1991b).

Stenella attenuata (Gray, 1846) - Pantropical spotted dolphin; *lomod, balakiki* (Figure 2d)

Sightings: approximately six encounters, with 200-800 individuals, off eastern Cebu (Hammond and Leatherwood, 1984); Batangas Bay, Verde Island Passage, 13 August 1988 (four individuals), off Brooke's Point, Palawan, May 1991, and between southeastern Siquijor and Selinog Island, 13 May 1992 (400 plus individuals); off Pescador Island, 11 June 1992 (250 individuals), 25 July 1992 (450 individuals) and 29

September 1992 (200 individuals), Panglao Island, 28 July 1992 (200 individuals), and Daco Island, 20 September 1992 (250 individuals). Directed takes: by harpoon off Brooke's Point, Palawan, 15 May 1991, 173 cm. male, "speckled stage" (Dolar *et al.*, 1991a, 1991b).

Stenella longirostris (Gray, 1828) - Long-snouted spinner dolphin; *lomod* (Figure 3a, 3b)

Sightings: August 1974, near Cebu City (Hammond and Leatherwood, 1984); Occasional off Calauit and Lincapacan islands, Puerto Galera, Oriental Mindoro, and San Jose, Occidental Mindoro, 1988-1991; Batangas Bay and Verde Island Passage - 30 July (six individuals), 13 August (12 individuals), 21 August (16 individuals), and 17 September (three individuals), 1988; around Siquijor, Pamilacan, and Selinog islands, off southeastern Negros, and off Brooke's Point; several sightings off Siaton, Dumaguete and San Francisco (Negros), Danao (Cebu), Camiguin and Ormoc (Leyte) and Balicasag, Pamilacan, and Marinduque Islands, and the species seen most frequently in Tañon Strait, 19 May - 30 September 1992. Directed takes: Brooke's Point (13 May 1981), Pamilacan and Selinog (frequent at both) (Dolar *et al.*, 1991a, b); San Francisco, Negros, 24 - 26 May 1992. Incidental Takes: in gillnets, Pamilacan and Selinog islands and Siaton and San Francisco, Negros (frequent) (Dolar *et al.*, 1991a, 1991b).

Lagenodelphis hosei Fraser, 1956 - Fraser's dolphin; *mayahon* (= sparrow like, for the short beak) (Figure 3c, 3d)

Sightings: the most conspicuous cetacean seen in the Camotes Sea and Bohol Strait, April 1974 - July 1975 (Hammond and Leatherwood, 1984); frequent observations off southeastern Negros, Dumaguete to Siaton, and around Siquijor, often with Risso's dolphins; possible sightings off Puerto Galera, 1988 - 1991; repeatedly seen in the presence of other cetaceans around Siquijor and Camiguin and in the channels between Siquijor and both Camiguin and Sumilon, 19 May - 30 September 1992. Stranding: 168.4 cm male, Anilao, Batangas, 15 September 1990. Dry mounted specimen and preserved organs at UPLB. Directed takes: 16 specimens captured live (Hammond and Leatherwood, 1984); Incidental takes: in gillnets, Siaton, Negros (Dolar 1992; Dolar *et al.*, 1991a, 1991b).

Subfamily Globicephalinae (Gray, 1866), Gill, 1872

Peponocephala electra (Gray, 1846) - Melon-headed whale; *pakatang* (Negros Oriental - for resemblance to floating logs) (Figure 4a, 4b)

Sightings: often seen on the periphery of herds of Fraser's dolphins off east central Cebu (Hammond and Leatherwood, 1984); sighting of 400-600 individuals,

with approximately 190 Fraser's dolphins, off Western Siquijor Island, April 1991; off San Francisco, Negros, 24 May 1992, and Camiguin, 31 May 1992, and together with Fraser's dolphins around southern Siquijor, 12 and 13 June 1992. Directed takes: 10 captured live of east Central Cebu, 1974-1975 (Hammond and Leatherwood, 1984); by harpoon at Pamilacan Island, May 1991, skull at SUML (Dolar *et al.* 1991a, 1991b).

Feresa attenuata Gray, 1874 - Pygmy killer whale

Sightings: Off eastern Camiguin (100 individuals), 31 May, and southern Siquijor (50 individuals) 12 June and in Tañon Strait (100 individuals) 21 June 1992.

Globicephala macrorhynchus Gray, 1846 - Short-finned pilot whale; *ambuhutan* (=spewing out, referring to the blow) in Lila, Bohol; *bugon siso*, at Pamilacan. (Figure 4c)

Sightings: Off southern Negros, May, 1991; 6-8 individuals in Lingayen Gulf; between Selinog Island and northern Mindanao, 16 June 1992 (two individuals), along the southwestern coast of Cebu, 18 June (50 individuals), 21 June (45 individuals) and 28 June (100 individuals) 1992, off Siaton, Negros, 8 July 1992 (15 individuals), off Balicasag Island (75 individuals), 29 July 1992, and off Siquijor (75 individuals) 10 August 1992. Strandings: 6 - 7 animals, about 15 August 1990, 1.5 km. north of Calategas, Narra, Palawan. Two of seven animals buried by locals. Skull with mandibles (No. P002), mandibles (Specimen 003), and miscellaneous vertebrae and ribs (Specimen 004) collected 28 March 1991, and deposited at UPLB. Six individuals at Binmaley, Pangasinan, reported to the authors 24 October 1991. Directed takes: by harpoon at San Francisco, Negros (Dolar *et al.*, 1991a, 1991b). Incidental takes: in gillnets, Siaton, Negros. Other: The American Museum of Natural History, New York, has 2 ribs (AM03578) and lower jaws (AM030576) of pilot whales collected by R. C. Andrews at Port Galera, Mindoro, 27 October 1909.

Superfamily Ziphioidea (Gray, 1865), Fraser and Purves, 1960
Family Ziphiidae Gray, 1865 - Beaked whales

Mesoplodon densirostris (de Blainville, 1817) - Blainville's beaked whale (Figure 4d-f)

Directed takes: Single individual harpooned by whalers from Pamilacan, 1991. Skull held at Silliman University Marine Laboratory.

Note: There have been 11 sightings of live beaked whales; in at least nine of those instances, the whales were not Blainville's beaked whales, but they could not be identified to species.

Superfamily Physeteroidea (Gray, 1821), Gill, 1872
Family Physeteridae Gray, 1821

Physeter catodon Linnaeus, 1758 - Sperm whale; *balyena* (Figure 5a)

Sightings: Repeated sightings of a single individual during a three-week period, 1974, one mile east of the harbor, Cebu City (Hammond and Leatherwood, 1984); sighting at Tubbataha Reef, Sulu Sea, 17 April 1991; encountered between Bohol and Camiguin, 29 May 1992 (12 individuals) and southwest of Balicasag Island, 10 August 1992. Directed takes: records of takes by yankee whalers, 1821-1899, of over 100 individuals from all months, off western and southwestern Mindanao, four individuals in July off Siquijor Island and three individuals in February east of the Batan Islands (Townsend, 1935); 1973 at Pamilacan Island (partial left lower jaw, 167 cm from condyle to first tooth socket, at SUBD); Brooke's Point, Palawan, 14 May 1988, 30-35 ft. physically mature female (photos, video tape, one maxillary tooth and about four ounces of spermaceti oil at UPLB).

Family Kogiidae (Gill, 1871), Miller, 1923

Kogia breviceps (Blainville, 1838) - Pygmy sperm whale

Directed take: by harpoon off Pamilacan Island, March 1990. Skull without mandibles collected 6 April 1991, at SUML.

Kogia simus (Owen, 1866) - Dwarf sperm whale

Sightings: repeated encounters in southern Tañon Strait, June - September 1992.

Suborder Mysticeti Flower, 1864 - Baleen or whalebone whales
Superfamily Balaenopteroidea Gray, 1868
Family Balaenopteridae Gray, 1866 - Rorquals; *Buncaras, balyena*
Subfamily Megapterinae Gray, 1866

Megaptera novaeangliae (Borowski, 1781) - Humpback whale; *balyena* (Tagalog)

Sightings: southwestern Palawan, northwest of Luzon, and off western Mindanao (Slijper *et al.*, 1964).

Subfamily Balaenopterinae (Gray, 1864), Brandt, 1872

Superfamily Physeteroidea (Gray, 1821), Gill, 1872
Family Physeteridae Gray, 1821

Physeter catodon Linnaeus, 1758 - Sperm whale; *balyena* (Figure 5a)

Sightings: Repeated sightings of a single individual during a three-week period, 1974, one mile east of the harbor, Cebu City (Hammond and Leatherwood, 1984); sighting at Tubbataha Reef, Sulu Sea, 17 April 1991; encountered between Bohol and Camiguin, 29 May 1992 (12 individuals) and southwest of Balicasag Island, 10 August 1992. Directed takes: records of takes by yankee whalers, 1821-1899, of over 100 individuals from all months, off western and southwestern Mindanao, four individuals in July off Siquijor Island and three individuals in February east of the Batan Islands (Townsend, 1935); 1973 at Pamilacan Island (partial left lower jaw, 167 cm from condyle to first tooth socket, at SUBD); Brooke's Point, Palawan, 14 May 1988, 30-35 ft. physically mature female (photos, video tape, one maxillary tooth and about four ounces of spermaceti oil at UPLB).

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Megaptera novaeangliae (Borowski, 1781) - Humpback whale; *balyena* (Tagalog)

Sightings: southwestern Palawan, northwest of Luzon, and off western Mindanao (Slijper *et al.*, 1964).

Subfamily Balaenopterinae (Gray, 1864), Brandt, 1872

Balaenoptera acutorostrata (Lacepede, 1804) - Minke whale; *balyena* (Tagalog)

Sighting: tentative identification, off Calauit Island (Aragones, 1989); Stranding: 3 January 1925, Bacoor, Cavite (Herre, 1925).

Balaenoptera edeni Anderson, 1878 - Bryde's whale; *balyena* (Tagalog) (Figure 5 b-e)

Sighting: off southeastern Siquijor, 9 June 1992. Directed takes: annually by whalers from Pamilacan Island and Lila, Bohol, identified from baleen and photographs. (Dolar *et al.*, 1991a, 1991b). Specimens at SUML and UPLB).

Order Sirenia
Family Dugongidae Lacepede, 1799

Dugong dugon (Muller, 1799) - Dugong; *baboy dagat* (= sea pig) (Tagalog region) and *Duyong* or *dugong* (Tagalog, Visayan and Mindanao regions)

Sightings: Formerly widely distributed in the Philippines, but now believed to be restricted to Palawan, eastern Luzon (Virac, Catanduanes), and Mindanao (Alcala, 1986), and in immediate danger of extinction; Recent sightings in Quezon Bay, western Palawan, 30 March 1991, El Nido Palawan, 1988 - 1992, Taytay Palawan, October 1988, Coron, Busuanga, and Cuilon (one to four individuals per sighting), 1989 - 1991; off Polilio island, Quezon, Palawan, (29 March 1991 and 20 May 1992), Brooke's Point, Palawan, (15 May 1992) and St. Paul Subterranean Park, Palawan (20 May 1992); Directed takes: by harpoon and dynamite in Coron and most of Palawan; Accidental takes: in nets in Coron and most of Palawan (Aragones, 1990).

In addition to confirming the above species for the island group, information was obtained strongly suggesting sightings and/or takes of the following other species: common dolphins, *Delphinus delphis*; goosebeaked whale, *Ziphius cavirostris*; Indo-Pacific humpbacked dolphins, *Sousa chinensis*; rough-toothed dolphins, *Steno bredanensis*; killer whales, *Orcinus orca*; and false killer whales, *Pseudorca crassidens*. Furthermore, from their distribution in other tropical areas, including waters of Indonesia, the Indian Ocean and the Western Pacific (Hembree, 1980; Leatherwood and Reeves, 1983, 1989; Jefferson *et al.*, 1992), it is reasonable to predict the occurrence in Philippine waters of at least the following species (see Heaney, 1989): Ginkgo-toothed beaked whales, *Mesoplodon ginkgodens*; striped dolphins, *Stenella coeruleoalba*; finless porpoises, *Neophocaena phocaenoides*; and blue whales, *Balaenoptera musculus*. However, these species cannot be added to the list of Philippine marine mammal fauna until confirmed by a specimen or photograph. Finally, there were intriguing reports from fishermen suggesting that bottlenose whales, *Hyperoodon* sp. occasionally wander into waters of the central Visayas.

ACKNOWLEDGEMENTS

The initial field surveys were sponsored by Greenpeace Environmental Trust; subsequent work by the Whale and Dolphin Conservation Society, Earth Island Institute and the Haribon Foundation for the Conservation of Natural Resources. The authors thank the crew of the *M/V San Antonio*, *R/V Melaena*, and *R/V Oikos III* for cheerful and competent help, the staff of Silliman University for many kinds of assistance, and the people of the sites visited for their hospitality and genuinely helpful spirits. Dr. James G. Mead, Smithsonian Institution, provided his catalog of marine mammal specimens and confirmed our tentative identification of the Blainville's beaked whale. Leatherwood was sponsored in part by the IUCN Cetacean Specialist Group and Texas A & M University.

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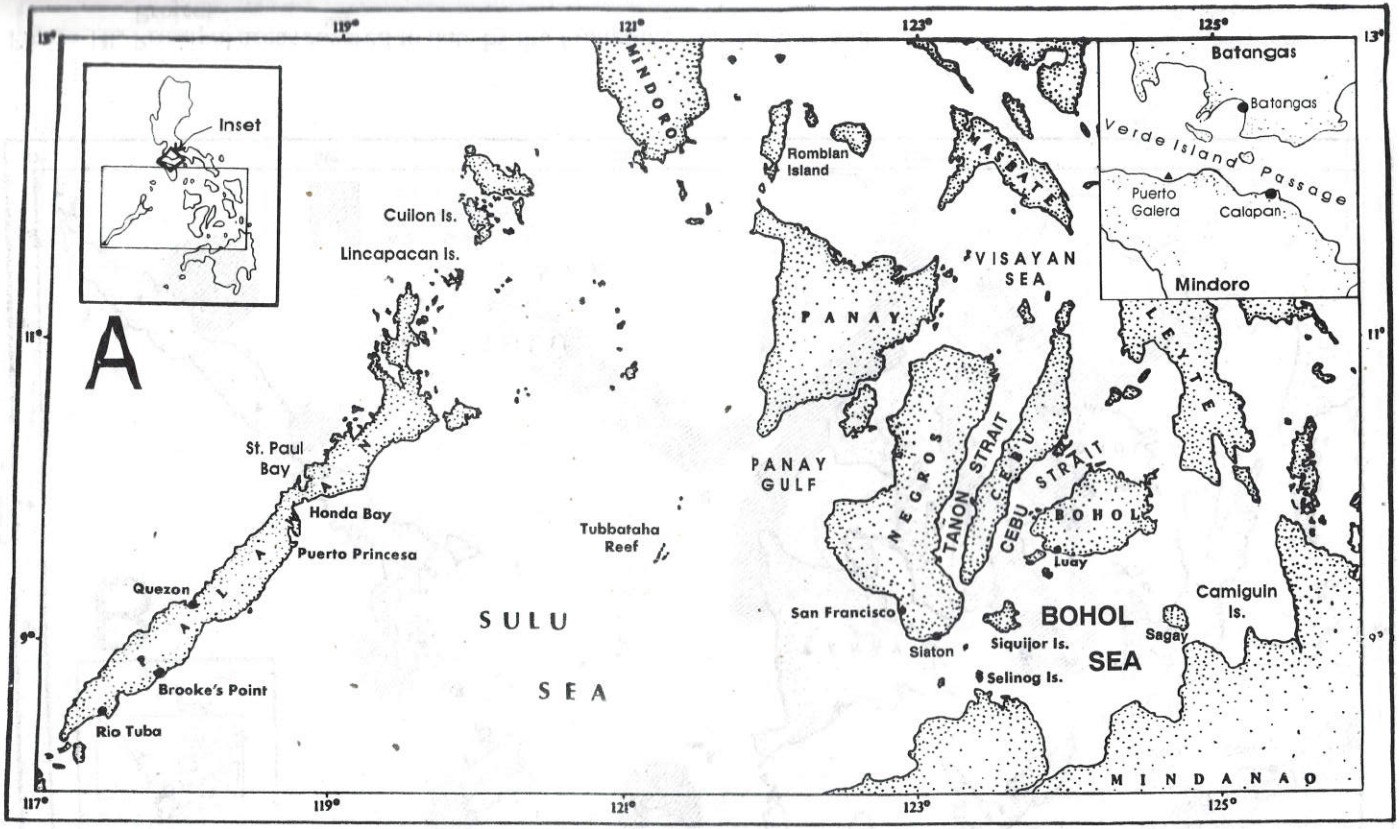

Figure 1A. The Philippines, showing some place names referred to in the text.

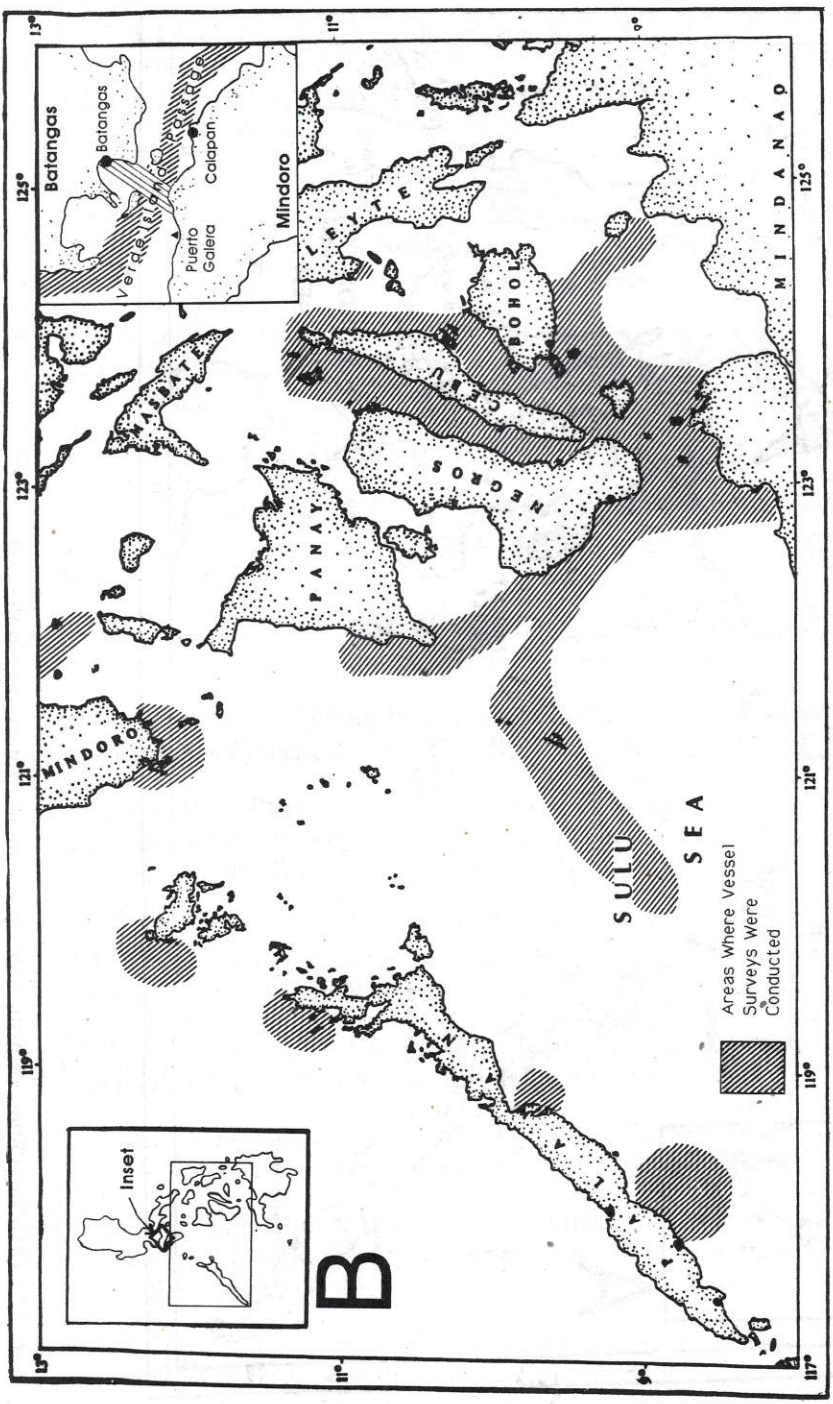

Figure 1B. Principal areas covered to date by the Philippine Marine Mammal Project.

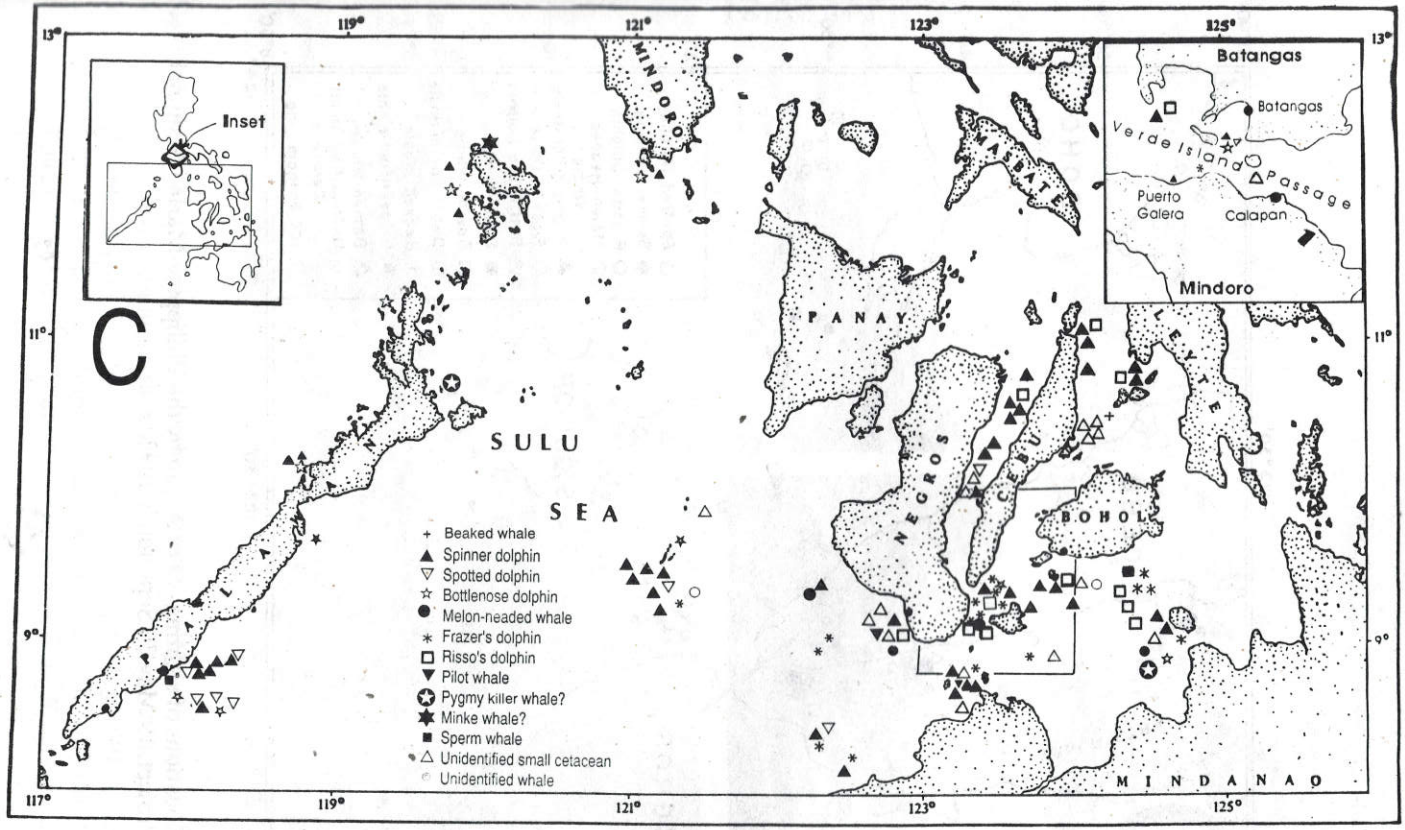

Figure 1C. Locations of sightings of cetacean by the Philippine Marine Mammal Project, 18 May 1992.

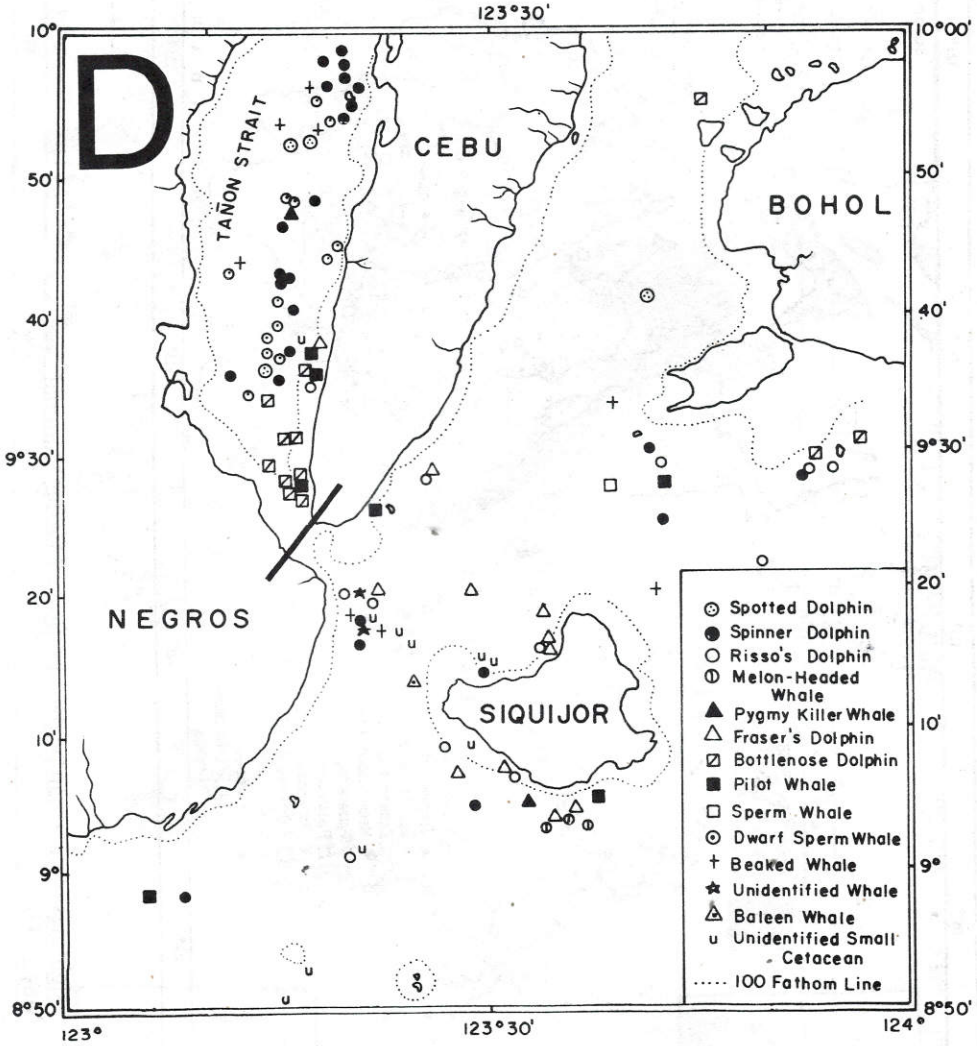

Figure 1D. Locations of sightings of cetacean by the Philippine Marine Mammal Project, 19 May-30 September 1992.

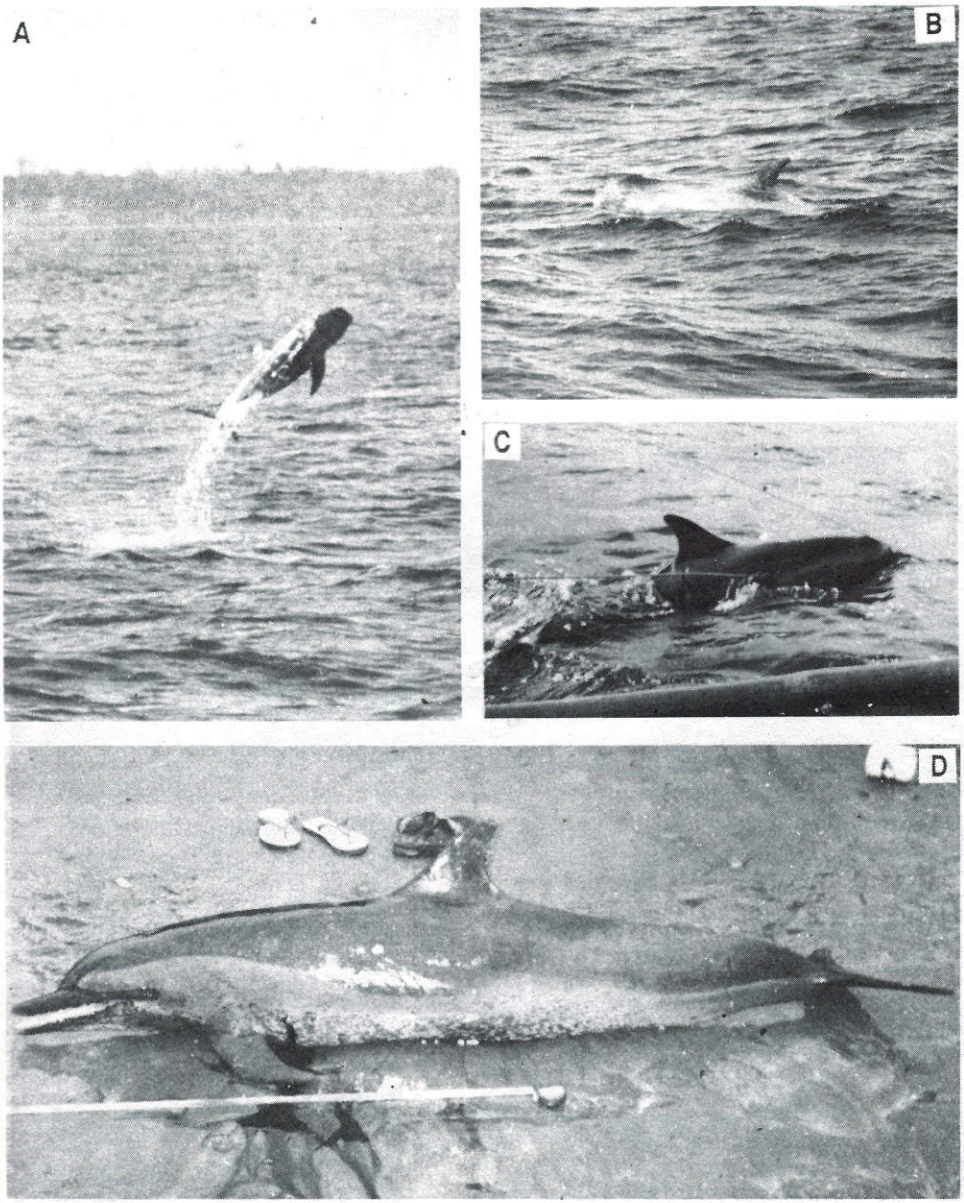

Figure 2. A. Risso's dolphins off Santa Monica, Negros, 9 April 1991. B. Off southeastern Siquijor, 14 May 1992. C. A bottlenose dolphin harpooned but later lost off Brooke's, Point Palawan, 15 May 1991. D. A "mottled" pantropical spotted dolphin harpooned for bait off Brooke's Point, Palawan, 15 May 1992. (Leatherwood, A and B; L. Aragones, C and D).

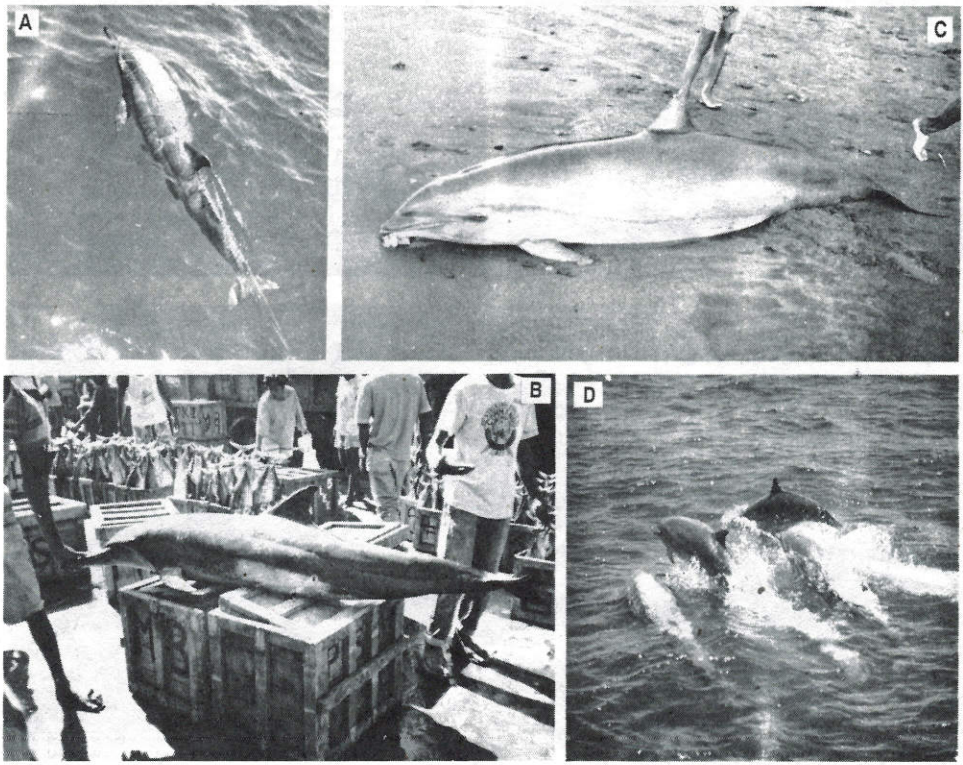

Figure 3. A. Spinner dolphin west of Larena, Siquijor, May 1991. B. In the market. C. This latter specimen was killed in a driftnet in the Sulu Sea; Fraser's dolphins - an 88 inch female taken in a driftnet off Siaton, 3 April 1991. D. Part of a herd off southeastern Siquijor, 13 May 1992. (M. L. Dolar, A and B; S. Leatherwood, C and D).

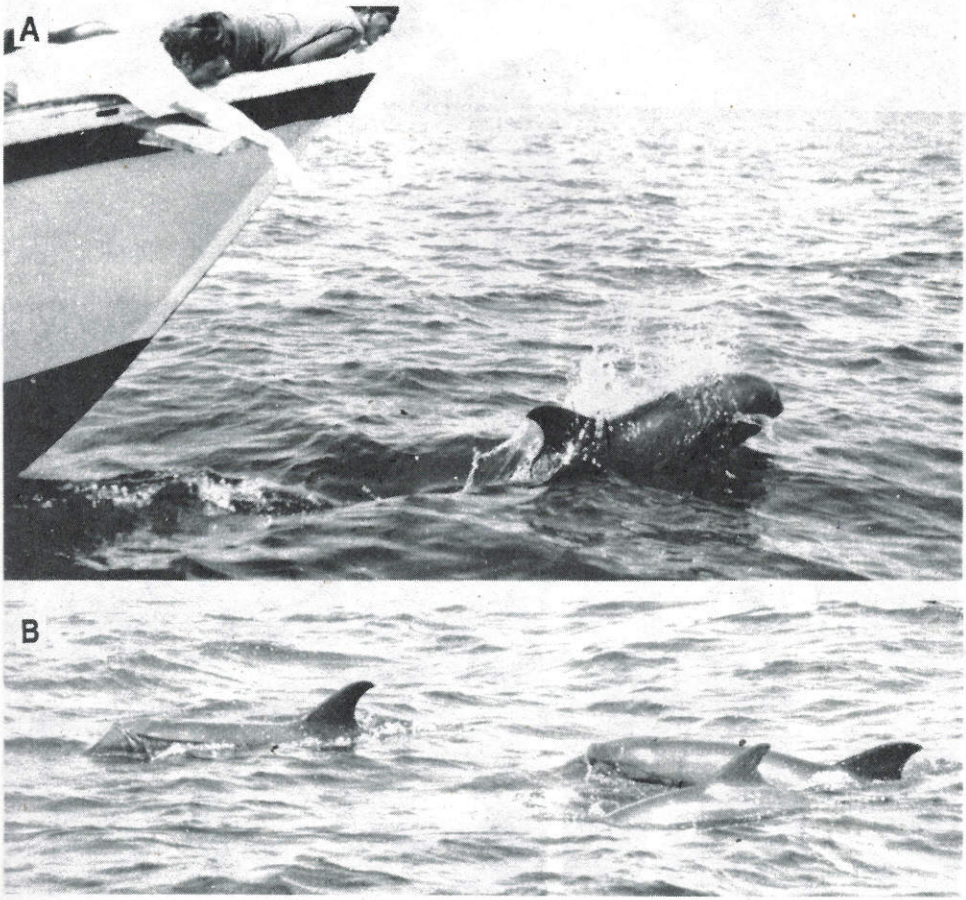

Figure 4A-B. Melon-headed whales north of Apo Island, 9 April 1991. (S. Leatherwood).

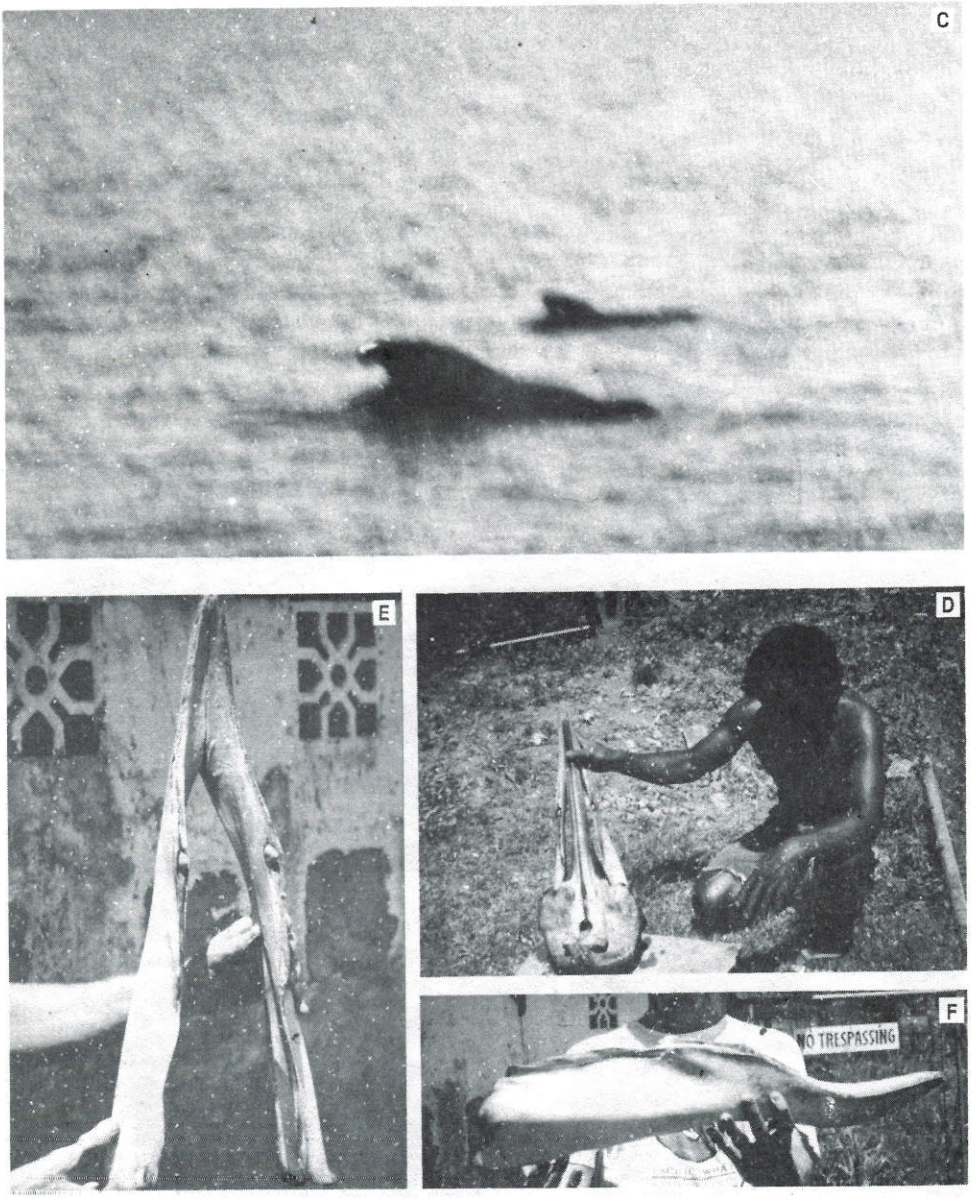

Figure 4. C. Short-finned pilot whales off San Francisco, Negros, May 1991. D-F. Blainville's beaked whale harpooned off Pamilacan Island. (S. Leatherwood, D-F; M. L. Dolar, C.).

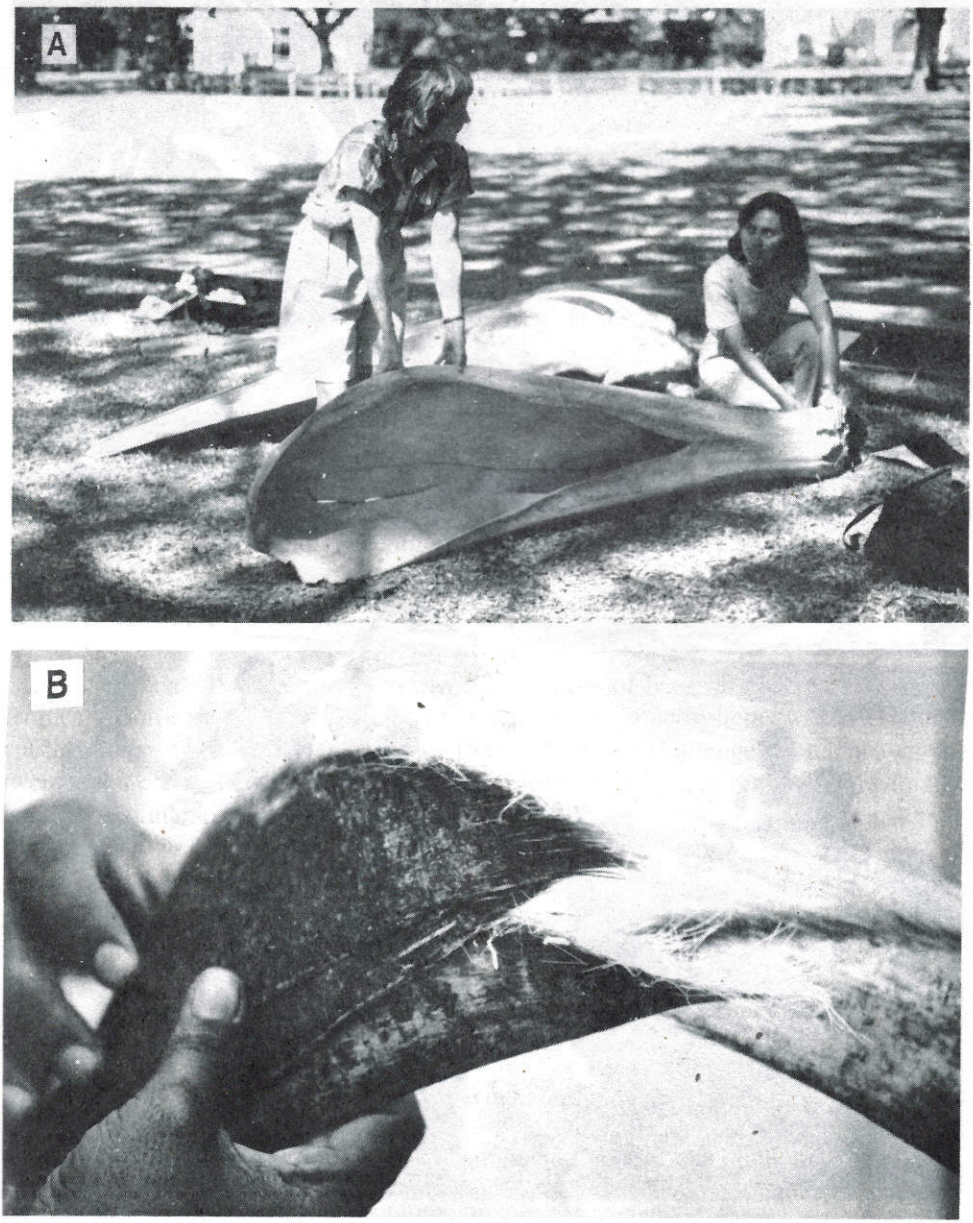

Figure 5. Whales taken by whalers at Pamilacan Island. A. mandible of a sperm whale killed in 1973, now at the SUBD (The Bryde's whale skull in the background also was removed from Pamilacan). B. Baleen of Bryde's whale killed May 1991 off Pamilacan Island and towed to Lila, Bohol, for butchering. [S. Leatherwood (A) and Maria Louella Dolar (B)].

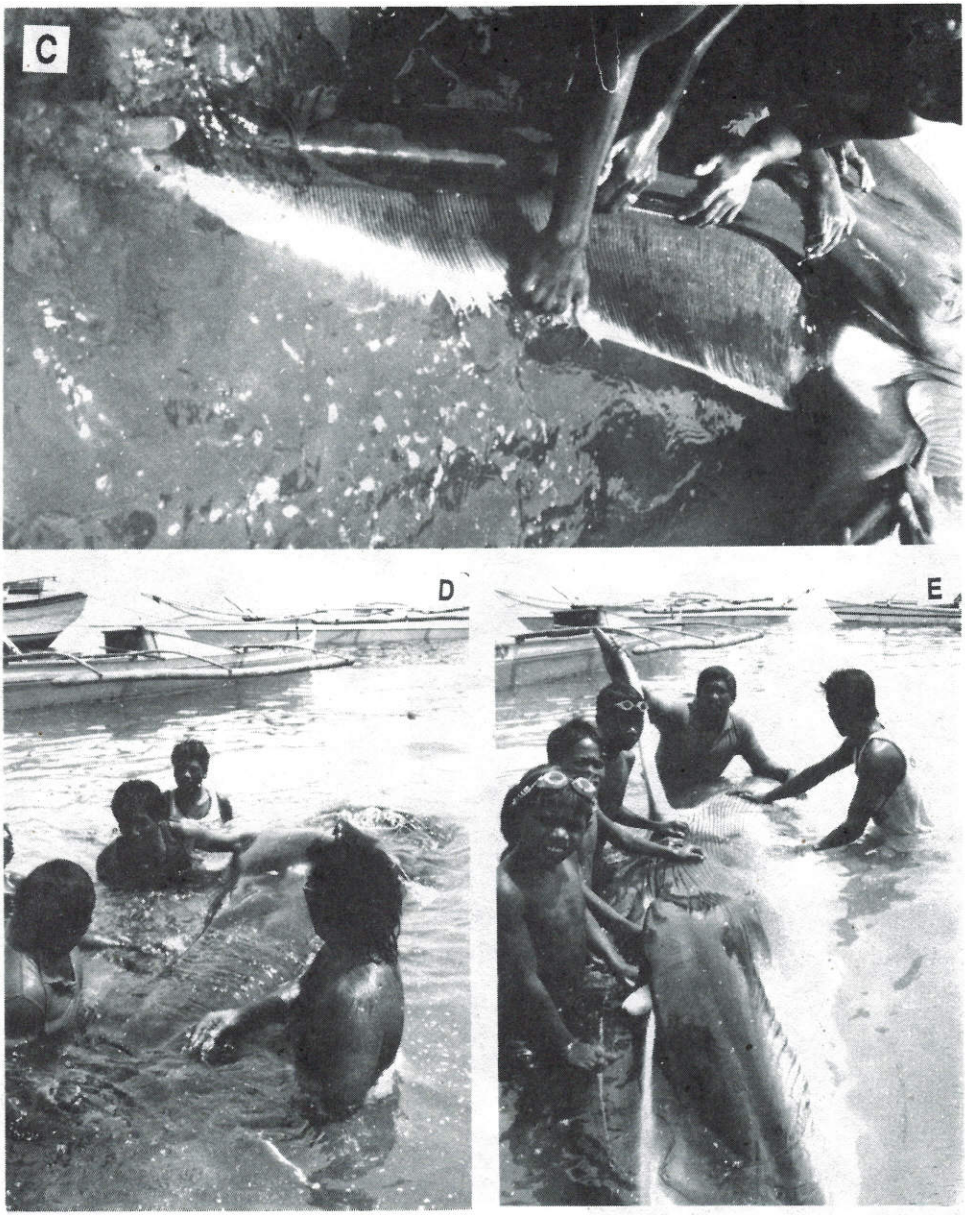

Figure 5C-E. A male Bryde's whale killed 12 May 1992. (Houck S. Reed).

HARNESSING THE LIVING FRESHWATER AND MARINE RESOURCES OF SOUTHEAST ASIA

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ABSTRACT.The freshwater and marine resources in Southeast Asia, with emphasis on those in the Philippines, are described. Strategies for sustainable use, some of them already tested to be effective in the Philippines, are discussed. In general, these strategies aim to conserve biodiversity, to maintain the integrity of the environment, to protect fishery stocks, to involve fishing communities in the management, and to use environmentally friendly technologies for enhancing fishery production.

INTRODUCTION

Southeast Asia is one of the world's centers of biodiversity. In this area are tropical rainforests and coral reefs, two major tropical ecosystems with the highest species diversity (Wilson, 1988; Ray, 1988). A major challenge to science in the twenty-first century is how to conserve this biodiversity and to make it work for the benefit of humankind.

This paper discusses the living aquatic resources in Southeast Asia, with particular reference to those in the ASEAN countries, and the activities and strategies of utilizing them at sustainable levels.

Oceanographic and Ecological Features of Southeast Asia

The land and the surrounding marine waters of Southeast Asia and the prevailing currents are shown in Figures 1, 2 and 3. The bodies of marine water bounded by the Pacific Ocean and the Indian Ocean, including the Andaman Sea, Timor Sea, and Arafura Sea, are considered as a distinct unit, the Southeast Asian Seas, covering an area of 8.94 million square kilometers, and containing nearly all types of oceanographic and geologic features, such as continental shelves, continental slopes, deep sea basins, troughs, trenches, and volcanic and coral islands (Soegiarto, 1985). So distinct is the Southeast Asian Seas that the United Nations Environment Program has developed the East Asian Seas Action Plan to deal with environmental problems in the region (Snidvongs, 1985).

The marine ecosystems or marine habitats in these waters are the estuaries, mangroves, seagrass beds, coral reefs, soft-bottom areas, and open water. One consequence of this diversification of habitats in the Southeast Asian Seas region is the high species richness. For example, Briggs (1974) described as a fertile triangle or area of highest species richness that portion of the Southeast Asian Seas formed by the Philippines, New Guinea, and the Malay Archipelago. In the Philippines alone, there are an estimated more than 2,000 species of fish (Herre, 1953), over 3,200 species of mollucs (Springsteen and Leobrera, 1986), over 400 species of corals in about 70 genera (Nemenzo, 1981), and 971 species of benthic algae in 209 genera (Silva, Meñez and Moe, 1987).

On land are freshwater habitats for aquatic organisms composed of rivers, lakes, marshes, and impoundments. There are extensive freshwater habitats in Thailand, Malaysia, and Indonesia inhabited by many freshwater fishery species. These are exploited for food and for aquarium purposes (Encyclopedia Britannica, 1971). Similarly, in the Philippines, where species richness is lower compared to Thailand, Malaysia, and Indonesia, lakes like Laguna de Bay (area 86,000 ha), rivers such as the Pampanga River (PCARR, 1981), and swamps such as the Liguasan marsh on Mindanao, supply fishery products.

The challenge is to manage the rich and varied aquatic resources of Southeast Asia, in the face of increasing human population pressure, for sustained productivity. In many cases, management requires rehabilitation and protection of the stocks in order to bring them back to their optimum productive levels.

Strategies for Sustainable Use of Living Aquatic Resources

Freshwater Ecosystems. Threats to the water quality of freshwater habitats must be minimized, if not removed, if these habitats are to work for humankind. These threats are pollution and flooding (Alcala, 1991). Sedimentation (a form of pollution) and flooding are generally caused by forest denudation in the uplands, although excessive sedimentation is sometimes the result of mining activities. Other sources of pollutants are waste effluents from agriculture, industries, and aquaculture (Alcala, 1991; Primavera, in press). It is obvious that the solution to this problem includes reafforestation of denuded area and programs in flood control and pollution control.

A bonus of massive reafforestation is the restoration of the normal water flow in rivers which in the past harbored many species of prawns and food fish (e.g. gobies and mullets; see Herre, 1927 and Roxas, 1934) and other animals yielding other products (e.g., crocodiles; see Alcala and Dy-Liacco, 1989). Dried up river systems could be rehabilitated to become productive again.

Another threat to the freshwater resources is over- exploitation, often with the use of destructive fishing methods. Rivers have been dynamited or poisoned with chemicals. Lakes are generally used for fishfarming, and it is not unusual to find overcrowding of water space by fish cages. Laguna de Bay in Luzon is a classic example (PCARR, 1981; SEGREAH UNDP/ADB, 1974). In this lake, species richness and fish yields have been reduced as a result of overexploitation and deterioration of water quality. Another example in the Philippines is Lake Lanao, which had lost most of its dozen species in eight genera of endemic cyprinid fishes (Herre 1924) before scientists were able to study them. Still another Philippine example is Lake Buhi in the Bicol region, home of the *sinarapan* (gobies), which are disappearing (see publications of Philippine Council for Aquatic and Marine Research and Development, Los Baños [PCAMRD]).

Aside from protection, research activities are very much needed. One research area is the study of culture ranching or aquarium potential of endemic fish species. Another is the genetic improvement of introduced species currently being used in aquaculture. Something is being done in determining potentials by research bodies such as PCAMRD, but more effort is needed. With regard to the genetics problem, the International Center for Living Aquatic Resources Management (ICLARM), the University of the Philippines-Marine Science Institute (UP-MSI), and the Central Luzon State University are involved in the genetic improvement of farmed tilapias (Pullin *et al.*, 1991).

Many species of finfish and shellfish in the freshwater habitats of Southeast Asia can be managed and protected to benefit human populations in the region.

Shallow-Water Marine Ecosystems. These productive ecosystems comprise estuaries, mangroves, seagrass beds, coral reefs, soft-bottom areas (in part), and open water (in part). Most marine production readily available to the larger mass of the human population occurs in shallow waters. Resources in these waters bear the brunt of human exploitation and pollution with the consequent depletion of fishery stocks and degradation of the environment (Yap and Gomez, 1985). In the case of mangroves, these have been logged for fuelwood and/or converted into fishponds (Fortes, 1988, Ruhabhorn and Phantumvanit, 1988). In recent years several management strategies have been implemented to address environmental problems.

Protective Management. One of these management strategies is protective management. Reserves, sanctuaries, and marine parks have been set up all over Southeast Asia. Thus, portions of coral reefs, or even whole reef areas have been temporarily or permanently closed to fishing (Johannes, 1978; Ruddle and Johannes, 1985). Coral reefs have also been used for multiple purposes (Kenchington, 1988). The concept of marine fishery reserves (MFRs), as applied to coral reefs, is gaining

acceptance as a viable option for sustainable coral reef fisheries (Plan Development Team, 1990). MFRs are reef areas permanently closed to human exploitation. They provide protection from fishing mortality to portions of reef fish populations which serve as spawning stock to ensure recruitment supply to the entire reef system as well as reefs elsewhere. The effectiveness of an MFR in the maintenance of species richness, abundance, and community structure within the reserve and of high fish yields outside of the reserve has been demonstrated by experiments in the central Visayas, Philippines. In brief, protective management through an MFR resulted in higher species richness, higher abundance, and higher fish yields on Sumilon Island (Russ, 1985; Alcala, 1988; Russ and Alcala, 1989; Alcala and Russ, 1990). Fish yields during the period of protection were higher than those during the period with no protection. There was obviously an export of fishes from the MFR to the fished area.

MFRs located throughout the Southeast Asian Seas region could be sources of fish larvae for coral reefs situated downstream of prevailing currents (Roberts and Polunin, unpubl.). This may be true of Palawan Island fisheries which could be replenished by fish larvae from the Tubbataha National Marine Park moving westward with the prevailing currents in the Sulu Sea (Figures 2 and 3).

Protection of mangrove ecosystems appears successful in some countries of Southeast Asia, such as Malaysia and Brunei (pers. comm.) but is being beset by problems in such countries as the Philippines, where mangroves are protected only on paper but not in reality. From our experience, there are probably only a few small mangrove patches that have been afforded some degree of protection in the country.

The seagrass beds are still neglected, despite the heroic efforts of seagrass workers like Fortes (1988, 1990). As far as the author knows, there are no protected seagrass beds in the country.

Similarly, no soft-bottom areas are strictly protected. However, occasional closure of certain bays to trawlers automatically protects the soft-bottom benthos. The important role of soft-bottom benthos in the overall productivity of shallow-water ecosystems has been reviewed by Alongi (1989).

The fishery production of shallow water environments is one cogent reason for protecting them. Coral reefs, for example, produce in excess of 30 tons of fish per square kilometer per year (Alcala, 1988; Alcala and Russ, 1990; Alcala and Gomez, 1985). Mangroves through their leaf litter have an important role in fisheries by supplying 13-47% of the carbon requirement of demersal food chains (Robertson *et al.*, 1988).

In Malaysia, Jothy (1984) estimated that 40% of fish landings are associated with mangroves. Many fish species are found in mangroves (Robertson and Duke, 1987). The currently accepted idea is that mangroves are nursery areas for fish. Seagrass beds have also been found to harbor a number of fish species, and also serve as fishery nursery sites. Fortes (1990) summarized the information from Southeast Asia. They may also export organic matter; this idea is being looked at by researchers such as Fortes (1991) and Oñate-Pacalioga and Estacion (1991).

Estuaries are generally productive areas, serving as fish nursery areas, but bear the brunt of pollution, especially sediment from upstream areas, chemicals from industries, and domestic wastes. The estuarine portions of Manila Bay are examples of polluted waters. Elsewhere in the country, mouths of rivers to which mine tailings find their way are additional examples. There are no protected estuaries in this country. Protection would appear to be one of the urgent needs of shallow- water marine ecosystems.

Protection should be extended to small island ecosystems that are as yet almost pristine. In Malaysia, small thickly forested islands, such as Pulau Tioman and Pulau Redang, have been converted into recreational or resort islands. It is important to maintain the balance between development and conservation to assure the survival of both marine and terrestrial components of these island ecosystems.

Rehabilitation Schemes. The other strategy to make our coastal ecosystems work for humankind is to rehabilitate degraded environments to allow the restoration of the original associated biota. Mangrove reafforestation, coral transplantation, and artificial reef establishment are examples of these schemes. In the Philippines, the Department of Environment and Natural Resources (DENR) has embarked on a national reafforestation program. In coastal areas, one result of this activity is to increase the amount of organic matter which will serve as base of food chains for organisms. This would increase the species diversity of these ecosystems and make available sources of proteins to the dependent human populations. Long before the DENR program of reafforestation, some island communities in the Visayas, Philippines had already started planting mangrove trees for use in building construction and to attract fishery species (pers. obs.). Other Southeast Asian countries, such as Malaysia, Indonesia, and Brunei, probably do not need to replant mangrove trees, as they still have large areas of primary mangrove swamps.

Coral transplantation has been shown to be feasible, and some species of economic importance (e.g., blue coral) have been observed to grow well. Gomez (1991) has summarized the work in this area at the UP-MSI. The purpose of coral transplantation is to rehabilitate denuded bottom areas to attract reef-associated organisms, including fish. In view of the widespread destruction of coral reefs throughout South-

east Asia and their importance as source of valuable products for man and as recreation areas for local populations and tourists, coral transplantation is one way of ensuring their usefulnesss to humankind.

The establishment of artificial reefs has been recommended with some precautions as a management tool for artisanal fishery and as a means of habitat enhancement (Polovina, 1991; Chou, 1991; Vande Vusse, 1991). Our experience with the first artificial reef in the Philippines (Alcala, 1979) has shown that it can indeed yield a reasonable biomass of fish with a relatively small economic effort. There is currently a widespread interest in artificial reefs in Southeast Asia (White *et al.*, 1990).

At the experimental stage is transplantation procedure for seagrasses to hasten the consolidation of loose bottom substratum. In the Philippines, the UP-MSI, Diliman, has been transplanting certain species of seagrass off Marinduque Island (pers. obs.).

Sea Ranching and Seafarming Schemes. Seagrass beds and coral reef areas may be utilized for sea ranching and seafarming activities. Normally, seagrass beds abound in several species of sea urchins and sea cucumbers, some of which are used for food. In addition, seagrass beds have turned out to be reasonably good sites for ranching giant clams and possibly abalone (Alcala, 1990).

Both seagrass beds and coral reefs can be used to farm the red alga *Eucheuma*, provided the floating method is used to prevent trampling on the corals (pers. obs.).

Fish farming with the use of floating cages over seagrass beds and coral reefs is being practiced in some parts of the country (pers. obs.). A simple technology of fish ranching on seagrass beds which are covered and uncovered daily by tides is practiced by residents of one small island off northern Negros, Philippines. The technology consists of piling dead coral rocks over an excavated seabed to form rock mounds which are colonized by fishes. Harvesting occurs at low tide.

Alternatives to Destructive Fishing and Overfishing. Over 300 species of fish, mostly from coral reefs, are highly desired for use in home aquaria abroad. Unfortunately, most of these fishes are caught with dip nets after exposure to poisonous cyanide chemicals underwater (pers. comm.). The result is that the fishes do not live long. But the more lasting effect is on the corals which die as a result of exposure to the chemicals, precluding sustainable harvests in the future. To address this problem, the HARIBON Foundation, an environmental non-governmental organization, has conducted community-based programs to persuade cyanide fishermen to use barrier

nets instead of poisonous chemicals. The program also educates the fishermen on the ecological importance of coral reefs and the need for environmental protection.

A study of the demersal (bottom) fishery resources of Manila Bay has shown that the resources have suffered from massive biological and economic overfishing (Silvestre *et al.*, 1987). These authors suggest as a solution the reduction in the number of fishing boats and the increase of the mesh size of nets from 2 cm to at least 5-6 cm. Pauly (1989) maintains that Philippine fisheries in general are already overexploited.

Community Participation. It has become clear that fisherfolk participation in the management of shallow-water marine resources is necessary. Management requires the cooperation and active participation of user communities. Fisherfolk organizations are often the key to successful protective management in relation to the strategies discussed earlier. This is amply demonstrated by the experience in the central Visayas (Savina and White, 1986; Abregana and Alcala, 1991). However, management of off-shore resources, such as atolls in the Sulu Sea, would require a strong enforcement component backed up by patrol craft.

Sustained Use for Recreation. Coral reefs are the most attractive ecosystems to tourists because of their natural beauty and also because coral reefs are new to them. An increasing number of tourists visiting Southeast Asia are expected to snorkel or scuba dive in coral reefs. This development is expected to bring substantial income into the country. However, many travel agencies and resort hotels serving tourists do not have educational or environmental programs to protect fragile corals from damage, accidental or intentional, in the course of diving operations. Or if they do, some of them are indifferent to their implementation (e.g., use of spearguns by their diving customers). It is obvious that those involved in the tourist trade should help protect the coral reef resources on which their business depends in the long-term.

Sea Tenure Issues. With increasing mariculture activity of fisherfolk in coastal ecosystems, questions on their sea rights have been raised. Cordell (1989, p. 5) defines sea tenure as referring to "...any system of informal, relatively closed, communal, shared, joint, collective, or even private property in fishing. Whether tenure is legal or illicit, more or less overt or covert, more or less secure, spoken or unspoken, these customs usually carry a special weight or legitimacy that can only be imposed from within, by a group on its members." Governments should address the issues of sea tenure before conflicts arising from the use of nearshore marine resources erupt and threaten the peace and harmony prevailing in fisherfolk communities.

Oceanic Fishery Resources

To this group belong the fishery resources at the sea bottom and in the water column of marine waters more than 200 m deep. Included here are the resources in the Exclusive Economic Zone (EEZ). The fishery species are pelagic, highly mobile fishes like tuna, tuna-like fishes, and squids. Marine mammals (dugong, porpoises, and whales), though not part of fishery resources, are mentioned here only because of the urgent need to protect most of them (Dolar 1992, in press).

Some Southeast Asian fishery authorities believe that the tuna fishery resources in the EEZ are under-exploited (Anonymous, 1987; Aprieto, 1990). However, Dalzell and Corpus (1990) presented evidence of biological overfishing of small pelagics, some of which are caught in nearshore waters. The *payao*, which is a fish-attracting device widely used in the Southeast Asian Seas, appears to be one of the reasons for this overfishing because it facilitates the capture of juveniles. At any rate, more research is indicated to settle the issue for the large tuna species being exploited in southern Philippines, for example.

The EEZ tuna resources are believed able to withstand more exploitation, but to exploit these resources modern fishing and oceanographic vessels are required. If this assessment is correct, the Philippines, which lags behind Indonesia and Malaysia in studies and exploitation of its EEZ resources, should be prepared to invest heavily in equipment in order to catch up with its ASEAN neighbors.

The bottom fisheries are not well known, and there is a need for more exploration of deep waters. One deep water species that is probably already extinct because of overexploitation is the chambered nautilus in Tañon Strait, between Negros and Cebu Islands, Philippines (pers. obs.). The author observed shark fishing by long line in the Sulu Sea at depths of 1,000- 2,000 m some years ago, but this activity is apparently seasonal.

Summary

The strategies and most of the activities suggested in this paper are ongoing. What are needed for the twenty-first century are the intensification of these activities and in some cases the institutionalization of the strategies. We can expect to continue to harness our shallow-water marine resources only if we simultaneously institute protective management and rehabilitation of these resources. There is a need to develop simple environmentally friendly technologies that will increase nearshore production. There is also a need for fisherfolk communities to participate in the management and protection of these resources. To make use of our deep sea ma-

rine resources in the EEZ, the Philippines has to invest in seaworthy oceanographic and fishing vessels.

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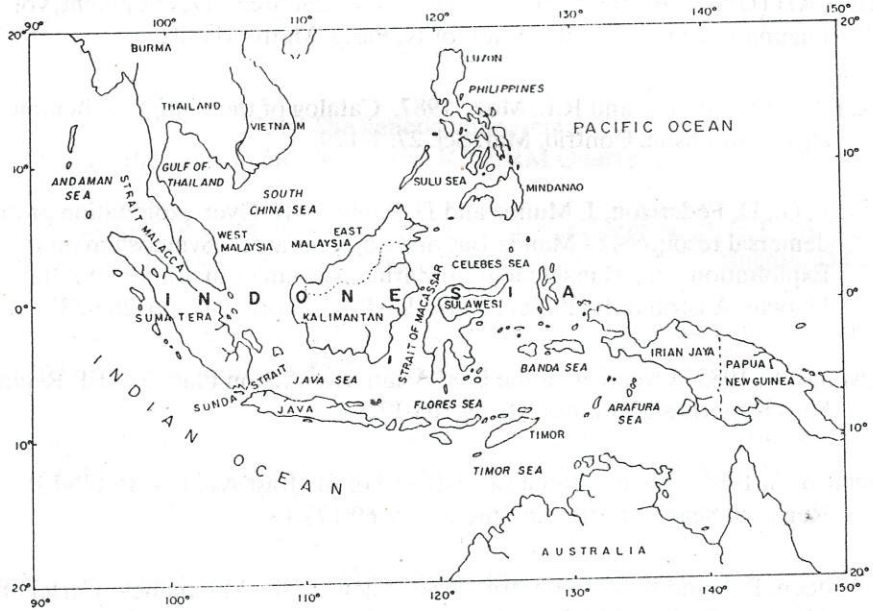

Figure 1. Map of the South-East Asean Seas. Taken from: Soegiarto, A. 1985. Oceanographic assessment of the East Asian seas. In: UNEP: Environment and Resources in the Pacific. UNEP Regional Seas Report and Studies No. 69. UNEP 2985. pp. 173-184.

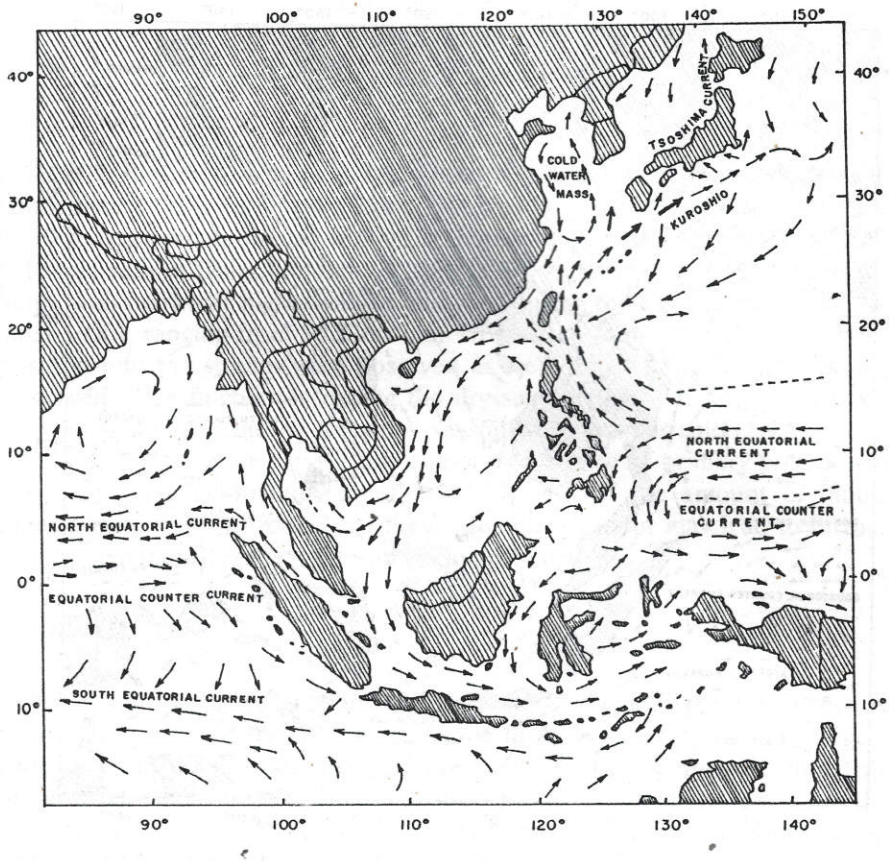

Figure 2. Surface current patterns of South-East Asian waters during the northeast monsoon (December-May).

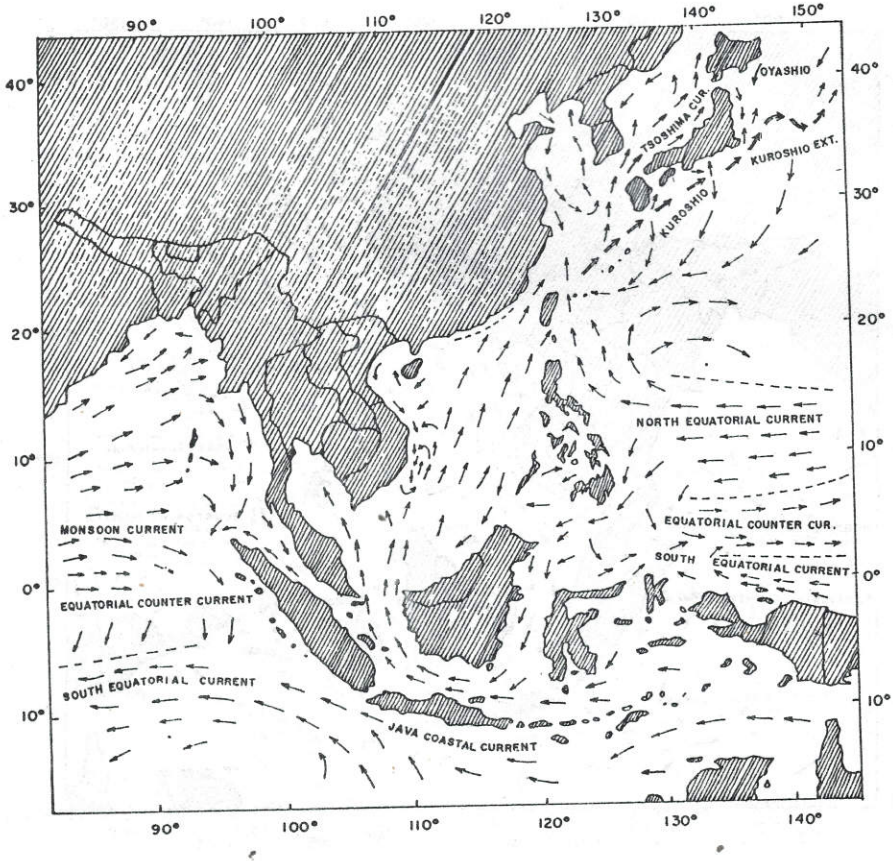

Figure 3. Surface current patterns of South-East Asian waters during the southeast monsoon (June-November).

SEASONALITY OF STREAM DISCHARGE AND LEAF LITTER DEPOSITION IN KAMALABOGONAN CREEK, CANDUGAY, SIATON, NEGROS ORIENTAL

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ABSTRACT. Stream discharge and leaf litter deposition data were collected for Kamalabogonan Creek, Candugay, Siaton, Negros Oriental, for January to December 1990. Discharge varied directly with monthly rainfall. Low values were recorded during the dry season (from January to May 1990), ranging from 0.09 m^3/min to 1.94 m^3/min, with markedly higher values observed during the rainy season (June to December 1990), ranging from 10.52 m^3/min to 41.10 m^3/min. Differences in leaf litter deposition into the stream were observed as well; deposition was generally higher and showed more fluctuation during the dry season (0.42 - 13.04 g dry weight/m^2) while values obtained during the rainy season were less variable (1.95 - 8.81 g dry weight/m^2). As leaf litter deposition represents a source of primary productivity for this stream via allochthanous input, quantification of the amount of input, the amount exported downstream, and the seasonality of input may lead to further understanding of the role of leaf litter in stream productivity.

INTRODUCTION

It is unfortunate that many of the rivers throughout the Philippines suffer from some degree of disturbance, even while their own biology remains largely unknown and unstudied. Research efforts have historically focused primarily on freshwater fisheries and lake biology (Juliano, 1975; Anonymous, 1975, 1981), with little or no mention made of stream or river systems. Locally, preliminary efforts have been made toward understanding the ecology of the major rivers of southern Negros Oriental (Luchavez, 1983; Alcala and Luchavez, 1982; Alcala and Alcala, 1987), but data were, for the most part, unpublished and sampling was limited. Cabanban and Luchavez (1982) studied the yield of the food plant 'kangkong' (*Ipomea aquatica* Forsskäl) in Ocoy River and Heideman, and Erickson (1987) completed a fairly extensive study of the Lake Balinsasayao watershed.

The objective of this study was to attempt to quantify the seasonal fluctuations in leaf litter deposition into a small, undisturbed stream. The importance of leaf litter to primary production of stream systems is particularly relevant considering the escalated rate of deforestation and forest conversion plaguing Philippine forests today. It has long been proven that deforestation upsets the hydrologic regime and

biota of a watershed (Dunne and Leopold, 1978; Merilainen, *et al.*, 1982), but little is known about its effects on stream productivity. Quantified data of this kind may be useful in formulating management policies for sensitive stream areas.

Study Area

Kamalabogonan Creek, Candugay, Siaton, is a small, undisturbed second-order stream, arising in the foothills of southern Negros Oriental (Fig. 1). It flows in a southwesterly direction through protected pastureland before joining the Canaway River north of the town of Siaton.

The stream is not subjected to chemical pollution, and biological pollution is minimal. Vegetation along the stream bank is thick and continuous (Fig. 2). Although the leased property is not heavily forested and largely covered with pasture grass, the ravine through which the creek flows has young secondary tree growth along the length of the stream. These trees were planted by the lessee over the last 40 years with narra (*Pterocarpus indicus* Willd.), teak, *Gmelina*, 'dalakit' (*Ficus balete* Merr.), 'kapok' (*Ceiba pentandra* (L) Gaertn.), mango (*Mangifera indica* L.), and bamboo (*Bambusa* sp). The tallest trees appear to be approximately eight to ten meters in height, and the width of this forest cover extends several meters on either side of the stream, depending on the width of the ravine. Understory growth has been allowed to develop naturally. A stream section approximately three kilometers long, in the center of the property, was chosen as the study area, due to its accessiblility and lack of disturbance.

Southern Negros is well-known for its marked dry season, due to the rain-shadow effect of the mountain range of Cuernos de Negros. This phenomenon has had a marked effect on the living conditions and agricultural practices of the inhabitants of this area mainly because of the seasonality of the water supply.

MATERIALS AND METHODS

Sampling was carried out monthly from January to December 1990. Five sampling stations were established along the stream, starting at the top of the major waterfall, to three kilometers upstream (Fig. 1). Stations were approximately equidistant from each other within this distance. During the first day of each field trip, at each station, stream width and depth were measured using a meter stick. Velocity was measured in the middle of the channel by timing how fast a square piece of rubber traveled one meter. Rubber was used because it does not absorb water and will not sink. This was done three times, and the mean value was calculated.

To determine leaf litter deposition, five pieces of 1m x 1m nylon fishing net were suspended above ground beneath overhanging trees and shrubs, next to the stream bank at each site. These nets were left in place at each site for 24 hours and retrieved the next day. Leaves caught in the net were considered to have fallen from the trees above, were collected, and brought to the laboratory. To determine how much leaf litter settled into the stream itself, plastic trays were placed in the water at each site, in protected areas away from the major currents where leaves were most likely to settle. These trays were also retrieved 24 hours later and all debris which had settled on the trays were collected and brought to the laboratory. In addition, a fish net with a 0.5-cm mesh size was stretched across the stream downstream of the first sampling site at the waterfall. This was also left in place for 24 hours to catch leaves washed downstream. These leaves represented those that were exported to areas downstream. Collected leaves were placed in aluminum foil trays, oven dried to constant dry weight at 40°C for seven days, then weighed using a triple beam balance.

Discharge was calculated using the following formula (modified from Dunne and Leopold, 1978): Q=WDaU; where W = stream width (in m); D = stream depth (in m); a = bottom friction factor; (0.8 = rock, gravel; 0.9 = mud, hardpan, bedrock) and U = stream velocity (in m/min).

RESULTS AND DISCUSSION

The dry season of southern Negros lasts from January to late April and is characterized by frequent brush fires. Many farmers, including the lessee, practice prescribed burning to control these fires and to stimulate the growth of new pasture grass. Rains begin in May, followed almost immediately by new vegetative growth. Within the duration of the project, two major storms occurred during the rainy season.

Stream parameters are presented in Table 1. Stream discharge demonstrated a marked seasonality, reflecting rainfall patterns characteristic of the Siaton area (Fig. 3). Two monthly trips, in fact, had to be postponed (August and November) because heavy rains and strong winds made the road impassable. Discharge, had it been obtained for these months, might have risen substantially higher than the 41.10m^3/min measurement obtained for July, especially during the few days of active storm weather.

Data on leaf litter deposition and settling rates in the stream appeared to be inversely proportional to discharge data (Table 2). Leaf litter in the stream was highest from February to April, corresponding to the dry season. This was typical of many tropical tree species, which shed their leaves in response to higher temperatures and low rainfall (Larcher, 1983). Deposition lessened somewhat as soon as

rainfall increased and new growth appeared. It must be noted, however, that these figures include leaves exported from upstream areas which settle during periods of lower discharge, not just newly-fallen litter. This is best indicated in both the September and December values, as both these collections were made after major storms, when higher-than-normal turbulence flushed out debris and carried it downstream.

Deposition on the ground did not show any seasonal variation, but remained fairly low throughout the year. This may be due to the difficulty in sampling fallen leaves, many of which may have been blown out of the net before they could be retrieved. The amount of litter trapped in the export net reflects the volume and velocity of stream discharge, as the amount of material carried downstream by moving water is a function of the water velocity.

Because discharge was observed to vary widely throughout the year, it had a marked impact on litter settling and export. During the dry season, parts of the stream above the third sampling site actually dried up, so large sections of the stream became isolated from each other and little downstream export could occur. The dry season, therefore, was the time when leaves were deposited, settled and began to decompose, while the rainy season flushed out a great deal of litter, in various stages of decomposition, and washed it downstream.

Leaf litter represents an important source of allochthonous primary production in this stream. Past research has shown that most stream systems worldwide exhibit detrital food chains, using leaf litter as the basic source of primary organic matter (Cole, 1979). Fisher and Likens (1973) measured allochthonous input into a small second-order temperate stream and found that leaf litter settling into the stream and exported from upstream areas contributed 99% of its energy input. The other 1% was contributed by autochthanous mosses. Qualitative ocular observation in Kamalabogonan Creek showed very little live plant growth. During April and May, a single dense patch of the freshwater tracheophyte, *Hydrilla* was observed, but aside from this, only occasional single plants were found. Filamentous green algae were rarely observed. This indicates that leaf litter input and settling may be the most important source of primary production for this stream and are probably the basis for the food chain.

CONCLUSIONS

Kamalabogonan Creek exhibited a marked seasonality in terms of both stream discharge and leaf litter deposition and export. Discharge was uniformly low during the dry season, and at times even zero, as portions of the stream dried up. Fluctuations and higher measurements were characteristic of the rainy season, serv-

ing to re-oxygenate the water and flush out accumulated debris. Leaf litter deposition into the stream, on the other hand, tended to be higher during the dry season, as many trees shed their leaves in response to lack of rain. Although the data were incomplete due to the nets being torn, there were indications that downstream export appeared to be more a function of the velocity of stream discharge than litter input.

These observations indicate that, on a yearly basis, the months from January to May were marked by low discharge and water mixing, and settling of deposited material. The rains from June to December served to increase discharge, flushing out the stream and washing partly-decomposed material downstream. This suggests that overall stream productivity would tend to fluctuate as well, as nutrient inputs and chemical characteristics of the water change.

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Table 1. Stream parameters for Kamalabogonan Creek, Siaton, January to December, 1990, (n = 5).

Month	Mean Velocity (m/min)	Mean Width (m)	Mean Depth (m)	Mean Discharge (m^3/min)
Jan	4.50 ± 3.90	1.23 ± 0.60	0.14 ± 0.03	0.47
Feb	0.66 ± 0.90	4.91 ± 2.00	0.75 ± 0.45	1.94
Mar	0.20 ± 0.40	4.03 ± 1.70	0.53 ± 0.29	0.36
Apr	0.11 ± 0.20	2.99 ± 0.31	0.32 ± 0.15	0.09
May	0.86 ± 0.60	3.45 ± 0.92	0.24 ± 0.15	0.59
Jun	16.00 ± 5.50	3.98 ± 0.97	0.51 ± 0.04	26.63
Jul	25.00 ± 20.00	4.59 ± 0.65	0.42 ± 0.08	41.10
Aug	--- no data collected ---			
Sep	7.67 ± 2.20	4.08 ± 0.79	0.41 ± 0.05	10.52
Oct	12.36 ± 5.50	4.62 ± 0.69	0.54 ± 0.09	25.87
Nov	--- no data collected ---			
Dec	11.34 ± 6.90	3.42 ± 1.07	0.39 ± 0.08	13.70

Table 2. Leaf litter deposition and downstream export, Kamalabogonan Creek, Siaton, February to December, 1990, (n = 5).

Month	Downstream export (g dry weight)	Deposition on ground (g dry weight/m^2)	Accumulation in stream (g dry weight/m^2)
Feb	30.95	1.41 ± 1.10	16.10 ± 12.40
Mar	12.20	0.47 ± 0.13	13.04 ± 12.88
Apr	23.70	1.19 ± 1.47	12.14 ± 10.59
May	6.50	0.78 ± 0.88	0.41 ± 0.72
Jun	15.87	0.05 ± 0.04	4.30 ± 0.64
Jul	net torn-	1.28 ± 1.49	3.44 ± 0.59
Aug		--- no data collected ---	
Sep	110.70	0.18 ± 0.24	8.81 ± 13.40
Oct	-net torn-	1.25 ± 1.50	1.95 ± 2.19
Nov		--- no data collected ---	
Dec	-net torn-	0.40 ± 0.67	6.76 ± 9.12

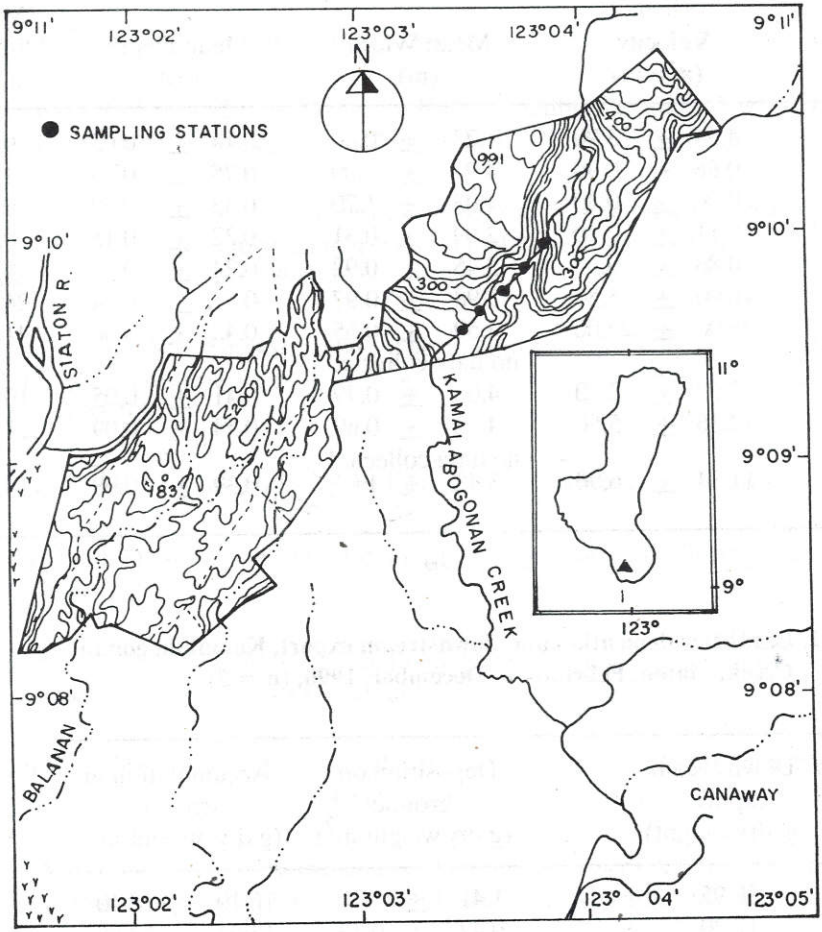

Figure 1. Map showing Kamalabogonan Creek and Canaway River in Candugay, Siaton, Negros Oriental.

Figure 2. Kamalobogonan Creek, Siaton. Photo shows bankful discharge, characteristic conditions during the rainy season, and continuous vegetation along the stream bank.

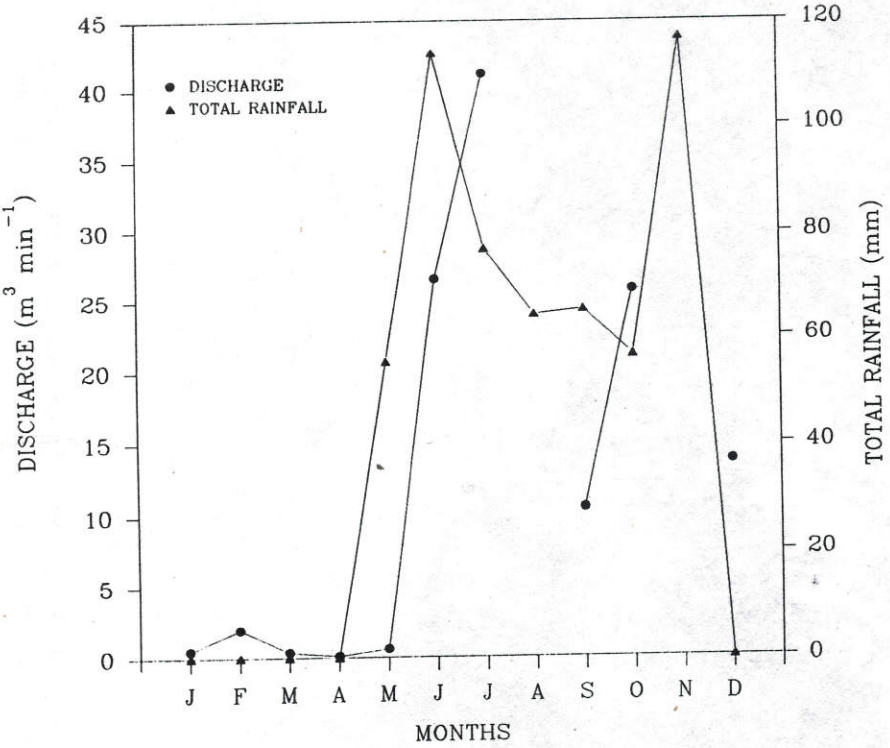

Figure 3. Monthly total rainfall vs. stream discharge, Kamalabogonan Creek, for the period of January to December, 1990.

MT. PINATUBO: A CASE OF MASS EXTINCTION OF PLANT SPECIES IN THE PHILIPPINES

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ABSTRACT. The eruption of Mt. Pinatubo in Zambales in July 1991 caused serious damage to the vegetation of that mountain and its vicinity. It is feared that several of the more than 60 endemic species recorded in this area have succumbed to the intense heat, ash fall, and lava flow that accompanied the eruption. A detailed floristic inventory of the mountain in the near future will give information on what plants survived and recovered.

INTRODUCTION

Until July 1991, Mt. Pinatubo was a tropical paradise covered with a verdant and luxurious primary forest from the lowland, evergreen rainforest on the lower slopes of the mountain to the montane (mossy) type of forest at elevations above 1,000 m. Not only was the biota teeming with plant species but many of these species were endemic. Elmer (1933) gave a sharp picture of the prevailing vegetation during a botanical survey in 1927:

> "Mt. Pinatubo with the other mountain masses, are (*sic*) awe-inspiring, and challenge (*sic*) any mountaineer. All in all it is (*sic*) a fine alpine spot very similar in places to the country about Baguio. But here there are no pine trees nor Benguet lilies....
>
> An easy way for a plant collector is to follow the wooded margins from the meadows or open grasslands. Among this rich marginal vegetation I collected the only "ash" species (*Fraxinus griffithii* Clarke) known from the Philippines, besides a couple of shrubby trees of the "huckle-berry" genus (*Vaccinium benguetense* Vid. and *Vaccinium igorotorum* H.F. Copel.). Several species of wild figs were found, among which one or two were of the strangling kind (*Ficus chrysolepis* Miq. and *Ficus perfulva* Elm.) Along the river which flows by the camping place, half a mile below it, are many interesting plants. Scattered in the shrubby wooded sides were the purplish to pink "mountain-rose" (*Carionia elegans* Naud.), and in the flats, *Saurauia elegans* (Choisy) F. Vill. was very common in the sand gravelly soil, ranging in size from 6 inches to 20 feet high trees (*sic*), all bearing a profusion of flowers; even the small unbranched plants bore flowers. In the elfin woods of the summit region, the pure white panicles of *Ligustrum glabrinerve* Elm. were seen everywhere as plume-like masses. Here also the *Medinilla whitfordii* Merr. was in its floristic splendor. In this chaparral formation, upon exposed ridges, was noticed the small leaved and blood red short tubular flowered *Rhododendron marivelesense* H.F. Copel. Over all the

moss-laden limbs and reclining stems were dense clusters of the golden flowered orchid, *Acoridium curranii* Ames. Another orchid, rare but far more showy and gorgeous in coloration, was *Dendrobium victoriae-reginae* Loher. In its native place, among the somber moss-covered trees and shrubs of wet sheltered ravines, its flowers present a most beautiful and delicate contrast. On the eastern very steep slope below Mt. Pinatubo the whole mountain flank was covered with a pure stand of the large circular-leaved, rank and herbaceous *Halorrhagis micrantha* (Thbg.). Upon raised benches of wide river flats and over which the winds have a free sweep, masses of different kinds of orchids were found, also clumps of sphagnum mosses, and various lot scale-mosses. In the drier stony flats of the river, a brittle ashy lichen densely covered the surface everywhere. *Nepenthes alata* Blco., a pitcher plant, was also growing in this same general region in great masses. In size, this species would vary from a few inches to rambling and finally shrub and tree climbing. The old stems are pliable and about as thick as a man's finger. Only the older plants bear flowers and fruits. The little plants bore thimble-sized pitchers, while those on the mature plants were nearly a foot long. After a rain, these pitchers are full of water, and when collecting in shrubby jungles where they are, the pitchers get tilted and spill their contents upon the collector. No matter how carefully a person tries to walk about in the early mornings among them with dry stockings on one's feet, the younger pitchers lying about on the ground would get turned over and manage here and there to pour their cold water contents upon and over the tops of one's shoes. In the woods of damp fertile soil one walks over *Selaginellas* shoe- or knee-deep. When one penetrates further in, into sheltered ravines and cuts where the sun seldom shines, and that only for a short duration, or in other humid flats, a collector encounters a mass of varied vegetation -- a tree canopy with vines and lianas, high and low shrubs, and different kinds of herbs. In these clammy pockets where one wonders why the ground vegetation never mildews, the observer usually finds plenty of ferns and their allies."

An ethnobotanical study of the Negritoes living on the skirts of Mt. Pinatubo (Fox, 1950) revealed the wealth of plants on this 'holy mountain' and how the indigenous people utilized the plants around them for food, shelter, clothing, medicine, and also social and religious purposes.

As mentioned earlier, in the hinterlands of Mt. Pinatubo may be found several of the most attractive wild orchids in the Philippines. These epiphytic orchids possess large and attractively-colored flowers highly prized in the local and international orchid trade. Merrill (1923-1926) listed 21 species and two varieties of plants endemic to the Zambales mountain range, which includes Mt. Pinatubo. Elmer (1934), on the other hand, described 39 endemic species from Mt. Pinatubo. Using these two sources together, the number of plant species endemic to Mt. Pinatubo or to the Zambales mountain range, including Mt. Pinatubo, totals 61 (Table 1). Indeed, Mt. Pinatubo stands out as one of the centers of endemism for flowering plants in the country. The size and height (1,780 meters above sea level) of the mountain are factors that must have allowed for the development of various types of vegetation from the lowland primary rainforest at the base of the mountain to the montane at the summit. The rugged topography as well as the various soil types and underlying rocks on the mountain slopes also create micro habitats that allow faster

speciation. Table 1 lists the species of plants found on Mt. Pinatubo and adjoining mountains based on Merrill's (1923-1926) and Elmer's (1933, 1943) works. The list is, however, not complete for it is most likely that a number of species still remain undiscovered in the forests.

Prior to its eruption in June 1991, Mt. Pinatubo was one of the richest botanical areas in Luzon, and in the entire country for that matter. Such condition is no longer true. It is feared that the devastation caused by the eruption has caused an irreversible catastrophe to biological diversity of the area. It is very likely that scores of endemic plants and animals inhabiting the mountain were decimated during and after the eruption. This apt to happen since endemic plants are usually delicate organisms that easily succumb even to slight environmental change. It is difficult to imagine how even the most sturdy and resilient plants living on the skirts of the mountain could withstand continuous heavy ash fall, mudflows, and prolonged exposure to extremely hot temperatures. The real damage, however, cannot be ascertained until an intensive botanical survey is made when the volcano has ceased to be active.

The case of Mt. Pinatubo has brought to light the impact of volcanic eruption on the extinction of plant and animal species. It is now clear that onslaught of this natural phenomenon can be as lethal as "kaingin," large-scale illegal logging, and charcoal-making to primary forests in our country. However, unlike illegal logging, "kaingin," and other man-made activities, which could be contained, minimized, or even-stopped through man's will, there is no way that species could be saved from extinction caused by natural phenomenon, here exemplified by the eruption of Mt. Pinatubo.

As a point of comparison, a similar tragedy struck Volcano Island, situated at the center of Taal Lake. In 1911, the volcano violently erupted, completely destroying the vegetation over most part of the island (Brown, Merrill and Yates, 1917; Yates, 1914). But unlike Mt. Pinatubo, where there was still considerable forest cover over most of the mountain, the vegetation of Volcano Island prior to its eruption in 1911 was depauperate and consisted mostly of "a mixture of grass and small trees, which covered all parts of the island except the slopes of the main crater and Mount Tabaro and the dry stream beds" (Brown, Merrill and Yates, 1917).

A study of the revegetation of the island 6 years after its eruption showed that a single species, *Saccharum spontaneum* L., was very prominent in colonizing the barren land. According to Brown, Merrill, and Yates (1917) the revegetation of Volcano Island proceeded very slowly owing, probably, to adverse environmental conditions, the most prominent of which were the presence of excessive amounts of sulphates in the soil, the lack of weathering of the soil particles, the scarcity or ab-

sence of humus, the scarcity of nitrogen, the low water-holding capacity of the soil, and erosion.

About 292 species of plants were found on Volcano Island six years since offer eruption in 1911, and very few of the species, except *Saccharum spontaneum*, had found favorable habitats over any considerable area on the island. The investigators theorized that birds were responsible for bringing various species to Volcano Island," as 54 percent of the total (species) on the island could have been carried to it by this means", (Brown, Merrill, and Yates, 1914). Fifty-six years after the eruption of Taal Volcano, J.V. Pancho (1967) published a floristic account of Volcano Island, showing how diverse the flora on the Volcano Island had become.

From this account of the revegetation of Volcano Island, one could perhaps project these vegetation of Mt. Pinatubo fifty years from now. However, the conditions on Volcano Island are quite different from Mt. Pinatubo: 1) the original vegetation in Volcano Island was a mixture of grass and small trees, while that of Mt. Pinatubo was forest on most of its slopes; 2) apparently there were no endemic species on Volcano Island before its eruption in 1911, while Mt. Pinatubo had many endemic species; 3) Volcano Island is an "isolated land mass," while Mt. Pinatubo has contiguous mountains. Thus, the process of revegetation or the colonizing of pioneer species may be quite different in these two situations.

A detailed ecological and floristic study of Mt. Pinatubo over a given period of time would give important information necessary in understanding the complex processes involved in "bringing back to life" this once tropical paradise.

This tragedy leads us to consider urgent and effective measures to conserve and preserve the remaining diverse species of flora and fauna of our country. The stake in terms of biodiversity is so high that concerted and effective measures must be drawn and immediately implemented to ensure the safety of these endangered biota. There are several options open for consideration. Priority must be focused on highly critical but biologically-rich volcanic mountains such as Mt. Canlaon in Negros, Mt. Irosin in Sorsogon, Mt. Apo in Davao, Mt. Mayon in Albay, Mt. Guiting-guiting on Sibuyan Island, Mt. Kitanglad in Bukidnon, and Mt. Halcon in Mindoro. Some of these mountains, (e.g., Mt. Mayon) have erupted mildly or have shown signs of activity at one time or another; other mountains dormant at present may become active in the future, as these are all of volcanic origin.

As conservation *in-situ*, seems not to be the practical measure here, *ex-situ* conservation through botanic gardens, arboreta, and gene banks should be considered. This is a more practical way of saving endangered plant species found on volcanic mountains since it is difficult to predict when a dormant volcano will sud-

denly become active and bring havoc to human life and to the plants and animals found there. In the case of Mt. Pinatubo a wealth of its rare and endemic plant species may have been saved if these were represented in botanic gardens or arboreta. Unfortunately, many of them must be extinct by now. Who knows if these now-extinct plants may have had the cure for cancer, AIDS, or other deadly diseases, or may have been species that could have been used to improve the quality of food plants and other economic plants. To think too, that these species succumbed so quickly, i.e., in a matter of days or probably weeks, compared to the normal rate of dying out of species, estimated to take thousand of years (Myers, 1983).

Those who cannot fully comprehend the meaning and importance of biodiversity, may not be alarmed at the demise of many rare plant and animal species brought about by Mt. Pinatubo's eruption. This is perhaps the appropriate time to arouse their interest and sentiment The plant species lost on Mt. Pinatubo will not come back to life again. Shall we let other species suffer the same fate?

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Table 1. List of endemic plants in Mt. Pinatubo and nearby mountains in Zambales

Species	Habitat	Source
Family Acanthaceae		
1. ***Hypoestes confertiflora*** Merr.	open places at low altitude	Merrill, 1923-26
Family Anacardiaceae		
2. ***Semecarpus thyrsoidea*** Elm.	wooded depression at 1,219m	Elmer, 1934
Family Annonaceae		
3. ***Artabotrys monogynus*** Merr.	forest at low altitude	Merrill, 1923-26
Family Apocynaceae		
4. ***Parsonsia oblancifolia*** Merr.	thickets and secondary forest at low altitude	Merrill, 1923-26
Family Asclepiadaceae		
5. ***Tylophora hybostemma*** Warb.		
Family Campanulaceae		
6. ***Lobelia nicotianaefolia*** Elm. var. ***mollis*** Elm.	wet ground covered with grasses and low shrubs on thicketed inclines of dense woods at 1,066m altitude	Elmer, 1934
Family Caprifoliaceae		
7. ***Viburnum zambalense*** Elm.	fringe of woods bordering open grasslands at 1,219m elevation	Elmer, 1934
Family Clethraceae		
8. ***Clethra castaneus*** Elm.	in summit shrubberies at nearly 1,828m	Elmer, 1934
Family Commelinaceae		
9. ***Commelina luzonensis*** Elm.	open places in moist ravines of dense wood at 1,066m altitude	Elmer, 1934
Family Elaeocarpaceae		
10. ***Elaeocarpus zambalensis*** Elm.	mixed wood with shrubs in moist depression, 1,219m altitude	Elmer, 1934
Family Euphorbiaceae		
11. ***Gelonium pinatubense*** Elm.	small wooded flat near loghouse 1,219m altitude	Elmer, 1934
12. ***Codiaeum trichocalyx*** Merr.	forest at low altitude	Merrill, 1923-26
13. ***Glochidion longistylum*** C.B. Rob.	forest at low altitude	Merrill, 1923-26
14. ***Phyllanthus cordatulus*** C.B. Rob.	forest at low altitude	Merrill, 1923-26
Family Fagaceae		
15. ***Lithocarpus castellarnauianus*** (Vid.) *A. Camus*= (***Quercus pinatubensis*** Elm.)	heavy or dense woods of moist deep ravine at 1,066m altitude	Elmer, 1934
Family Flacourtiaceae		
16. ***Casearia luteocarpa*** Elm.	humid wooded flats at 1,066m altitude	Elmer, 1934
17. ***Hypericum lackeyi*** Elm.	stony ground of wooded plants near the river or in rock crevices of river beds at 998m above sea level	Elmer, 1934

Table 1. continued

Species	Habitat	Source
Family **Gesneriaceae**		
18. ***Cyrtandra pinatubensis*** Elm.	wet gravelly ground along stream beds of dark, densely wooded gulches at 1,066m altitude	Elmer, 1934
19. ***Cyrtandra quisumbingii*** Elm.	dry humus covered ground of wooded bluffs at 1,219m above sea level	Elmer, 1934
20. ***Cyrtandra quisumbingii*** Elm. var ***minor*** Elm.	narrow ravines or deep cuts of the peak region at 1,828m elevation	Elmer, 1934
Family **Juglandaceae**		
21. ***Engelhardtia permicrophylla*** Elm.	among chaparral formation of the peak region at 1,828m elevation	Elmer, 1934
22. ***Engelhardtia zambalensis*** Elm.	in dense woods mixed with shrubs in dry stony ground of depressions bordering grasslands and along river at 1,219m	Elmer, 1934
Family **Labiatae/Lamiaceae**		
23. ***Pogostemon williamsii*** Elm.	gravelly ground in rock crevices near river at 1,066m elevation	Elmer, 1934
Family **Leguminosae/Fabaceae**		
24. ***Milletia canariifolia*** Merr.	thickets or secondary forest at low altitude	Merrill, 1923-24
25. ***Dalbergia pinatubensis*** Elm.	jungles along dry deep creek cut of open grasslands at 990m	Elmer, 1934
26. ***Derris zambalensis*** Elm.	dense jungles of dry woods or thickets along creek bed at 1,066m elevation	Elmer, 1934
Family **Melastomataceae**		
27. ***Astronia pulchra*** Vid. var. ***obovata*** Merr.	mossy forest on Mt. Tapullo, 1,500m	Merrill, 1923-24
28. ***Astronia zambalensis*** Elm.	densely wooded jungle among grasslands near ridge of the mountain chain 1,219m elevation	Elmer, 1934
29. ***Medinilla negrito*** Elm.	very densely and deeply wooded, wet stony soil along streamlet with series of small waterfalls at 1,219m	Elmer, 1934
30. ***Melastoma pinatubense*** Elm.	scrub thickets near summit of the mountain at 1,752m elevation	Elmer, 1934
Family **Meliaceae**		
31. ***Aphanamixis pinatubensis*** Elm.	damp woods among other shrubs and low trees at 1,219m altitude	Elmer, 1934
Family **Moraceae**		
32. ***Ficus zambalenses*** Elm.	in damp dense woods at 1,143m	Elmer, 1934
Family **Myrsinaceae**		
33. ***Ardisia zambalensis*** Merr.	exposed ridges altitude 1,000-1,400m	Merrill, 1923-24

Table 1. continued

Species	Habitat	Source
Family **Myrtaceae**		
34. ***Syzygium squamiferum*** (C.B. Rob.) Merr.	forest, altitude about 700m	Merrill, 1923-26
35. ***Syzygium subfalcatum*** (C.B. Rob.) Merr.	slopes along streams at low medium altitude	Merrill, 1923-26
Family **Oleaceae**		
36. ***Ligustrum glabrinervae*** Elm.	alpine chaparral formation of the summit region at 1,828m altitude	Elmer, 1934
Family **Orchidaceae**		
37. ***Bulbophyllum zambalense*** Ames	collected at 1,700 m altitude	
38. ***Dendrochilum foxworthyi*** Ames	Mt. Pinatubo, altitude 1,800m	Merrill, 1923-26
39. ***Phaius ramosii*** Ames	exact location in Zambales unknown.	
40. ***Renanthera monachica*** Ames	open grassland at about 100m altitude	
41. ***Tuberalabium sarchochiloides*** (Schltr.) Garay	exact location in Zambales unknown.	
42. ***Vanda boxalii*** Reichb. f.	in Mt. Pinatubo and other parts of Zambales mountain range.	Merrill, 1923-26
Family **Palmae/Arecaceae**		
43. ***Calamus dimorphacanthus*** Becc. var. ***zambalensis*** Becc.	mossy forest on exposed ridge, altitude 2,000m	Merrill, 1923-26
Family **Rosaceae**		
44. ***Rubus zambalensis*** Elm.	mossy forest on Mt. Tapulao, 2,000m	Elmer, 1934
Family **Rubiaceae**		
45. ***Neonauclea monocephala*** Merr.	in forest at low altitude	Merrill, 1923-26
46. ***Lasianthus zambalensis*** Elm.	among scrub vegetation upon a ledge of stream at 1,219m	Elmer, 1934
47. ***Mussaenda pinatubensis*** Elm.	hot and dry river embankments at 1,066m altitude more or less	Elmer, 1934
48. ***Ophiorrhiza bicolor*** Elm.	wet humus covered ground along shaded stream beds	Elmer, 1934
49. ***Ophiorrhiza zambalensis*** Elm.	wet humus covered ground along shaded stream bed at 1,219m above sea level	Elmer, 1934
50. ***Rubia philippinensis*** Elm.	thickets of moist ledges along river at 1,066m elevation	Elmer, 1934
51. ***Williamsia viridescens*** Elm.	in deeply cut densely wooded ravine and upon steep wooded ledges at 1,066m	Elmer, 1934
Family **Rutaceae**		
52. ***Evodia zambalensis*** Elm.	wooded fringes along the meadows at 1,219m elevation	Elmer, 1934

Table 1. continued

Species	Habitat	Source
Family **Staphyleaceae**		
53. ***Turpinia sambucifolia***	in light woods of open grass regions along horse trail at about 914m altitude	Elmer, 1934
Family **Scrophulariaceae**		
54. ***Staurogyne neesii*** (Vid.) C.B. Clarke ex Merr.	along streams at low altitude	Merrill, 1923-26
Family **Symplocaceae**		
55. ***Symplocos purpurascens*** Brand.	ridge forest, altitude about 1,300m	Merrill, 1923-26
Family **Ulmaceae**		
56. ***Trema philippinensis*** Elm.	dry and warm creek banks of open places at 1,219m altitude	Elmer, 1934
Family **Urticaceae**		
57. ***Elatostema brunneolum*** Elm.	wet humus covered stream banks of densely shaded woods at 1143m elevation, more or less	Elmer, 1934
58. ***Pipturus subalpinus*** Elm.	very wet and densely wooded ravines at 1,066m elevations	Elmer, 1934
Family **Verbenaceae**		
59. ***Callicarpa magna*** Elm. var. ***lilacena*** Elm.	in dense very damp wooded flat at about 1,219m elevation	Elmer, 1934
60. ***Clerodendrum philippinense*** Elm.	humid woods at 914m above sea level	Elmer, 1934
Family **Zingiberaceae**		
61. ***Alpinia pinatubensis*** Elm.	locality undetermined	

VEGETATION OF THE TALABONG MANGROVE FOREST RESERVE : SUGGESTIONS FOR REHABILITATION

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ABSTRACT. A total of 13 species of mangroves occur in the 200-ha Talabong Forest Reserve. Of these, only *Rhizophora* spp. occur in substantial stands, the rest consist of just a couple of trees. Immediate multispecies reforestation is critical in the maintenance of diversity in this forest. Establishing the area as a botanical garden may be the only effective long-term management option.

INTRODUCTION

The Talabong Mangrove Forest located in South Bais Bay, Negros Island, Philippines (Fig. 1) covers an area of about 200 ha. The presence of birds, mammals, amphibians, and reptiles (Alcala, pers. comm.), as well as edible fish, molluscs, crustaceans, and echinoderms (Alcala, 1979; Alcala and Alcazar, 1984), and the pressure of local population placed on them prompted its establishment as a wildlife sanctuary in 1985.

Studies by de Leon (1992) quantified the productivity of the forest and its contribution to the overall productivity of the Bay. The figures show that the contribution for just two species of mangroves, *Rhizophora apiculata* Blume and *R. mucronata* Lamk. is substantial. If the forest were decimated, the productivity in terms of loss of organic fertilizer and, subsequently, its effect on fisheries may also be substantial.

This paper gives an inventory of the species and number of mangrove trees in Talabong and outlines a program of rehabilitation of the Forest in particular and the entire Bay in general.

List of Species

Family: RHIZOPHORACEAE

Brugiera gymnorhiza (L.) Lamk.: flowering and fruiting in July, 1989; one tree on landward side (Fig. 2A)

B. sexangula (Lour) Poir: fruiting, no flowers in July, 1989; many on landward side

Ceriops decandra (Roxb..) Ding Hou: fruiting in July, 1989; many on landward side (Fig. 2B)

Rhizophora apiculata Blume: forming a fringe around the forest

Rhizophora mucronata Lamk.: growing with *R. apiculata*

Rhizophora stylosa Griff.: smaller trees that look like *R. mucronata*; growing in the intertidal

Family: COMBRETACEAE

Lumnitzera racemosa Willd.: flowering and fruiting in July, 1989; many in landward side

Family: VERBENACEAE

Avincennia marina (Forssk.) Vierh.: many landward; fruiting in July 1989

Avicennia alba Blume: many on landward side; flowering and fruiting in July 1989

Family: MYRTACEAE

Osbornia octodonta F. Mueller: flowering in July, 1989; many on landward side, especially near the intertidal

Family: MYRSINACEAE

Aegiceras corniculatum (L.) Blanco: fruiting in July, 1989; rare in landward side (Fig. 2C)

Family: ACANTHACEAE

Acanthus ilicifolius L.: flowering; many on landward side

Family: LYTHRACEAE

Pemphis acidula J.R. et G. Frost: flowering and fruiting; on landward side

Family: SONNERATIACEAE

Sonneratia alba Smith: flowering in July, 1989; many in intertidal zone (Fig. 2D)

Two species of flowering plants, *Scypophora hydrophyllaceae* Gaerta f. (Family: Rubiaceae) and *Pongamia pinnata* (L.) Pierre (Family: Fabaceae) are also present on the landward side, flowering and fruiting in July, 1989, the former rare, the latter abundant. Recent plantations of *Moringa pterygosperma* Gaertn. (=*M. oleifera* Lamk., "malunggay") and *Leucaena leucocephala* (Lam.) de Wit. ("ipil-ipil") by local inhabitants for vegetable, and fodder respectively, were observed.

Multispecies Reforestation

The central guiding principle in the rehabilitation of Talabong is multispecies reforestation. This is to preserve the biointegrity of the area by maintaining its diversity. The scheme is to recognize that the forest itself is topographically diverse and different species of mangroves have different affinities to different susbstrates and environmental conditions. Naturally-occurring mangrove forests have distinct zonation patterns, with some species preferring the landward side. Monospecific reforestation threatens the diversity of ecosystems, inviting uncontrollable explosion of pests.

Extension and Education

The other plan is to make a nature trail through the forest so that children and adults alike can become acquainted with the trees as well as the organisms that dwell in and on them. In short, this is could provide a botanical garden for learning. Other benefits from such a scheme are the preservation and propagation of endangered species and the generation of income both to the city government and local inhabitants from tourism.

ACKNOWLEDGEMENTS

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Figure 1. Acrial view of Talabong Mangrove Forest.

Figure 2. Some of the rarer species in Talabong Mangrove Forest. A. *Brugiera gymnorhiza*, B. *Ceriops decandra*, C. *Aegiceras corniculatum*, and D. flowers of *Sonneratia alba*.

DIVERSITY AND CONSERVATION OF PHILIPPINE LAND VERTEBRATES: AN ANNOTATED BIBLIOGRAPHY

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ABSTRACT. Summaries of 111 important publications on the diversity and conservation of Philippine land vertebrates are presented as an aid to research and management.

INTRODUCTION

As we enter the final decade of the second millennium A.D., scientists, the lay public, and government leaders have clearly recognized that the Philippine environment is approaching a critical juncture. The action that we take in the next few years will make a huge difference not just in the number of species and habitats that can be saved, but in the prosperity of the human population of the archipelago.

Once a heavily forested country where freshwater, wildlife, and fertile land were abundant, the Philippines now suffers from widespread erosion, increasing frequency of floods and droughts, and permanent (and growing) loss of biological diversity. All of these problems are associated with the loss of forests and the consequent loss of watershed protection (Myers, 1988; Portet and Ganapin, 1988). A "now-or-never" situation is rapidly approaching: either the last remnants of the native environments of the Philippines will disappear, leaving behind a nation blighted by massive, irreversible damage, or thoughtful, rapid action will avert the worst of the environmental degradation, preserving an environment that simultaneously supports humankind and protects a portion of the natural heritage of the Philippines.

Recent events in the Philippines provide good reason to hope this latter, nurturing course will be followed. Conservation organizations are flourishing in the Philippines; the national government has initiated programs that meaningfully address watershed protection while promoting rural development, and a review and

rejuvenation of the national park system has begun. International conservation and development organizations have become actively involved in all these activities. Immediate work on many fronts, including management and research, will make crucial, long-lasting differences to the Philippine environment. However, both management and further research must be carefully planned and executed; to do so requires the best information available.

The precarious state of the wildlife of the Philippines, especially the more conspicuous, aesthetically attractive land vertebrates, has attracted special attention. The number of studies that have dealt broadly with conservation of these species--documenting patterns of diversity and endemism, determining ecology and habitat needs free-living of populations, determining the conservation status of species and habitats, and developing captive breeding programs for critically endangered species--is gradually increasing. Although much remains to be learned, and large gaps exist in our knowledge of conservation in the Philippines, a great deal of useful information is already in print.

Ready access to this information is often inhibited because it is scattered in hard-to-obtain literature, making it inaccessible to many researchers and decision-makers. As a means of facilitating access to literature pertinent to conservation in the Philippines, a compilation list of 111 publications on the diversity and conservation of Philippine land vertebrates considered to be critically important references are included, and brief summaries of each paper prepared. These will not substitute for the publications themselves, but is hoped that this compilation will substantially ease the job of identifying useful references and tracking them down.

Choosing which publications to include has been difficult, but space limitations have made it essential to exclude some references. Recent papers and those of broad importance are emphasized, but some early studies that have been particularly important in the historical development of Philippine vertebrate biology are deliberately pointed out. Similarly, it has been difficult to determine what aspects of each publication to emphasize, and in the end as much information as could be provided in the fewest words possible is given. Undoubtedly some critical references are missed, and the compilers beg the forgiveness of the authors and the readers for these oversights. Suggestions of references to include in updates of the bibliography will be welcomed.

Alcala, A. C. 1962. Breeding behavior and early development of frogs of Negros, Philippine Islands. Copeia, 4:679-726. Life histories of 11 Philippine frogs were studied in relation to their ecology, evolution, and phylogeny. Delineated the genus *Platymantis* from the other genera of the family Ranidae based on the former's direct mode of development, without passing through the aquatic larval stage, thus demonstrating the taxonomic importance of the modes of reproduction among the Philippine anurans.

Alcala, A. C. 1976. Philippine Land Vertebrates. New Day Publishers, Quezon City. 167 pp. Summarizes the habitats, zoogeography, life history, population structure and dynamics, and behavior of terrestrial Philippine mammals, birds, lizards, snakes, turtles, and amphibians. Reviews the conservation status and discusses the threats to the survival of Philippine land vertebrates. Suggests research areas that would provide basis for the conservation of Philippine land vertebrates.

Alcala, A. C. 1986. Guide to Philippine Flora and Fauna. Vol. X. Amphibians and Reptiles. Natural Resources Management Center and University of the Philippines, Quezon City. 213 pp. An illustrated guide to 66 species of amphibians (including 42 endemic species) and 205 species of turtles, lizards, and snakes (127 endemic). Includes notes on habitats, distribution, and ecological status.

Alcala, A. C. and W. C. Brown. 1982. Reproductive biology of some species of *Philautus* (Rhacophoridae) and other anurans. *Kalikasan*, Philippine Journal of Biology, 11:203-226. Discusses the life histories of ranid and rhacophorid anurans in the Philippines. Presents complete data on the life history of *Philautus lissobrachius* which confirms Inger's prediction of direct development among the species of this genus.

Alcala, A. C., C. A. Ross and E. L. Alcala. 1988. Observations on reproduction and behavior of captive Philippine crocodiles (*Crocodylus mindorensis* Schmid). Silliman Journal, 34:18-28. A report on captive breeding of the endangered Philippine freshwater crocodile at Silliman University from 1982-1984. Describes the courtship, mating, and nesting behavior of captive crocodiles. Reproductive activity occurs from January to August; incubation requires 77-85 days.

Alcasid, G. L. 1970. Checklist of Philippine Mammals. Philippine National Museum, Manila. 51 pp. A detailed synopsis of the taxonomy and distribution of 221 species and subspecies of mammals then known from the Philippines.

Auffenberg, W. 1988. Gray's Monitor Lizard. University of Florida Press, Gainesville. 419 pp. A detailed study of the ecology and biology of *Varanus olivaceus*(= *V. grayi*) in the Bicol Peninsula, Philippines. The species occurs mostly in lowland dipterocarp forests below 650 meters, on top or along forested ridges of karst or limestone hills. Courtship occurs from June to September and eggs are laid from middle of June to early November. Most females lay one clutch of 5 to 8 eggs and incubation may take months to one year. Gray's monitor is partially herbivorous: 46 food types were recorded (27 animals and 19 plants), with mollusks (11 species) most commonly eaten. Pili nut (*Canarium* sp.) is the most common plant eaten. The species is threatened by the loss of forest habitat.

Auffenberg, W. and T. Auffenberg. 1988. Resource partitioning in a community of Philippine skinks (Sauria: Scincidae). Bulletin of the Florida State Museum, Biological Sciences 32:151-219. Suggests that species diversity of Philippine skinks is positively correlated with vegetation density. Stomach analysis of 11 species of sympatric skinks yielded no evidence of food niche partitioning except for those that live in specialized habitats. Seasonal prey switching and presence of abdominal fat were linked to seasonal insect prey abundance.

Auffenberg, W. and T. Auffenberg. 1989. Reproductive patterns in sympatric Philippine skinks (Sauria: Scincidae). Bulletin of the Florida State Museum, Biological Sciences 34:202-247. Reproductive activity in 11 sympatric species was generally lowest during the dry months preceeding each of the monsoon periods and highest after the first (June and July) and second (September through December) monsoons. The number of eggs laid by oviparous species typically exceeds the number of offspring born by viviparous species.

Barbehenn, K., J. P. Sumangil and J. L. Libay. 1973. Rodents of the Philippine croplands. Philippine Agriculturalist 56:217- 242. Reviews the taxonomy, geographical distribution, habitat preferences, and economic importance of commensal murid rodents in the Philippines. Four species--*Rattus rattus mindanensis*, *R. argentiventer*, *R. exulans*, and *R. norvegicus*--are considered major pest species. Concludes that forest destruction threatens some rare forest-dwelling species and increases colonization by pest species.

Brown, W. C. and A. C. Alcala. 1961. Populations of amphibians in the submontane and montane forests of Cuernos de Negros, Philippine Islands. Ecology 42: 628-636. Records 14 species of amphibians, 27 species of lizards, and 26 species of snakes associated with different forest zones. Fifty- one species were primarily forest-dwelling forms, of which 20 were associated with submontane and montane zones and 20 species were found below the submontane zone. Most of the submontane and montane forest species were considered rare.

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Brown, W. C. and A. C. Alcala. 1978. Philippine Lizards of The Family Gekkonidae. Monograph Series 1. Silliman University, Dumaguete City. 146 pp. A revision of 10 genera and 33 species of Philippine gekkonid lizards of which two genera and 23 species are endemic, including three species which are new to science. Includes descriptions of species, diagnostic keys, and notes on ecology, distribution, and reproduction. Suggests that the Philippine species are primarily Oriental or Oriental-Australian in origin.

Brown, W. C. and A. C. Alcala. 1980. Philippine Lizards of the Family Scincidae. Monograph Series, Silliman University, Dumaguete City. No. 2, 264 pp. First revision of Philippine skinks since 1922. Recognizes 10 genera and 64 species of Philippine scincid lizards, of which 53 are endemic species and seven species are new to science. Includes descriptions of species, keys to genera and species, and notes on ecology, distribution, and reproduction. Documents similar biogeographical patterns as in gekkonid lizards.

Brown, W. C. and A. C. Alcala. 1982. A new cave *Platymantis* (Amphibia: Ranidae) from the Philippine Islands. Proceedings of the Biological Society of Washington 95:386-391. Describes a new frog, *Platymantis spelaeus*, that is endemic to caves in forested regions of southern Negros Island, and summarizes the distribution of the genus in the Philippines.

Brown, W. C. and A. C. Alcala. 1982. Modes of reproduction of Philippine anurans. pp. 416-428. In: A. G. J. Rhodin, and K. Miyata (eds.), Advances in Herpetology and Evolutionary Biology, Essays in Honor of Ernest E. Williams. Museum of Comparative Zoology. Cambridge, Massachusetts. 725 pp. Discusses the diversity of reproductive modes of Philippine anurans and proposes 18 specific modes within two primary categories: with aquatic larval stage and without aquatic larval stage (direct development). Documents modes of reproduction of 28 anuran species in the Philippines and concludes that there is no or little intrageneric diversity of reproductive modes among these species. Also concludes that families with greater numbers of species exhibit greater diversity in modes of reproduction.

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Fooden, J. 1991. Systematic review of Philippine macaques (Primates, Cercopithecidae: *Macaca fascicularis* subspp.). Fieldiana: Zoology 64:1-44. Recognizes two subspecies of macaques in the Philippines, *Macaca fascicularis fascicularis* and *M. f. philippinensis*, based on comparative morphology, blood proteins, and natural history. Suggests two waves of dispersal into the Philippines by ancestral macaques from Borneo: dispersal by the ancestor of *M. f. philippinensis* during the penultimate glacial maximum via Balabac-Palawan route and dispersal by the ancestor of *M. f. fascicularis* during the most recent glacial maximum via Sulu route.

Gonzales, P. C. 1983. Birds of Catanduanes. Zoological Papers, National Museum, Manila, No. 2, pp. 1-125. Describes 138 species of birds collected on Catanduanes Island with notes on distribution and ecology of each species. The composition of the avifauna supports the view that Catanduanes was connected to Luzon during the late Pleistocene.

Gonzales, P. C. and C. P. Rees. 1988. Birds of the Philippines. Haribon Foundation for the Conservation of Natural Resources, Inc., Manila. 184 pp. A guide featuring 133 species of Philippine birds grouped according to associated ecosystems. Includes notes on distribution and habits, a list of selected places accessible for birdwatching in the Philippines, and an updated checklist of Philippine birds.

Gonzales, R. B. 1968. A study of the breeding biology and ecology of the monkey-eating eagle. Silliman Journal 15:461-491. The first published documentation of the nesting biology of the Philippine Eagle. Reports that eagles feed mainly on monkeys and flying lemurs and a single egg is incubated for 60 days. Estimated the total population of eagles as 36 individuals.

Goodman, S. M. and P. G. Gonzales. 1990. The birds of Mt. Isarog National Park, southern Luzon, with particular reference to altitudinal distribution. Fieldiana: Zoology 60:1-39. Species accounts of 116 resident and 19 migratory species of birds recorded on Mt. Isarog with notes on taxonomy and ecology of many species. Comparison of the avifauna of Mt. Isarog with that of three other mountains in the Philippines shows that species richness decreases with elevation on all the mountains. Results of the 1988 survey indicate that at least 42% of the birds in lowland forest recorded by Rabor in 1961 are now locally extirpated. Recommends measures for protecting the remaining undisturbed forest on Mt. Isarog.

Groves, C. P. 1969. Systematics of the anoa (Mammalia, Bovidae). Beaufortia 17:1-12. A discussion of systematics of the genus *Anoa*, with reference to nomenclature and taxonomic history. Assigns the tamarao (*Bubalus mindorensis*) to the genus and subgenus *Bubalus*, rather than to *Anoa*.

Grubb, P. and C. P. Groves. 1983. Notes on the taxonomy of the deer (Mammalia, Cervidae) of the Philippines. Zoologischer Anzeiger 210:119-144. Recognizes *Cervus alfredi* (Visayan spotted deer) and *C. mariannus* (Philippine brown deer) as valid species, and the Calamian deer as a subspecies of the hog deer (*C. porcinus calamianensis*).

Hatchisuka, M. 1931-35. The Birds of the Philippine Islands. H. F. Witherby, London. 908 pp. A two-volume monograph on Philippine birds with an early description of the country and its people. Notes on the mammal fauna are also included.

Hauge, P., J. Terborgh, B. Winter and J. Parkinson. 1986. Conservation priorities in the Philippine archipelago. Forktail 2:83-91. Analyzes the distributions of terrestrial mammals, birds, reptiles, and amphibians in the Philippines. They conclude that all groups show strongly similar distribution patterns, and that a wildlife reserve system designed for one group will protect the others as well. Mindanao, Luzon, and Palawan together support 86% of the vertebrate fauna and 72% of the single-island endemics, and therefore deserve conservation priority, although some smaller islands deserve attention because they hold significant numbers of endemic species which may be especially vulnerable to extinction.

Heaney, L. R. 1985. Zoogeographic evidence for Middle and Late Pleistocene land bridges to the Philippine Islands. Modern Quaternary Research in Southeast Asia 9:127-144. Geologic evidence and mammal zoogeographic data show that, during the Pleistocene, Palawan was connected to Borneo but not to the rest of the Philippines, that the other islands remained isolated from the Asian continent, and that the present islands of the Philippines were united into larger islands.

Heaney, L. R. 1986. Biogeography of the mammals of Southeast Asia: estimates of colonization, extinction, and speciation. Biological Journal of the Linnean Society 28:127-165. Identifies four major island categories in Southeast Asia based on Pleistocene land-bridge connections. Characterizes six faunal regions in the Philippines by their mammalian faunas and concludes that majority of the non-volant mammals of the Philippines originated from the Sunda Shelf. Suggests that speciation within the Philippines has contributed between 50% and 70% of its non-volant mammal species. Also suggests that murid rodents are the most successful colonizers and the carnivores are the least successful.

Heaney, L. R. 1991. An analysis of patterns of distribution and species richness among Philippine fruit bats (Pteropodidae). Bulletin of the American Museum of Natural History 206:145-167. Indicates four patterns of distribution for 23 species of Philippine fruit bats including 14 endemics : Southeast Asian, Sundaic, Philippine endemic, and single-island endemic. Shows that species richness is positively correlated

with island area; several of the endemic species are members of a single phylogenetic clade that has undergone substantial diversification within the Philippines. Concludes that fruit bats in the Philippines exhibit similar biogeographic patterns observed among non-volant mammals but notes that fruit bats have higher rates of colonization and lower rates of extinction and local speciation than non-volant mammals.

Heaney, L. R., P. C. Gonzales and A. C. Alcala. 1987. An annotated checklist of the taxonomic and conservation status of land mammals in the Philippines. Silliman Journal 34:32-66. A summary of the distribution, taxonomy, and conservation status of each of the 165 species of terrestrial mammals found in the Philippines.

Heaney, L. R. P. C. Gonzales, R. C. B. Utzurrum and E. A. Rickart. 1991. The mammals of Catanduanes Island: implications for the biogeography of small land-bridge islands in the Philippines. Proceedings of the Biological Society of Washington 104:399-415. Lists 35 species of mammals. No endemic species are present, all but one are known from Luzon, and the fauna is smaller than that of Luzon; all of these are general patterns among mammal faunas on small islands once connected to larger islands. Birds on Catanduanes show similar patterns.

Heaney, L. R. and P. D. Heideman. 1987. Philippine fruit bats, endangered and extinct. Bats 5:3-5. Concludes that Chapman's bare-backed fruit bat (*Dobsonia chapmani*) is extinct, *Acerodon lucifer* may be extinct, *Acerodon jubatus* and *Pteropus vampyrus* are declining, and the Negros tube- nosed bat (*Nyctimene rabori*) is seriously threatened.

Heaney, L. R., P. D. Heideman, E. A. Rickart, R. B. Utzurrum and J. S. H. Klompen. 1989. Elevational zonation of mammals in the central Philippines. Journal of Tropical Ecology 5:259-280. On both Leyte and Negros, diversity of small non-volant mammals increases with increasing elevation, but fruit bat diversity declines with elevation. Murid rodents found at higher elevations on Leyte are members of old endemic Philippine clades, while those found at lower elevations are members of recently arrived groups. Recommends preserving large tracts of primary forest along complete elevational gradients for conservation of wildlife.

Heaney, L. R. and E. A. Rickart. 1990. Correlations of clades and clines: geographic, elevational, and phylogenetic distribution patterns among Philippine mammals. pp. 321-332. In: G. Peters and R. Hutterer (eds.), Vertebrates in the Tropics. Museum Alexander Koenig, Bonn. 424 pp. A summary of ongoing research on mammalian biogeography and evolution in the Philippines with a discussion of patterns of distribution and endemism, elevational changes in species richness, and phylogeny of pteropodid bats and murid rodents.

Heaney, L. R. and R. C. B. Utzurrum. 1991. A review of the conservation status of Philippine land mammals. Association of Philippine Systematic Biologists Communications. In press. Thirty-two species of endangered Philippines mammals are listed in categories according to conservation status with a brief, current summary of their biology and ecology.

Heideman, P. D. and L. R. Heaney. 1989. Population biology and estimates of abundance of fruit bats (Pteropodidae) in Philippine submontane rainforest. Journal of Zoology (London) 218:565-586. Discusses community composition, local heterogeneity, movement distances, longevity, population size, and density of pteropodid bats on Negros Island based on mark and recapture studies. Suggests that small pteropodids may live for up to ten years and may occur at densities of up to ten bats per hectare. Estimated densities from mark-and-recapture studies are highly correlated with rank-order abundances in netted samples of 100 bats, which means that samples of 100 captures may be used to accurately estimate fruit bat communities.

Heideman, P. D., L. R. Heaney, R. L. Thomas and K. R. Erickson. 1987. Patterns of faunal diversity and species abundance of non- volant mammals on Negros Island, Philippines. Journal of Mammalogy 68:884-888. Documents habitat associations of small mammals on Negros Island, and shows that assessment of relative abundance of small mammals based on bones in the scats of predators is very similar to that based on trapping.

Hoogstraal, H. 1951. Philippine Zoological Expedition, 1946-1947. Narrative and itinerary. Fieldiana: Zoology 33:1-86. A detailed itinerary of the single largest vertebrate inventory project in the Philippines; collecting took place on Luzon, Mindanao, and Palawan. Includes valuable descriptions of the vegetation and habitats of many current national park sites, including Mt. Data, Mt. Apo, and southern Palawan.

Inger, R. F. 1954. Systematics and zoogeography of Philippine Amphibia. Fieldiana, Zoology 33:181-531. A comprehensive systematic and zoogeographic treatment of Philippine amphibians. Traces dispersal to the Philippines from Borneo via Palawan and Sulu-Mindanao, and from New Guinea via Papua-Moluccas-Talaud. Sets a tentative order of amphibian invasions in the Philippines with the relict species *Barbourula busuangensis* as the oldest invader, followed by non-relict endemics in early but subsequent invasions, and finally by the non-endemics as the most recent arrivals. Concludes that Palawan has an amphibian fauna distinct from the rest of the Philippines, but similar to that of Borneo.

Jones, G. S. and D. B. Jones. 1976. A Bibliography of the Land Mammals of Southeast Asia, 1699-1969. Bishop Museum Special Publications. 238 pp. A compilation of 5213 individual titles on anatomy, behavior, ecology, paleontology, parasitology, physiology, systematics, and zoonoses of mammals in Southeast Asia published between 1699 and 1969.

Kennedy, R. S. 1977. Notes on the biology and population status of the monkey-eating eagle of the Philippines. Wilson Bulletin 89:1-20. Describes the hunting behavior of Philippine Eagles and their dipterocarp forest habitat. Estimates the home range of a pair to be 12 to 100 km^2. Estimates the population size of Philippine Eagles in 1970 - 1973 at 200 - 400 birds.

Kennedy, R. S. 1981. Saving the Philippine Eagle. National Geographic 159:846-856. An account of the efforts to study and document the life history of the Philippine Eagle. Reports that eagles feed mainly on flying lemurs, breed once every two years, and fledge the young after five months.

Kennedy, R. S., E. C. Dickinson and M. D. Bruce. 1985. Bibliography of Philippine ornithology. Nemouria 29:1-86. A listing of 1152 references dealing with the biology, distribution, and taxonomy of Philippine birds, particularly endemic species.

Koopman, K. F. 1989. Distributional patterns of Indo-Malayan bats (Mammalia: Chiroptera). American Museum Novitates 2942:1-19. An enumeration of the bat faunas of the Indochinese and Malayan subregions and their outliers, including the Philippines. Analysis of the distributional patterns shows that oceanic islands such as the Philippines and Sulawesi are depauperate in bat faunas but have much higher degrees of endemism than continental islands.

Kornfield, I. and K. E. Carpenter. 1984. Cyprinids of Lake Lanao, Philippines: taxonomic validity, evolutionary rates and speciation scenarios. pp. 69-84. In: A. A. Echelle and I. Kornfield (eds.), Evolution of fish species flocks. Orono Press: University of Maine. A discussion of the systematics and zoogeography of the endemic fresh-water cyprinids of Lake Lanao based on comparative electrophoresis. Concludes that the endemic Lake Lanao cyprinid complex descended from an extant common ancestor, *Puntius binotatus*, and is therefore monophyletic. Suggests that the ancestral cyprinid colonized Mindanao via the Sulu land-bridge before the Pleistocene.

Kuehn, D. W. 1986. Population and social characteristics of the Tamarao (*Bubalus mindorensis*). Biotropica 18:263-266. Gives an estimate of at least 51 tamaraos in a 20 km^2 study area in Mt. Iglit Game Refuge and Wildlife Sanctuary, Mindoro. Comparisons of social behavior of tamaraos and water buffalos suggests that adult tamaraos are less sociable than water buffalos and that this could be an adaptation of the tamaraos to forest habitat.

Leviton, A. E. 1963. Remarks on the zoogeography of Philippine terrestrial snakes. Proceedings of the California Academy of Sciences 31:369-416. Records 87 species and subspecies of terrestrial snakes in the Philippines, including 34 endemic and 32 non-endemic species. Considers the Philippine terrestrial snakes to be of Indo-Malayan affinities and excluded Celebes, the Papuan region, and Taiwan as sources of Philippine snakes. Suggests that the Philippines can be divided faunistically into five districts based on the zoogeography of its terrestrial snakes.

Lewis, R. E. 1986. A rain-forest raptor in danger. Oryx 20:170- 175. Presents an overview of the current status of the endangered Philippine Eagle and its habitat. Concludes that the eagle's population in Mindanao has been severely reduced due to forest habitat fragmentation and that the Sierra Madre mountains in Luzon could be the last stronghold for the species.

Lewis, R. E. 1988. Mt. Apo and other national parks in the Philippines. Oryx 20:170-175. A description of the present conservation status of Mount Apo and the persistent threats to its ecological integrity.

McGregor, R.C. 1907. Notes on birds collected in Cebu. Philippine Journal of Science 2:298-309. Provides a taxonomic listing with behavioral notes on 114 bird species collected out of 149 species that were known to occur on Cebu. Provides notes on extirpated forms such as the Red-vent Cockatoo (*Cacatua haematuropygia*), Cebu Hanging Parakeet (*Loriculus*) sp. and the now extinct flowerpecker, *Dicaeum quadricolor* (=*Prionichilus*).

McGregor, R. C. 1920. Some features of the Philippine *Ornis* with notes on the vegetation in relation to the avifauna. Philippine Journal of Science 16:361-438. An extensive analysis of the distribution of 469 species of endemic birds in the Philippines based on Worcester's grouping of islands. Discusses the distribution of birds relative to forest type and concludes that large islands with large areas of intact lowland forests and high elevations tend to have more species of birds than smaller islands, low-lying islands, or islands with little remaining forest.

Mendoza, M. M. 1987. Updated list of Mt. Makiling avifauna. Philippine Journal of Science 116:31-46. Species accounts of 132 species of birds recorded on Mt. Makiling and vicinity.

Morioka, H. and R. V. Sison. 1987. Birds of the highlands of Mt. Halcon, Mindoro, Philippines. Japanese Journal of Ornithology 35:109-124. Species accounts of the highland avifauna collected and observed on Mt. Halcon, Mindoro. Suggests that the highland avifauna of Mt. Halcon is poor in species, that it is more similar to that of northern Luzon than to that of Palawan, and that the absence of endemics in the highlands is caused by a higher rate of extinction than in the lowlands, where many endemics are found.

Musser, G. G. 1977. *Epimys benguetensis*, a composite, and one zoogeographic view of the rat and mouse faunas in the Philippines and Celebes. American Museum Novitates 2636:1-14. Lists the many taxonomic synonyms of the commensal murid rodents of the genera *Mus* and *Rattus*. In the Philippines and Indonesian Archipelago east of Wallace's Line, endemic murid rodents are restricted to primary forest habitats, and in both places a common assemblage of commensal murid rodents is associated with man-made habitats.

Musser, G. G. 1979. Results of the Archbold Expeditions. No. 105. Notes on the systematics of Indo-Malayan murid rodents, and descriptions of new genera and species from Ceylon, Sulawesi, and the Philippines. Bulletin of the American Museum of Natural History 168:225-334. Separates murid rodent groups previously referred to *Rattus* into four genera. Diagnoses, descriptions, and comparisons are provided. A new genus and species of murid rodent, *Anonymomys mindorensis*, is described from Mindoro.

Musser, G. G. 1982. Results of the Archbold Expeditions. No. 108. The definition of *Apomys*, a native rat of the Philippine Islands. American Museum Novitates 2746:1-43. Provides diagnosis of forest mice of the genus *Apomys*, the most speciose murid in the Philippines, and differentiates it from *Rattus* based on comparative morphology. Separates eight species of *Apomys* into two groups: *Apomys datae* and *Apomys abrae-hylocetes* groups.

Musser, G. G. 1982. Results of the Archbold Expeditions. No. 110. *Crunomys* and the small-bodied shrew-rats native to the Philippine Islands and Sulawesi (Celebes). Bulletin of the American Museum of Natural History 174:1-95. Describes two new species of murid rodents from the Philippines, *Crunomys rabori* from Leyte Island and *Archboldomys luzonensis* from Mt. Isarog, southeastern Luzon. Compares Philippine and Celebes murid rodents and finds no close phylogenetic relationships.

Musser, G. G. and L. K. Gordon. 1981. A new species of *Crateromys* (Muridae) from the Philippines. Journal of Mammalogy 62:513-525. Describes a new species of cloud rat, *Crateromys paulus,* from Ilin Island, Mindoro, and suggests that *C. paulus* is closely related to *C. schadenbergi*; several of the diagnostic characters of *C. paulus* appear primitive relative to *C. schadenbergi.*

Musser, G. G. and P. W. Freeman. 1981. A new species of *Rhynchomys* (Muridae) from the Philippines. Journal of Mammalogy 62:154-159. Describes *Rhynchomys isarogensis*, from Mt. Isarog, southeastern Luzon, with a discussion of its distribution and origins. Suggests that during the Pleistocene, the montane forest *Rhynchomys* habitat might have been more extensive or even continuous between the Central Cordillera and Mt. Isarog.

Musser, G. G. and L. R. Heaney. 1985. Philippine *Rattus*: a new species from the Sulu Archipelago. American Museum Novitates 2818:1-32. Describes *Rattus tawitawiensis* from Tawi-tawi Island. Morphological characteristics of *R. tawitawiensis* indicate that it is most similar to *Rattus tiomanicus* in the Maratua Archipelago on the Sunda Shelf. However, analysis of the zoogeography of mammals in the Sulu Archipelago suggests that Sulu had no recent land bridge connections with either Borneo or Mindanao.

Musser, G. G. L. R. Heaney and D. S. Rabor. 1985. Philippine rats: description of a new species of *Crateromys* from Dinagat Island. American Museum Novitates 2821:1-25. Describes *Crateromys australis* from Dinagat Island. Concludes that *C. australis* is more primitive than *C. schadenbergi* and *C. paulus* based on morphological characteristics.

Myers, N. 1988. Environmental degradation and some economic consequences in the Philippines. Environmental Conservation 15:205-213. Discusses the implications on the Philippine economy of deforestation, soil erosion, disruption of hydrological systems, over-exploitation of fisheries, destruction of coral reefs, extinction of species, and high human population density. Points out that national development is largely dependent upon the natural resources of the Philippines and that environmental degradation could lead to major adverse economic consequences.

Ota, H. and R. I. Crombie. 1989. A new lizard of the genus *Lepidodactylus* (Reptilia: Gekkonidae) from Batan Island, Philippines. Proceedings of the Biological Society of Washington, 102:559-567. Describes a new gekko, *Lepidodactylus balioburius*, that is endemic to Batan Island; its closest relative occurs on a small island adjacent to Taiwan. Summarizes the distribution of the genus in the Philippines.

Parkes, K. C. 1973. Annotated list of the birds of Leyte Island, Philippines. Nemouria 11:1-73. A list of the 180 species of birds known from Leyte with notes on behavior, breeding habitat, and taxonomy. Traces the history of ornithology of Leyte and briefly discusses the zoogeographic affinity of Leyte with Samar and Bohol.

Peters, J. L. 1939. Collections from the Philippine Islands: Birds. Bulletin of the Museum of Comparative Zoology 86:74-128. Species accounts of 179 species of birds collected on Basilan, Cebu, Luzon, Mactan Island, Marinduque, Mindanao, Mindoro, and Palawan.

Porter, G., and D. J. Ganapin, Jr. 1988. Resources, population, and the Philippines' future: a case study. World Resources Institute, Washington, D.C., Paper No. 4, pp. 1-68. An excellent treatise on the complex inter-connections among the many environmental problems and the economic prospects of an ever-increasing human population in the Philippines.

Quinnel, R. and A. Balmford. 1988. A future for Palawan's forest? Oryx 22:30-35. Discusses the present environmental status of Palawan and the impact of commercial logging, kaingin, mining, and hunting on wildlife and its habitat.

Rabor, D. S. 1955. Notes on mammals and birds of the central northern Luzon highlands, Philippines. Pt. 1. Notes on mammals. Silliman Journal 2:193-218. Discusses behavior, geographic variation, and habitats of mammals and birds on Mt. Data, Mt. Kapilingan, and Abra highlands in northern Luzon observed during the 1946-1947 Philippine Zoological Expedition.

Rabor, D. S. 1959. The impact of deforestation on birds of Cebu, Philippines, with new records for that island. Auk 76: 37-43. Documents the disappearance of nine of 10 endemic birds of Cebu, the first record of avian extinction in the Philippines due to extensive logging. Records six resident and four migrant species of birds new to Cebu.

Rabor, D. S. 1966. Conservation in the Philippines. Silliman Journal 13:594-604. An expression of concern over the destruction of natural resources in the Philippines. Traces the causes of conservation problems to poor implementation of laws, rampant logging, misguided policies of government, and others. Proposes effective implementation of existing laws and extensive conservation education as the primary solutions.

Rabor, D. S. 1966. A report on the zoological expeditions in the Philippines for the period 1961-1966. Silliman Journal 13:604- 616. Summarizes ten expeditions to various islands, including dates, membership of the research teams, objectives, sponsors, data gathered, museums where specimens were deposited, and publications that resulted.

Rabor, D. S. 1977. Notes on the ecology of the Sulu Archipelago. Pterocarpus 3:33-41. Notes on the geographical, floral, and faunal features of the Sulu Archipelago and some recommendation for the conservation of its natural resources.

Rabor, D. S. 1977. Philippine birds and mammals. University of the Philippines Press, Quezon City. 284 pp. A non-technical guide featuring description and illustrations of 102 bird species and 33 terrestrial mammals. Measurements and notes on habits, food, and distribution of these species are included.

Rabor, D. S. 1986. Guide to Philippine Flora and Fauna. Vol. XI. Birds and Mammals. Natural Resources Management Center and University of the Philippines, Quezon City. 213 pp. A illustrated guide to 70 species of passerine birds and 75 species of mammals. Sixty-one of the bird species and 58 of the mammals featured are Philippine endemics. Notes on biology, distribution, economic importance, and ecological status are given.

Rabor, D. S., A. C. Alcala and R. B. Gonzales. 1970. A list of the land vertebrates of Negros Island, Philippines. Silliman Journal 17:297-316. An update of the 1958 land vertebrate faunal list of Negros Island; brings species totals to 16 amphibians, 1 turtle, 1 crocodile, 33 lizards, 30 snakes, 268 birds, and 39 mammals.

Rand, A. L. 1951. Birds of Negros Island. Fieldiana: Zoology 31:571-596. Discusses 29 species of birds from Negros Island. Includes a thoughtful discussion of geographic variation and a strong argument against the indiscriminant naming of subspecies.

Rand, A. L. and D. S. Rabor. 1960. Birds of the Philippine Islands: Siquijor, Mt. Malindang, Bohol, and Samar. Fieldiana, Zoology 35:222-411. Species lists, with notes on habits, of birds recorded on Siquijor, Bohol, Samar, and Mt. Malindang. Suggests that the depauperate fauna of Siquijor is due to its small size and that the avian colonization of Siquijor is affected more by prevailing winds than by its distance from neighboring islands. Shows that Bohol and Samar have very similar avifaunas.

Rickart, E. A. and L. R. Heaney. 1991. A new species of *Chrotomys* (Muridae) from Luzon Island, Philippines. Proceedings of the Biological Society of Washington 104:387-398. Describes *Chrotomys gonzalesi* from Mt. Isarog, southeastern Luzon and distinguishes it from *C. mindorensis*, *C. whiteheadi*, and *Celaenomys*; stomach contents, morphological features, and trapping data indicate that *C. gonzalesi* feeds primarily on annelid worms, is active both day and night, and is semifossorial. Concludes that the distribution of *Chrotomys* supports vicariant speciation patterns observed between murid rodent faunas of northern and southern Luzon, and comments on Mt. Isarog as a center of endemism.

Rickart, E. A., L. R. Heaney and R. B. Utzurrum. 1991. Distribution and ecology of small mammals along an elevational transect in southeastern Luzon, Philippines. Journal of Mammalogy 72:458-469. A discussion of the ecology, distribution, and feeding habits of one species of shrew and seven species of murid rodents on Mt. Isarog. Results indicate four trophic patterns: omnivory in three species, insectivory in two species, vermivory in two species and granivory-frugivory in one species. Observed pattern of increased species richness, abundance, and endemism with increasing elevation support previous predictions for small mammals in the Philippines.

Ripley, S. D. and D. S. Rabor. 1961. The avifauna of Mount Katanglad. Postilla 50:1-20. A summary of the 1960 expedition, which obtained 41 species, bringing the total for the mountain to 97. Two species (*Serinus mindanensis* and *Erythrura coloria*) and two subspecies are described as new.

Ross, C. A. and A. C. Alcala. 1983. Distribution and status of Philippine crocodile (*Crocodylus mindorensis*). *Kalikasan*, Philippine Journal of Biology 12: 169-173. Describes the former range of *Crocodylus mindorensis:* Camarines, Manila Bay, Laguna de Bay of Luzon, Mindoro, Masbate, Samar, Negros, Mindanao including Zamboanga, and Jolo. Suggests that the Philippine endemic is one of the world's most threatened crocodiles.

Sanborn, C. C. Philippine Zoological Expedition, 1946-1947. Mammals. Fieldiana: Zoology, 33:89-158. A report on 95 species of mammals obtained by the expedition, including nine species and six subspecies described as new.

Sanguila, W. M. and B. R. Tabaranza, Jr. 1979. A list of land mammals of Mindanao. Mindanao Journal 5:130-140. An enumeration of 97 species and subspecies of terrestrial mammals recorded from Mindanao.

Smith, G. A. 1981. The origins of Philippine parrots and the relationships of the Guiabero, *Bolbopsittacus lunulatus*. Ibis 123: 345-349. Concludes that the unique endemic Guiabero is most closely related to the fig-parrots (subfamily Psittaculirostrini) based on similarities in skull and basihyal bone and is therefore Australian in zoogeographical origin.

Talbot, L. M. and M. H. Talbot. 1966. The tamaraw *Bubalus mindorensis* (Heude): observations and recommendations. Mammalia 30:1-12. Provides rare observations of wild tamaraw on Mt. Iglit, Mindoro. The species' population decline is identified as due principally to hunting, and secondarily to conversion of the habitat to cattle grazing, logging, and cultivation. Concludes that the tamaraw is a seriously threatened species and urgently needs an effective preservation program.

Tate, G. H. H. 1946. Geographical distribution of the bats in the Australasian archipelago. American Museum Novitates 1323:1-21. A detailed discussion of the zoogeography of bats in the Indo-Australian region. Divides the Australasian bat fauna into three major faunal regions based on distributional patterns, namely: Asiatic-Malaysian, New Guinea-Australian, and Intercontinental. Concludes that the bat fauna of the Intercontinental region, which includes the Philippines and Celebes, is primarily of Asiatic origin characterized by many distinct fruit bats and contains more indigenous megachiropterans than microchiropterans.

Taylor, E. H. 1920. Philippine amphibia. Philippine Journal of Science 16:213-360. A comprehensive treatment of the taxonomy of Philippine amphibians. Includes 22 species that are erroneously recorded for the Philippines and a bibliography of major works on amphibians. Describes 66 species including one genus and 19 species new to science. Suggests that 11 of the 15 genera found in the Philippines dispersed from Borneo via Sulu and Palawan.

Taylor, E. H. 1921. Amphibians and Turtles of the Philippine Islands. Monographs of the Bureau of Science, Manila. 15:1-193. Systematic accounts of 16 genera and 65 species of amphibians and seven genera and eight species of turtles in the Philippines, their economic value, reproduction, food, and distribution. Provides a list of species considered as doubtful records for the Philippines and a bibliography of major taxonomic works on Philippine amphibians.

Taylor, E.H. 1922. The Snakes of the Philippine Islands. Monographs of the Bureau of Science, Manila. 16:1-312. Systematic accounts of 41 genera and 113 species and subspecies of snakes. Included list of local names of snakes, erroneously attributed species of snakes in the Philippines, and bibliography of major taxonomic works. Discusses distribution of snakes and suggests that the herpetofauna of the Philippine exhibits greatest affinity with that of Borneo.

Taylor, E.H. 1922. The Lizards of the Philippine Islands. Monographs of the Bureau of Science, Manila. 17:1-269. Systematic accounts of 29 genera and 100 species and subspecies, of which one species and three subspecies are new to science. Includes remarks on the distribution and ecology, list of species erroneously recorded for the Philippines, and a bibliography of major taxonomic works on Philippine lizards.

Thomas, O. 1898. On the mammals collected by Mr. John Whitehead during his recent expedition to the Philippines with field notes by the collector. Transactions of the Zoological Society of London 14:377-412. Virtually the first description of the unique endemic rodents of the Philippines. List 38 species of mammals from Luzon, Mindoro, Negros, and Samar, including 14 species of murid rodents from the highlands of northern Luzon, of which five genera and seven species are new to science.

Utzurrum, R.C.B. 1991. Philippine island biogeographic patterns: practical applications for resource conservation and management. Association of Philippine Systematic Biologists, Communications. In Press. Draws attention to the implications of the major mammalian faunal regions of the Philippines for the conservation of its biological diversity, specifically in the design and management of national parks and reserves. Discusses the benefits and effectiveness of a protected area design consisting of a network of a few selected national parks and reserves which encompass centers of major biological diversity and endemism, and a series of smaller protected areas to protect single-island endemics.

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