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Imminent extinction crisis among the endemic species of the forests of Yanbaru, Okinawa, Japan

Yosiaki Itô, Kuniharu Miyagi and Hidetoshi Ota

Abstract The natural forest in Yanbaru, the northern part of the main island of Okinawa (Okinawa Hontô), is an important area for nature conservation, because it has a large number of endemic animals and plants. First, we explain the status of the most important endemic animals of Yanbaru, stressing that most of them are endangered and near extinction. Second, we show especially high species diversity of trees, insects and mites in the Yanbaru forest. However, the integrity of the Yanbaru forest is seriously threatened by clear-cutting and complete removal of forest undergrowth. Although an area in Yanbaru occupied by the US Marine Corps has, to date, preserved good natural forest, a new plan to establish seven military helipads in this area is now being examined. Possible outcomes of such a development are evaluated. In addition, requests by Japanese biologists for the Defence Facilities Administration Agency, Japan to consider alternate sites for the helipads are described.

Keywords Endangered species, endemism, Japan, Okinawan forests, species diversity, Yanbaru.

Introduction

Yanbaru, the northern montane part of Okinawa Hontô, the largest island (1202 sq km) of the Ryukyu Archipelago of Japan is an important area from both ecological and aesthetic points of view, because it supports a number of specialized endemic animals and plants (see Appendix).

The climax vegetation of Yanbaru (300 sq km in area) is subtropical rain forest, dominated by the evergreen oak or chinquapin *Castanopsis sieboldii* with other evergreen broadleaf trees such as *Distylium racemosum* and *Schefflera octophylla* (Plate 1). Although the true virgin forest is restricted to a few small areas because a large part of the forest is subjected to thinning or clear-cutting, forest sections that were thinned or cut 40–50 years ago (chiefly for the reconstruction of houses burned completely or destroyed during the war) have recovered the basic features of the climax community. Following the definition by the Nature Conservation Society of Japan (Anonymous, 1995), we refer to parts of the Yanbaru forest dominated by *C. sieboldii* trees older than 30 years as natural forests, and to those including some pine trees *Pinus luchuensis* as secondary forests (pine trees cannot survive in the climax forest of Okinawa) (Tsuchiya & Miyagi, 1991; see also Yokota, 1994 for English explanation).

Most of the characteristic Okinawan wildlife, including mammals and birds endemic to this island, can breed only in natural forests. However, except for the forests located in the US Marine Corps Northern Training Area (NTA, hereafter), which occupies *c.* 25 per cent of the Yanbaru on the eastern slope of the central montane area (Fig. 1), the natural forests of Yanbaru are now being destroyed by clear-cutting and complete removal of undergrowth by national and prefectural governments. Thus, extensive areas of natural forest now remain in the NTA only (Fig. 1).

A new problem, however, arose in 1999. In response to a request from the Marine Corps, the Defence Facilities Administration Agency (DFAA) of Japan is now planning to establish seven helipads within two of the best preserved natural forest areas in the NTA (see Fig. 1). One of the main reasons for the publication of this article is to highlight the biodiversity of the sites that are planned for development.

Endangered animal species

The Appendix shows a list of species and subspecies of terrestrial vertebrates living on Okinawa Hontô, including their distribution characteristics and status according to the revised Red Lists of the Environmental Agency of Japan (Anon., 1997, 1998). Although

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there are some endangered species in the sea around Yanbaru (e.g. *Dugong dugong*), we discuss hereafter terrestrial vertebrates only. High proportions of species or subspecies that are endemic to Okinawa Hontô (including some species which are endemic to Yanbaru) or endemic to the Amami Islands and Okinawa Islands (N-MR) are notable (69 per cent of mammals, 74 per cent of reptiles and 75 per cent of amphibians). Migratory species, stragglers, and species belonging to groups that live on the seashore, around rivers or ponds, crags and buildings were omitted from the list of birds. Nevertheless, of the 22 species found in the forests of Yanbaru, two species and one subspecies are unique to Yanbaru, and 17 are subspecies that are endemic to the Ryukyu Archipelago.

Table 1 shows the numbers of Critically Endangered (CE), Endangered (E) and Vulnerable (V) species of terrestrial vertebrates living in Yanbaru, as compared with the numbers in the whole of Japan. Yanbaru has a notably large proportion of threatened vertebrate species, despite its small area (*c.* 0.08 per cent of the total area of Japan). For example, Yanbaru has 2 (16.7 per cent) of 12 CE species and 4 (20 per cent) of 20 E species of mammals living in Japan.

In addition, it is worth noting that 5 of the 11 CE and E species of 4 tetrapod classes, shown in the Appendix, are endemic to Yanbaru only, and the other 6 species are endemic to the Ryukyu Archipelago. Even for the latter, extinction of the Yanbaru population may induce a high risk of complete extinction of these species from the earth, because populations living in the other islands (especially Amami-Oshima Islands and Tokunoshima Islands) seem to be smaller than those in Yanbaru.

In the revised Red Lists of Japan, only a part of which have been published to date, the Environmental Agency is using three subcategories of the category 'Threatened', namely CE, E and V (see explanation in Anon., 1997, 1998), similar to the new IUCN Red Lists (IUCN, 1999). However, due to the lack of good quantitative data on the current population size and rate of recent population declines in many species, the

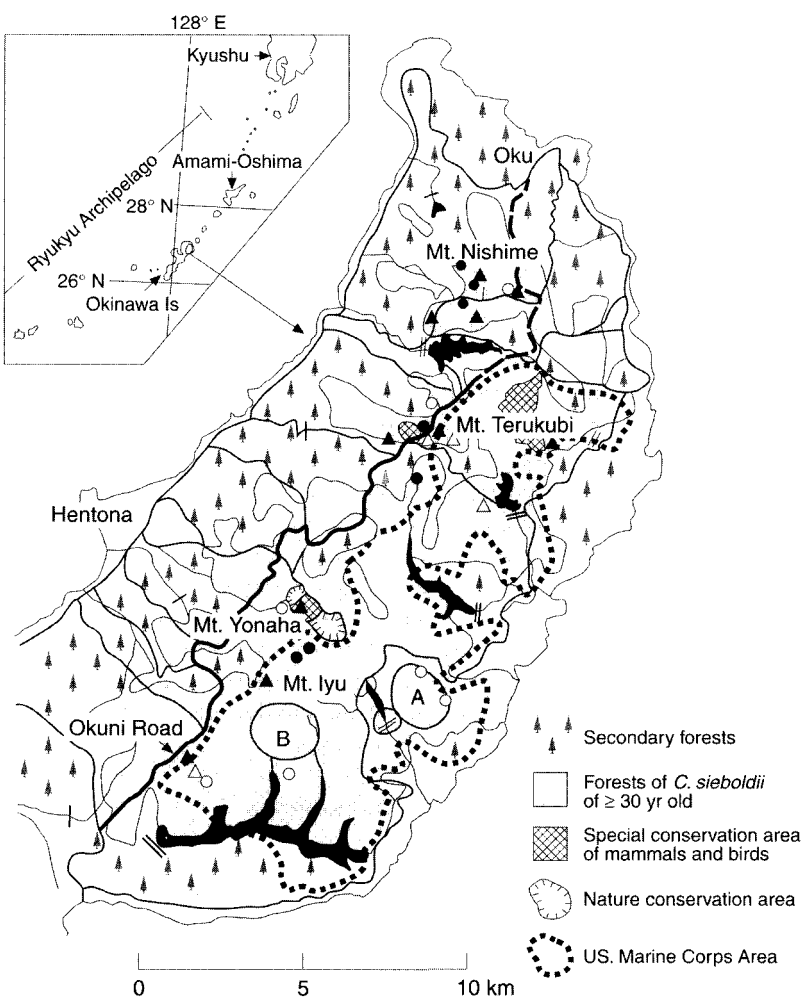

Fig. 1 Map of Yanbaru, showing natural forests, US Marine Corps Northern Training Area (NTA) and areas proposed for establishment of Marine Corps helipads (A and B).

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Table 1 Number of Critically Endangered and Endangered species, living in the whole of Japan and Yanbaru, described in the new Red Lists of the Environmental Agency of Japan (Anon., 1997, 1998)

Category	Area	Mammals	Birds	Reptiles	Amphibians
Critically Endangered	Whole of Japan	12	17	2	1
	Yanbaru	2	1	0	0
Endangered	Whole of Japan	20	25	5	4
	Yanbaru	4	2	0	1
Vulnerable	Whole of Japan	16	48	11	9
	Yanbaru	0	2	2	4

categorical designations in the Japanese Red Lists are not sufficient to satisfy the conditions necessary to define the status of a species according to the IUCN categories. In addition, the Environmental Agency uses subspecies in the Red List of Japan. For example, *Tokudaia osimensis osimensis* from Amami-Oshima and Tokunoshima Islands and *T. o. mueninki* from Yanbaru are listed as two independent Threatened species (although some Japanese mammalogists consider that the Yanbaru population belongs to a separate species, *T. mueninki*, different from *T. osimensis*: Abe *et al.*, 1994).

Nevertheless, at least for the mammals and birds of Yanbaru, the CE and E categories of the new Red Lists of Japan are almost equivalent to those of the IUCN. As discussed below, the numbers of living individuals of three CE species listed in the Appendix are believed to be fewer than 1000 and those of six E species of mammals and birds are fewer than 3000 (of which two species are possibly represented by fewer than 1000 individuals; see below). The Yanbaru whiskered bat *Myotis yanbarensis* was newly discovered in the NTA in 1997 (Maeda & Matsumura, 1998), and since then only three individuals, including the two specimens used for the description, have been found from a small area (K. Maeda, pers. comm.). In recent years, only two dead individuals of the Okinawa spiny rat *T. osimensis mueninki* (Plate 2) have been found and only one living individual was photographed by an ultraviolet-activated camera, although spinous hairs of this species were found recently in the faeces of feral cats (Yambaru Chapter, Wild Bird Society of Japan, 1997). According to Azama (1996), the number of Noguchi's woodpecker (or Pryer's woodpecker *Sapheopipo noguchii*) adults (Plate 4) in 1992 was estimated to be between 400 and 500 (based on counts of nest holes and the identification of adults after hearing their territorial song induced by playback of recorded birdsong).

Among E species, the Ryukyu tube-nosed bat *Murina ryukyuana* (Plate 2) was also discovered in the NTA in 1997 (Maeda & Matsumura, 1998). Since then, only about 10 living animals have been detected from an area of *c.* 100 sq km (K. Maeda and S. Matsumura, pers. comm.). A living individual and a dead individual of the Ryukyu long-haired rat *Diplothrix legata* (Plate 2) were found in 1999; these are the only specimens that have been found in the last 5 years. Thus, the mean numbers of individuals of these two species in recent years are believed to be fewer than 1000. Although quantitative data are not available, numbers of living individuals of other E species in Yanbaru, such as the Okinawan rail *Gallirallus okinawae* (Plate 3), are not believed to exceed 10,000.

As far as invertebrates are concerned, the giant long-armed scarab beetle *Cheirotonus jambar* (Plate 3) is at risk because it may be close to extinction. Its larvae can grow only by feeding on the humus that accumulates in large holes on large trees (i.e. stem diameter of breast height, DBH, ≥ 40 cm: Azuma *et al.*, 1985, 1986; Azuma, 1994), but a few large trees only remain in areas outside the NTA due to clear-cutting, and these trees are often checked by poachers who sell beetles illegally; the giant long-armed scarab beetle is a special national emblem of Japan. Egg size (6 mm diameter) of *C. jambar* is exceptionally large among insects, females lay only about 20 eggs during their lives, and the larval period is 3–4 years (Azuma *et al.*, 1985, 1986). The mean number of adults that emerge each year is possibly fewer than 1000 (S. Azuma, pers. comm.).

Biodiversity in Yanbaru forests

Table 2 shows the numbers of species of some groups of animals and plants in Yanbaru relative to those in the whole of Japan and Hokkaido, the northernmost main island of Japan. It can be seen that Yanbaru has a remarkably large number of species. Of Japan's native fauna and flora, around 8 per cent of mammals, 40 per cent of ants and *c.* 25 per cent each of reptiles, anurans, cicadas and vascular plants are found on Yanbaru.

Twenty-two species of resident birds are known to breed in the forest of Yanbaru (Appendix; species that live in Yanbaru but that breed on the seashore, in cultivated fields and buildings, for example, *Passer montanus*, are excluded). Of these, two (*Sapheopipo noguchii* and *Gallirallus okinawae*) are endemic to this area, and two (*Accipiter gularis* and *Scolopax mira*) are endemic to the Ryukyu Archipelago at the full-species level. Of the remainder, 17 are endemic to the Ryukyu Archipelago at the subspecies level, whereas the other,

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Plate 1 Forest of Yanbaru, dominated by the evergreen oak, *Castanopsis sieboldii* (*Y. Itô*).

Plate 3 Top: The Okinawan rail *Gallirallus okinawae* is a flightless rail, also strictly endemic to Yanbaru (*C. Tamaki*). Bottom: The giant long-armed beetle *Cheirotonus jambar* is strictly endemic to Yanbaru. This species is considered to be most at risk of extinction (*T. Sasaki*).

Plate 2 Top: The Ryukyu tube-nose bat *Murina ryukyuana* discovered in 1997 (*K. Maeda*). Only about 10 individuals have been found to date, despite 3 years of extensive searching following the discovery of the species. Middle: The Ryukyu long-haired rat *Diplothrix legata*, the largest rat in Japan (*M. Kudaka*). Endemic to Yanbaru, Amami-Oshima Island and Tokunoshima Island. Only one dead and one living individual have been found in Yanbaru since 1995, despite extensive searching. Bottom: The Okinawa spiny rat *Tokudaia osimensis mueninki* (*M. Kudaka*). Although *T. o. osimensis* is found on Amami-Oshima Island and Tokunoshima Island, some believe that the Okinawa spiny rat is an independent species, *T. mueninki*. Only three individuals (two dead and one photograph of a living rat) have been found in Yanbaru in recent years.

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Table 2 Number of species living in Yanbaru compared with those in the whole of Japan and on Hokkaido. All species except introduced species (e.g. *Rattus rattus* and *R. norvegicus*), and Cetacea and Pinnipedia are included. Feral cats and dogs in Yanbaru, which are now breeding and have become predators of endemic mammals and birds, are also excluded.

	Whole of Japan	Yanbaru			Hokkaido Island			
Group	No. species	No. species	Per cent	Endemic species	No. species	Per cent	Endemic species	Source*
Mammals	108	10	9.2	2	38	35.2	1	Department of Nature Conservation, Environmental Agency, 1991; Abe *et al.*, 1994; Environmental Agency of Japan, 2000
Terrestrial reptiles	68	19	27.9	0	8	11.8	1	Ota & Nakagawa, 1985; Ota, 2000
Anurans	39	10	25.6	2	3	7.7	1	Maeda & Matsui, 1989
Cicadas	37	8	21.6	2	11	29.7	1	Nakao, 1990
Ants	261	103	39.5	12	62	23.8	1	Myrmecological Society of Japan, 1989, 1991, 1992; Terayama & Kihara, 1994
Higher plants	*c.* 3900	1089	*c.* 28	19	*c.* 1600	*c.* 41	—	Shinjo & Miyagi, 1988; T. Kohyama, pers. comm.
Area (sq km)	378,000	300	0.079		82,100	21.7		

* If two sources are cited, the first one includes data for Yanbaru and the second one includes data for the whole of Japan and Hokkaido. If one source only is cited, the paper includes data for all areas.

Columba janthina janthina, is seen in both the Ryukyu Archipelago and the main islands of Japan (Hanawa, 1998).

Many indices have been proposed to measure species diversity, including species richness and heterogeneity of numbers of individuals among species in a community.

For the purposes of this paper, we use two non-parametric species diversity indices, $1/D$ and $1-D$, where D is Simpson's index (Simpson, 1949):

$$D = \sum \frac{n_i(n_i - 1)}{N(N-1)},$$

and n_i and N are the number of individuals of ith species and total number of individuals, respectively.

We also use the equitability index suggested by Pielou (1969):

$J' = H'/H'_{max}$, where H' is Shannon–Weaver index or MacArthur's diversity (MacArthur, 1955):

$H' = -\Sigma(n_i/N \log_2 n_i/N)$ and H'_{max} is $\log_2 S$ (S is the number of species).

Larger vlaues of $1/D$ and $1-D$ indicate high species diversity (for $1-D$, the maximum value is 1), and a larger value of J' shows evenness of the numbers of individuals of species in a community (when $J' = 1$, individual numbers of all species are the same). Lande (1996) recommends the use of $1-D$, but we also apply $1/D$ and the equitability index because they are frequently used by other researchers.

Table 3 shows the number of species, total number of individuals, and species diversity indices calculated for the following groups of plants and of animals living in Yanbaru: trees (DBH > 4.5 cm), insects living in the underlayer of forests; ants; and oribatid mites living in soil. (For methods of sampling insects, ants and mites, see Azuma *et al.*, 1997; Itô *et al.*, 1998; Itô & Aoki, 1999, respectively.)

As shown here, the diversity of tree species in the natural forests of Yanbaru is much higher than that of the deciduous broadleaf forests of Hokkaido, and higher than the evergreen broadleaf forests of Kyushu. In the forests of both Yanbaru and Kyushu, the dominant tree is *C. sieboldii*. Table 3 also demonstrates that tree species diversity of the secondary forests (< 20 years old) of Yanbaru is lower than that of natural forests. Tree species diversity of the forests of Yanbaru is possibly the highest among Japanese forests. In sub-arctic and cool-temperate forests, tree species diversity increases during the early stage of succession but decreases in the subsequent stage (e.g. in Hokkaido, the diversity decreases from the broadleaf deciduous forest to the climax sub-arctic coniferous forest). In contrast,

Table 3 Number of species (S), total number of individuals (N), and species diversity indices ($1/D$, $1-D$, H' and J') of some groups of plants and animals in Yanbaru and other places. Mean ± SD is given for data of three or more samples. Values for Hokkaido and Kyushu were calculated using data from published articles (see 'Source').
DBH: diameter at breast height. 'Eberg. brl.' and 'Decid. brl.' denote evergreen broadleaf forest and deciduous broadleaf forest, respectively. All forests in Yanbaru, which are not described in this column, are evergreen broadleaf forests. Regarding Insects, Ants and Oribatid mites, 'natural' refers to natural evergreen forests while 'no u.g.' refers to forests from which the undergrowth was completely cut and removed (see text)

Group and area	S	N	$1/D$	$1-D$	H'	J'	Note	Source
Trees (DBH > 4.5 cm). Surveyed area: 4 acres in Yanbaru and Kyushu, 5 acres in Hokkaido								
Yanbaru natural forests (>50 years old)	29.4 ± 2.5	149 ± 26	12.6 ± 1.3	0.92 ± 0.01	3.66	0.83 ± 0.05	Everg. brl.	Itô, 1997b
Yanbaru secondary forests (<20 years old)	23.7 ± 10.4	191 ± 92	6.57 ± 3.0	0.83 ± 0.07	3.31	0.73 ± 0.11	Everg. brl.	Itô, 1997b
Hokkaido	5	80.5	3.03	0.34	0.96	0.43	Decid. brl.	Tatewaki & Igarashi, 1971
Kyushu	12.8 ± 2.4	181 ± 4	4.76 ± 2.0	0.79 ± 0.10	2.85	0.76 ± 0.12	Everg.brl.	Omura *et al.*, 1969
Insects (sweep net survey, total of 45 min by three people and three sites; numbers of Lepidoptera, Hymenoptera Diptera are excluded)								
Yanbaru, natural	75.7 ± 3.1	282 ± 47	16.5 ± 5.7	0.94 ± 0.02	5.03	0.81 ± 0.06		Azuma *et al.*, 1997
Yanbaru, no u.g.	66.7 ± 4.5	553 ± 200	7.3 ± 2.9	0.85 ± 0.06	4.12	0.68 ± 0.11		Azuma *et al.*, 1997
Iriomote, natural	58	202	15.8	0.94	4.94	0.84		Azuma, 1974
Iriomote, secondary	53	256	6.6	0.85	4.00	0.70	Everg. brl.	Azuma, 1974
Ants (nest counts over a period of 30 min)								
Yanbaru, natural	14	43	10.0	0.90	3.41	0.90		Itô *et al.*, 1998
Hokkaido	7	183	1.50	0.33	1.08	0.39	Decid. brl.	Itô *et al.*, 1998
Iriomote	16	46	7.29	0.86	3.35	0.83	Everg. brl.	Itô *et al.*, 1998
Oribatid mites (Tullgren extraction of three soil samples of 10 × 10 × 5 cm)								
Yanbaru, natural	38 ± 8	161 ± 31	15.0 ± 5.3	0.93 ± 0.03	4.38	0.84 ± 0.03		Itô & Aoki, 1999
Yanbaru, no u.g.	33 ± 10	293 ± 176	9.30 ± 0.73	0.89 ± 0.01	3.84	0.77 ± 0.02		Itô & Aoki, 1999

diversity values increase linearly with forest age from 25 to 55 years in Yanbaru (Itô, 1997b).

The natural forests of Yanbaru show high species diversity of insects (data for 14 orders, excluding Lepidoptera, Diptera and Hymenoptera, were used for this calculation because many specimens of moths and mosquitoes are destroyed in the net during sweeping. In addition, the identification of small parasitoid wasps was difficult due to the incompleteness of taxonomy; see Azuma *et al.*, 1997).

Species diversity of Coleoptera in natural forests of Yanbaru is about the same as that in the natural (*C. sieboldii*-dominated) forest of Iriomote Island, in southern Ryukyus, and far higher than the secondary forests or pine plantation on the island (for undergrowth-eliminated forests in Yanbaru, see below). The species diversity of ants, using data collected by 30-min counts of nests, also shows a far higher diversity in Yanbaru than in Hokkaido. The species diversity of soil-inhabiting oribatid mites in Yanbaru natural forests is also high.

The values of the indices, however, are not the only important consideration; the characteristics of the species found in the natural forests are important as well. Ants can be divided into eurychoric species, i.e. those having a world-wide geographic distribution—including tramp species living in close association with humans—and stenochoric species, i.e. those with a narrower geographic distribution. Table 4 shows the ratios of stenochoric and Ryukyu-endemic species to all ant species (in this paper, stenochoric species are defined as those endemic to South-east Asia). The results indicate that although the number of species in natural forests of Yanbaru does not differ greatly from that in both the secondary forests and logged areas, the ratio of stenochoric species decreases from about 80 per cent in the natural forests to 60 per cent in the secondary forests and 20 per cent in the logged area of Yanbaru. Similarly, the ratio of species endemic to the Ryukyu Archipelago decreases from more than 20 per cent in natural forests to 0 per cent in logged area.

Destruction of the Yanbaru forests

Since 1972, when Okinawa was returned to Japan, the natural forests of Yanbaru have been destroyed seriously in two ways: first, by large-scale clear-cutting and, second, undergrowth removal funded by national and prefectural subsidies.

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Table 4 Numbers and percentages (in parentheses) of stenochoric species (S) and species endemic to the Ryukyu Archipelago (R) of ants in the Yanbaru area. Yamauchi & Ogata (1995) is a report of a joint survey by members of the Myrmecological Society of Japan.

Source	Yamauchi & Ogata (1995)			Itô *et al.* (1998)
	Logged sites	Secondary forests	Natural forests	Natural forests
No. species	21	18	20	32
No. and (per cent) of S	4 (19)	11 (61)	16 (80)	25 (78)
No. and (per cent) of R	0	2 (11)	4 (20)	10 (31)

The extent of Yanbaru forests cut during the 13 years from 1979 to 1991 was 2443 ha (Department of Agriculture and Forestry, Okinawa Prefectural Government, 1992). More than 60 per cent of the area cut is in the central part of Yanbaru, and nearly half of all natural forests outside of the NTA were clear-cut. Complete cutting and removal of undergrowth (i.e. tree seedlings, shrubs and herbs lower than 2 or 3 m above ground) was also carried out under a government subsidy through the 'Natural Forest Improvement Project' (Plate 5). According to a table shown by the Department of Agriculture and Forestry Okinawa Prefectural Government to the Association for Preserving the Yanbaru Mountains, the undergrowth was removed from 3069 ha of the forest over a 21-year period from 1972 to 1992 (Itô, 1995, 1997a). Although this area includes some secondary forests, we estimate that the undergrowth was removed from about half of the 'natural forests'. Despite the recommendation from the Ecological Society of Japan in 1994 and 1995, the Okinawa Prefectural Government still continues with clear-cutting activities and the removal of undergrowth.

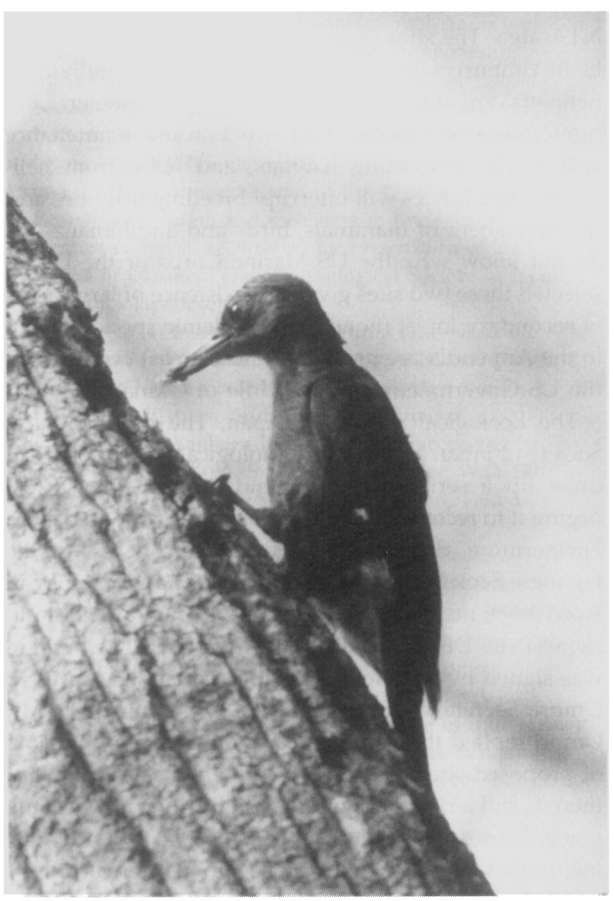

Plate 4 The Noguchi's woodpecker (or Pryer's woodpecker) *Sapheopipo noguchii* is strictly endemic to Yanbaru (*K. Taira*). Population size is possibly fewer than 1000.

Large-scale clear-cutting of the forest deprives it completely of the endemic biota of its natural habitat. Even the removal of undergrowth affects populations of ground animals such as the Okinawa spiny rat *T. osimensis mueninki*, the Ryukyu long-haired rat *D. legata* and the Okinawan rail *Gallirallus okinawae*. It was observed that larvae of the giant long-armed beetle *Cheirotonus jambar* died in forests without undergrowth, due to the dryness of humus in holes of remaining large trees (S. Azuma, pers. comm.).

Table 3 shows that the species diversity of insects and mites in 'no undergrowth forests' is always lower than that of intact natural forests. Although the total number of individuals (N) in forests without under-

Table 5 Distribution of oribatid mite species affected by undergrowth removal and those relatively unaffected by it. (n.s.) indicates species described for the first time during our survey

Distribution	Species
A. Species of which the number of individuals was remarkably decreased by undergrowth removal	
Endemic to Ryukyus	*Perscheloribates clavatus torquatus*
	Galmna glanalata
	Trichotocepheus amamiensis
Hokkaido and Okinawa	*Pergalumna intermedia*
Yanbaru only	*Yambaramerus itoi* (n.s.)
	Allogalumna rotundiceps (n. s.)
B. Species of which the number of individuals was not affected by undergrowth removal	
Widely distributed species	*Oppiella nova*
	Rostrozetes ovulum
Mainland and Okinawa	*Eremovelba japonica*
	Hammerella pectinata
	Arcoppia vioerea
	Yoshiobodes nakatamarii
	Zetorchestes aokii
	Dolicheremaeus baloghi
Yanbaru only	*Dimidiogalumna azumai* (n.s.)

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Plate 5 Undergrowth of an intact natural forest (top) and a forest from which undergrowth has been eliminated (bottom; 'no u. g.' in Table 3) in Yanbaru (*Y. Itô*).

growth is apparently larger than that in the intact forest, this is due to an outbreak of small insects, which are not normal inhabitants of the natural forest but are aliens feeding on rotten logs or herbs, invading into the 'gaps' of forests without undergrowth. Some species of oribatid mites decreased or disappeared from the forests with no undergrowth but this was not the case for other species. Table 5 shows that all of the species affected by the removal of undergrowth (except for *Pergalumna intermedia*) are known only from the Ryukyu Archipelago or Yanbaru (including two newly-described species), while all those unaffected by undergrowth removal (except for *Dimidiogalumna azumai*) are cosmopolitan or widely-distributed species. This finding suggests that many endemic small animals have been seriously damaged by the removal of undergrowth, and some of them might have become extinct already.

Other problems associated with clear-cutting and undergrowth removal are the destruction of 'living reservoirs' (forests) and soil erosion. Chronic water shortage is a major social problem in Okinawa and the government has established many reservoirs in an attempt to address it. Without good natural forests, however, reservoirs cannot receive a constant supply of water. Heavy rainfalls generated by typhoons, which are quite common in Okinawa, may soak through several layers of leaves and accumulate in the soil, which is bound by a high density of roots. Undergrowth removal, however, deprives the watershed of this sponge-like effect. Erosion of soil into the coastal ecosystem kills corals and inhibits their recovery, and no large living coral reef remains around Yanbaru today (Ohmija, 1997). The estuaries of about 80 per cent of rivers in the Yanbaru area have been blocked by the soil and sand (Itô, 1995, 1997a). Although water can pass into the sea through infiltration, diadromous fish and crustaceans, including several endemic species, are thus unable to swim up to rivers or to return to the sea.

During the 20th century, the NTA provided large natural areas for the conservation of biodiversity and endemic species. However, a new problem arose in 1999. According to The Special Action Committee on Okinawa (by the governments of Japan and the USA), the northern portion of the NTA will be returned to Japan. Following a request from the US Government, the DFAA is planning to construct seven helipads in southern part of the NTA area. The sites proposed are shown in Fig. 1; both lie in Yanburu's best natural forest areas. The individual helipads are not very large (75 m in diameter), but numerous access roads for construction and maintenance will break up existing habitats, and noise from helicopters and lorries will interrupt breeding activities and the movement of mammals, birds and amphibians. We do not know why the US Marine Corps or the DFAA selected these two sites given the existence of large areas of secondary forest (none of the endemic species shown in the Appendix are present in these areas) occupied by the US Government in the middle of Okinawa Hontô.

The Ecological Society of Japan, The Entomological Society of Japan and The Ornithological Society of Japan drew up a series of recommendations to the DFAA, urging it to reconsider the location of the proposed sites. Furthermore, during the 43rd annual congress of the Japanese Society of Applied Entomology and Zoology in April 1999, members of the Society started a petition to request the DFAA to reconsider its plans. The petition was signed by 677 members and was handed to Mr. K. Omori, Secretary Officer of DFAA, on 9 July 1999. Mr. Omori replied that 'we will carefully consider the biota of proposed sites before making the final decision', but there is still a risk that nothing will be done to revise the plans. Under the 1960 Sikes Act (USA), activities and manipulations that would cause serious destruction of endemic biota in military bases can be halted. We hope that our colleagues in the USA and other countries will support our attempts to mitigate the extinction of a large number of endangered animals and plants in Okinawa.

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Appendix

Species of terrestrial Vertebrata living on Okinawa Hontô, including their distribution and categories according to new Red Lists (RDB) (1997 and 1998) of the Environmental Agency, Japan and IUCN.

Only Extinct (EX), Critically Endangered (CE), Endangered (E) and Vulnerable (V) species are shown. IUCN categories are shown in parentheses. Species or subspecies that are endemic to an island or the Yanbaru area are indicated by '(end)' or '(end, subsp.)' in the column entitled 'Distribution & endemism'. The Yanbaru area in the northern part of Okinawa Hontô is abbreviated to 'Yanb'. For mammals, reptiles and amphibians, all species shown listed as 'R (end)' or 'N-MR (end)', except the Asian common bat, are found in Yanburu.

Source of nomenclature: mammals—Abe *et al.*, 1994; birds—McWhirter *et al.*, 1996; Ornithological Society of Japan, 1997; reptiles—Ota, 2000; amphibians—Ota, 2000.

Species	Distribution & endemism*	RDB category in Japan (& IUCN)
Mammals		
Watase's shrew *Crocidura watasei*	N-MR (end)	
Ryukyu musk shrew *Suncu murinus temminckii*	R (introduced?)	
Ryukyu flying-fox *Pteropus dasymallus inopinatus*	O (end, subsp.)	
Okinawa flying-fox *Pteropus loochoensis*	O (end)	EX (EX)
Okinawa least horseshore bat *Rhinolophus pumilis*	O, M (end)	E
Yanbaru whiskered bat *Myotis yanbarensis* (n.s.)†	Yanb (end)	CE
Asian common bat *Pipistrellus abramus*	R	
Ryukyu tube-nosed bat *Murina ryukyuana* (n.s.)†	Yanb (end)	E
Rykyu bent-winged bat *Miniopterus fuscus*	A, T, O, Y (end)	E
Okinawa spiny rat *Tokudaia osimensis muenink*	Yanb (end, subsp.)	CE (E)
Ryukyu long-haired rat *Diplothrix legata*	A, T, Yanb (end)	E
Ryukyu mouse *Mus caroli*	O	
Okinawan wild boar *Sus scrofa riukiuanus*	R	
Six introduced species: *Rattus rattus*, *R. norvegicus*, *Mus musculatus*, *Herpestes javanicus* (mongoose), feral cat and dog.		
Birds (species breeding in forests and woods of Yanbaru are shown. Winter visitors, migrants and stragglers are excluded. *Passer montanus* and species belonging to the following seven families: Pedicipedidae, Ardeidae, Anatidae, Rostratulidae, Charadriidae, Apodidae and Hirundinidae are not shown although some species of these families breed on Okinawa Hontô). Species that are known to breed in Yanbaru forest are indicated thus: •. Some subspecies endemic to the Ryukyu Archipelago but with no English name for the subspecies are described as '(R subsp.)' in the 'Species' column.		
Japanese lesser sparrow hawk *Accipiter gularis*	R (end) •	
Barred Bottonquail Turnix suscitator	R	
Okinawa rail *Gallirallus okinawae*	Yanb (end) •	E (E)
Ruddy crake (R subsp.) *Porzana fusca phaepyga*	R (end, subsp.)	
Common gallinule *Gallinula chloropus*	R	
Amami woodcock *Scolopax mira*	A, T, O (end) •	E (V)
Japanese wood pigeon *Columba janthina*	R •	
Ryukyu wood pigeon *Columba jouyi*	R (end)	EX (EX)
Oriental turtle dove (R subsp.) *Streptopelia orientalis stimpsoni*	R (end, susbsp.) •	
Red-capped green pigeon (R subsp.) *Sphenurus formosae permagnus*	O (end, subsp.) •	
Ryukyu scops owl *Otus elegans elegans*	O (end, subsp.) •	
Collared scops owl *Otus lempiji pryeri*	R (end, subsp.) •	V
Brown hawk owl (R subsp.) *Ninox scutulata totogo*	R (end, subsp.) •	
Ruddy kingfisher (R subsp.) *Halcyon coromanda bangsi*	R (end, subsp.) •	
Common kingfisher *Alcedo atthis*	R	
Noguchi's woodpecker *Sapheopipo noguchii*	Yanb (end) •	CE (CE)
Japanese pigmy woodpecker (R subsp.) *Dendrocopos kizuki nigrescens*	O (end, subsp.) •	
Ryukyu minivet *Pericrocotus divaricatus tegimae*	R (end subsp.) •	
Brown-eared bulbul (R subsp.) *Hypsipetes amaurotis pryeri*	R (end, subsp.) •	
Ryukyu robin *Erithacus komadori namiyei*	Yanb (end, subsp) •	V
Blue rockthrush *Montocola solitarius philippensis*	R	
Japanese bush warbler (R subsp.) *Cettia diphone riukiuensis*	R (end, subsp.) •	
Fan-tailed warbler *Cisticola juncidis*	R	
Narcissus flycatcher (R subsp.) *Ficedula narcissima owstoni*	R (end, subsp.) •	
Black paradise flycatcher (R subsp.) *Terpsiphone atrocaudata illex*	O, M, Y (end, susbsp.) •	
Varied tit (R subsp.) *Parus varius amamii*	R (end, subsp.) •	

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Appendix (Continued)

Species	Distribution & endemism*	RDB category in Japan (& IUCN)
Great tit (R subsp.) *Parus major okinawae*	O (end, subsp.) †	
Japanese white eye (R subsp.) *Zosteropus japonicus loochooensis*	O, M, Y (end, subsp.) †	
Jungle crow (R subsp.) *Corvus macrorhynchos connectens*	O, M, Y (end. subsp.) †	
Two introduced species: *Amaurornis phoenicurus* and *Lonchura punctualata*.		
Reptiles		
Japanese black-breasted leaf turtle *Geoemyda japonica*	O and islands near O (Kerama Islands, Kume Is. (end)	V (E)
Stump-toed gecko *Gehyra mutilata*	R	
Hokou gecko *Gekko hokouensis*	R	
House gecko *Hemidactylus frenatus*	R	
Bowring's gecko *Hemidactylus bowringii*	R	
Kuroiwa's ground gecko *Goniurosaurus kuroiwae kuroiwae*	O (end, subsp)	V (V)
Okinawan tree lizard *Japalura polygonata polygonata*	N-MR (end, subsp.)	V
Okinawa blue-tailed skink *Eumeces marginatus marginatus*	O (end, subsp.)	
Barbour's blue-tailed skink *Eumeces barbouri*	N-MR (end)	V
Ryukyu short-legged skink *Ateuchosaurus pellopleurus*	N-MR (end)	
Green grass lizard *Takydromus smaragdinus*	N-MR (end)	
Brahminy blind snake *Ramphotyphlops braminus*	R	
Ryukyu odd-scaled snake *Achalinus weneri*	N-MR (end)	
Ryukyu green snake *Cyclophiops semicarinatus*	N-MR (end)	
Ryukyu odd-tooth snake *Dinodon semicarinatum*	N-MR (end)	
Pryer's keelback snake *Amphiesma pryeri*	N-MR (end)	
Okinawan coral snake *Hemibungarus japonicus boettgeri*	N-MR (end, subsp.)	
Habu *Trimeresurus flavoviridis*	N-MR (end)	
Himehabu *Ovophis okinavensis*	N-MR (end)	
Eight introduced species: *Chinemys reevesii*, *Trachemys scripta*, *Mauremys mutica*, *Pelodiscus sinensis*, *Lepidodactylus lugubris*, *Anolis carolinensis*, *Elaphe taeniura* and *Trimeresurus mucrosquamatus*.		
Amphibians		
Anderson's crocodile newt *Tylototriton andersoni*	N-MR (end)	V (E)
Sword-tailed newt *Cynops ensicauda*	N-MR (end)	
Hallowell's tree frog *Hyla hallowellii*	N-MR (end)	
Ryukyu brown frog *Rana okinavana*	N-MR (end)	
Indian rice frog Rana limnocharis limnocharis	R	
Ryukyu tip-nosed frog *Rana narina*	Yanb (end)	V
Namie's frog *Rana namiyei*	Yanb (end)	V (V)
Ishikawa's frog *Rana ishikawae*	A, Yanb (end)	E (V)
Holst's frog *Babina holsti*	O (end)	E (V)
Okinawa green frog *Rhacophorus viridis viridis*	O (end)	
Ryukyu kajika frog *Buergenia japonica*	R	
Ornate narrow-mouthed toad *Microhyla ornata*	R	
Two introduced species: *Rana catesbeiana* and *Polypedates leucomystax*.		
Appendix		
Insect		
Giant long-armed beetle *Cheirotonus jambar*	Yanb (end)	CE

* Localities—O: Okinawa Hontô (sometimes including small islets near O); A: Amami-Oshima Islands; T: Tokunoshima Islands; M. Miyako Islands; Y: Yaeyama Islands; R: Whole part of the Ryukyu Archipelago; N-MR: Amami Islands and Okinawa Islands, including Kume Islands and Kerama Islands.

† Species newly described in 1998 (Maeda & Matsumura, 1998). They have been seen so far only in the NTA of Yanbaru, although one or two of them may also occur on Amami-Oshima as well (K. Maeda, pers. comm.).

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