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Abstract: *New World Conservation Union criteria for globally threatened status are applied to the Anatidae (ducks, geese, and swans) at the subspecific level. Various characteristics of the 48 threatened taxa are considered. These taxa are compared to the 180 taxa that are nonthreatened to explain what aspects of a taxon's distribution, migration pattern, and habitat use make it likely to be globally threatened. Habitat loss, hunting, and exotic introductions are the major causes of globally threatened status, affecting 73%, 48%, and 33% of threatened Anatidae respectively. Although the habitat use patterns of threatened and nonthreatened Anatidae are similar, inland lentic wetland and forest inhabitants are most threatened by habitat loss, whereas marine ecosystem, grassland, tundra, arable land, and scrub dwellers are least threatened. Insular taxa are more likely to be threatened or extinct than taxa occurring on continental land masses. Nonmigratory taxa are more likely to be threatened or extinct than migratory taxa, but there is no significant difference when insular taxa are excluded from the analysis. Taxa with their breeding distribution centered above a latitude of 20° north are less threatened than those found farther south. Taxa with their breeding distribution centered at or above 55° north are even less threatened. Russia holds 14 threatened Anatidae taxa, more than any other country. There is an exceptional concentration of 7 threatened, migratory taxa confined to the east-Asian flyway. Despite the fact that the Ramsar Convention was established with the conservation of the Anatidae in mind, only 31% of globally threatened taxa have ever been recorded on the world's 685 Ramsar sites. For the 21 highly threatened taxa this proportion drops to 10%. Compared with globally threatened birds in general, the threatened Anatidae have a different geographical distribution but share habitat loss as the most important threat. Hunting and introductions are more important threats to the Anatidae, and trade and small population ranges are less important. All these findings have important implications for waterbird and wetland conservation programs.*

Análisis de la globalmente amenazada Anatidae en relación con amenazas, distribución, patrones de migración y uso del hábitat

Resumen: *Los nuevos criterios de la Unión Mundial para la Naturaleza para los taxones globalmente amenazados se aplican a las Anátidas (patos, gansos y cisnes) a nivel subespecífico. Se consideran varios caracteres de los 48 taxones en peligro de extinción. Se comparan estos taxones con los 180 que no están amenazados para explicar qué aspectos de la distribución del taxón, pauta de migración y uso del hábitat lo convierten en objeto de amenaza global. La pérdida del hábitat, la caza y la introducción de especies exóticas son las causas principales del estatus de globalmente amenazado, que afecta al 73%, 48% y 33% de las Anátidas amenazadas respectivamente. Aunque el uso del hábitat por parte de las Anátidas tanto amenazadas como no es similar, los humedales interiores lénticos y los bosques son los hábitats más amenazados, mientras que los ecosistemas marinos, los pastizales, la tundra, la tierra de cultivo y el matorral son los que menos peligro sufren. Los taxones insulares están más amenazados de extinción que los de los que habitan las extensiones terrestres continentales. Los taxones no migratorios sufren más probabilidades de amenaza o de ex-*

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tinción que los migratorios, pero no hay diferencias significativas cuando los taxones insulares se excluyen del análisis. Los taxones cuya distribución se centra por encima de los 20°N están menos amenazados que los situados más al sur. Aquellos cuya área de cría está centrada en o por encima de los 55°N están incluso menos amenazados. Rusia contiene 14 taxones de Anátidas amenazadas, más que cualquier otro país. Hay una concentración excepcional de siete taxones migratorios confinados a la ruta oriental asiática. A pesar de que la Convención Ramsar se fundó con el objetivo de la conservación de las Anátidas, solamente alguna vez se ha registrado el 31% de los taxones globalmente amenazados en todos los 685 sitios Ramsar del mundo. Para los 21 taxones en el máximo peligro de extinción, esta proporción cae hasta el 10%. En comparación con las aves globalmente amenazadas en general, las Anátidas amenazadas tienen una distribución geográfica distinta, pero comparten la pérdida del hábitat como la amenaza más importante. La caza y las introducciones representan las amenazas relativamente más importantes para las Anátidas, mientras que el comercio y las áreas de distribución o poblaciones pequeñas son relativamente las menos. Todos estos hallazgos suponen implicaciones importantes para los programas de conservación de aves acuáticas y zonas húmedas.

Introduction

The role of demographic and life-history variables in determining the extinction risk of populations has been studied extensively (Terborgh & Winter 1980; Pimm et al. 1988; Laurance 1991), and the results have been applied in a revision of the threatened species categories used by the World Conservation Union (IUCN; Mace & Lande 1991; Mace & Stuart 1994). A final version of the revised categories has recently been formally adopted by The World Conservation Union (1994).

Studies comparing Red Lists of threatened animals and plants with nonthreatened taxa have usually been restricted to a small region (Lahti et al. 1991; Berg et al. 1994). Studies of the biology and distribution of threatened organism groups at a global level, which are important for nature conservation, are lacking (see, however, Laurila & Järvinen 1989). One reason for this is that data on the status of organisms are usually lacking in some parts of the world. Information on the status and biology of the Anatidae (ducks, geese, and swans) is relatively good on a worldwide scale (del Hoyo et al. 1992; Rose & Scott 1994). In this study the new IUCN red list categories (World Conservation Union 1994) are applied to the Anatidae at the subspecific level to produce a list of the globally threatened taxa. This list is justified in detail elsewhere (Green 1996) and follows from earlier attempts to identify the globally threatened Anatidae (Ellis-Joseph et al. 1992; Green 1992; Callaghan & Green 1993), which used an earlier version of the proposed new IUCN criteria (Mace & Lande 1991).

Humans have long had a unique relationship with the Anatidae, reflected in their widespread harvesting for food, domestication, breeding in captivity, and their influence on human culture (Kear 1990). In modern times conservationists have paid particular attention to Anatidae to minimize the impact of recreational hunting (Moser et al. 1993) and to attempt to resolve increasing problems of agricultural damage (van Roomen & Madsen 1992). The Anatidae have acquired great importance as flagships for wetland conservation (Kear 1990), and concern for their status was central to the adoption of the first global treaty for nature conservation (Matthews 1993), the Ramsar Convention (Convention on Wetlands of International Importance, especially as Waterfowl Habitat [Ramsar 1971]).

I consider the various threats facing the globally threatened Anatidae in order to establish which factors are most responsible for putting Anatidae at risk of extinction. I analyze the distribution of globally threatened taxa, identifying those countries and regions where they are concentrated. Their distribution is related to that of the growing network of wetlands protected under the Ramsar Convention to establish what protection this network provides to globally threatened Anatidae. I also compare the distribution and threats facing the globally threatened Anatidae and those for all globally threatened birds, using analyses recently conducted by Collar et al. (1994) for all threatened bird species (only 2% of which are Anatidae).

The globally threatened Anatidae are compared to the nonthreatened Anatidae in an effort to identify parameters related to extinction risk, as identified by the IUCN categories. It is well known that extinction risk is correlated with population size, range size, extent of fragmentation, and extent of population fluctuation, and the new IUCN criteria are based on such parameters (Mace & Lande 1991; World Conservation Union 1994). Thus, these parameters will obviously differ for threatened and nonthreatened taxa. Previous work has shown that there are no clear differences between globally threatened and nonthreatened Anatidae taxa in terms of life-history traits such as body size and clutch size (Laurila & Järvinen 1989). This study compares parameters of distribution, habitat use, and migration patterns. Island birds have been found to have a high extinction risk (Moors 1985; Terborgh & Winter 1980), and I compare the status of insular and noninsular Anatidae. I also compare the latitudinal breeding distribution of threatened and nonthreatened Anatidae to identify the consequences of the concentration of economically developed countries and of arctic and subarctic land masses (exploited for breeding by migratory Anatidae) in the northern hemisphere. Anatidae are recorded in a wide range of habitat

types, and different rates of destruction seem likely to make taxa using certain habitats more prone to extinction than others. Thus, I compare the habitat use of threatened and nonthreatened taxa and consider the significance of habitat loss as a threat. It might be predicted that migratory taxa are more likely to be threatened because they are dependent on different areas during the breeding season, winter, and migration. A threat operating in just one of these areas could have a severe impact (Salathé 1991). Therefore, I compare the status of migratory and nonmigratory Anatidae. I am aware of only one previous study in which migrant or resident status has been related to extinction risk in birds (Pimm et al. 1988). The results of these analyses have important implications for waterbird and wetland conservation programs and will be influential in shaping an IUCN action plan for the Anatidae, which is currently being prepared by the Wetlands International and The Wildfowl & Wetlands Trust.

Methods

The new IUCN criteria (World Conservation Union 1994) were applied to all Anatidae at the subspecies level (Green 1996). The members of the Anatidae family considered follow the taxonomy of Morony et al. (1975). The list of subspecies considered is that of Madge and Burn (1988) and del Hoyo et al. (1992). The three globally threatened categories are, in order of increasing risk of extinction, vulnerable (VU), endangered (EN), and critically endangered (CR). A taxon can qualify for threatened status by meeting any of several criteria that address rates of decline, population size, range size, extent of fragmentation, and nature of demographic fluctuations (Mace & Lande 1991; see World Conservation Union [1994] for details of the criteria and categories). Some Anatidae taxa are assigned the category of extinct (EX) because there is no reasonable doubt that the last individual has died. Those extant taxa that do not satisfy the criteria for any of the three threatened categories are categorized as lower risk (LR).

Data on distribution, migratory status, and habitat use patterns for all Anatidae taxa were taken from Madge and Burn (1988), Marchant and Higgins (1990), del Hoyo et al. (1992), Green (1992), and Callaghan and Green (1993). Ramsar site directories (Ramsar 1990; Jones 1993) together with access to the Ramsar site database held by the Wetlands International at Slimbridge, United Kingdom, identified which threatened taxa are recorded on the 685 wetlands in the world that are protected by the Ramsar Convention.

I divided taxa into those that are migratory and nonmigratory, using a broad definition of migratory which included all those taxa that regularly undergo movements across national frontiers, including partial migrants. Taxa making predictable, long-distance movements between breeding and wintering grounds that do not cross national frontiers (e.g. the Aleutian Canada Goose [*Branta canadensis leucopareia*]) were also included. Taxa that have both migratory and nonmigratory populations were categorized as migratory. Taxa were divided into those restricted to islands and those not restricted to islands. I used two size classes of islands: small islands with an area of up to 20,000 km^2 (including the Falkland Islands [to United Kingdom] and the Kerguelen Islands [to France]) and large islands with an area of between 20,000 km^2 and 1,000,000 km^2 (including Madagascar, New Guinea, and Borneo). Two taxa restricted to small islands, but only during the breeding season (the Recherche Cape Barren Goose [*Cereopsis novaehollandiae grisea*] and the Aleutian Canada Goose), were regarded as small-island taxa.

In analyses of habitat use I used the following broad categories of habitat type: forest (including woodland and mangroves); marine environment (including sea shores and estuaries); lake wetlands (all inland lentic wetlands, including reservoirs, swamps, and ricefields); river wetlands (all inland lotic wetlands); grasslands (including steppes and pasture); arable land (plowed, agricultural land); tundra; and scrub. Only those habitats in regular use by Anatidae are assigned to a taxon, so a complete list of all habitat types on which the taxon has ever been recorded is not included.

The threats assigned to each taxon are those considered the major causes of its globally threatened status (Green 1992; Callaghan & Green 1993; Green 1996) and do not give a complete list of all those negative factors that are impinging on the taxon. The various threats are divided into the categories used by Collar et al. (1994) for all threatened bird species, with the exception that a threat of hybridization due to the introduction of a closely related taxon is treated separately from other effects of exotic introductions (of predators, competitors, introduced plants, *etc.*). "Habitat loss" includes all kinds of habitat alteration apart from pollution. "Hunting" includes egg-collecting, accidental trapping, and other kinds of persecution. "Small range" includes small population and is only listed as a threat when it is the principal reason the taxon qualifies for globally threatened status. "Pollution" includes poisoning from pesticides or other chemicals. Statistical analyses were conducted using χ^2 tests on contingency tables, joining some categories in habitat analyses in order to prevent excessively low expected frequencies (Siegel & Castellan 1988).

Results

Threatened Anatidae

Forty-eight Anatidae taxa are globally threatened (27 vulnerable [VU], 12 endangered [EN], 9 critically endangered

Table 1. The Anatidae taxa categorized as globally threatened or extinct, using IUCN criteria (World Conservation Union 1994).

Common name	*Latin name*	*Category*[a,b]	*Criteria*[b]	*Threats*[c]	*Ramsar*[d]
New Britain Whistling Duck	*Dendrocygna arcuata pygmaea*	CR	C2b;D	L, I	
Black-billed Whistling Duck	*Dendrocygna arborea*	VU	C1;C2a	H, L	B
Madagascar White-backed Duck	*Thalassornis leuconotus insularis*	VU	A1ce;C1	H, L, I	
Recherche Cape Barren Goose	*Cereopsis novaehollandiae grisea*	CR	C2b	U	
Swan Goose	*Anser cygnoides*	VU	A1cd;A2cd	L, H	B
Middendorf's Bean Goose	*Anser fabalis middendorfi*	VU	A1acd;C1	L, H	Y
Thick-billed Bean Goose	*Anser fabalis serrirostris*	VU	A1acd	L, H	Y
Tule Goose	*Anser albifrons gambelli*	VU	D2	S	
Lesser White-fronted Goose	*Anser erythropus*	VU	A1acd	U, L, H	B
Hawaiian Goose	*Branta sandvicensis*	EN	B1+2bde;C2a	I, L	
Aleutian Canada Goose	*Branta canadensis leucopareia*	VU	D2	I	
Dusky Canada Goose	*Branta canadensis occidentalis*	VU	D2	L, H	
Red-breasted Goose	*Branta ruficollis*	VU	A2c;B1+2bcd	L	Y
Freckled Duck	*Stictonetta naevosa*	VU	C1	L	B
Crested Shelduck	*Tadorna cristata*	CR	D	U, S	
Blue Duck	*Hymenolaimus malacorhynchos*	EN	C2a	L, I	
Columbian Torrent Duck	*Merganetta armata columbiana*	EN	C2a	L, P, I	
Peruvian Torrent Duck	*Merganetta armata leucogenis*	VU	C1;C2a	L, P, I	
White-winged Duck	*Cairina scutulata*	EN	C2a	L	
Australian Cotton Pygmy Goose	*Nettapus coromandelianus albipennis*	EN	C2b	L, I	
Salvadori's Duck	*Salvadorina waigiuensis*	VU	C1;C2a	L, H	
Coue's Gadwall	*Anas strepera couesi*	EX		U	
Baikal Teal	*Anas formosa*	VU	A1abcde	H, P	Y
Merida Speckled Teal	*Anas flavirostris altipetens*	VU	C1;C2b	L, H	
Andean Speckled Teal	*Anas flavirostris andium*	VU	C1;C2b	L, H	
Madagascar Teal	*Anas bernieri*	EN	C2b	L	
Andaman Teal	*Anas gibberifrons albogularis*	CR	C2b	L, H	
Rennell Island Grey Teal	*Anas gibberifrons remissa*	EX		I	
Auckland Island Teal	*Anas aucklandica aucklandica*	VU	D2	I	
Brown Teal	*Anas aucklandica chlorotis*	EN	A1ace;B1+2abcde	I, L	
Campbell Island Teal	*Anas aucklandica nesiotis*	CR	C2b;D	I	
Marianas Mallard	*Anas platyrhynchos oustaleti*	EX		L, H	
Laysan Duck	*Anas laysanensis*	CR	B1+3d;D	L, I, S	
Meller's Duck	*Anas melleri*	VU	A2cd;C1;C2b	L, H	
New Zealand Grey Duck	*Anas superciliosa superciliosa*	EN	A1bce;A2bce	I, Z	B
Philippine Duck	*Anas luzonica*	VU	A1abcd;A2cd	L, H	
Crozet Island Pintail	*Anas eatoni drygalskii*	EN	B1+2bde	I	
Kerguelen Island Pintail	*Anas eatoni eatoni*	VU	A2e	I	
Niceforo's Pintail	*Anas georgica niceforoi*	EX		U	
Tropical Cinnamon Teal	*Anas cyanoptera tropica*	EN	C2b	L, H	
Borrero's Cinnamon Teal	*Anas cyanoptera borreroi*	CR	C2b	L, H	
Marbled Teal	*Marmaronetta angustirostris*	VU	A2c	L, H	B
Pink-headed Duck	*Rhodonessa caryophyllacea*	EX		U, L	
Banks Island Hardhead	*Aythya australis extima*	VU	D2	U, S	
Baer's Pochard	*Aythya baeri*	VU	A1acd;C1;C2b	L, H	B
Ferruginous Duck	*Aythya nyroca*	VU	A1abcd	L, H	B
Madagascar Pochard	*Aythya innotata*	CR	B1+2e;C2b;D	L, H	
Steller's Eider	*Polysticta stellerii*	VU	A1ab	U	Y
Spectacled Eider	*Somateria fischeri*	EN	A1b	U	
Labrador Duck	*Camptorhynchus labradorius*	EX		U	
Brazilian Merganser	*Mergus octosetaceus*	CR	C2a;D	L	
Scaly-sided Merganser	*Mergus squamatus*	EN	C2b	L, H	Y
Auckland Islands Merganser	*Mergus australis*	EX		H, I	
White-headed Duck	*Oxyura leucocephala*	VU	A2e	L, H, Z	B
Colombian Ruddy Duck	*Oxyura jamaicensis andina*	VU	C1,C2b	L	

[a] *Vulnerable, VU; endangered, EN; critically endangered, CR; and extinct, EX.*
[b] *See World Conservation Union (1994) for details.*
[c] *Unknown, U; loss of habitat, L; hunting, H; introduced species, I; hybridization, Z; small range, S; pollution, P.*
[d] *Recorded breeding on Ramsar sites, B; recorded on Ramsar sites, but not breeding, Y.*

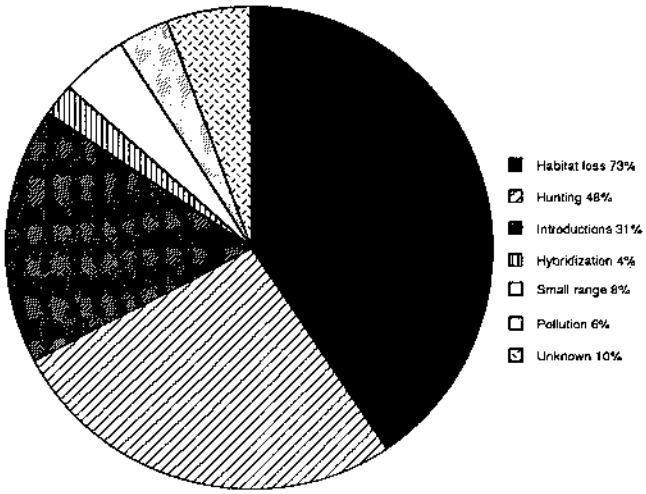

Figure 1. Threats affecting the 48 globally threatened Anatidae taxa, and the percentage of taxa affected by each threat.

[CR]), 180 are lower risk, and 7 have gone extinct in recent times (Table 1). Of the various threats facing the globally threatened Anatidae (Table 1), habitat loss is the most important, affecting 73% of taxa (Fig. 1). Hunting, which affects 48% of taxa, and exotic introductions (excluding hybridization problems), which affects 31% of taxa, are the two other major threats. When hybridization is considered together with other problems caused by introductions, collectively they affect 33% of threatened taxa.

Distribution

I identified those countries that hold the largest number of threatened (VU, EN, or CR) and highly threatened (EN or CR) Anatidae taxa (Table 2). With 14 taxa, Russia has the most threatened Anatidae. The seven countries with the most threatened Anatidae are in the Northern Hemisphere, but only 56% of all threatened Anatidae taxa have their breeding distribution centered in the northern hemisphere. Five of the seven countries with the most threatened taxa are in east Asia because a set of seven threatened, migratory taxa is confined to this region. The rankings for highly threatened taxa are different: New Zealand, Colombia, Madagascar, and Australia have more Anatidae taxa in this category than China, Japan, North Korea, and South Korea (Table 2). Three of the seven countries with the most highly threatened taxa are in the Southern Hemisphere.

Table 2. Countries holding the most globally threatened (vulnerable, endangered, or critically endangered) and highly threatened (endangered or critically endangered) Anatidae taxa.

Threatened taxa			*Highly threatened taxa*		
Country	*Taxa*[a]	*Rank*[b]	*Country*	*Taxa*[a]	*Rank*[b]
Russia	14	16	New Zealand	4	13
China	11	4	USA	3	4
Japan	8	18	Russia	3	28
USA	7	9	Colombia	3	3
India	7	5	India	2	12
North Korea	7	36	Madagascar	2	18
South Korea	7	33	Australia	2	14

[a] *Number of taxa.*
[b] *Equivalent ranking for each country calculated for all threatened bird species (Collar et al. 1994).*

There is little similarity between the importance of a country for threatened Anatidae and its importance for all threatened bird species. Four of the seven countries with the most threatened Anatidae rank sixteenth or below for all birds (Table 2).

The proportion of threatened taxa restricted to big or small islands is much higher than the proportion of lower-risk taxa (Fig. 2). Whereas only 14% of extant, noninsular Anatidae taxa (n = 194) are threatened, 62% of extant, insular taxa (n = 34) are threatened (χ^2 = 37.02, df = 1, $p < 0.001$). Hence, a taxon restricted to an island is much more likely to become globally threatened, and the smaller the island the more threatened the taxon (Fig. 2). Similarly, most Anatidae extinctions have been of taxa confined to small islands (Fig. 2).

The status of Anatidae taxa with breeding distributions centered above a latitude of 20°N was considered because all the developed countries (United Nations

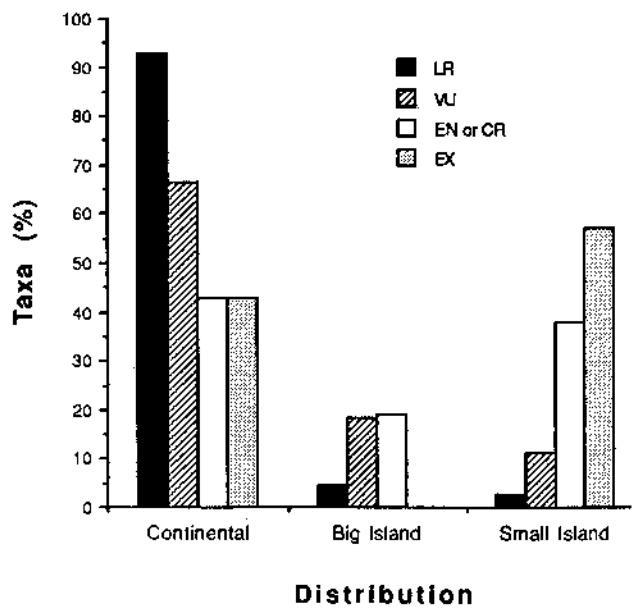

Figure 2. Percentage of lower risk (LR), vulnerable (VU), highly threatened (endangered [EN] or critically endangered [CR]) and extinct (EX) Anatidae taxa that are restricted to small islands (< 20,000 km^2), restricted to big islands (< 1,000,000 km^2), and found on continental land masses.

classification) of the Northern Hemisphere occur above it. Only 18% (n = 108) of taxa with breeding distributions centered above 20°N are globally threatened, compared with 24% (n = 120) of the taxa with breeding distributions that occur farther south (χ^2 = 1.11, df = 1, NS). Only 5% of taxa centered above 20°N are highly threatened (EN or CR), compared with 13% of the taxa occurring farther south (χ^2 = 4.16, df = 1, $p < 0.05$). Thus, Anatidae taxa breeding in the great land masses of North America and Eurasia are less likely to be highly threatened than those breeding farther south. This is particularly true of taxa whose breeding range is in the extreme north, centered at or above a latitude of 55°N. Only 13% (n = 68) of these taxa are threatened, compared with 24% (n = 161) of taxa occurring farther south (χ^2 = 2.92, df = 1, NS). Only 1% of taxa centered above 55°N are highly threatened, compared with 13% of the taxa occurring farther south (χ^2 = 5.69, df = 1, $p < 0.02$).

Only 31% of globally threatened Anatidae have ever been recorded on Ramsar sites, and only 19% have been recorded breeding on them (Table 1). Only 10% of highly threatened taxa have been recorded on Ramsar sites (Table 1). Of 33 threatened taxa not recorded on Ramsar sites, 23 have at least one range state that is a contracting party to the convention and is thus able to designate sites.

Whereas 63% of threatened taxa with breeding distributions centered above 20°N (n = 19) are recorded on Ramsar sites, only 10% of threatened taxa occurring farther south (n = 29) are recorded on Ramsar sites (χ^2 = 12.55, df = 1, $p < 0.001$). Similarly, 71% of migratory, threatened Anatidae (n = 17) are recorded on Ramsar sites, whereas only 10% of nonmigratory, threatened Anatidae (n = 31) are recorded on Ramsar sites (χ^2 = 16.23, df = 1, $p < 0.001$). This bias toward covering northern and migratory taxa on Ramsar sites is largely explained by the distribution of sites: 80% are located above 20°N. Although all migratory, threatened taxa have breeding distributions centered above 20°N, this is true for only 6% of nonmigratory, threatened taxa.

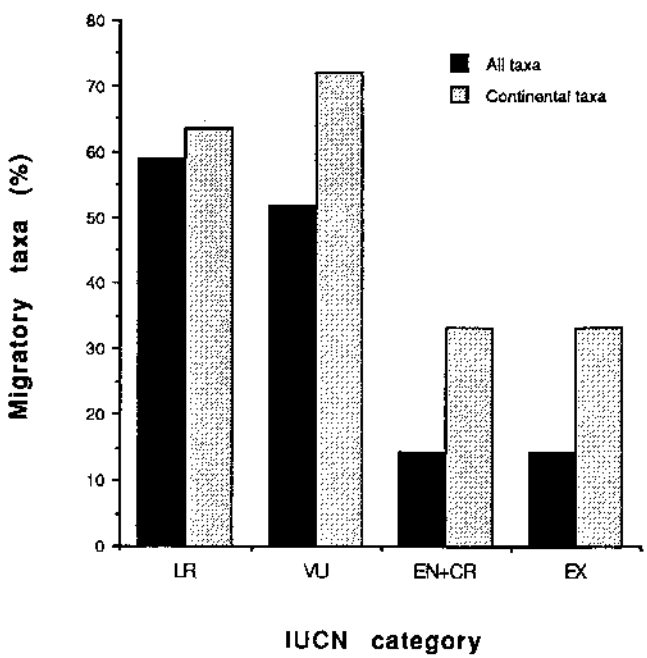

Figure 3. Percentage of lower risk (LR), vulnerable (VU), highly threatened (EN or CR) and extinct (EX) Anatidae taxa that are migratory, for all Anatidae taxa and for those found on continental land masses.

Migration Patterns

Migratory Anatidae taxa are less likely to be threatened and much less likely to be highly threatened than nonmigratory taxa (Fig. 3). Only 14% of migratory taxa (n = 123) are threatened, whereas 30% of nonmigratory taxa (n = 105) are threatened (χ^2 = 7.49, df = 1, $p < 0.01$). Only 2% of migratory taxa are highly threatened (EN or CR), compared with 17% of nonmigratory taxa (χ^2 = 12.94, df = 1, $p < 0.001$). Whereas 54% of extant taxa are migratory, only one of seven (14%) extinct taxa is migratory (the Labrador Duck [*Camptorhynchus labradorius*]).

To find out if these results were a consequence of the higher extinction risk facing nonmigratory, insular taxa, I repeated the analysis using only taxa occurring on continental land masses (Fig. 3). Whereas 13% of continental, migratory taxa (n = 122) are threatened, 15% of continental, nonmigratory taxa (n = 72) are threatened (χ^2 = 0.04, df = 1, NS). Only 2% of continental, migratory taxa are highly threatened, compared with 8% of continental, nonmigratory taxa (χ^2 = 2.33, df = 1, NS). Thus, among continental taxa, the nonmigratory ones are more threatened but not significantly so. Only one out of three continental, extinct taxa is migratory.

Patterns of Habitat Use

Habitat-use patterns are similar for threatened and lower-risk taxa (Fig. 4a), and the differences are not statistically significant (χ^2 = 6.22, df = 6, NS). In my comparison the impact of different rates of loss of different habitat types on the Anatidae taxa may be obscured because many threatened taxa are not threatened by habitat loss but by other factors (Fig. 1) and because those affected by habitat loss in one habitat type often occur in other habitats at different times of the life cycle where habitat loss is not a problem.

To establish the relative importance of habitat loss in different habitats on threatened Anatidae, I compared the distribution of threatened habitats for those taxa affected by habitat loss with the distribution of unthreatened habitats (Fig. 4b). The differences in distribution

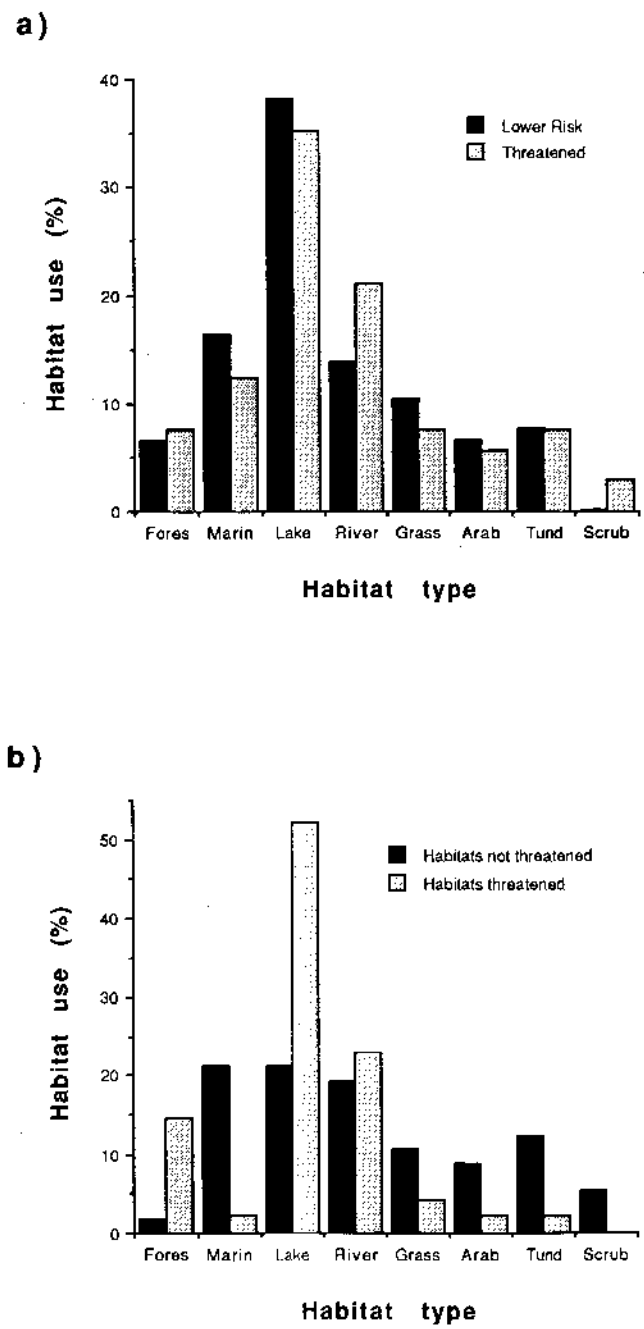

Figure 4. Comparison of the importance of different habitats for Anatidae taxa: habitat use of lower risk and globally threatened taxa (a); habitat use by globally threatened taxa only, comparing those habitats threatened by habitat loss with those not threatened by habitat loss (b). Habitat types are forests and woodlands (Fores), marine ecosytems (Marin), lake-type wetlands (all inland lentic wetlands) (Lake), river type wetlands (all inland lotic wetlands) (River), grasslands (Grass), arable land (Arab), tundra (Tund), scrub (Scrub). The y axis gives the percentage of the total number of habitat codes that are allocated to each type (each taxon may be allocated several habitat codes).

were highly significant ($\chi^2 = 29.76$, df = 5, $p < 0.001$). Forest and lentic (lake-type) habitats are most affected by habitat loss, while marine, grassland, arable, tundra, and scrub habitats are least affected.

Discussion

Distribution of Threatened and Lower-Risk Anatidae

Russia is extremely important for threatened Anatidae because it holds 14 taxa. New Zealand is particularly important for highly threatened Anatidae. It holds one critically endangered and three endangered taxa. The importance of Russia is not surprising given the particularly large number of migratory Anatidae taxa that breed there (del Hoyo et al. 1992). The overwhelming importance of east Asian countries for globally threatened Anatidae suggests there are particularly serious conservation problems for waterbirds that use the east Asian flyway. Seven threatened, migratory taxa are only found in this flyway, yet the threats affecting these taxa and the sites where these threats are operating vary considerably, and there is no single factor providing a common explanation of their threatened status. There is a need for more-effective measures in waterbird and wetland conservation in this region, which may be addressed by an agreement on the conservation of migratory waterbirds in the Asian-Pacific region being developed under the Bonn Convention (Müller-Helmbrecht 1996).

The importance of New Zealand to highly threatened Anatidae reflects the serious plight of insular taxa. New Zealand has eight endemic Anatidae taxa. The fact that Anatidae taxa restricted to islands are more likely to become globally threatened or extinct is typical of all insular birds (Moors 1985), particularly because island taxa have small ranges and are so badly affected by introduced predators. Similarly, the smaller the island, the more threatened are the Anatidae taxa because extinction risk increases with smaller range (Terborgh & Winter 1980). Six of the nine critically endangered Anatidae taxa are insular, suggesting that future extinctions of Anatidae will continue to be concentrated among island taxa.

The finding that those Anatidae taxa with a breeding distribution centered above a latitude of 20°N are relatively less threatened than those found farther south is consistent with the finding by Green (1996) that Anatidae confined to developing countries (United Nations classification) are more likely to be threatened than those occurring in developed countries. Although the extent of wetland destruction to date has probably been greater in areas above 20°N than those below it (Finlayson & Moser 1991; Scott 1993), this does not seem to have led to a greater loss of Anatidae biodiversity. This probably results largely from the fact that the many taxa breeding in the huge land masses of the northern Arctic and sub-

arctic tend to have naturally wider distributions or larger population sizes and are relatively less affected by development and hunting pressure during the breeding season owing to the low density of humans in these areas (Anonymous 1990). This explains why Anatidae taxa with breeding distributions at or above 55°N are particularly unlikely to be highly threatened.

In addition, the effective use of hunting regulations and habitat protection in developed countries has undoubtedly played an effective role in preventing some taxa from attaining globally threatened status. The Greenland White-fronted Goose (*Anser albifrons flavirostris*; Stroud 1993) and Trumpeter Swan (*Cygnus buccinator*; Conant et al. 1991) are clear examples. Although globally threatened Anatidae taxa are concentrated to the south of 20°N, conservation programs for Anatidae and their habitats have so far been concentrated to the north.

The analysis of how many globally threatened Anatidae occur on Ramsar sites shows that the existing network of Ramsar sites will make a limited contribution to preventing the extinction of these taxa. Even among those 15 threatened taxa recorded on Ramsar sites, in most cases only a small proportion of the population is protected. The three species given the most protection by Ramsar sites are all Western Palearctic duck species: the White-headed Duck (*Oxyura leucocephala*), the Marbled Teal (*Marmaronetta angustirostris*), and the Ferruginous Duck (*Aythya nyroca*). All three of these species occur on a number of Ramsar sites at different stages of the life-cycle (Jones 1993).

The Ramsar site network gives the best coverage to Anatidae taxa that are migratory and that have breeding distributions centered above 20°N, particularly those found in the western Palearctic. This is because Ramsar sites and long-standing contracting parties to the Ramsar Convention are concentrated in this region (Jones 1993), largely for historical reasons (Matthews 1993). Nevertheless, the distribution of Ramsar sites in areas supporting globally threatened Anatidae suggests that Ramsar sites have rarely been selected on the basis of their importance to these taxa, despite the fact that the Anatidae are of more historical importance in the establishment of the Ramsar Convention than any other taxonomic group of fauna or flora (Matthews 1993). The numbers of Anatidae present on a site have been more influential in determining whether or not the site is designated under the convention than the presence or absence of globally threatened taxa (see Jones 1993).

An analysis of the extent to which the entire global protected-area system protects the globally threatened Anatidae would be desirable, but readily accessible data were not available to incorporate such an analysis in this study. Numerous taxa certainly are not found in any protected areas (e.g., three threatened taxa endemic to Madagascar).

Migration Patterns

Nonmigratory Anatidae tend to be more threatened than migratory Anatidae. This is perhaps surprising because migratory taxa depend on different areas at different stages of their life-cycle and might be expected to encounter more conservation problems than residential taxa dependent on only one area (Salathé 1991). The main cause of this pattern is the existence of many threatened, nonmigratory taxa on islands. However, even among the Anatidae occurring on continental land-masses, a higher proportion of the nonmigratory taxa are globally threatened, although this difference is not statistically significant. Pimm et al. (1988) found that on small British islands migratory bird species were at greater risk of extinction than resident species. The reasons for this are not discussed by Pimm et al., but are perhaps due to a higher dispersal rate of migratory species away from small islands.

The greater threat to nonmigratory Anatidae has important implications for waterbird conservation policy. The conservation of Anatidae has strong historical roots in northern Europe and North America, where the great majority of Anatidae taxa are migratory. Consequently, considerable attention has been directed to the conservation and monitoring of migratory taxa through the development of flyway management plans, international monitoring schemes based on annual, midwinter counts, and other initiatives. The North American Waterfowl Management Plan (Blohm & Wendt 1993), the new Agreement on the Conservation of African-Eurasian Migratory Waterbirds under the Bonn Convention (Boere 1996), and the International Waterfowl Census, which covers most continents (van Vessem & Rose 1993), are specific examples.

In comparison, the conservation and monitoring of nonmigratory Anatidae have received less attention. Thus, 71% of threatened, migratory Anatidae are recorded on Ramsar sites, compared with 10% of threatened, nonmigratory Anatidae. Nonmigratory Anatidae tend to be confined to developing countries (United Nations Classification) with few economic resources for wetland and waterbird conservation and research (Green 1996), and because none of them migrates to developed countries in the Northern Hemisphere, they attract less attention from foreign donors and research programs than migratory taxa found in the same regions. For example, much more is known about the status and distribution of the Blue-winged Teal (*Anas discors*) wintering in Colombia than the various nonmigratory Anatidae found there because these Blue-winged Teal breed in North America (Botero et al. 1996).

Habitat Use

There are no clear differences in habitat use by threatened and nonthreatened Anatidae taxa. Thus, habitat

use itself is not a good predictor of whether or not a taxon is globally threatened, although this may be partly because we have used habitat categories that are too broad and insensitive. But analysis of threatened taxa shows that habitat loss has had the greatest effect on taxa using inland, lentic wetlands or forests. The rates of destruction of these habitat types by drainage schemes, hydrological changes, logging, and so forth, has been particularly high (Collins et al. 1991; Finlayson & Moser 1991; Frayer 1991; Scott 1993). In comparison, the loss and degradation of marine habitats, tundra, grasslands, arable land, and scrub have probably been less extensive, and Anatidae dependent on these habitats appear less likely to become globally threatened by habitat loss.

Threatened Anatidae and other Threatened Birds

Threatened Anatidae and globally threatened birds in general tend not to occur in the same countries, and there is little overlap between countries important to Anatidae and those important to all threatened bird species (Table 2). Indonesia, Brazil and the Philippines hold the most threatened bird species (Collar et al. 1994), but they hold very few threatened Anatidae. This is largely because most threatened birds are forest-dwellers (Collar et al. 1994), whereas threatened Anatidae are mainly wetland birds. Only 18% of threatened Anatidae depend on some kind of forest. Furthermore, bird diversity is more concentrated in tropical regions than is Anatidae diversity (International Council for Bird Preservation 1992). One thing in common between the Anatidae and all birds is the importance of Colombia and the U.S. to highly threatened taxa (Table 2). This is principally because Colombia and the Hawaiian Islands are important centers of endemism for Anatidae and other birds (International Council for Bird Preservation 1992).

The proportion of full species that are globally threatened is higher for the Anatidae (16% in Collar et al. 1994) than for birds as a whole (11% in Collar et al. 1994). Habitat loss is the most important threat to the Anatidae and is even more important to all bird species (see Fig. 6 in Collar et al. 1994). Among the Anatidae, hunting and exotic introductions are more important threats than for all birds, whereas small range or population and trade are relatively less important. Trade does not represent a major threat to any of the Anatidae. These differences are consistent with the finding by Green (1996) that, compared to birds in general, the Anatidae qualify for globally threatened status more often by IUCN criteria A (rapid declines) and less often by IUCN criteria B (small range plus any two of the criteria of fragmented, declining, or fluctuating). Hunting and introductions are both important causes of rapid declines.

The greater importance of hunting as a threat to the Anatidae reflects the fact that these birds are quarry favored by hunters throughout the world (Moser et al. 1993). The greater importance of exotic introductions is probably partly a consequence of the ground-nesting habits of most Anatidae, making them particularly susceptible to the introduction of predators. It also results from the widespread keeping of exotic Anatidae in captivity, the widespread breeding and release of Mallards (*Anas platyrhynchos*) for hunting, and the relative ease with which Anatidae species can hybridize and produce fertile offspring (Kear 1990). Although hybridization affects only two globally threatened Anatidae taxa, it is a very important threat because it is so hard to prevent and can become unstoppable. This has probably already occurred for the New Zealand Grey Duck (*Anas superciliosa superciliosa*), which is being genetically swamped by hybridization with the introduced Mallard (Gillespie 1985; Williams 1994; Rhymer et al. 1994).

The extent to which the analyses presented here may be typical of all waterbird families is unclear because I am unaware of any comparable studies of other families. Numerous reviews of the conservation status of birds have been conducted recently at the family level (Seal et al. 1994) but have included no comparable analyses of the characteristics of threatened and nonthreatened taxa.

Conclusions

Although the globally threatened Anatidae can be expected to benefit from general wetland conservation programs, measures focused on specific taxa are essential if future extinctions of Anatidae are to be minimized. The removal of introduced mammals from islands to benefit Auckland Island Teal (*Anas aucklandica aucklandica*) is one example of such measures (Williams 1994). The measures required include applied research (Green 1996). The great majority of Anatidae research undertaken has been on lower-risk taxa, and there is much scope and need to focus more research on threatened taxa in the future. My study reveals an urgent need for conservationists and researchers to address the requirements of the nonmigratory Anatidae, which are relatively unknown but particularly threatened. New initiatives, such as the IUCN Action Plan for the Anatidae, should address this need. The funding of conservation of nonmigratory taxa is complicated because most of them occur in poor countries. The U.S., U.K., and France all have threatened, insular taxa on their dependent territories (Green 1996) and should be encouraged to improve their status. A high priority for migratory taxa is to improve their conservation status in east Asia. The contribution of the Ramsar Convention to the conservation of the globally threatened Anatidae could be greatly improved. The contracting parties to the convention should be encouraged to designate more sites important to globally threatened Anatidae.

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