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Amphibians and reptiles in tropical rainforest fragments on Negros Island, the Philippines

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SUMMARY

To elucidate effects of fragmentation and degradation of tropical rainforest on Negros Island (Philippines) on tropical herpetofauna, nine tropical rainforest fragments (eight limestone and one non-limestone), ranging in area from five to 122 ha (total area = 352 ha) in south-western Negros were surveyed using cruising and quadrat sampling methods, between December 2001 and October 2002. A 14-ha limestone plantation forest served as a reference site. Ten to fifteen of the total 61 species (16.4–24.6%) expected in the nine forest fragments (taken as a whole) had been lost in the previous 50 years. These species are known to occur in the tropical rainforest on Cuernos de Negros and environs in south-eastern Negros Island at altitudes <500 m above sea level. The factors responsible for the loss of these species appear to be (1) removal of large trees, which decreases canopy cover causing physical changes; and (2) forest fragmentation, which increases the edge areas. However, it is not possible to separate the effects of each of these two factors. The main factor that was correlated with the number of species in the limestone forest fragments appeared to be area. Two species of frogs appeared to be represented by relatively moderate population densities: the Negros cave frog (*Platymantis spelaeus*) and the common forest frog (*Platymantis dorsalis*). The burrowing skink (*Brachymeles boulengeri taylori*) also exhibited a relatively higher density than the other burrowing species of skinks. The other herpetofaunal species exhibited low population densities.

Keywords: deforestation, fragmentation, habitat degradation, herpetofauna, limestone, Philippines

INTRODUCTION

A recent review of threatened non-fish vertebrates and vascular plants of the world has placed the Philippines among the world's top biological diversity 'hot spots', 'areas of exceptional concentrations of endemic species and experiencing exceptional loss of habitat' (Myers *et al*. 2000). The massive loss of the tropical rainforest and its fragmentation on virtually all islands of the Philippines (see Brooks *et al*. 1997; Heaney & Regalado 1998) have given rise to questions as to the present status of the forest-associated vertebrate fauna, especially the endemic species. About 1100 species are currently listed as Philippine land vertebrates, the majority of which are forest-dwelling species (Brown & Alcala 1978, 1980; Alcala 1986; Dickinson *et al*. 1991; Alcala & Brown 1998; Heaney & Regalado 1998; Heaney *et al*. 1998). Sixty to seventy-five per cent of these are endemic to the Philippines.

Recent studies on the effects of habitat degradation and fragmentation on Philippine vertebrates have generally been concerned with birds (see Brooks *et al*. 1997; Collar *et al*. 1999; Curio 2002), mammals (see Heaney & Regalado 1998; Heaney *et al*. 1998), and both birds and mammals (see Brooks *et al*. 1990, 1997), but have excluded amphibians and reptiles. Studies on Philippine amphibians and reptiles (especially burrowing and arboreal forms) are desirable because these animals may be highly sensitive to the effects of forest degradation and fragmentation for a number of reasons, such as site fidelity, limited dispersal ability and changes in their habitat quality (see review with reference to amphibians in Marsh & Pearman 1997). Species abundance may be part of censuses intended to determine extinction rates in fragmented habitats (see Shafer 1990; Rosenzweig & Clark 1994). A reduced population density could be an indicator of the adverse effect of habitat degradation and fragmentation on the herpetofauna.

The herpetofauna of Negros Island is the best studied in terms of systematics and ecology compared to those of the other larger islands of the Philippines. Following the pioneering and comprehensive studies on amphibians and reptiles by Taylor (1922*a*,*b*) and a review of amphibians by Inger (1954), scientists associated with Silliman University, in Dumaguete City, Negros Oriental and their research collaborators have been conducting research on these two vertebrate groups since the mid-1950s (Brown & Alcala 1961, 1964, 1970, 1978, 1980; Leviton 1963; Alcala & Brown 1966, 1982, 1998; Alcala 1976, 1986; Alcala & Alcala 2000; Brown *et al*. 2001). Data from these publications serve as a baseline for the present study.

The present paper deals with the populations of amphibians and reptiles in south-western Negros Island, where lowland

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forest fragments of variable areas and shapes still exist. The objective was to determine the species of amphibians and reptiles occurring in the forest fragments in this part of Negros and, where possible, assess their population densities.

Study area

Negros Island, in the central Philippines, had a continuous blanket of tropical rainforest covering about 77% of its total land area of 13 000 km^2 in 1875. This forest cover was reduced to 48% by 1949, 24% by 1970, and to only about 3% (39 000 ha) by 1994 (Heaney & Regalado 1998). The primary forest rapidly dwindled in size during the period from the 1950s to mid-1980s, coinciding with intensive logging and conversion of upland areas to agricultural farms in response to population pressure. The primary forest in south-western Negros has been gradually reduced to scattered forest fragments over the last 50 years. These fragments, having been part of a continuous forest, had similar overall content of forest habitat (see Villard *et al*. 1999), and were therefore true forest fragments, forest 'samples' or 'habitat islands', as distinguished from 'isolates' (Shafer 1990; Patterson & Atmar 2000).

The study area (100–300 m above sea level) was located in south-western Negros Island, within the territorial jurisdiction of the towns of Cauayan and Hinobaan, in the province of Negros Occidental, and consisted of nine fragments that served as study sites (Fig. 1). The Cauayan fragments had an open canopy cover of about 42.5% (<50% considered 'open' canopy cover and >50% considered 'closed' canopy cover; Swedish Space Corporation 1988). The non-limestone Hinobaan fragment had a closed canopy (87.5%). The 14-ha Sipalay limestone plantation forest with 7.5% canopy cover served as a reference site. Five of the eight forest fragments in Cauayan were inter-connected by narrow corridors of secondary growth forest. One of these eight fragments (Linab in Cauayan) was separated from the others by about 10 kilometres. The Canlabac forest fragment in Hinobaan stands isolated from the Cauayan forest fragments. The total area of the nine forest fragments (excluding the reference site) was about 352 ha. Two forest fragments, one limestone in Cauayan and another non-limestone in Hinobaan, were titled private lowland forests; all others were public forests. Commercial logging was effectively stopped in these fragments in the 1990s, but tree cutting by local residents had occurred occasionally. The owner of the Hinobaan forest had stopped tree cutting in the 1960s.

Eight of the nine forest fragments that made up our present study area could be described as open canopy, disturbed limestone rainforest, still relatively rich in many primary forest plant elements, but lacking in moisture absorbers such as forest-floor duff and humus, and moisture-loving plants such as screw pines, large-leaved Araceae, arboreal ferns and other epiphytes, lianas, climbing palms (including rattans) and mosses. These forest fragments had lost the arboreal stratum of microhabitats and only the ground stratum of humus, forest duff and rock outcrops remained. The most distinctive trees (*c*. 12 species) in the forest fragments belonged to the family Dipterocarpaceae, the source of the 'Philippine mahogany.' Many of these trees are large enough to attract illegal tree cutters.

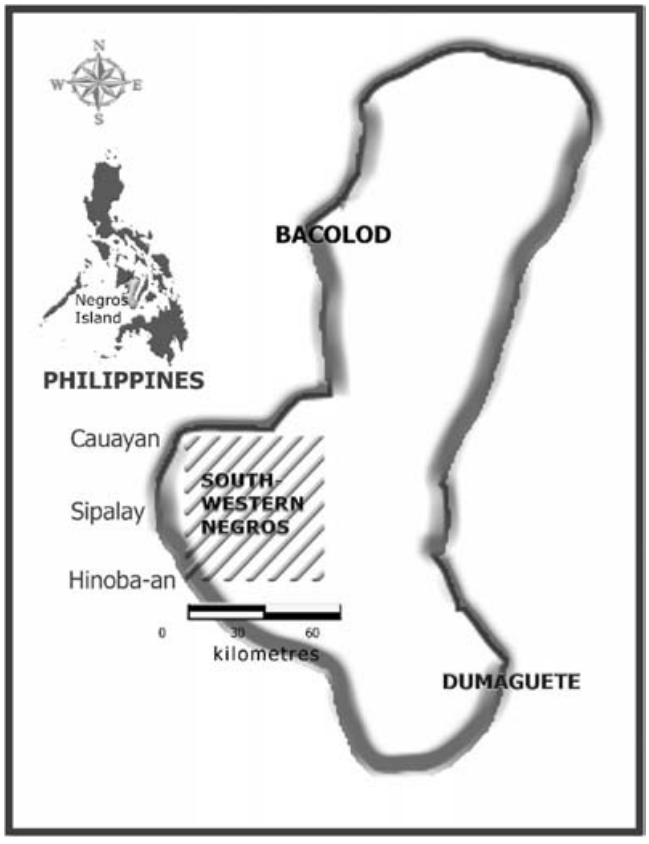

Figure 1 Diagrammatic map showing the location of study areas in south-western Negros Island, Philippines.

South-western Negros is influenced by two distinct climatic seasons, namely the rainy season (May–November) and the dry season (December–April). In the 1950s, the closed canopy lowland rainforest throughout Negros Island generally retained moisture at all times. This was not the case in the present study. The forest floor was observed to be dry, except during periods between rainfalls.

MATERIALS AND METHODS

We undertook fieldwork between December 2001 and October 2002. Using a team of four experienced field assistants and collectors, the field effort was 40 man-days at Canlabac, Hinobaan, 148 man-days at Pinamayan, Cauayan, and 28 man-days at Torque, Sipalay, with about equal effort during the wet and the dry seasons for Hinobaan and Cauayan. Two local field guides also assisted us in all of the field sampling. In Hinobaan, the team spent 10 days in December 2001 (beginning of dry season) and two days in August 2002 (wet season). In Cauayan, we spent 37 days sampling during the

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dry season (December 2001, February–April 2002) and the wet season (October–November 2002). Seven of the eight limestone forest fragments were contiguous to each other, allowing repeated samplings from our camp site. Sipalay, the reference site, was visited on only one occasion, for seven days during the wet season (October–November 2002).

We used cruising and quadrat methods to capture amphibians and reptiles, mainly during daylight hours. We undertook 3–4 hours sampling at night every other day with the assistance of two local field guides. Security dictated this reduced night-time field activity. Cruising consisted of 4–5 field assistants walking over the whole forest and thoroughly exploring microhabitats of amphibians and reptiles such as rotting vegetation, tree stumps, humus, leaf axils of screw pines (*Pandanus*), rock crevices and tree trunks. To determine herpetofaunal abundance, we explored sixteen 10 m × 10 m quadrats (eight during the wet season and eight the during dry season) in the central part of the 8-ha non-limestone forest fragment located on a mountain slope at Hinobaan. This part of the forest was divided into four sections, each one hectare. Two quadrats near or at the centre of each section, and separated from each other by at least 10 m, were selected and searched for herpetofaunal species. In the limestone forest fragments, forest floor amphibians and reptiles (except the cave frog) were censused during the day in 8–16 quadrats within each forest fragment; there were 96 quadrats in all (48 during the dry season and 48 during the wet season). Quadrats were set up in non-rocky forest floor with soil and leaf litter cover. The cave frog, which inhabits rock crevices, was censused using the quadrat method only at night. Four or five experienced field assistants used shovels to dig into the leaf litter, humus and topsoil, beginning at one side of quadrats or at the bottom of sloping quadrats and proceeding forward or upward to sample surface and burrowing forms. Care was taken to prevent the escape of frogs, lizards and snakes by using shovels to clear the ground around the boundaries of a quadrat before the start of the census. The frogs, lizards and snakes were caught and placed in damp cloth bags, and at the end of a census were identified, measured, sometimes photographed and released at or near the points of capture. All specimens, except the few badly injured individuals judged likely to die, were released. The injured animals were preserved as museum specimens. A permit from the Philippine Protected Areas and Wildlife Bureau allowed us to collect a few examples when necessary for identification purposes.

We prepared a species list from the survey of the forest fragments in south-western Negros. Some mobile lowland species of snakes may have been missed (for example *Cyclocorus lineatus*). We compared our list with the lists of species known from the whole island of Negros and from Cuernos de Negros and environs in south-eastern Negros derived from several past studies. The species number for south-western Negros is partly an inferred estimate (see Table in www.su.edu.ph/suakcrem/index.htm).

RESULTS

Species richness

Eighty-seven species of frogs and toads, lizards, snakes, crocodiles and freshwater turtle have been recorded from Negros Island (land area 1.3 million ha; Brown & Alcala 1970; Rabor *et al*. 1970; Alcala & Brown 1998). Seventy-four species have been recorded from Cuernos de Negros and environs (forest area *c*. 10 000 ha; Brown & Alcala 1961, 1964, 1970) over a period of 50 years. In the nine forest fragments and the one forest plantation in the three municipalities within south-western Negros, we observed 40 herpetofaunal species in Cauayan (area 344 ha), 28 in Hinobaan (area 8 ha) and 15 in Sipalay (area 14 ha) (Fig. 2). Forty-six herpetofaunal species in all were observed and identified in these three areas, namely one species of introduced toad (family Bufonidae), 11 species of frogs (families Ranidae, Rhacophoridae and Microhylidae), 17 species of lizards (families Agamidae, Dibamidae, Gekkonidae, Scincidae and Varanidae), 16 species of snakes (families Colubridae, Pythonidae, Viperidae and Typhlopidae) and one species of freshwater turtle (family Bataguridae). With a field crew of six, and using the same field sampling methods (cruising and quadrat methods), Brown and Alcala (1961) surveyed the amphibians and reptiles found in the montane and submontane forests of Cuernos de Negros, south-eastern Negros, for about 45 days from 22 March to 13 May 1958 and reported 51 primary forest-dwelling species of amphibians and reptiles. A later listing of amphibians and reptiles (Rabor *et al.* 1970) added only two gekkonid species to the 1958 list, despite the continuing field work in the area during the intervening period; one of the two was a very rare gekkonid lizard hatched from eggs by A.C. Alcala. The studies of Brown and Alcala (1961, 1978, 1980), Alcala and Brown (1998) and Leviton (1963) indicate about 15 more species of herpetofauna (Table 1) are expected to occur in these forest fragments, but we did not observe them during the present survey. Many of these species inhabit forest microhabitats. These may be added to the 46 species we observed to make a total of 61 species as the total probable number of herpetofaunal species that used to be present in the forest fragments.

The forest fragments we studied here were not previously sampled, but A.C. Alcala conducted field collections near one of the Cauayan forest fragments when the primary tropical rainforest still existed, and collected the uncommon skink (*Lipinia auriculata*) and the larvae and adults of the frog, *Rhacophorus appendiculatus*, in April 1957 and May 1959 (Brown & Alcala 1961; Alcala & Brown 1982). The calls of *Platymantis negrosensis* were also heard at that time. These three species were not observed in the studied forest fragments (Table 1). The 14-ha Sipalay reference site harboured 15 species, all of which (except the burrowing skinks dependent on forest conditions) occupied a range of forest microhabitats. Assuming that the fauna of the fragments was a random subset of the total available species pool (see Cutter 1991; Patterson & Atmar 2000), minus the high-altitude (>500 m) species

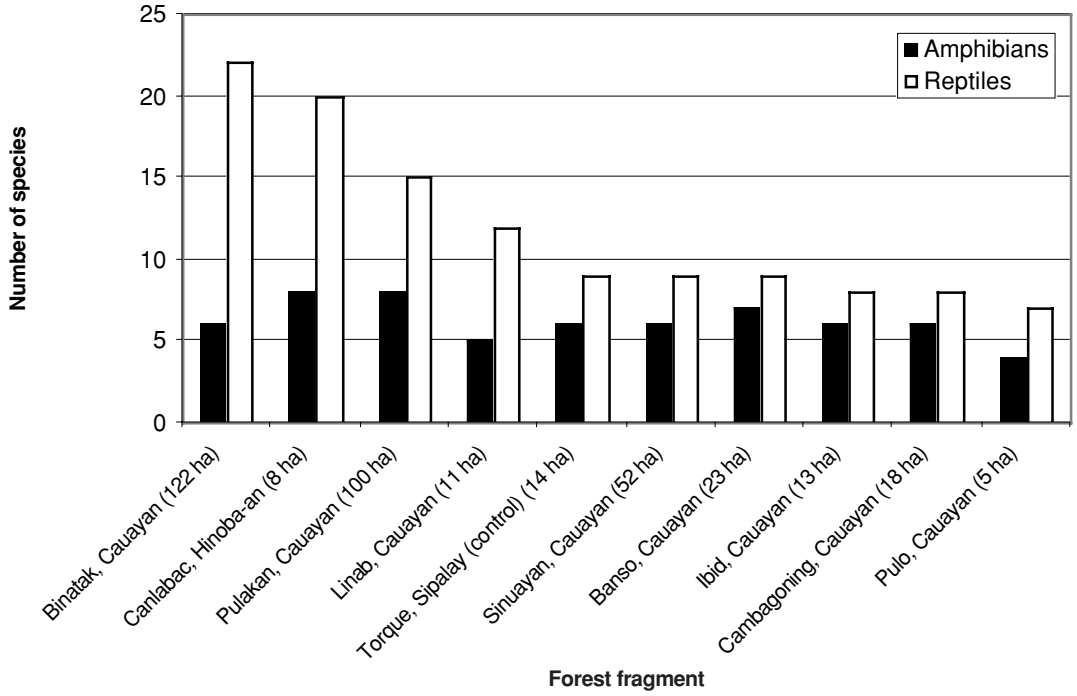

Figure 2 Numbers of amphibian and reptile species recorded in the 10 forest fragments of south-western Negros Island.

Table 1 Species of frogs, lizards (excluding house geckos) and snakes at altitudes ≤500 m expected to occur in the Negros Island forest fragments but not observed. *Philippine endemics,**Negros-Panay endemics and ***Negros endemics.

Species	*Habitats in forest*
Frogs	
*Platymantis negrosensis***	Arboreal ferns, screw pines
Rhacophorus appendiculatus	Low shrubs and trees
Lizards	
Hemiphyllodactylus typus typus	Trees, arboreal ferns
*Lepidodactylus christiani****	Arboreal ferns, screw pines
*Lepidodactylus herrei herrei**	Arboreal ferns, screw pines
*Lipinia auriculata**	Arboreal ferns, moss on large trees
*Lipinia pulchella taylori**	Forest trees
*Lipinia quadrivittata**	Forest trees
*Mabuya indeprensa**	Duff of forest floor
Snakes	
*Cyclocorus lineatus alcalai**	Duff and humus of forest floor
*Dendrelaphis caudolineatus terrificus**	Forest floor
*Dryophiops philippina**	Forest floor
*Gonyosoma oxycephala**	Forest floor, trees
*Oxyrhabdium modestum**	Duff and humus of forest floor
*Calliophis calligaster gemianulis***	Duff of forest floor

reported from the Cuernos de Negros area (Brown & Alcala 1961), 61 species were expected to occur in the forest fragments. Only 46 species (75.4%) were observed and thus 15 species, exclusive of house geckos (24.6%), have probably been lost from the study area during the past 50 years (Table 1). This percentage would be an overestimate of the local extinction if some species listed in Table 1 turned out to be still present. If five species listed in Table 1 were still present in the study area, the percentage loss would be 16.4%. Thus our estimate of the species loss could range from 16.4% to 24.6%. Among the 15 species listed in Table 1, 13 are endemic; three are endemic to Negros-Panay and 10 endemic to the Philippines.

Species-area relationships

There was no correlation between the number of herpetofaunal species and the perimeter: area ratio, indicating that, for the 10 forest fragments, attributes such as shape and perimeter did not appear to determine the number of species (Fig. 3*a*). Area appeared to influence the number of species ($R^2 = 0.59$, $p = 0.015$; Fig. 3*b*). The Canlabac forest fragment was excluded from the regression analysis because it was non-limestone and had a relatively closed canopy; it had more species than the limestone fragments of similar area. When plotted on a double log scale, the number of species in Negros Island, Cuernos de Negros in south-eastern Negros and south-western Negros (the study area) was linearly related to area ($R^2 = 0.87$; Fig. 3*c*).

Species abundance

Amphibians

Only four species of frogs, *Platymantis dorsalis, Platymantis spelaeus, Limnonectes visayanus* and *Kaloula conjuncta*

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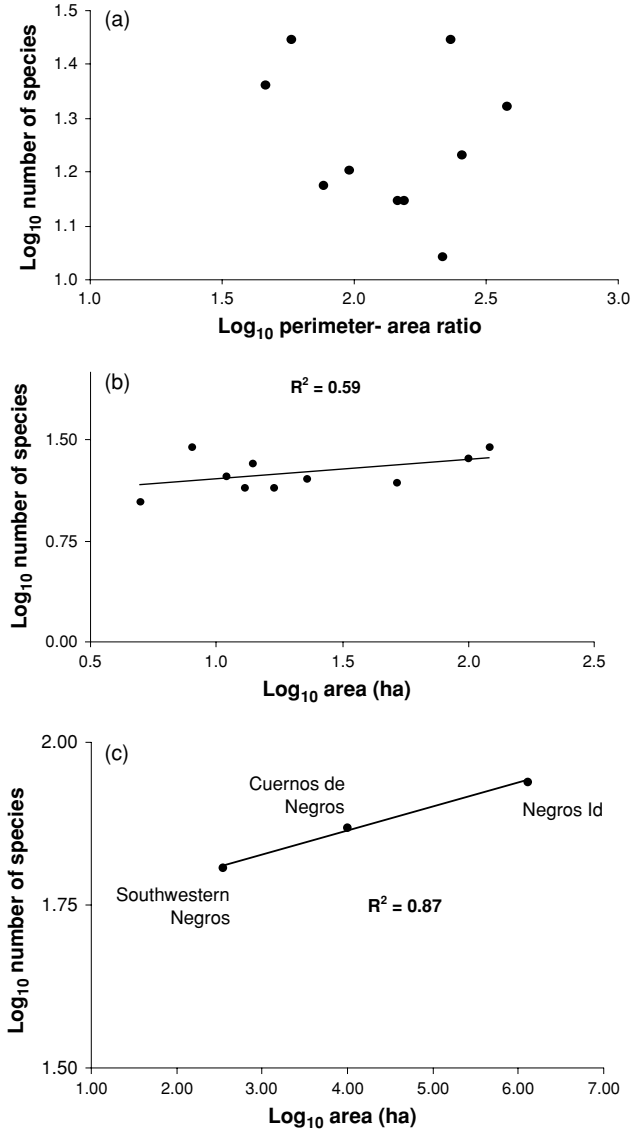

Figure 3 Log plots of numbers of herpetofaunal species versus (*a*) perimeter:area ratio in forest fragments, (*b*) area of forest fragments (Canlabac non-limestone forest fragment excluded), and (*c*) area of the whole of Negros Island, Cuernos de Negros and environs, and the ten forest fragments in south-western Negros (number of species in Negros Island and Cuernos de Negros based on empirical data, that for south-western Negros partly inferred).

negrosensis, were found in the quadrats (Table 2). All others were observed while cruising. *K. conjuncta negrosensis* was caught in two quadrats and *L. visayanus* in one quadrat.

Both species of *Platymantis* were found in all limestone forest fragments except one (Linab), where only *P. spelaeus* was observed (Table 2). *P. dorsalis* was also absent from the Sipalay reference site. But it was present in the 8-ha non-limestone Canlabac, Hinobaan forest, where *P. spelaeus* was absent.

The mean density (±SE) of adult and subadult *P. dorsalis* in the Hinobaan forest fragment was 220 frogs ha^{-1}. Because only about four hectares of this forest fragment were suitable as frog microhabitat, the total population of this frog in the Canlabac forest was therefore approximately $220 \times 4 = 840$ individuals. In the seven limestone forest fragments where *P. dorsalis* was found, the mean density was lower than in Canlabac, namely 54 frogs ha^{-1} (Table 2).

The Negros cave frog, *P. spelaeus,* was absent from the Canlabac non-limestone fragment, but it occurred in eight limestone forest fragments, as well as in the reference site at Sipalay (Table 2). The mean density in the eight limestone forest fragments was 7.38 ± 1.56 per 100 m^2, which was similar to that in the Sipalay reference site, which was 8.00 ± 0.67 per 100 m^2. The population density of this species in the limestone forest fragments was 738–800 individuals ha^{-1} (Table 2).

Reptiles

Seven reptile species were found in a few quadrats in one or two limestone forest fragments. These species and the number of forest fragments in which they were found are: the burrowing lizard *Dibamus argenteus* (1 fragment); the lizard *Mabuya multicarinata* (2 fragments); the lizard *Sphenomorphus steerei* (2 fragments; but also in the non-limestone fragment); the small burrowing snake *Calamaria gervaisi iridiscens* (2 fragments); the burrowing snake *Oxyrhabdium leporinum visayanum* (2 fragments); the burrowing snake *Pseudorabdion oxycephalum* (2 fragments); and the burrowing snake *Pseudorabdion mcnamarae* (1 fragment).

Only seven species of burrowing and surface-dwelling reptiles (six lizards and one snake) were found in quadrats in at least three limestone forest fragments (Table 2). These were the three species of *Brachymeles*, two species of Sphenomorphus, one species of *Mabuya* and the common burrowing snake, *Ramphotyphlops*. None of the species exceeded the density of 50 individuals ha^{-1}. The most common is the ubiquitous surface skink *Mabuya multifasciata* with 50–62 individuals ha^{-1}.

Brachymeles boulengeri taylori and *B. talinis* and *Sphenomorphus arborens* were less dense on average in the eight forest fragments at Cauayan than in the lone non-limestone forest fragment at Hinobaan (Table 2).

DISCUSSION

The numbers of species are probably near the actual numbers in the forest fragments based on past experience in south-eastern Negros. There has been an apparent reduction of 15 species (24.6%), 13 of which are endemic, of frogs, lizards and snakes in the study sites as compared with that documented in south-eastern Negros over a period of half a century. Assuming that five of these species may still exist in the study area, the inferred local extinction would be 16.4%. The range of 16.4–24.6% is within the postulated range of animal species extinctions (13–42%) expected in South-east Asia over the next century as a result of massive habitat loss

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Table 2 Population densities (individuals per 100 m^2 quadrat) of some amphibian and reptile species in tropical rainforest fragments in south-western Negros, the Philippines, on limestone ($n = 96$ quadrats), non-limestone ($n = 16$ quadrats) and the reference site ($n = 8$ quadrats).

Species	*Limestone forest fragments (Cauayan)*		*Non-limestone forest fragment (Hinobaan)*		*Sipalay limestone reforested fragment (reference site)*	
	Range	*Mean ± SE*	*Range*	*Mean ± SE*	*Range*	*Mean ± SE*
Amphibians (frogs)						
Platymantis dorsalis	0–4	0.54 ± 0.22	0–5	2.20 ± 0.32	–	–
Platymantis spelaeus	0–24	7.38 ± 1.56	–	–	3–11	8.0 ± 0.67
Reptiles (lizards and snakes)						
Brachymeles boulengeri taylori	0–2	0.36 ± 0.04	0–2	1.06 ± 0.13	–	–
Brachymeles talinis	0–1	0.03 ± 0.00	0–1	0.75 ± 0.00	–	–
Brachymeles tridactylus	0–2	0.12 ± 0.03	–	–	–	–
Sphenomorphus arborens	0–2	0.27 ± 0.07	0–2	0.5 ± 0.12	–	–
Sphenomorphus jagori grandis	0–2	0.11 ± 0.03	0–1	0.06 ± 0.00	–	–
Mabuya multifasciata	0–2	0.50 ± 0.10	0–2	0.27 ± 0.07	0–1	0.62 ± 0.00
Ranphotyphlops braminus	0–1	0.08 ± 0.00	–	–	–	–
Calamaria gervaisi iridiscens	–	–	0–2	0.31 ± 0.13	–	–

(Brook *et al.* 2003). Herpetofauna, particularly amphibians, which more directly depend on particular critical factors in both land and freshwater environments in order to survive, are probably more prone to local extinction than birds and mammals. Our data for fruit bats in the same forest fragments seem to confirm this statement. However, Brook *et al.* (2003) have shown the opposite, pointing out that they require less habitat space, among other reasons.

The reduction in the expected number of herpetofaunal species in the forest fragments studied in south-western Negros is most likely the result of changes in the biological-physical conditions in the fragmented forests occurring over the past 50 years (see Davies *et al.* 2001). The removal of the large trees by logging in the past reduced the canopy cover of the forest fragments to about 42.5%, except for Canlabac, which retained 87.5% canopy cover. Removal of large trees, primarily dipterocarps, reduced the humus and leaf litter on the ground and decreased the moisture content of the air, thus making the environment inhospitable for aerial plants serving as microhabitats of frogs and lizards. We probably did not observe *Lipinia auriculata*, *Rhacophorus appendiculatus* and *Platymantis negrosensis* because their usual microhabitats, such as arboreal ferns and *Pandanus*, no longer exist. Habitat diversity of the forest fragments, all of which lacked the arboreal stratum, was not studied. Undisturbed rainforests on Negros Island are characterized by a high relative humidity (70–100%) and relatively low substrate temperature (usually <25°C (Alcala & Brown 1966), but open canopy forests have generally lower relative humidity of 50–70% (unpublished records in the 1970s). Physical changes in fragmented landscapes are greatest at the edges of forest fragments (Davies *et al.* 2001). At Canlabac, Hinobaan, the forest frog *Platymantis dorsalis* did not occupy the edges of the forest, as they were much drier and warmer. The edge effect could be related to size and shape of fragments and might affect some species populations (Shafer 1990).

A recent study in Sabah in 2000–2003 (A. Wong, unpublished data 2003) indicated that habitat destruction by logging reduced species richness and abundance of ground forest frogs in tropical rainforests. Conventional logging procedures had significantly reduced species richness and abundance in comparison with forest subjected to reduced-impact logging procedures, which compared favourably with control virgin forest.

A straight-line relationship was found between species and area but not between species and perimeter:area ratio. The species-area curves for the amphibians and reptiles of Negros Island, the south-eastern Negros and the south-western Negros conformed to the expectations for samples or habitat islands, such as forest fragments (Preston 1962*a*,*b*; Shafer 1990), in that the z values in the Preston (1962*a*,*b*) equation $S = cA^z$ were lower (with steeper slopes) than the z values for isolated islands. The z values were 0.21 (Fig. 3*b*) and 0.07 (Fig. 3*c*). MacArthur and Wilson (1967) showed this species-area relationship for the herpetofauna of the West Indian islands.

For amphibians, the estimates of density and total population in the forest fragments refer only to the two species of *Platymantis*, for which we had sufficient data. Little information on reduced population density is available for amphibians and reptiles in the tropical rainforest on Negros Island, and the quantitative data from the present investigation were only preliminary and at best only indicative of changes in abundance. The density of *P. dorsalis* in the non-limestone forest was 220 individuals ha^{-1} and the total adult population was 880. The density (54 individuals ha^{-1}) in the limestone forest fragments refers only to the non-rocky parts, the areas of which are not known. It was not possible to estimate the total population in each of the limestone forest fragments. It appears that density estimates for this species in the study area were lower than that for Cuernos de Negros in south-eastern Negros (588.5 individuals ha^{-1}), based on two 100 ft × 100 ft quadrats (hence no error

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estimates) at an altitude of 1100 m (Brown & Alcala 1961). However, this comparison does not allow us to conclude that the species population in south-western Negros has been reduced, because of the differences in altitudes at which the two populations were sampled and the fact that this frog is more abundant at medium than at low altitudes in south-eastern Negros (Brown and Alcala 1961). *P. dorsalis*, which is found all over Negros Island (Inger 1954; Brown & Alcala 1961), is a primary forest species; it is generally absent in secondary and plantation forests. The 14-ha reference forest at Sipalay did not harbour this species. Its absence in the Linab forest (11 ha), a highly disturbed limestone forest, indicates its vulnerability to forest degradation and it is considered 'near threatened' (Global Amphibian Assessment, South-east Asia Workshop, Bangkok, Thailand, 30 September–4 October 2002). The main reason for its absence in Linab and Sipalay would appear related to the open canopy and the resultant dry condition of the forest floor. Because its population density in the forest fragments in south-western Negros is low, *P. dorsalis* conservation status should be upgraded to 'threatened' in this part of Negros Island. *P. spelaeus* has apparently adapted to the conditions in the Sipalay reference site.

Based on quadrats censused at night in rocky areas considered representative of the microhabitat of this species, the overall population density of the Negros cave frog in the limestone forest fragments in south-western Negros was 738–800 frogs ha^{-1}. A study in 2000, based on a visual count of adults and subadults, including calling males, in the Basay area of Negros Oriental (C. Dolino, unpublished data 2001) provided an estimate of 1800 individuals ha^{-1}. The population density of this species appears to range from about 700–800 to 1800 individuals ha^{-1} in limestone forests of south-western Negros. This frog species is adapted to limestone forests with open canopy, including secondary forests and tree plantations in south-western Negros. An earlier call for the upgrade of its conservation status from 'endangered' to 'critically endangered' (Alcala & Alcala 2000) must now be rescinded. However, because the species is found only in limestone areas not greater than 600 km^2 in area (Fig. 1), it should retain its 'endangered' status.

With the exception of the endemic burrowing skink *Brachymeles boulengeri taylori*, which had a density of 106 individuals ha^{-1} in the non-limestone forest, all reptile species had densities <100 individuals ha^{-1} in limestone and non-limestone forests (Table 2). Lizards belonging to the genera *Brachymeles* and *Sphenomorphus* are generally forest forms; their low densities in open canopy forests is not surprising. Lack of density data in undisturbed non-limestone tropical rainforests precludes meaningful comparisons. The data seem to indicate that the forest conditions at Hinobaan are more favourable to these forest species than those at the Cauayan limestone forests. Pending availability of more comparative data from non-limestone forest fragments, it is not possible to draw a conclusion. The density of the small *Sphenomorphus steerei* (19 individuals ha^{-1}) in the Hinobaan forest fragment is much smaller than the 107.6 individuals ha^{-1} on Mt Canlaon, northern Negros, at 1088 m altitude (Alcala 1976). The common, non-endemic mabuya thrives in the open canopy forest fragments, with a population density of 50–62 individuals ha^{-1}; in Dumaguete City, Negros Oriental, the density is 16–24 individuals ha^{-1} (A. Alcala, unpublished data 1964).

The density data on amphibians and reptiles may indicate whether these species still have the minimum viable population sizes (effective population sizes) to maintain genetic diversity and ensure short-term fitness, according to the 500/50 rule (Shafer 1990). It appears that *Platymantis spelaeus* is well above these minimum population sizes, but *P. dorsalis* may be close to the minimum population size. The absence of *P. dorsalis* in Linab highlights a risk of local extinction of some frog species in forest fragments.

The data are insufficient to allow forward projections for any of the reptiles. However, it is clear that all species of *Brachymeles* (except *B. boulengeri taylori*) and all species of *Sphenomorphus* have low population densities in the forest fragments and seem likely to lose genetic diversity and fitness in future.

CONCLUSIONS

About 16–24.6% of an estimated 61 herpetofaunal species expected to occur in the study area in south-western Negros, Philippines, appear to have been lost during the past 50 years. This inferred local extinction is attributed to the removal of large trees (primarily dipterocarps) and the resulting fragmentation and degradation of the original forest. This finding has important implications for forest-dwelling herpetofaunal species throughout the Philippines, where the tropical rainforest continues to contract in size, become fragmented and be degraded. It is highly probable that many species of amphibians and reptiles have already been lost from many forest areas of the Philippines. The extent of local extinctions needs much more research because 13–42% of animal species in South-east Asia may become extinct over the next century as a result of habitat loss (Brook *et al*. 2003).

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