Use and conservation of Cracidae (Aves: Galliformes) in the Peruvian Amazon

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Four species of the avian family Cracidae were studied in the Pacaya-Samiria National Reserve in north-eastern Peru. These large-bodied birds are an important source of protein for local communities on the periphery of the reserve. An estimated 425 kg of Cracidae biomass were harvested over a 1-year period by three communities. Pipile cumanensis *was the most frequently hunted bird, both in terms of individuals hunted and biomass extracted.* Mitu tuberosa *and* Penelope jaquacu *also made up a substantial amount of the biomass extracted, but were hunted less frequently. Densities of all species of Cracidae within 5 km of the villages were substantially lower than in the interior of the reserve. Our results suggest that* M. tuberosa *and* P. cumanensis *are overharvested and* P. jaquacu *and* Ortalis guttata *are harvested within the maximum estimated sustainable levels. In this study hunting grounds were along waterways and adjacent to protected populations, which created a source–sink arrangement. If sink areas are overhunted, the unhunted populations inland of the waterways could be acting as source populations that replenish overhunted areas.*

Introduction

Members of the Cracidae constitute a substantial part of the avian biomass in Neotropical bird communities (Terborgh, 1986). Cracids are an important element for maintaining plant communities, because they often defecate intact seeds (Erard and Sabatier, 1994; A.J.B., unpublished data) and move widely while foraging (Terborgh, 1986). Cracids are also important for rural people in the Neotropics (Terborgh, 1986; Vickers, 1991; Begazo, 1996). Studies on subsistence hunting show that cracids contribute substantial amounts of meat for rural people (Ayres *et al.*, 1991; Vickers, 1991).

In many areas of Latin America cracid populations are declining. Subsistence hunting is an important cause of these declines (Delacour and Amadon, 1973; Thiollay, 1989; Ayres *et al.*, 1991; Silva and Strahl, 1991; Strahl and Grajal, 1991; Vickers, 1991; Collar *et al.*, 1992). Habitat destruction has also been responsible for population declines of several species (Strahl and Grajal, 1991) and for the near extinction of one curassow (Texeira and Snow, 1982).

Several studies have concluded that cracids are not suitable for wild-meat harvests because of their slow rate of population recovery (Lovejoy and Brash, 1984; Terborgh, 1986; Estudillo-Lopez, 1988; Silva and Strahl, 1991; Strahl and Grajal, 1991). Thus, conservation of cracids has focused only on fully protected areas (Estudillo-Lopez, 1988; Strahl and Grajal, 1991). Many cracid populations, however, inhabit areas outside parks and are hunted by rural people to varying degrees.

In this paper we use data on intensity of hunting and status of standing populations of four species of Cracidae – razor-billed curassow *Mitu tuberosa*, Spix's guan *Penelope jaquacu*, common piping-guan *Pipile cumanensis* and speckled chachalaca *Ortalis guttata* – to assess sustainability of harvesting wild populations of cracids in the Peruvian Amazon. We examine subsistence hunting activities of people in three rural communities.

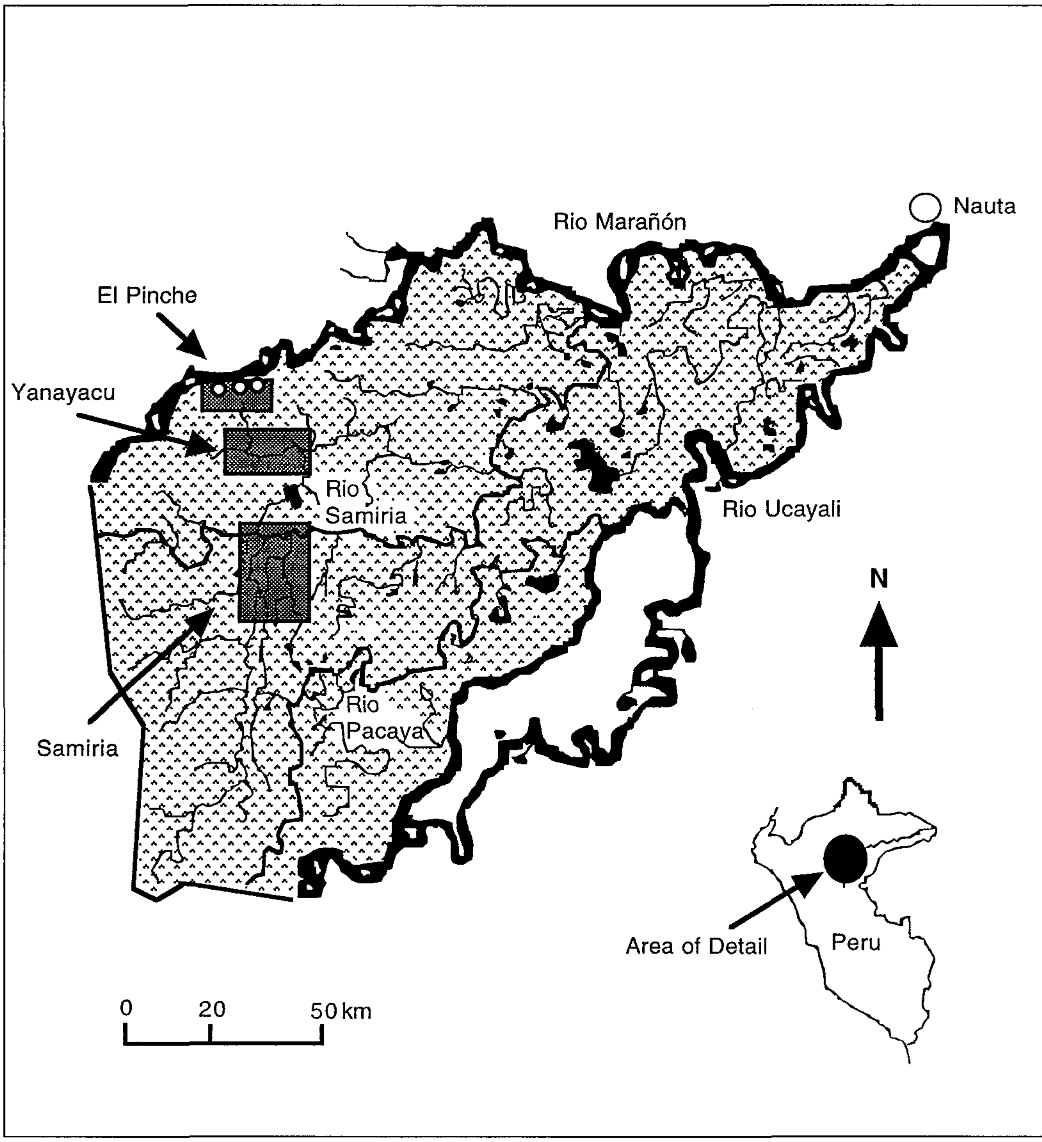

Figure 1. Map of the Pacaya-Samiria National Reserve showing the persistently hunted study site of El Pinche, the moderately hunted site of Yanayacu, and the lightly/non-hunted site of Samiria.

Methods

The study was conducted in three sites. The first site was located in the vicinity of the communities of Nueva Esperanza, Maipuco and San Antonio. These rural settlements are located along the Marañon River in the buffer zone of the Pacaya-Samiria National Reserve (PSNR) in north-eastern Peru. People residing in these villages use the reserve to extract natural resources, despite these activities being prohibited.

The other two sites are within the PSNR at different distances from human settlements (Figure 1). The habitats at all study sites are dominated by *várzea* forest (seasonally

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flooded) and floodplain levees (high forest). The study was conducted between May 1995 and August 1996.

Breeding biology

Data on the breeding biology of cracids were collected from interviews with hunters and from published records on the reproductive biology of these species in captivity. Hunters were asked the following questions: (i) How many nests of each species of cracid have you found while living in the region, (ii) how many eggs did you see in each nest, (iii) which month of the year were the nests found, (iv) which month of the year do you see adult birds with fledglings, and (v) which month of the year are cracids most active vocally? Clutch size of each species was estimated as the average number of eggs found in nests reported by hunters.

Habitat preferences

Hunters were asked to rank the four species of cracids by their likelihood of being found in: (i) forest prone to inundation, (ii) floodplain levees or (iii) other types of forest. These data provided patterns of cracid biology from hunters who have many years' experience in the region. The results were analysed using the G2 (Likelihood-ratio) test.

Population density estimates

Densities of cracids were estimated in this study. These estimates were obtained from censuses carried out in the heavily hunted site of El Pinche (within 5 km of the villages), the moderately hunted site of Yanayacu (within 20 km of the villages) and the lightly/non-hunted site of Samiria, all within the Pacaya-Samiria National Reserve. The intensity of hunting in the three sites was deduced from interviews with hunters and reserve guards. Transects were surveyed in the mornings between 07.00 and 12.00 h. We recorded the perpendicular distances between the bird and the trail (Buckland *et al.*, 1993) and used the program DISTANCE (Laake *et al.*, 1994) to estimate population densities. All transects were done on trails cut especially for density surveys. Transects in the heavily hunted site totalled 380 km surveyed on five 5-km-long trails. Transects in the moderately hunted site totalled 87 km and used trails and water courses. Transects in the lightly/non-hunted site totalled 402 km censused in 10 trails of 4 and 5 km long. Perpendicular distance was taken from the edge of the water to the location of the animal on censuses along water courses. A measure of 1 m was assigned for birds flying across water course transects (Silva and Strahl, 1991).

Hunting

The number of cracids harvested came from records of hunted animals kept by hunters, and from interviews. Hunters either kept a portion of the total number of birds they hunted as part of an ongoing participatory wildlife programme, or they reported hunting orally. Hunting activities were determined by direct observation at the villages and at hunting grounds 5 and 20 km from the villages. One of the authors A.J.B. spent 3 months in the villages (11 May–14 August 1995) and, because hunting pressure does not vary through the year, was able to obtain an estimate of the annual harvests. Mammalian game biomass consumed in the three villages was compared with the cracid data, and was obtained from a 1-year-long study at the same villages (Bodmer *et al.*, in press).

Sustainability of cracid hunting

The production model of Robinson and Redford (1991) was used to evaluate whether cracids were overharvested. Production was calculated as:

$$P_{max} = [0.6D \times L_{max}] - 0.6D$$

where maximum production is assumed to occur when the population density is at 60 per cent of carrying capacity, D = density at carrying capacity (individuals/sq km), and L_{max} = the maximum finite rate of population increase from time T_o to T_{+1}. Densities at carrying capacity were estimated from the lightly/

Table 1. Reproductive parameters used to estimate L_{max} for cracid species in the Pacaya-Samiria National Reserve in a study carried out between May 1995 and August 1996

Species	Body mass (kg)	Age of first breeding (years) (a)	No. female young (young/year) (b)	Age of last breeding (years) (w)	L_{max}	r_{max}
Mitu tuberosa	3.06	3	1	18	1.46	0.3818
Penelope jacquacu	1.28	3	1.1	14	1.49	0.3993
Pipile cumanensis	1.3	3	1.3	14	1.54	0.4337
Ortalis guttata	0.5	3	2	14	1.76	0.5276

Table 2. Comparison of clutch size of cracids from the literature and from reports by hunters interviewed in a study in the Pacaya-Samiria National Reserve carried out between May 1995 and August 1996

Source	Species			
	Mitu tuberosa	*Penelope jacquacu*	*Pipile cumanensis*	*Ortalis guttata*
Literature	2	2.5	3–4	2–4
Hunters	2 ± 0 (*n* = 36)	2.2 ± 0.6 (*n* = 52)	2.6 ± 1.3 (*n* = 26)	4 ± 1.3 (n = 28)

n, number of nests reported by hunters.

Table 3. Population densities of cracids in the three study sites in the Pacaya-Samiria National Reserve from a study carried out between May 1995 and August 1996

Sites/ Species	Density ind./sq km	% Coefficient of Variation	d.f.	95% Confidence Interval
Fully protected area				
Samiria site				
Mitu tuberosa	1.65	24.37	20	1.00–2.72
Penelope jacquacu	5.46	25.71	22	3.23–9.23
Pipile cumanensis	6.79	33.09	11	3.34–13.82
Ortalis guttata	3.28	59.0	2	0.30–35.08
Moderately hunted area				
Yanayacu site				
Mitu tuberosa	2.08	50	4	0.56–7.7
Penelope jacquacu	5.46	25.71	22	3.23–9.23
Pipile cumanensis	9.37	28.87	12	5.06–17.36
Ortalis guttata	3.6	54.01	3	0.73–18.26
Heavily hunted area				
El Pinche site				
Mitu tuberosa	0.02	–	–	*
Penelope jacquacu	0.22	70.71	2	0.14–3.45
Pipile cumanensis	0.44	40.82	6	0.17–1.16
Ortalis guttata	5.95	44.72	5	1.98–17.84

* Sample size was too small to measure confidence interval.

non-hunted site. In the model, the maximum rate of population increase (L_{max}) was estimated by taking the exponential of r_{max}, which was calculated using Cole's equation (1954).

$$1 = e^{-r_{max}} + be^{-r_{max(a)}} - be^{-r_{max\,(w+1)}}$$

Where (a) is the age of first reproduction, (w) is the age of last reproduction, and (b) is the annual birth rate of female offspring (Table 1). The sustainable maximum harvest was assumed to be 20 per cent of P_{max}, which accounts for prereproductive and adult mortality (Slade *et al.*, 1998). Sustainability of the current cracid harvest was assessed by comparing estimates of maximum sustainable harvest with current rates of harvest. We estimated the catchment area by mapping the location of hunting grounds. Because hunters used canoes and limited their hunting activities to 2 km into the forest from the edge of water courses, we multiplied the length of the rivers and small tributaries by four to obtain the catchment area.

Results

Breeding biology

Reproductive biology of the four cracids was determined from 169 nests reported by 53 hunters. Hunters reported a clutch size of 2 ± 0 for *M. tuberosa*, which is the same as previously published reports (Estudillo-Lopez, 1988; Schifter, 1989). However, hunters reported a clutch size of 2.6 ± 1.3 for *P. cumanensis*, 2.2 ± 0.6 for *P. jacquacu* and 4 ± 1.3 for *O. guttata*, which differ from previous reports (Delacour and Amadon, 1973; Estudillo-Lopez, 1988; Schifter, 1989; Table 2). Nests were found between the months of November and February. Adult birds with fledglings were also seen between November and February ($n = 37$). The peak of singing activity was in November and December. A.J.B. observed a family group of *O. guttata* with fledglings of *c.* 2 months old in mid-May, which suggests that the breeding season may extend into March. Age of fledglings was estimated by the size and characteristics of plumage relative to adults (Delacour and Amadon, 1973).

Habitat preferences

Hunters reported that cracids in Pacaya-Samiria have habitat preferences (G2 = 146.2, d.f. = 6, $P < 0.001$). *Mitu tuberosa* associates more with forests prone to inundation, termed *bajial* (G2 = 61.73, d.f. = 1, $P < 0.001$), and to a lesser extent with floodplain levees, termed *restingas* (G2 = 4.19, d.f. = 1, $P = 0.034$). *Penelope jacquacu* associates more with floodplain levees (G2 = 64.47, d.f. = 1, $P < 0.001$) and less with forest prone to inundation and other types of forest (G2 = 7.64, d.f. = 1, $P = 0.006$). There was no clear association of *P. cumanesis* and *O. guttata* with any habitat type (G2 = 3.51, d.f. = 2, $P = 0.173$).

Population density estimates

Density estimates of Cracidae were higher in the lightly/non-hunted and moderately hunted sites than near the villages (Table 3). In heavily hunted areas at 5 km from the villages, populations of *M. tuberosa* have been reduced by 98 per cent compared with the lightly/non-hunted site, *P. jacquacu* by 95 per cent and *P. cumanensis* by 94 per cent. *Ortalis guttata*, the smallest cracid in the region, thrives on forest edges and agricultural areas and because of its small size, is seldom hunted.

Hunting

Hunting of cracids differed between communities: 71 per cent of cracids taken were hunted in Nueva Esperanza, 21.2 per cent in Maipuco, and 7.6 per cent in San Antonio. The most frequently hunted cracid was *P. cumanensis*, making up 59.1 per cent of the total cracid harvest, followed by *M. tuberosa* comprising 19.7 per cent, *P. jacquacu* making up 16.4 per cent, and *O. guttata* comprising 4.5 per cent (Table 4).

Cracids represent an important source of meat for people at the three villages. Hunters were estimated to extract 425 kg of cracid biomass during a year. Indeed, *P. cumanensis* was the most frequently hunted animal in the three communities (Table 5). Hunting trips of local people were usually short trips within 5–7 km

Table 4. Ninety-day recorded harvests and estimated annual harvests of cracids in three villages on the edge of the Pacaya-Samiria National Reserve between 11 May and 14 August 1995

	90-day harvest				
Species	Maipuco	Nueva Esperanza	San Antonio	All villages	Estimated annual harvest
Mitu tuberosa	2	10	1	13	53
Penelope jacquacu	2	9	0	11	45
Pipile cumanensis	10	25	4	39	158
Ortalis guttata	0	3	0	3	3
Total	14	47	5	66	259

Table 5. Annual cracid and mammalian harvest by no. of individuals hunted and biomass harvested, together with ranked indices, in three villages on the edge of the Pacaya-Samiria National Reserve from studies carried out between 11 May and 14 August 1995 (cracids) and between August 1994 and August 1995 (mammals)*

Species					
Scientific name	English name	No. harvested	Rank no. harvested	Biomass harvested (kg)	Rank biomass harvested
Tayassu pecari	White-lipped peccary	52	6	1716	1
Tapirus terrestris	Lowland tapir	9	17	1440	2
Agouti paca	Paca	86	4	770	3
Dasyprocta fuliginosa	Black agouti	122	2	610	4
Mazama americana	Red brocket deer	14	14	445	5
Tayassu tajacu	Collared peccary	18	13	438	6
Hydrochoerus hydrochaeris	Capybara	29	10	390	7
Cebus apella	Brown capuchin	97	3	337	8
Alouatta seniculus	Red howler monkey	34	8	268	9
Pipile cumanensis	Common piping guan	158	1	205.4	10
Mitu tuberosa	Razor-billed curassow	53	5	162.2	11
Dasypus novemcinctus	Nine-banded armadillo	32	9	160	12
Lagothrix lagothrica	Common wolly	8	18	121	13
Cebus albifrons	White-fronted capuchin	25	11	74	14
Potos flavus	Kinkajou	22	12	65	15
Panthera onca	Jaguar	1	22	60	16
Penelope jacquacu	Spix's guan	45	7	57.6	17
Ateles paniscus	Black spider monkey	7	19	55	18
Felis concolor	Puma	1	22	45	19
Tamandua tetradactyla	Collared anteater	6	20	28	20
Pithecia mocachus	Monk saki monkey	10	16	19	21
Bidelphidae	Opossums	7	19	11	22
Felis pardalis	Ocelot	1	22	10	23
Bradypus variegatus	Three-toed sloth	2	21	8	24
Saimiri spp.	Squirrel monkeys	9	17	7.2	25
Ortalis motmot	Speckled chacalaca	12	15	6	26
Aotus nancymae	Night monkey	6	20	4.8	27
Sciurus spp.	Squirrels	6	20	4.5	28
Saguinus fuscicollis	Saddlebacked tamarin	1	22	0.8	29

* Data from Bodmer *et al.*, in press.

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Table 6. Estimates of P_{max} and maximum sustainable harvest levels for cracids in the Pacaya-Samiria National Reserve from a study carried out between May 1995 and August 1996

Species	Density ind./sq km	P_{max} ind./sq km	Max. sustainable annual harvest ind./sq km	Max. sustainable annual harvest ind./276 sq km	Current annual harvest within the 276 sq km
Mitu tuberosa	1.56	0.43	0.08	23	53
Penelope jacquacu	5.46	1.61	0.32	88	45
Pipile cumanensis	8.08	2.62	0.52	144	158
Ortalis guttata	3.06	1.89	0.37	102	3

of the villages, mostly by land, and usually only lasting a day, or long trips covering large distances and large catchment areas along watercourses, which last from several days to entire weeks.

Sustainability of cracid hunting

Current harvests of *M. tuberosa* and *P. cumanensis* in the 276-sq-km catchment area are not sustainable, because current harvest levels exceed estimated maximum sustainable harvests (Table 6). In contrast, current harvests of *P. jaquacu* and *O. guttata* are within estimated maximum sustainable levels and therefore might be sustainable.

Discussion

Cracids are vulnerable to extinction. For example, of the 44 known species of Cracidae (Delacour and Amadon, 1973), 30 per cent are listed in the red data book of Neotropical birds (Collar *et al.*, 1992). Thirty-seven percent of guans and curassows (the largest members of the family) are listed in several categories of threat, which is significantly higher than the 8–10 per cent listing rate for most bird families (Collar *et al.*, 1992). Two species of curassow and four species of guans are listed on Appendix I and populations of four curassows, one chacalaca and two guans on Appendix II of the Convention on International Trade in Endangered Species (IUCN, 1996). Extinction of cracids will be more than species-specific events, because many of them are considered to be ecologically important and their declines will probably have negative impacts on forest structure (Levey, 1994).

Conservation of cracids in Latin America is important but the strategies need to be broadened. We concur that low rates of recovery of cracid populations make it difficult for them to tolerate high levels of continuous hunting (Lovejoy and Brash, 1984; Delacour and Amadon, 1973; Strahl and Grajal, 1991). However, this does not mean that fully protected areas are the only option for cracid conservation in the wild (Delacour and Amadon, 1973; Lovejoy and Brash, 1984; Estudillo-Lopez, 1988; Stahl and Grajal, 1991). Indeed, fully protected areas only represent a small fraction of cracid habitat.

Conservation of cracids should also focus on the vast areas inhabited by humans and subject to hunting. A critical characteristic of the lowlands of tropical America is that they are largely inhabited by local people (Raez-Luna, 1995). Land used by rural Amazonians is estimated to cover 1,727,797 sq km of rain forest in Peru, Colombia and Brazil. For example, in Peru 1000 Indian communities occupy 736,443 sq km of Amazonian land, but only 50,000 sq km are currently protected (Raez-Luna 1995).

This study suggests that the impact of hunting cracids may be minimized if the hunting is in extensive areas, is sporadic, and these hunting areas are surrounded by unhunted populations. Silva and Strahl (1991) have proposed a similar strategy for conserving cracids. Many rural Amazonians use wildlife in a way similar to the hunting described in this study (Alcorn, 1993; Redford and Stearman, 1993).

Therefore, habitat outside protected areas needs to be managed in a way that combines hunted and non-hunted areas (McCullough, 1996).

Understanding the impact hunters have on cracid populations is critical for managing cracid hunting. In the Pacaya-Samiria National Reserve hunters might be creating sink areas along waterways during longer hunting trips. In turn, cracids may repopulate these sink areas created by hunting. For example, hunters that go on longer hunting trips distribute their hunting activities sparsely in large areas along waterways. If these areas are overhunted, the unhunted populations inland of waterways could be acting as source populations that replenish overhunted areas. The constant flux of individuals from unhunted areas and the sparse nature of hunting in these areas help maintain seemingly stable populations of game animals under harvest pressure (Novaro, 1995). In contrast, areas close to villages have a higher and more constant hunting pressure. This greater intensity of hunting may be too great for cracid populations to sustain, either by reproduction or immigration.

Determining sustainability of cracid harvests relies on many assumptions. Results indicated that current harvests of *P. jaquacu* and *O. guttata* may be sustainable. However, the Robinson and Redford model does not allow us to determine if these harvests are actually sustainable. Harvests of *M. tuberosa* and *P. cumanensis* were clearly not sustainable.

Body-size differences may explain the greater harvest pressure on *M. tuberosa*, which is the largest cracid in the region. The rate of harvest depends on the frequency of hunter–bird encounters. Hunters often pass smaller-sized birds and pursue the largest cracid upon encounter. A similar pattern has been observed with hunting of mammals in the Peruvian Amazon (Bodmer, 1995).

Conservation of cracids will be enhanced by working with rural Amazonians on converting unmanaged harvests to managed hunting. This in turn will help prevent cracid populations from becoming rare and prone to local extinction. However, studies such as this one on the impact of hunting cracid populations are needed to implement appropriate management. These studies can then help develop management programmes to convert overhunting to more sustainable harvests.

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