Nest Poaching in Neotropical Parrots

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Abstract: *Although the poaching of nestlings for the pet trade is thought to contribute to the decline of many species of parrots, its effects have been poorly demonstrated. We calculated rates of mortality due to nest poaching in 23 studies of Neotropical parrots, representing 4024 nesting attempts in 21 species and 14 countries. We also examined how poaching rates vary with geographic region, presence of active protection programs, conservation status and economic value of a species, and passage of the U.S. Wild Bird Conservation Act. The average poaching rate across all studies was 30% of all nests observed. Thirteen studies reported poaching rates of ≥20%, and four reported rates of >70%. Only six studies documented no nest poaching. Of these, four were conducted on islands in the Caribbean region, which had significantly lower poaching rates than the mainland Neotropics. The other two studies that showed no poaching were conducted on the two species with the lowest economic value in our sample (U.S. retail price). In four studies that allowed direct comparison between poaching at sites with active nest protection versus that at unprotected sites, poaching rates were significantly lower at protected sites, suggesting that active protection efforts can be effective in re-*

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ducing nest poaching. In those studies conducted both before and after the passage of the U.S. Wild Bird Conservation Act, poaching rates were found to be significantly lower following its enactment than in the period before. This result supports the hypothesis that the legal and illegal parrot trades are positively related, rather than inversely related as has been suggested by avicultural interests. Overall, our study indicates that poaching of parrot nestlings for economic gain is a widespread and biologically significant source of nest mortality in Neotropical parrots.

Saqueo de Nidos de Loros Neotropicales

Resumen: *Aunque se piensa que el saqueo de polluelos para el mercado de mascotas contribuye a la declinación de muchas especies de loros, no se han demostrado sus efectos. Calculamos las tasas de mortalidad debido al saqueo de nidos en 23 estudios de loros neotropicales, que representan 4,024 intentos de anidar en 21 especies y 14 países. También examinamos la variación de las tasas de saqueo por región geográfica, la presencia de programas activos de protección, el estatus de conservación y el valor económico de las especies y la aprobación del Acta de Conservación de Aves Silvestres de E. U. A. La tasa promedio de saqueo en todos los estudios fue del 30% del total de nidos observados. Trece estudios reportaron tasas de saqueo ≥20% y 4 estudios reportaron el saqueo de >70%. Solo 6 estudios no documentaron saqueo de nidos. De estos, 4 se llevaron a cabo en islas de la región del Caribe, que tuvieron niveles de saqueo significativamente menores que en el continente. Los otros dos estudios que no mostraron saqueo se llevaron a cabo con las 2 especies de menor valor económico en nuestra muestra (precio de venta en E.U.A.). En cuatro estudios que permitieron comparaciones directas entre el saqueo en sitios con protección activa de nidos versus sitios sin protección, las tasas de saqueo fueron significativamente menores en los sitios protegidos, lo que sugiere que los esfuerzos activos de protección pueden ser efectivos para reducir el saqueo de nidos. En los estudios llevados a cabo antes y después de la aprobación del Acta de Conservación de Aves Silvestres de E. U. A., las tasas de saqueo fueron significativamente menores después que antes de la probación del Acta. Este resultado apoya a la hipótesis de que el comercio legal e ilegal de loros están positivamente relacionados, y no inversamente relacionados como sugieren los intereses de aricultura. En conclusión, nuestro estudio indica que el saqueo de pollos de loros para su venta es un factor de mortalidad de nidos de loros neotropicales generalizado y biológicamente significativo.*

Introduction

Parrots (family Psittacidae) are among the most highly threatened birds in the world, with more endangered species than any other bird family (Collar et al. 1994). This situation is particularly acute in the Neotropics, where 46 of 145 species (31%) are at risk of global extinction (Collar et al. 1994).

Although a number of factors are implicated in the global decline of parrot populations, two are considered of primary importance: habitat loss and the capture of individuals for the pet trade (Collar & Juniper 1992; Juniper & Parr 1998; Snyder et al. 1999). Juniper and Parr (1998) estimate that habitat loss alone affects 73 of the 90 species currently endangered, that trapping for the pet trade alone affects 39 species, and that 28 species experience both forms of pressure. Other factors thought to play a role in the decline of some species include hunting for food and feathers (McCormack & Künzle 1996; Martuscelli & Yamashita 1997), competition for food and nest sites with non-native species (Wilson et al. 1998), predation from non-native species (Kuehler et al. 1997; Wilson et al. 1998), disease and parasitism (Snyder et al. 1987), and disturbance from hurricanes (Snyder et al. 1987; Christian et al. 1996).

The effect of these factors is exacerbated by the reproductive biology of parrots, which is generally characterized by low rates of reproduction related to small clutch size, one clutch per year (with rare exceptions), low survival of chicks and fledglings, late age of first reproduction, large proportions of nonbreeding adults, and restrictive nesting requirements (Saunders 1986; Snyder et al. 1987; Rowley 1990; Gnam & Rockwell 1991; Munn 1992; Emison et al. 1994; Lindsey et al. 1994). The resulting low recruitment of juveniles in many parrot populations may decrease their ability to recover from reductions in population size caused by anthropogenic disturbances and thus may explain the large number of species threatened with extinction (Bennett & Owens 1997).

Conservation biologists and aviculturists have engaged in much debate over the relative importance of habitat loss versus poaching for the pet trade in the decline of parrot populations (Collar & Juniper 1992; Etchepare 1995; Desborough 1996; Johnson et al. 1997). These two groups have put forth opposing views about the causes of parrot population declines and how best to reverse them. Members of the international avicultural industry have focused on habitat loss and have suggested that the most viable strategy for parrot conservation is to increase the capture and trade of wild parrot chicks so as to have sufficient populations for captive breeding and eventual reintroductions (Desborough 1994; Etchepare 1995; Voren 1995).

Few conservation biologists studying parrots would deny that habitat loss has had grave effects on many species. Many are alarmed, however, by the enormous trade in parrots fueled in large part by the poaching of wild chicks from nests. For example, a recent study of the international trade in parrots listed by the Convention on Trade in Endangered Species (CITES) found that 1.2 million parrots were exported between 1991 and 1996, with the majority of these birds coming from the Neotropics (Beissinger 2001). These figures are thought to be a gross underestimate of the actual number of birds taken from the wild because they exclude pre-export mortality, which has been estimated to reach 60% of all birds harvested (Iñigo-Elias & Ramos 1991). International trade figures also do not account for illegal international trade and domestic trade within tropical countries; both types of trade are thought to be substantial but neither are well quantified (Beissinger 2001). When these other factors are taken into consideration, the number of chicks taken from the wild is estimated at 400,000–800,000 per year (Beissinger 2001). Similar estimates were obtained for Neotropical parrots over the period of 1982–1986 (Thomsen & Brautigam 1991). The large number of parrots harvested from the wild raises the possibility that many parrot populations are depressed well below the levels that could exist in natural habitats (Redford 1992). Furthermore, some conservationists argue that conservation-oriented captive breeding programs are expensive, dependent on skilled workers, and likely to succeed only under limited conditions (Derrickson & Snyder 1992; Snyder et al. 1994; Sanz & Grajal 1998). Thus, most parrot conservationists have called for a reduction in the trade of wild parrots as a necessary adjunct to efforts to protect natural habitat (Snyder et al. 1999). This approach received some legislative support in 1992 when the U.S. Congress passed the Wild Bird Conservation Act (WBCA), which banned the import of all CITES-listed parrots (WBCA 1992).

Few published studies have quantified levels of poaching and compared mortality rates from poaching to those from natural causes (but see Perez & Eguiarte 1989; Rinke 1989; Lambert 1993; Martuscelli 1995; Juste B. 1996). These data are essential to assessment of the risk posed by poaching for wild populations of parrots. We present data on nesting success collected from a wide range of parrot species and countries in the Neotropics, representing the largest study to date of nest mortality in parrots. We examine how poaching rates vary with species-specific trade demands, presence of active protection programs, geographic region, conservation status, commercial value in the United States, and the passage of the WBCA.

Methods

The first two authors (T.W. and C.T.) solicited data sets gathered from 1979 to 1999 from investigators conducting ecological or behavioral studies on Neotropical parrots. Potential contributors were identified through literature searches and membership in the Association for Parrot Conservation, whose membership includes most of the parrot researchers and conservationists active in the Neotropics. We included in this analysis all data sets that consisted of more than five nests (Table 1), and the investigators responsible appear as co-authors. Published data from Perez and Eguiarte (1989) were combined with unpublished data for the same species and sites in Mexico (Table 1). There was no intentional bias toward inclusion of data sets with high poaching levels or from any specific parrot taxa or geographic area within the Neotropics. There may, however, be a bias toward studying threatened species, because much of research funding for Neotropical parrots is directed toward species of conservation concern. This bias probably explains the preponderance in our analysis of species from the genus *Amazona*, which includes 19 species classified as threatened or near-threatened with extinction (Collar et al. 1994). We follow the species nomenclature of Juniper and Parr (1998) throughout.

These data were collected in 23 studies of parrot ecology or behavior. In each study, investigators monitored nests during the breeding season and collected data on nesting success. Monitored nests were classified as either "successful fledge" (at least some chicks fledged), "failed naturally" (all chicks were taken by predators or died of natural causes while in the nest), "poached" (all chicks unambiguously taken from nest by humans), "suspected poached" (poaching suspected but not confirmed), or "other" (sources of mortality falling outside designated categories). The category of "other" constituted $<1\%$ of all nests studied. Renesting by pairs in the same year was extremely rare ($<1\%$ of nesting attempts). The primary unit of analysis was thus a single yearly nesting attempt by a breeding pair (a nest-year), and our level of analysis for mortality was the nest rather than the individual nestling (Table 1). Some studies also included data from multiple sites within a country. The total number of breeding seasons observed at all sites for a given study is listed in Table 1 as site-years. Methodological details for each study can be obtained by contacting the authors responsible for that study (Table 1).

We consider these estimates of poaching levels to be conservative measures of the actual numbers of chicks taken from nests. No corrections were made for differences among studies in the time span of nest observations; such corrections usually raise estimates of nest mortality (Mayfield 1975). Likewise, it was difficult to quantify the effect of observers on poaching rates. In

Table 1. Field studies included in the analysis of poaching rates in Neotropical parrots.

Species[a]	*Scientific name*	*Conservation status*[b]	*Country*	*Years studied*	*Total site-years*[c]	*Total nest-years*[d]	*Investigators*
Black-billed Amazon	*Amazona agilis*	vulnerable	Jamaica	1996–1998	3	59	S. Koenig
Orange-winged Amazon	*Amazona amazonica*	unlisted	Ecuador	1985–1989, 1996–1998	8	15	A. Sosa-Asanza
Red-necked Amazon	*Amazona arausiaca*	vulnerable	Dominica	1994	1	6	S. Koenig
Yellow-naped Amazon	*Amazona auropalliata*	unlisted	Costa Rica	1993–1997	7	37	T. Wright
Yellow-naped Amazon	*Amazona auropalliata*	unlisted	Guatemala	1991–1994	4	68	A. Brice, K. Joyner, C. Toft, J. Wiley
Yellow-cheeked Amazon	*Amazona autumalis*	unlisted	Mexico	1985, 1990–1999	22	176	E. Enkerlin-Hoeflich, J. Gonzalez-Elizondo (Perez & Eguiarte 1989)
Yellow-shouldered Amazon	*Amazona barbadensis*	vulnerable	Venezuela	1990–1997	8	296	A. Trujillo, F. Rojas-Suárez, V. Sanz, M. Albornoz, A. Rodríguez-Ferraro
Red-tailed Amazon	*Amazona brasiliensis*	endangered	Brazil	1989–1995	7	78	P. Martuscelli
Yellow-billed Amazon	*Amazona collaria*	near-threatened	Jamaica	1996–1997	2	8	S. Koenig
Lilac-crowned Amazon	*Amazona finschi*	near-threatened	Mexico	1996–1998	3	28	K. Renton
White-faced Amazon	*Amazona kawalli*	unlisted	Brazil	1996	1	25	P. Maruscelli
Cuban Amazon	*Amazona leucocephala*	near-threatened	Cuba	1979–1991	13	2862	V. Berovides-A., X. Gálvez-A., J. Wiley
Yellow-crowned Amazon	*Amazona ochrocephala*	unlisted	Panamá	1998	1	21	A. Rodríguez
Yellow-headed Amazon	*Amazona oratrix*	endangered	Mexico	1985, 1990, 1992–1999	13	57	E. Enkerlin-Hoeflich, J. Gonzalez-Elizondo (Perez & Eguiarte 1989)
Hispanolan Amazon	*Amazona ventralis*	near-threatened	Dominican Republic	1993–1997	5	156	F. Vilella
St. Lucia Amazon	*Amazona veriscolor*	vulnerable	St. Lucia	1993–1997	5	38	J. Gilardi
Vinaceous Amazon	*Amazona vinacea*	endangered	Brazil	1993–1996	4	25	P. Martuscelli
Green-cheeked Amazon	*Amazona viridigenalis*	endangered	Mexico	1985, 1990–1991, 1993–1999	22	145	E. Enkerlin-Hoeflich, J. Gonzalez-Elizondo (Perez & Eguiarte 1989)
Green-cheeked Amazon	*Amazona viridigenalis*	endangered	Puerto Rico	1993	1	5	J. Meyers
Puerto Rican Amazon	*Amazona vittata*	critical	Puerto Rico	1989–1995	7	38	F. Vilella
Green-rumped Parrotlet	*Forpus passerinus*	unlisted	Venezuela	1988–1994	7	36	S. Stoleson, S. Beissinger
Monk Parakeet	*Myiopsitta monachus*	unlisted	Argentina	1993, 1995	2	17	J. Eberhard
Blue-headed Parrot	*Pionus menstruus*	unlisted	Ecuador	1985–1989, 1998	5	8	A. Soza-Asanza
Total	21 species, 23 studies		14 countries	20 years	151	4204	

[a]*Two species appearing twice were studied separately in different countries.*
[b]*Conservation status following Collar et al. (1994).*
[c]*Total number of breeding seasons observed over all sites in a study.*
[d]*Number of yearly breeding attempts observed in a study.*

most cases researchers probably provide some protection to nests under study by inhibiting illegal poaching. The converse situation, in which researchers inadvertently lead poachers to previously unknown nests, is less likely because of the conspicuous behavior of many species around nests and their tendency to reuse nest sites over many years (Enkerlin-Hoeflich 1995).

To assess the effect of the WBCA on nest poaching, we compared poaching levels before and after 1992 in the 10 species for which we had data for both time periods (Table 1). We also compared regional patterns of nest mortality in studies from mainland Neotropical countries ($n = 15$) to those from the Caribbean islands ($n = 8$).

Most of the populations studied were protected from poaching in some form, ranging from legal prohibitions against capture and trade to active patrolling of nest areas by armed guards. The effectiveness of this protection varied widely, however. Investigators classified each site within their study into one of two categories: (1) unprotected, with no active efforts toward enforcement of legal protections or preventing poaching, and (2) protected, with some degree of active protection for nests or nest sites. Four studies had enough sites of both categories to permit direct comparisons of poaching levels between protected and unprotected sites: *Amazona autumnalis, A. oratrix*, and *A. viridigenalis* in Mexico and *A. auropalliata* in Costa Rica.

The conservation status of individual species follows the categories of Collar et al. (1994): near-threatened, vulnerable, endangered, and critical (the last three levels are all considered threatened with extinction). Species not currently considered of conservation concern were classified as unlisted. In some analyses, these categories were converted to ranked numerical values: 0, unlisted; 1, near-threatened; 2, vulnerable; 3, endangered; 4, critical.

We collected retail prices for individual parrots by searching advertisements posted on the internet by bird breeders and pet stores based in the United States. We obtained price information for all species included in this study except *Amazona agilis*, *A. arausiaca*, *A. brasiliensis*, *A. kawalli*, *A. versicolor*, *A. vinacea*, and *A. vittata*, all of which are rarely seen in captivity in the United States. For comparison, we also collected price data on related species and other species common in the pet trade.

We calculated yearly poaching levels by adding the number of poached nests and suspected poached nests at each site within a study and transforming this amount into a proportion of all nests studied at that site (suspected poached constituted only 1% of all nests). We then calculated poaching levels for each country and species combination by taking the mean across all sites and years. We calculated the levels of yearly natural nest failure as the proportion of all nests observed that failed because of natural causes and the total nest failure level as the sum of poached nests and naturally failed nests. We employed an arcsine square-root transformation for proportional data and used parametric or nonparametric statistics as appropriate for a given data distribution. For those four species for which we had data from both protected and unprotected sites within a single country, we

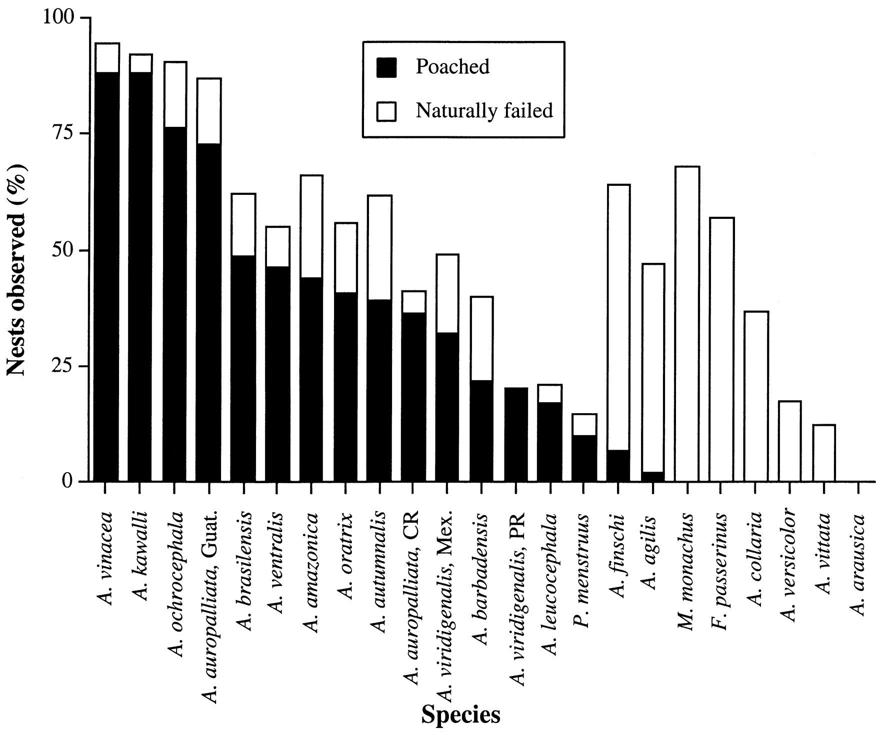

Figure 1. Nest mortality in the 23 studies included in the analysis of poaching rates. The shaded portion of each bar indicates the percentage of poached nests; the unshaded portion indicates the proportion that failed from natural causes, and the combined height of the bar indicates total mortality from both sources. The name of each species appears below the bar, and species are arranged from highest to lowest level of poaching. Two species appear twice and are identified by the country in which they were studied: CR, Costa Rica; Guat., Guatemala; Mex., Mexico; PR, Puerto Rico). See Table 1 for full species names, country of study, and number of nests observed in each study.

calculated poaching levels separately for these two conditions. We used mean poaching levels from unprotected areas for these four species and overall mean poaching levels from the other species in comparisons between poaching levels and retail U.S. price and species conservation status.

Results

We collected data from 23 studies examining nesting success in 21 species in 14 Neotropical countries (Table 1). In total, 4204 nesting attempts were recorded between 1979 and 1999. The mean poaching rate across all studies was 30%. Some degree of nest poaching was found in most studies (Fig. 1). Thirteen studies reported ≥20% of nests poached, and 4 studies reported >70% of nests poached. Only 6 species had no documented nest poaching (Fig. 1). Mortality from nest poaching was higher than mortality from natural causes in species that experienced poaching (Wilcoxon signed rank test, $n = 17$, $Z = -2.4$, $p = 0.02$) but not when all species were considered (Wilcoxon signed rank test, $n = 23$, $Z = -1.2$, $p = 0.2$). Overall, mortality of eggs and nestlings was higher for species that experienced poaching (57% nests failed) than for those that did not (32% nests failed), but this difference was not significant (Mann-Whitney U test, $n = 23$, U prime $= 76$, $p = 0.08$).

In the 10 species for which direct comparison was possible, poaching was lower in the period following the enactment of the WBCA in 1992 than in the years prior to its enactment (20% post–WBCA vs. 48% pre–WBCA; Wilcoxon signed rank test, $n = 10$, $Z = -2.5$, $p = 0.01$). Nest poaching over all study sites was lower after 1992 (26%) than before (36%), but this difference was not significant (Mann-Whitney U test, $n = 151$, U prime $= 2903$, tied $p = 0.1$).

Poaching was higher in unprotected sites than in protected sites for those four species for which direct comparisons were possible. Overall, the difference in poaching levels between protected and unprotected sites for these four species was highly significant (Fig. 2; Mann-Whitney U test, $n = 64$ sites, U prime $= 838$, tied $p < 0.0001$). Mann-Whitney U test comparisons within species indicated that this difference was significant in three of the four species: *A. autumnalis* ($n = 22$, U prime $= 106$, tied $p = 0.0002$), *A. oratrix* ($n = 13$, U prime $= 19.5$, tied $p = 0.09$), *A. viridigenalis* ($n = 22$, U prime $= 112$, tied $p < 0.0001$), and *A. auropalliata* ($n = 7$, U prime $= 10$, $p = 0.05$).

Levels of nest mortality differed between island and mainland Neotropical countries, with the higher poaching levels found in the mainland studies contributing to greater overall nest mortality there than in studies from Caribbean islands. Levels of nest poaching differed between island and mainland studies (40% mainland vs. 10% islands; t test, df $= 21$, $t = 2.7$, $p = 0.01$), as did overall mortality levels (62% mainland vs. 26% island; t test, df $= 21$, $t = 3.9$, $p = 0.001$). Levels of nest mortality due to natural causes did not differ among the two regions (23% mainland vs. 16% island; t test, df $= 21$, $t = 1.2$, $p = 0.25$).

Of the 21 species included in this analysis, 13 are classified at some level of conservation risk, with 9 listed as threatened with extinction and 4 as near-threatened (Table 1). Across all studies, the level of poaching experienced by a species was not significantly related to its conservation status. The mean poaching level for species at risk (threatened or near-threatened) did not differ significantly from that experienced by nonthreatened species (30% of nests poached for species of concern vs. 49% for nonthreatened; Mann-Whitney U test with protected sites excluded, $n = 23$, U prime $= 79$, tied $p = 0.3$). Poaching level was not correlated with a species'

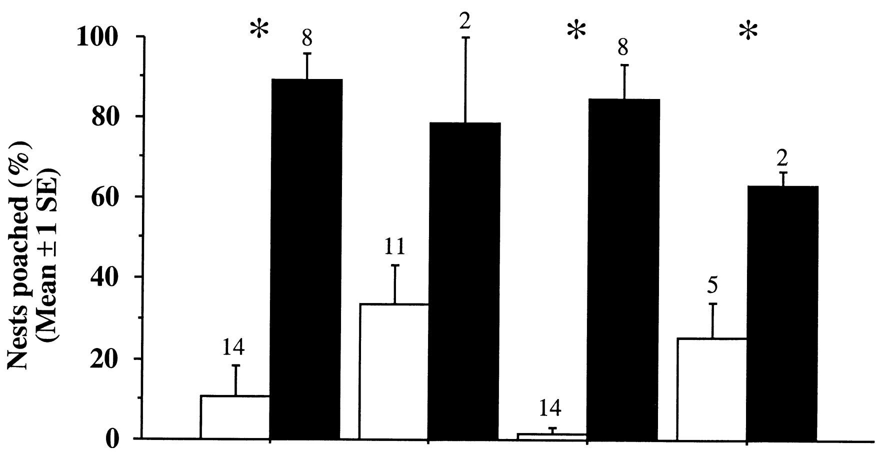

Figure 2. Percentage of nests (mean ± 1 SE) poached at protected sites (unshaded bars) versus unprotected sites (shaded bars) in four studies. Amazona autumnalis, A. oratrix, *and* A. viridigenalis *were studied in Mexico, and* A. auropalliata *was studied in Costa Rica. Asterisks above the bars denote those within-species contrasts significant at the α = 0.05 level. Sample sizes in site-years are above the bars.*

ranked conservation status (Spearman rank correlation, protected sites excluded, $n = 23$, tied Rho $= -0.06$, tied $p = 0.8$).

Most of the species for which nesting data were collected were advertised for sale over the internet by aviculturists based in the United States (Table 2). The mean prices for an individual of a given species ranged from $151 for *Myiopsitta monachus* to $2566 for *Amazona leucocephala*, with the majority of prices falling between $500 and $1500 (mean = $818, SD = $562). The U.S. retail price for a given species was not correlated with the level of poaching that it experienced in the wild in a Spearman rank correlation (protected sites excluded, $n = 16$, tied Rho $= 0.2$, tied $p = 0.4$). This anal-

Table 2. Retail prices for species and selected subspecies of Neotropical parrots included in the analysis (*) and for related species common in the pet trade.[a]

		Price (U.S. $)			
Common name	*Scientific name*	*mean*	*maximum*	*minimum*	*no. of ads*[b]
Blue-fronted Amazon	*Amazona aestiva*	711	900	350	15
Black-billed Amazon*	*A. agilis*	—[c]			
White-fronted Amazon	*A. albifrons*	458	600	225	6
Orange-winged Amazon*	*A. amazonica*	575	800	300	9
Red-necked Amazon*	*A. arausiaca*	—[c]			
Yellow-naped Amazon*	*A. auropalliata*	825	1100	543	15
Yellow-cheeked Amazon*	*A. autumnalis*	681	875	500	11
Salvin's	*A. a. salvini*	250	250	250	1
Yellow-shouldered Amazon*	*A. barbadensis*	1150	1500	800	2
Red-tailed Amazon*	*A. brasiliensis*	—[c]			
Yellow-billed Amazon*	*A. collaria*	1300	1500	1100	2
Mealy Amazon	*A. farinosa*	762	1000	650	4
Costa Rican	*A. f. virenticeps*	900	900	900	1
Festive Amazon	*A. festiva*	2150	2500	1800	2
Lilac-crowned Amazon*	*A. finschi*	625	900	250	4
White-faced Amazon*	*A. kawalli*	—[c]			
Cuban Amazon*	*A. leucocephala*	2567	3500	1200	3
Yellow-crowned Amazon	*A. ochrocephala*	724	800	595	6
Panama*	*A. o. panamaensis*	600	600	600	1
Yellow-headed Amazon*	*A. oratrix*	844	1300	500	16
Tres Marías	*A. o. tresmariae*	1162	1800	525	2
Tucuman Amazon	*A. tucumana*	693	850	550	5
Hispaniolan Amazon*	*A. ventralis*	1100	1100	1100	1
St. Lucia Amazon*	*A. versicolor*	—[c]			
Vinaceous Amazon*	*A. vinacea*	—[c]			
Green-cheeked Amazon*	*A. viridigenalis*	587	800	135	9
Puerto Rican Amazon*	*A. vittata*	—[c]			
Yellow-faced Amazon	*A. xanthops*	925	950	900	2
Hyacinth Macaw	*Anodorynchus hyacinthinus*	7300	9000	6000	5
Blue-and-yellow Macaw	*Ara ararauna*	878	1400	600	30
Green-winged Macaw	*A. chloroptera*	1426	2000	1000	19
Scarlet Macaw	*A. macao*	1269	2000	800	15
Military Macaw	*A. militaris*	729	1150	450	12
Chestnut-fronted Macaw	*A. severa*	688	1000	500	13
Pacific Parrotlet	*Forpus coelestis*	175	225	125	2
mutation	*F. coelestis*	875	875	875	1
mutation "split"	*F. coelestis*	570	570	570	1
Green-rumped Parrotlet*	*F. passerinus*	150	150	150	1
Monk Parakeet*	*Myiopsitta monachus*	151	225	125	4
mutations green/blue	*M. monachus*	225	300	150	2
mutations cinnamon	*M. monachus*	3100	3600	2600	2
mutations blue	*M. monachus*	900	1000	800	2
mutations cinn./blue	*M. monachus*	8500	8500	8500	1
Bronze-winged Parrot	*Pionus chalcopterus*	425	550	300	2
Scaly-headed Parrot	*P. maxmiliani*	360	450	250	5
Blue-headed Parrot*	*P. menstruus*	517	550	450	3
White-crowned Parrot	*P. senilis*	308	450	225	3

[a]*Prices obtained from advertisements posted on the internet in July 1988 by bird breeders and pet stores.*
[b]*Number of advertisements for a given species.*
[c]*Species for which no U.S. prices are available.*

ysis, however, may have had low power to detect a correlation because most of the prices were in the intermediate range of \$500–\$1200. We did detect significantly lower poaching levels in species with retail prices below \$500 than in those with a greater retail value (Mann-Whitney U test with protected sites excluded, $n = 16$, U prime $=$ 27.0, tied $p = 0.04$).

Discussion

Our survey found that nest poaching is a widespread and significant cause of nest mortality in Neotropical parrots. For those species experiencing nest poaching, mortality due to poaching was significantly greater than mortality due to natural causes. High rates of nest poaching have also been documented on parrot species outside the Neotropics (Joseph 1988; Rinke 1989; Lambert 1993; Juste B. 1996). These results confirm data from trade figures (Thomsen & Brautigam 1991; Beissinger 2001) and species-level conservation surveys (Mountfort 1989; Collar et al. 1994) which suggest that nest poaching for the pet trade is a major conservation threat for many parrot species.

Effect of Poaching on Wild Populations

The low rates of reproduction experienced by many parrot species strongly suggest that poaching levels over 70%, as found in four of the species studied here, will lead to severe declines of natural populations (Beissinger & Bucher 1992; Beissinger 2001); such declines have been observed in a number of parrot species (Collar et al. 1994; Juniper & Parr 1998). Almost half of the studies, however, reported poaching levels in the range between 10% and 50% (Fig. 1), and some degree of uncertainty exists as to whether viable populations can be sustained under this pressure. The long lifespan of most parrots means that longer-term studies are necessary to measure the relative effect of different rates of poaching, and few such detailed data sets are available for species outside of Australia (e.g., Saunders 1986; Rowley 1990; Emison et al. 1994; but see Beissinger & Bucher 1992). Furthermore, the effects of nest poaching on population levels may be particularly difficult to detect with such studies because adult populations of long-lived species would take a long time to show the declines resulting from mortality at the nestling stage. Demographic models are an alternative method for understanding the effects of poaching on wild populations. We (T.W. and C.T.) are currently developing a model that incorporates known poaching and demographic parameters for a variety of parrot species. Although firm conclusions on population sustainability await these results, the high levels of poaching we report should be cause for concern, particularly for species currently threatened with extinction.

Demographic models of sustainable harvesting of nestlings for the pet trade previously have been developed for the Green-rumped Parrotlet (*Forpus passerinus*) (Beissinger & Bucher 1992). Because of its small body size, low age at first reproduction, high clutch size combined with hatching asynchrony, and possible limitation by nest sites (Beissinger & Bucher 1992), the Green-rumped Parrotlet is indeed a candidate for successful sustainable harvest (Stoleson & Beissinger 1997). These life-history characteristics also allow it to breed abundantly in captivity, and the market value for wild-type parrotlets (both *F. passerinus* and *F. coelestis*) is low (Table 2). No poaching was recorded on the Green-rumped Parrotlet in the 7-year study included in this analysis (Fig. 1), and many of its life-history characteristics set the parrotlets apart from the larger parrots that constitute the majority of species in this study (Snyder et al. 1987; Forshaw 1989; Gnam & Rockwell 1991; Munn 1992; Juniper & Parr 1998). For these reasons, the harvesting model developed for the Green-rumped Parrotlet does not provide good estimates of the long-term demographic effects of poaching for many of the species in this analysis (see also Stoleson & Beissinger 1997).

Poaching, Habitat Destruction, and Conservation Strategies

Destruction and degradation of natural habitats are widespread and have been implicated in the decline of many bird species from the Spotted Owl (*Strix occidentalis*) (Noon & McKelvey 1996) to Neotropical migrant songbirds (Hagan & Johnston 1992). Habitat loss is also thought to play a role in the decline of a wide range of parrot species, both alone and combined with poaching pressures (Collar & Juniper 1992; Nores & Yzurieta 1994; Best et al. 1995; Christian et al. 1996; Juniper & Parr 1998). Although either habitat loss or poaching alone can pose serious conservation risks, these two factors can also act in concert such that parrot populations initially depressed by habitat degradation are subsequently driven to critical levels by intensified poaching (Gochfeld 1974; Fitzgerald 1989; Lambert 1993).

The most dramatic example of this process is Spix's Macaw (*Cyanopsitta spixii*), a species that is virtually extinct in the wild and precarious in captivity (Juniper & Yamashita 1991). This species probably always occurred at low density and was limited to highly vulnerable riparian forests (Forshaw 1989; Juniper & Yamashita 1991). Once Spix's Macaw became rare in the wild, the demand from wealthy collectors for captive birds intensified to the extent that prices reached at least \$20,000 per individual (Fitzgerald 1989; Clubb 1992). A similar process has occurred with the Hyacinth Macaw (*Anodorhynchus hyacinthinus*) (Wilcove 1996; Johnson et al. 1997). The high value placed on such rare species ensures that wild populations will continue to be pressured by poaching (Wilcove 1996), causing populations to be smaller than they would otherwise be in degraded habitat that could nonetheless support some level of reproduction.

The dynamic by which a species threatened by habitat destruction is subject to increasing levels of harvesting as it becomes increasingly rare can be considered a type of "extinction vortex" (Gilpin & Soulé 1986). This "collector's vortex" is produced by a mentality that confers increasing value on species as they become more rare. Parrot species threatened or extirpated by this extinction vortex include not only the Spix's and Hyacinth Macaws, but also the other large blue macaws (*Anodorhynchus leari, A. glaucus, Ara glaucogularis*), the Caribbean amazons (especially *Amazona tucumana, A. barbadensis, A. leucocephala, A. guildingii*), and the Golden Conure (*Guaruba guarouba*) (Gochfeld 1974; Oren & Novaes 1986; Yamashita 1987; Collar & Juniper 1992; Yamashita & Valle 1993; Wilcove 1996).

Even those aviculturists actively concerned with the conservation of parrot species often discount the threat posed by poaching. The American Federation of Aviculture (AFA) strongly opposed the renewal of the Wild Bird Conservation Act in 1995 and argued that parrots benefited from an active trade that removed birds from threatened habitats (Clubb 1992; Desborough 1994; Etchepare 1995; Voren 1995; Desborough 1996). Some aviculturists argued that by itself the maintenance of these species in captivity is sufficient for conservation (e.g., Etchepare 1995; Voren 1995; Desborough 1996). Others suggested that their private breeding programs could provide birds for release into wild populations (arguments are summarized by Clubb 1992; but see Desborough 1997). Although the AFA's official opposition to the WBCA has moderated in recent years (Clifton 1998), its emphasis remains on captive breeding as a conservation tool. We suggest that, because of demonstrated problems with the release of captive-bred parrots (Wiley et al. 1992; Snyder et al. 1994; Sanz & Grajal 1998), successful conservation of most parrot populations should be focused on the protection of existing parrot populations and their habitats rather than on captive breeding (Derrickson & Snyder 1992).

Factors Influencing Poaching Rates

Poaching of parrots from the wild is an economic activity driven by a combination of the market demand for parrots as pets, the large profits to the pet industry, and the rural poverty in many countries with wild-parrot populations. Although a detailed discussion of the economics of the wild-bird trade is beyond the scope of our paper (see discussions by Iñigo-Elias & Ramos 1991; Thomsen & Brautigam 1991; James 1992; Thomsen & Mulliken 1992; Beissinger 2001), our results highlight several factors that influence rates of poaching on various species.

The first of these factors is the price paid for parrots in the retail market. Price is set in part by demand, and demand for a particular species is influenced by rarity and by attributes related to the species value as a pet, including beauty, mimicry ability, personality, and size. Our data indicate that poaching rates are significantly lower for species valued under $500 (U.S. retail price) than for those priced above this value. Aviculturists independently concur that species priced above $500 are more likely to be imported illegally into the United States because they can be sold more cheaply than domestically bred birds (Harris 1994; Sefton 1995). These data suggest that the high value of most parrot species (Table 2) provides a continuing incentive for poaching of all but the lowest-priced species. The exception to this rule is for species in which domestically bred individuals with color mutations fetch a higher price than wild-type individuals (e.g., *Forpus passerinus* and *Myiopsitta monachus*; Table 2), providing a strong disincentive for further capture and import of wild-caught individuals. Ironically, education of aviculturists aimed at discouraging domestication practices (such as breeding for mutations and hybrids) may help maintain demand on the part of aviculturists for wild birds to fill captive breeding programs (Desborough 1996).

The second factor is the presence of international controls on trade. Prior to the enactment of the WBCA, the United States represented almost 50% of the international market for imported parrots (Thomsen & Mulliken 1992). Poaching rates were significantly lower in the years after enactment of the WBCA. Although this result may be partly confounded by an increase in conservation activities directed toward parrots in the same period (Snyder et al. 1999), it does suggest that importation bans reduce poaching in exporting countries by limiting demand by consumers in developed countries. The decrease in poaching after the WBCA enactment also indicates that the legal and illegal trades in parrots are positively correlated, as was true for the ivory trade (Bolze 1992), a finding that counters arguments by some aviculturists (Desborough 1996). The European Economic Union (E.E.U.) accounted for over 75% of all parrots legally imported in the 3 years immediately following the enactment of the WBCA in the United States (Beissinger 2001). We believe that if importation bans similar to that of the WBCA were enacted by the E.E.U., poaching rates would decline even further.

International controls, however, affect only a portion of the trade in parrots. Although there are few published data on the precise extent of domestic trade in Neotropical parrots, there are some indications that it involves a substantial portion of birds captured from the wild (Desenne & Strahl 1991; Iñigo-Elias & Ramos 1991; Thomsen & Brautigam 1991; Best et al. 1995). Many of the countries covered by this study have had domestic bans on exporting parrots in place for years (Thomsen & Mulliken 1992), but several also have species with poaching levels of >30% (e.g., Mexico, Costa Rica, Guatemala, Brazil). Current controls in these countries are not sufficient to eliminate poaching of these species. Thus, we suggest that international controls be complemented with the strengthening and increased enforcement of domestic bans on capturing and trading Neotropical parrots (Smiet 1985; Evans 1991; Best et al. 1995).

A third factor influencing poaching is the active protection of nest sites, which can significantly reduce poaching levels over those of unprotected nest sites for the same species. Some protection programs have reported success with direct protection of nest sites from human and other predators (Snyder et al. 1987; Christian et al. 1996). Such protection can be expensive and difficult to extend over large areas, however, suggesting that it has relatively low potential as a sustainable strategy for preserving large populations of most parrot species.

Other factors that can reduce poaching have been highlighted elsewhere, prime among these being conservation education programs and campaigns for national pride (Butler 1992; Christian et al. 1996). These programs have been implemented in a number of Caribbean island nations and may account for the lower levels of poaching recorded in that region.

Further research into the mechanisms of the bird trade is needed to assess the relative importance of domestic and international markets for Neotropical parrots and to design appropriate control measures. Although the reduction in poaching after the WBCA is positive for the conservation of endangered parrots, levels of poaching remain high and in many cases are probably too high to sustain viable populations of parrots. In combination with habitat degradation, poaching remains a significant cause for concern in parrot conservation.

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