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Impact of protection on nest take and nesting success of parrots in Africa, Asia and Australasia

D. J. Pain[1,*], T. L. F. Martins[1,*,†], M. Boussekey[2], S. H. Diaz[2], C. T. Downs[3], J. M. M. Ekstrom[4], S. Garnett[5], J. D. Gilardi[6], D. McNiven[1], P. Primot[7], S. Rouys[8,9], M. Saoumoé[7], C. T. Symes[10], S. A. Tamungang[11], J. Theuerkauf[12], D. Villafuerte[2], L. Verfailles[7], P. Widmann[2] & I. D. Widmann[2]

1 RSPB, The Lodge, Sandy, Bedfordshire, UK
2 Katala Foundation, Puerto Princesa City, Palawan, Philippines
3 School of Biological & Conservation Sciences, University of KwaZulu-Natal, Scottsville, Pietermaritzburg, South Africa
4 Birdlife International, Wellbrook Court, Girton, Cambridge, UK
5 Institute of Advanced Studies, Charles Darwin University, Northern Territory, Australia
6 The World Parrot Trust, Glanmor House, Hayle, Cornwall, UK
7 Association pour la Sauvegarde de la Perruche d'Ouvéa (ASPO), Ouvéa, Loyalty Islands, New Caledonia
8 Marine Laboratory for Environmental Resources Studies, University of New Caledonia, Nouméa, New Caledonia
9 Wildlife Conservation Research Unit, University of Oxford, Tubney, Oxon, UK
10 Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa
11 Department of Animal Biology, University of Dschang, Dschang, Cameroon
12 Museum and Institute of Zoology, Polish Academy of Sciences, Wilcza, Warsaw, Poland

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Correspondence
D. J. Pain, RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, UK.
Email: debbie.pain@rspb.org.uk

*Joint first authors. Subsequent authorship alphabetical.
†Current address: Centre for Ecology and Conservation, University of Exeter in Cornwall, Cornwall, UK.

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Abstract

Wild parrots represent one of the greatest commercial interests in the legal trade in wild birds. Although it is difficult to quantify, there is a considerable illegal trade in wild parrots. Thirty-six per cent of the world's parrot species are listed by the International Union for the Conservation of Nature as threatened or near threatened, and 55% of these are threatened to some degree by trade. In this paper, we investigate the impact of protection on the number of nests that failed because of nestlings being taken by humans (hereafter nest take) and on nesting success in parrots. We collate data on parrot nest take from published and unpublished studies from Africa, Asia and Australasia, including countries and sites with and without national and local parrot protection measures in place. Nest take was insignificant in Australia, where all studies were from areas with both local and national protection. For less developed countries, levels of nest take were variable between studies, spanning the whole range from 0 to 100%. Protection significantly reduced nest take and correspondingly increased nesting success. Our results corroborate those for the Neotropics; thus, the advantages of protection appear to be independent of geographical location or political and economic conditions. We analysed data on legal trade in wild-caught parrots before and after implementation of the 1992 Wild Bird Conservation Act (which practically eliminated import of parrots to the USA) and found that there was no apparent shift in parrot imports to other global regions from the Neotropics. We suggest that conservation of parrots globally would benefit from similar legislation introduced in other regions, such as the EU (15), which is responsible for more than 60% of global imports of wild parrots.

Introduction

Millions of wild birds are traded annually both legally and illegally (Broad, Mulliken & Roe, 2002). Although parrots account for only a small proportion of all traded birds, they constitute a high proportion of the most frequently traded species and are of relatively high monetary value, and thus represent considerable commercial interest (e.g. Thomsen, Edwards & Mulliken, 1992). Accurate estimates of the numbers of wild birds in trade are not available, as no inclusive monitoring systems exist. CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is a trade regulation convention and, through CITES, data are gathered on legal international trade in birds and other taxa that are listed in the convention's appendices. However, little information is available on the substantial illegal trade, domestic trade or the high proportion of birds that reportedly die after capture but before licensing and export (Iñigo-Elios & Ramos, 1991; Beissinger, 2001). Consequently, the numbers of birds removed from the wild for trade may be two to four times higher than that suggested by CITES figures (Beissinger, 2001).

A high proportion of the world's parrot species (36%) are listed under IUCN criteria as threatened or near threatened (BirdLife International, 2004, 2005); the majority of parrots appear in CITES Appendices I or II. International trade in Appendix I-listed species is not permitted (other than in exceptional circumstances); trade is permitted in Appendix II-listed species, but within limits determined by annual quotas. The main problems faced by wild parrot populations are habitat loss and exploitation; the latter is largely for the wild bird trade. In some cases, such as when people chop down trees to remove nestlings, the wild bird trade can exacerbate habitat loss by removing nesting sites, which may be a limiting factor for parrot populations (BirdLife International, 2004). In some local situations, other factors may also be important, such as exploitation of parrots for their feathers (e.g. Mack & Wright, 1998) or the presence of introduced predators on islands (BirdLife International, 2004). However, trade is an important threat, affecting 55% of the threatened or near-threatened parrots of the world, and many studies have identified the exploitation of nestlings, juveniles and/or adults for trade as a threat to the stability of wild parrot populations (Mountford, 1990; Gnam, 1991; Juste, 1996; Wilkinson, 1998; Wright *et al.*, 2001; BirdLife International, 2004; Symes & Perrin, 2004). Trapping for the wild bird trade is also strongly linked to one of the most recent cases of extinction in the wild of a bird species, Spix's macaw *Cyanopsitta spixii*. Although the historical scarcity of Spix's macaw has been linked to a reduction in habitat because of grazing pressure, trapping for the wild bird trade was the proximate cause of the rarity that resulted in its extinction in the wild in 2000 (Forshaw & Cooper, 1989; Juniper & Parr, 1998; BirdLife International, 2004).

Wright *et al.* (2001) published an analysis of 'mortality rates' due to nest poaching (i.e. the illegal taking of nestlings) in neotropical parrots and investigated the impact of both local protection measures and the passage of the US Wild Bird Conservation Act (WBCA) in 1992 on nest poaching. The WBCA prohibits the import of all birds on CITES Appendices I and II to the USA unless they are from licensed captive breeding facilities or sustainable harvesting programmes. The authors found very elevated and locally, unsustainable poaching rates in some species. However, they found that active protection efforts can effectively reduce nest poaching, and that poaching rates were significantly lower after the passage of the WBCA than in the period before the act. The fact that legal and illegal parrot trade fell after the WBCA supports the hypothesis that they are positively correlated. Beissinger (2001) looked at the annual numbers of parrots traded legally internationally between 1991 and 1996, and found that while legal parrot imports to the USA declined from $>100\,000$ birds annually to a few hundred after passage of the WBCA, there was no concomitant shift of Latin American birds to other importing countries, as trade figures in other countries did not increase post-1992. This suggests that initially the WBCA had a global effect on neotropical parrot trade and did not simply displace trade elsewhere.

In this study, we wished to replicate the work of Wright *et al.* (2001) for other regions of the world. This paper presents the results of published and unpublished studies on parrot nest take for Africa, Asia and Australasia, and investigates the impacts of different levels of protection on nest-take rates and nesting success. We also expand on the work of Beissinger (2001) to investigate whether the US WBCA resulted in a shift of Latin American birds to other importing countries up to 2003. We recommend conservation measures for parrots based upon the results of both this and earlier studies.

Methods

We searched peer-reviewed and grey literature to identify studies in which parrot nest success, failure and reasons for failure were recorded across Africa, Asia and Australasia. We included all studies containing the requisite information in our data set, irrespective of date and sample size. We also solicited information from researchers that had conducted ecological studies on parrots in these regions, and had collected relevant, but unpublished, data. We identified potential contributors through the literature, the World Parrot Trust and the BirdLife International network, which together are in contact with a wide variety of researchers across the world. Again, we used no criteria to limit the inclusion of studies other than availability of relevant data; therefore, there was no intentional bias towards data sets with either high or low levels of nest take. References are given for data taken from published sources, and researchers providing unpublished data are included as coauthors in this paper. Thirty-six per cent (129/354) of extant parrot species are threatened or near threatened (BirdLife International, 2004), compared with five threatened and one near-threatened species of the 17 included in our study (34%). There is therefore unlikely to be bias towards studies of threatened species in the data set.

Contributors collected data throughout the parrot breeding seasons, recorded nest success and failure, along with reasons for failure (where known), and provided data on protection status. The unit of analysis in our study was the nest rather than individual nestlings. We classified nests from which one or more chicks fledged as successful. We categorized nest failure as due to 'nest take' (chicks taken from the nest by humans), 'natural failure' (chicks died in the nest or taken by predators) or 'other' (causes of failure falling outside other categories, i.e. weather, competition, logging, nest occupied by bees and unknown causes of failure, which may or may not have been natural). Although some 'other' causes were also natural, nest failure was classified in this way so that we could investigate whether there may be a compensatory relationship between nest take and our so-called 'natural' causes of nest failure. 'Nest take' included illegal (i.e. nest poaching) and legal take; whereas some take was established as illegal, legality could not be established in most studies. In one case, two young New Caledonian parakeets *Cyanoramphus saisetti* from a nest of three were poached, whereas one chick was left in the nest. Although the exact location of this nest was not established, it was believed to have been in an area with no local protection. We did not include this observation in our summary of nest take (Table 1) or detailed analyses, as the outcome for the final nestling was not established. Nest take was recorded when chicks were unambiguously taken by humans, but also included two cases (of 67) when there was good reason to suspect nest take. The rates of nest take recorded in this study may in general be conservative as the presence of researchers could reduce any illegal nest take (excluding McGowan, 2001, where trappers located nests). In addition, if any young fledged, the nest outcome was recorded as successful, and this could mask partial nest loss from nest take. In some cases, several sites and breeding seasons were studied within a country. Where this occurred, and site protection status was similar, data were combined across sites and years for each species by country as sample sizes were insufficient to include site and year within statistical models. Only in one case was local site protection status different between studies of a species within a country (grey-headed parrot *Poicephallus fuscicollis suahelicus* in South Africa). In this case, we did not combine data. Information on 'site-years' (sum of breeding seasons covered at all sites within a country) is given in Table 1.

We recorded protection against nest take at a site as 'national' protection (primarily legislative protection such as national bans on the taking or trading of birds, as was in place for all CITES Appendix I-listed species) or 'local' protection (including any form of local protection from tribal laws banning exploitation, to reserve designation). In the case of New Caledonia, national protection includes protection both by French and by New Caledonian law. 'No protection' included cases where species were listed under CITES Appendix II, with no additional measures, as this alone does not stop trade. We did not attempt to discriminate between different forms of local protection, as the number of studies included was too small. No data were available from sites studied both before and after the introduction of either national or local protection measures. One study (Tamungang, 1997; Table 1) was based in both a locally protected area (Korup Park) and its supporting zone. We classified this study as having local protection. As national protection status was sometimes difficult to assess, we subsequently classified studies in the following way: 'low' level of protection (no local protection and no national protection, or national protection that is ambiguous or not enforced), 'medium' level of protection (either local or effective national protection but not both) and 'high' level of protection (studies where both national and local protection measures were in place). We then analysed the whole data set to estimate and compare nest success rates and nest take in the presence of different levels of protection. We subsequently analysed the data set excluding studies from Australia. Australia is the most developed country included in the data set, and enforcement of local and national protection may be resourced at different levels from other countries included in the analysis. In addition, both 'local' and national protection, that is a high level of protection, was present at all study sites in Australia, and sample sizes from Australia were large, heavily influencing the results.

In addition, we repeated the analyses both including and excluding a study from Nigeria on African grey parrots (McGowan, 2001; Table 1). In this study, grey parrot nests were identified by parrot trappers, and the results were used as part of a population survey. Consequently, it was not surprising that nest take was 100%. There is an argument for excluding this study from the analysis, as the nature of the study was different from the other research studies included. However, as trappers could potentially harvest only a proportion of the nests, or harvest in a sustainable way, there may be an argument for including this kind of study in the analysis.

We analysed the data using a SAS 9.1 statistical package using a generalized linear model with binomial error distribution, rescaling for overdispersion of the data. The response variable was the number of nests successful, or recorded as nest take, and the binomial denominator was the number of nests.

To evaluate the potential impacts of import restrictions on parrot conservation, we used the UNEP-WCMC database on legal trade in wild birds to investigate the numbers of wild-caught parrots imported legally to the USA, EU (15) and elsewhere before and after the effective enactment of the US WBCA (enacted in 1992 and in effect from October 1993).

Results

Data were collected from 20 species by country combinations (hereafter described as studies). This represented 66 site-years, and 1966 nesting attempts between 1970 and 2005 (Table 1). Seven species in our data set were listed on CITES Appendix I; international trade in wild specimens of these species is strictly regulated and excludes any commercial activity, that is they cannot be traded legally. Two of these seven species (yellow-crested cockatoo *Cacatua sulphurea* and Uvea parakeet *Eunymphicus cornutus uvaeensis*) changed from Appendix II to Appendix I following CITES recommendations during our study period. All the remaining 11 species were listed on CITES Appendix II, that is commercial trade in wild specimens is subject to regulation by a system of permits.

In some cases national protection status proved hard to define. Parrot exports are banned in Nigeria under national legislation (the Endangered Species Decree), within which CITES is translated into Nigerian law. However, African grey parrots were exported throughout the 1980s and 1990s until a temporary moratorium was placed on the issuance of CITES permits for this species by the Nigerian CITES Management Authority in October 2000, lifted again in

Table 1 Nest take in parrots from protected and unprotected areas across Africa, Asia and Australasia

Species	Scientific name	Conservation status	CITES	Country	Years studied	National protection	Local protection	Protection level	Total site years	Total nest years	% nest take	% nest success	Investigators
African grey parrot	*Psittacus erithacus*	LC	II – 1981	Nigeria	2001	1[a]	1	Low	1	38	100	0	McGowan (2001)
Grey-headed parrot	*Poicephalus fuscicollis suahelicus*	LC	II – 1981	South Africa	2000	1	1	Low	1	1	100	0	C. Symes
Red shining parrot	*Prosopeia tabuensis*	LC	II – 1981	Eua-Tonga	1983	1	1	Low	1	19	79	0	Rinke (1989)
Vasa parrot	*Corapsis vasa*	LC	II – 1981	Madagascar	1999–2001	1	1	Low	3	32	9	38	J. Ekstrom
Cape parrot	*Poicephalus robustus*	LC	II – 1975	South Africa	1993, 1995, 2001–2003	1	1	Low	5	9	0	78	C. Downs & Wirminghaus *et al.* (2002)
African grey parrot	*Psittacus erithacus*	LC	II – 1981	Cameroon	1997	1	2	Medium	1	12	42	25	S. Tamungang & Tamungang (1997)
Grey-headed parrot	*Poicephallus fuscicollis suahelicus*	LC	II – 1981	South Africa	2000	1	2	Medium	1	4	0	75	C. Symes
Grey-headed parrot	*Poicephallus fuscicollis suahelicus*	LC	II – 1981	Zimbabwe	1999	1	2	Medium	1	1	0	100	C. Symes
Ruppell's parrot	*Poicephalus rueppellii*	LC	II – 1981	Namibia	1999	2	1	Medium	1	12	0	58	Selman, Hunter & Perrin (2000)
Uvea parakeet	*Eunymphicus cornutus uvaeensis*	EN	II – 1975 I – 2000	New Caledonia	1997–2001	2	2	High	5	22	18	36	P. Primot & M. Saoumoé
Yellow-crested cockatoo	*Cacatua sulphurea citrinocristata*	CR	II – 1981 I – 2005	Indonesia	2002	2	2	High	1	8	0	12.5	Walker, Cahill & Marsden (2005)
Echo parakeet	*Psittacula eques*	CR	I – 1975	Maurititus	1996	2	2	High	1	12	0	25	Jones & Swinnerton (1997)
New Caledonian parakeet	*Cyanoramphus saisetti*	NT	I – 1977	New Caledonia	2002–2005	2	2	High	3	8	0	75	J. Theuerkauf & S. Rouys
Philippine cockatoo	*Cacatua haematuropygia*	CR	I – 1992	Philippines	1999–2002	2	2	High	4	51	0	69	P. Widmann, I. D. Widmann, M. Boussekey & S. H. Diaz
Glossy black cockatoo	*Calyptorhynchus lathami halmaturinus*	LC	II – 1977	Australia	1996–1998	2	2	High	3	118	0	38	Garnett, Pedler & Crowley (1999), S. Garnett
Golden shouldered parrot	*Psephotus chrysopterygius*	EN	I – 1975	Australia	1993–2003	2	2	High	11	800	0	32	S. Garnett
White-tailed black cockatoo	*Calyptorhynchus funereus latirostris*	LC	II – 1981	Australia	1970–1976	2	2	High	12	543	0	61	Saunders (1982)
Palm cockatoos	*Probosciger aterrimus*	LC	I – 1987	Australia	1999	2	2	High	1	41	0	22	Murphy, Legge & Heinhson (2003)
Eclectus parrot	*Eclectus roratus*	LC	II – 1981	Australia	1997–2000	2	2	High	4	146	0	27	Heinsohn & Legge (2003)
Major Mitchell cockatoo	*Cacatua leadbeateri*	LC	II – 1981	Australia	1977–1982	2	2	High	6	89	1	85	Rowley & Chapman (1991)

National protection is primarily active legislative protection such as national bans on the taking or trading of birds. Local protection includes sites listed as reserves or parks, protected by local or tribal laws, or with any kind of active protection. 1, protection absent; 2, protection present.

'Low' protection (no local protection and no national protection, or national protection that is ambiguous or not enforced), 'medium' protection (either local or national protection but not both), and 'high' protection (studies where both national and local protection measures were in place).

Total site-years represent the sum of breeding seasons covered at all sites within a country. Total-nest years represent the number of yearly breeding attempts observed in the study.

Conservation status is taken from BirdLife International (2004). From the highest level of threat: CR, critically endangered; EN, endangered; NT, near threatened; LC, least concern.

The grey-headed parrot *Poicephalus fuscicollis suahelicus* has been recognized as a separate species from the Cape parrot *Poicephalus robustus* (Clancey 1997; Wirminghaus *et al.*, 2002).

[a]Classification of national protection status in Nigeria is ambiguous for reasons described in the Results. Statistical analyses were therefore conducted both with and without inclusion of this study.

March 2001. Although the species may have been considered to be nominally protected by national legislation during the period of the study, in effect there was no active protection, and national CITES legislation in Nigeria appears to be ambiguous. Statistical analysis was conducted both including and excluding this study for both this and other reasons (see Methods).

During the period of the study on Vasa parrots in Madagascar, there was an international CITES ban on imports of this species to other CITES signatory countries, but no apparent national legislation banning the taking of birds (e.g. for internal trade).

Of the 17 parrot species included in the study, three are classified as critically endangered, two as endangered, one as near threatened (BirdLife International, 2004) and the remainder are not considered to be at risk. The level of nest take did not appear to be related to conservation risk, and nest take was recorded in only one threatened species, Uvea parakeet. There were two cases of nest take of CITES Appendix I-listed species, one Uvea parakeet in 2001 and two New Caledonian parakeets in the 2004/2005 season (not included in Table 1 – see Methods).

The most developed country included in the data set was Australia, accounting for six of the 20 species by country combinations, 37 site-years and 1737 nesting attempts. Nest take was experienced in seven of the 20 studies, and accounted for between 1 and 100% of nest failure in these studies (Table 1; Fig. 1a and b). As the Australian data set is disproportionately large, and Australia is the most developed country for which studies were available, Australian data have been analysed separately from other data unless otherwise stated.

Nest failure from nest take is described in Table 2. Nest failure from other causes accounted for 13% of nest failure in Australian studies, and less than 3% in studies from elsewhere, although this was very variable between studies.

Impact of protection

Information was available for 11 species × country combinations with high protection, four with medium protection and five with low protection. All six Australian studies enjoyed a high level of protection. An increase in the level of protection resulted in a reduction in nest take and an increase in nest success (Table 2). Nest take was significantly reduced (by >8 times, $P = 0.007$) and nest success was significantly greater (by 2.7 times, $P = 0.034$) when anything above a low level of protection was in place (Table 2). When the Nigerian study was excluded from the analysis, nest take was reduced by 4.5 times ($P = 0.08$) and nest success was increased by 1.7 times (n.s.) when medium or high protection was in place.

When Australian data were included in the analysis, nest take was significantly reduced with medium or high protection (by >50 times, $P < 0.001$ both including and excluding the Nigerian study); however, increased nest success, while 1.6–2.3 times higher with medium or high rather than low protection, did not reach statistical significance (Table 2).

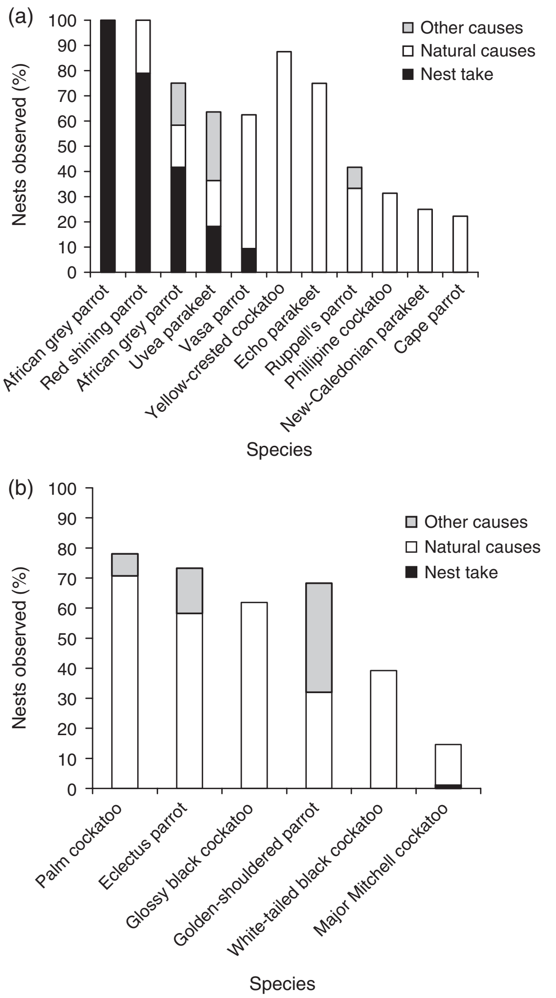

Figure 1 Nest failure from nest take, natural causes and other causes for (a) countries excluding Australia and (b) Australia. Nest failure was categorized as due to 'nest take' (chicks taken from the nest by humans), 'natural failure' (chicks died in the nest or taken by predators) or 'other' (causes of failure falling outside other categories, including unknown causes of failure, which may or may not have been natural). Only studies with >5 nest years have been included.

Sample sizes in each category were not sufficiently large to establish statistically whether the effects of local and national protection were additive, or to compare all three (low, medium or high) protection categories individually. However, nest take was significantly reduced when studies with a high level of protection were compared with those with low + medium protection (Table 2). This, along with decreases in the actual nest-take rate moving from medium to high levels of protection (Table 2), suggests that the effects of local and national protection may be additive.

Impact of the US WBCA

The WBCA came into effect in October 1993. Imports of parrots to the EU (15) were roughly constant from the

Table 2 Actual percentage of nest success and nest take of parrots in Africa, Asia and Australasia in relation to protection status

		Low	Medium	High	Low + medium	Medium + high	χ^2 L versus M + H	Significance (*P*)	χ^2 L + M versus H	Significance (*P*)
Nest success	Excluding Australia	19.2 (31.1)	48.3	52.5	25.8 (36.7)	51.5	4.50 (1.61)	0.034 (0.20)	2.62 (1.04)	0.105 (0.30)
Nest take		57.6 (31.1)	17.2	4.0	48.4 (26.7)	6.9	7.24 (3.10)	0.007 (0.08)	5.72 (3.8)	0.017 (0.052)
Nest success	Including Australia	As above		43.9	As above	43.9	1.66 (0.27)	0.20 (0.61)	1.05 (0.12)	0.30 (0.73)
Nest take				0.3		0.5	34.0 (15.2)	< 0.001 (< 0.001)	38.30 (25.3)	< 0.0001 (< 0.0001)

Data were analysed using a generalized linear model with binomial error distribution, rescaling for overdispersion of the data. The response variable was the number of nests successful, or recorded as 'nest take', and the binomial denominator was the number of nests.
Percentages are total nest success or nest take including all species, sites, countries and years in the 'low', 'medium' and 'high' level of protection categories, except for figures in brackets, when the study on African grey parrots from Nigeria (McGowan, 2001) has been excluded from the analysis (see Methods).
Statistical comparisons are for low versus medium or high levels of protection, and low or medium versus high levels of protection.

mid-1980s to 1991. Imports to the USA declined from the mid-1980s to 1991. Figure 2a and b illustrate that there was a massive reduction in the numbers of wild-caught parrots imported to the USA, both from Central and South America and from the rest of the world, following the WBCA. Parrot imports to the USA were already declining before the WBCA, but the act appears to have largely curtailed the import of wild parrots (except in 2001, where imports to the USA from Guyana are reported). Although the numbers of parrots imported to the EU (15) and the rest of the world fluctuated between 1991 and 2003, these do not appear to have increased post-1993 to incorporate parrots that would otherwise have been destined for the USA (see also Beissinger, 2001 for a global analysis to 1996). The data suggest that parrot imports to the EU (15) and elsewhere from Central and South America may have declined somewhat for a few years following the WBCA, and subsequently increased, but only to pre-WBCA levels. Thus, the impact of the WBCA on imports of Central and South American parrots to the EU has been minimal.

Discussion

Our results should be considered in the context of the extent of trade in parrots. The data in Fig. 2a and b show that *c*. 150 000 parrots a year have been legally harvested from Africa, Asia and Australasia for at least the last 10 years. Even with our efforts to compile the most complete data set possible from peer-reviewed and grey literature, we have only shown a snapshot of the situation, and our data set will clearly miss some major species or areas of nest take.

Our study shows that nest take occurred in six (or seven including the New Caledonian parakeet) of the 17 species studied, and seven of the 20 studies. The rates of take above 70% as shown in a few studies (Table 1) are very likely to be unsustainable and could, if allowed to continue without respite, lead to severe population declines (Beissinger & Bucher, 1992; Beissinger, 2001). Such declines due to exploitation for trade have already been observed in a number of species (Juniper & Parr, 1998; BirdLife International, 2004). The highest rates of nest failure due to nest take were

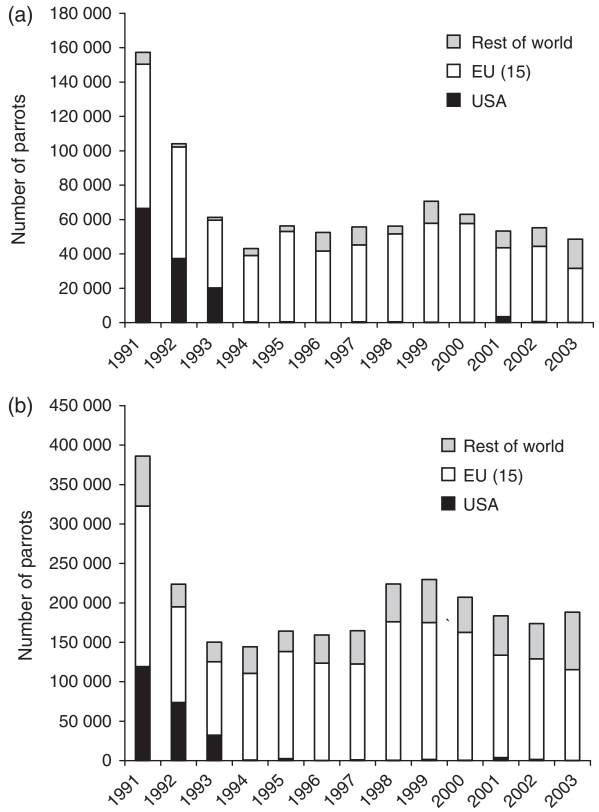

Figure 2 (a) Total imports of wild parrots from Central and South America (including Mexico) to the USA, EU (15) and the rest of the world before and after the 1992 US Wild Bird Conservation Act (in effect from October 1993). (b) Total global imports of wild parrots to the USA, EU (15) and the rest of the world before and after the 1992 US Wild Bird Conservation Act (in effect from October 1993).

recorded in the African grey parrot *Psittacus erithacus* and the red shining parrot *Prosopeia tabuensis*. The African grey parrot is one of the most heavily traded parrots in the world, and for the one study from Nigeria, the trapper took chicks from all nests located within an area (Table 1). However, although nest take in some areas can be very high and locally unsustainable in African grey parrots (Juste, 1996), take of adult birds (and fledged young) could have a more significant impact on populations of this species overall. Adult birds are heavily traded (e.g. Ngenyia, Nzooh & Usongo, 2003), many die before export (Fotso, 1998), parrots have low reproductive rates, and in many species only a proportion of potential breeders breed in any one year (Stoleson & Beissinger, 1997).

Two studies in our data set show rates of take between 10 and 50%. It is uncertain whether exploitation at this level is sustainable (Wright *et al*., 2001), and long-term studies would be required to evaluate this as most parrot species have high adult survival. It may be possible to use population modelling to indicate the likely sustainability of take rates. This would require specific information on exploitation rates and demographic parameters. However, demographic parameters are not well documented for many parrot species, and would often need to be derived from long-term studies on parrots of similar lifespan and size (e.g. Saunders, 1982; S. Garnett, pers. comm.). In the absence of such information, some of the exploitation levels shown in this study are concerning, at least in a local context, particularly for species that are currently globally threatened, such as the Uvea parakeet. This is especially true given that the rates of nest take recorded in our study may be conservative (see Methods).

Our study shows that effective national and/or local protection (i.e. medium or high) can successfully reduce nest take (from 31–58 to 0.5–7%) and considerably increase nesting success (from 19–31 to 44–52%). These results support those of Wright *et al*. (2001) for the Neotropics, and suggest that the advantages of protection are likely to be independent of geographical location or political and economic conditions.

Our study also shows examples of high nest failure, even in the absence of nest take. The highest nest-failure rates from natural causes (outside Australia) were recorded in the yellow-crested cockatoo and Echo parakeet *Psittacula eques*, two critically endangered species. The Echo parakeet population crashed because of wholesale destruction of its forest habitat in Mauritius, and low nest success may now result from food shortage due to deterioration of remaining forest (Greenwood, 1996; Swinnerton, 1998). Although the yellow-crested cockatoo declined and became critically endangered primarily because of the trade in wild birds (BirdLife International, 2004), the high nest failure during the study reported was attributed to bad weather, as the study year was the wettest year on Sumba for a decade (Walker, Cahill & Marsden, 2005). For species already affected by exploitation or other factors, stochastic events such as bad weather could drive local populations to critical levels. Today, many parrot populations are simultaneously threatened by several factors, particularly habitat degradation and exploitation (BirdLife International, 2004).

Although protection resulted in a considerable increase in nest success, it had a more significant effect on reducing nest take. This raises the possibility that there may be some compensatory reduction in nest failure from natural causes when nest take is high. However, the increase in nest success found with protection indicates that this effect is unlikely to be great (Table 2).

Our results show that two CITES Appendix I-listed species were taken from nests. As trade always precedes listing, it is perhaps not surprising that Appendix I listing does not totally stop trade. Indeed, trade in some species is known to continue long after Appendix I listing (e.g. the salmon-crested cockatoo *Cacatua moluccensis* in Indonesia; Bagnall & Field, 1996; Kinnaird *et al*., 2003). However, CITES Appendix I listing is an important component of national protection, and, overall, the results of our study, and that of Wright *et al*. (2001), show that protection reduces nest take. The benefits of CITES Appendix I listing are also reflected by evidence suggesting that legal trade masks illegal trade. For example, Wright *et al*. (2001) found that nest poaching in the Neotropics dropped dramatically following enactment of the WBCA; that is in the absence of commercial trade, reductions in the poaching of nestlings followed suit.

Although there are obvious benefits to CITES Appendix I listing, listing on the CITES appendices tends to be reactive. Consequently, populations may have declined, even dramatically, and sometimes as a direct result of trade, before being listed on CITES Appendix I. For example, CITES trade statistics officially recorded an export of $>$40 000 wild-caught yellow-crested cockatoo from Indonesia between 1981 and 1993 (CITES database online), although by the late 1980s it was evident that the population had declined dramatically throughout its range (Collar & Andrew, 1988; Andrew & Holmes, 1990). The current estimated population lies below 10 000 birds (BirdLife International, 2004). When species reach this stage, populations are often small and vulnerable to stochastic events, such as bad weather (as in the yellow-crested cockatoo study cited in this paper). A change is needed for CITES to become a proactive mechanism for the promotion of sustainable trade and conservation. This would require, as suggested by Beissinger (2001), a switch in the CITES appendices from long lists of species that are too threatened to be in trade, to short lists of species that can be traded, with quotas set scientifically at conservative levels. For trade to connect to resource conservation requires quotas to be established at the site level, to tie in with local conditions, to help ensure that local people accrue a higher proportion of the economic benefits of trade, and to provide a local impetus for conservation and sustainable exploitation. Until such conditions exist, sustainable trade in parrots, and indeed other avian species if conducted on any significant scale, is unlikely.

An alternative for the conservation of parrots and other species is the introduction of legislation like the US WBCA, prohibiting all imports unless these are from captive breeding or sustainable harvesting programmes. Figure 2b shows that the WBCA appears to have had a real effect on parrot conservation in the Neotropics, in that the large number of parrots no longer exported to the USA do not appear to have been taken up by other countries. Although the majority of species covered by our study are not regularly imported to the EU, there is no reason to suggest that the species included or results are unrepresentative. Consequently, conservation of parrots globally would likely benefit from similar legislation introduced in other regions, such as the EU (15), which is responsible for more than 60% of global imports of wild parrots.

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