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# Seasonal variation in occurrence of macaws along a rainforest river

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ABSTRACT. Seasonal variations in occurrence of the Blue-and-yellow (*Ara ararauna*), Red-and-green (*A. chloroptera*), and Scarlet (*A. macao*) Macaw were evaluated in the floodplain rainforest of the Manu Biosphere Reserve, southeast Peru. One-hour surveys of macaws were conducted while traveling along the Rio Manu in a motorized canoe during both the dry and rainy season. There was a significant three-fold decline in the number of macaws encountered during the dry season compared to the rainy season. Encounter rates also varied significantly among macaw species, and may be due to behavioral characteristics or habitat preferences of species. Rapid or short-term surveys used to establish trade quotas and the status of species may be susceptible to biases and inaccuracies resulting from seasonal variations and behavioral characteristics of psittacine species.

SINOPSIS. **Variaciones estacionales de la presencia de *Ara* spp. a lo largo de un rio en un bosque pluvial**

Se evaluaron las variaciones estacionales de la presencia de tres especies de guacamayos (*Ara ararauna*, *A. chloroptera*, y *A. macao*) a lo largo de un río en la Reserva de la Biosfera de Manú, Perú. Se llevaron a cabo censos de una hora para determinar la presencia de guacamayos a lo largo del Río Manú durante las temporadas de lluvia y sequía. Los censos se llevaron a cabo en canoas motorizadas. Se encontró una reducción significativa en el número de guacamayos durante la época de sequía al comparar esta con la temporada de lluvias. Se encontró además una variación significativa entre las diferentes especies, lo que muy bien pudiera deberse a características particulares de conducta o la preferencia de habitat de las especies. Los censos rápidos o de corto alcanze que se utilizan para establecer cuotas de captura y el estatus de estas especies, pudiera ser susceptible a sesgo y a poca precisión, como resultado de las variaciones estacionales y la conducta particular de estas especies de aves.

*Key words:* *Ara ararauna*, *A. chloroptera*, *A. macao*, Manu Biosphere Reserve

Effective monitoring and control of international trade in psittacines requires reliable data on the population density and distribution of species (Thomsen and Brautigam 1991). However, little is known of many species which occur in expansive areas of Amazonian rainforest. The Blue-and-yellow (*Ara ararauna*), Red-and-green (*Ara chloroptera*), and Scarlet Macaw (*Ara macao*) are all widely distributed in South American rainforest (Forshaw 1989). Of these, the Scarlet Macaw is listed as endangered on Appendix I of the Convention on International Trade in Endangered Species (CITES), prohibiting trade in this species. However, the Blue-and-yellow Macaw and the Red-and-green Macaw frequently occur in international trade, and the Blue-and-yellow Macaw is among the 15 most heavily traded species of neotropical psittacine (Roet et al. 1982; Thomsen and Brautigam 1991).

Various methods have been used to survey parrot populations, including variable circular plots (Lambert 1993; Marsden 1999), lookout point counts (Snyder et al. 1987; Gilardi and Munn 1998), roost counts (Gnam and Burchsted 1991), and line transects (Casagrande and Beissinger 1997). Surveying psittacines in Amazonian rainforest is constrained by the inaccessibility of most areas, logistical difficulties, and behavioral characteristics of the species concerned. Large macaws may be highly mobile and occur at low densities (Forshaw 1989; Thiollay 1989). Seasonal variations in surveys (Drapeau et al. 1999) may also have implications for the reliability of data used to set trade quotas of psittacines or to evaluate the potential for sustainable management of species.

River channels provide a means of access to areas of Amazon rainforest. Determining the presence or absence of psittacines in the forests along these river systems can provide useful information, such as the impact of human settle-

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ment on the occurrence of large macaws (Munn 1992). The present study utilizes repeated surveys along a floodplain river in the Manu Biosphere Reserve, Peru, during both the dry season and the rainy season, to determine whether there are seasonal variations in encounter rates of macaws in undisturbed rainforest.

## METHODS

Surveys of macaws were conducted along the Rio Manu from 71°02′W 12°14′S to 71°38′W 11°55′S in both the Reserve Zone and the National Park of the Manu Biosphere Reserve, southeastern Peru. The study site comprises tropical humid forest along the 6-km wide floodplain of the Rio Manu (Foster 1990). Average annual rainfall is just over 2000 mm, with 87% of the annual rainfall occurring during the rainy season from October to April. The dry season extends from June to October. Temperatures throughout the year fluctuate by only 4–6°C around a mean of 25°C. Exceptions to this occur in June and July when occasional cold fronts, known as 'Friajes,' maintain maximum daily temperature below 18°C (Terborgh 1983).

The area of the river to be surveyed was divided into four sections demarcated by known stations and guard posts: (1) Romero Guard Post to Manu Lodge (25 km); (2) Manu Lodge to Pakitza Guard Post (33 km); (3) Pakitza Guard Post to Cocha Cashu Biological Station (23 km); (4) Cocha Cashu Biological Station to Rio Cumerjali (26 km). Sections 1 and 2 were in the Reserve Zone, whereas sections 3 and 4 were in the National Park zone of the Biosphere Reserve.

A total of 68 one-hour surveys were conducted while traveling along the river in a motorized canoe during the rainy season of January–April ($N = 29$) and the dry season of July–September ($N = 39$) in 1989. Additional one-hour surveys were conducted during the dry season of July–September in 1990 ($N = 23$). Due to the opportunistic nature of river journeys, surveys were allocated in four daily time bands of three h each: 05:30–08:29; 08:30–11:29; 11:30–14:29; and 14:30–17:29. Surveys were evenly distributed between river sections and time bands, with the exception that only 7.4% of surveys were conducted along Section 1 of the Rio Manu, as this was traveled while entering and leaving the Manu Biosphere Reserve.

At the start of each survey a note was made of the date, weather conditions, percent cloud cover, location, and start time. Encounter rates were then recorded for the Blue-and-yellow, Red-and-green, and Scarlet Macaw, including data on time, number encountered, activity (perched, flying, or vocalizing), and method of detection. If a macaw was detected by vocalization but not seen, the species was identified and recorded as one individual. If it was not possible to determine the species of macaw encountered, the observation was recorded as unidentified and excluded from the analysis of species encounter rate. No surveys were conducted during heavy rain; however, six one-hour surveys were conducted on overcast days. In addition, five one-hour surveys occurred on the colder days of a Friaje between 8–12 July 1989.

Observations were also made at a *Mauritia flexuosa* palm swamp roost site for Blue-and-yellow Macaws along Section 1 of the Rio Manu. Counts of macaws roosting at the site were made from 17:20 to 18:10 during the rainy season on 19 and 23 March 1989 and the dry season on 22 and 24 September 1989.

The survey data were grouped by river section, time band, and season, and transformed by natural log when this was required to meet the assumptions of a normal distribution for analysis of variance (ANOVA). A general linear model was used for analysis of variance on unbalanced data sets. Preliminary analysis was conducted to determine variations in encounter rates of macaws due to weather conditions and river section surveyed. The pooled survey data were then analyzed for seasonal variations in encounter rates of macaws. The 0.05 significance level was used in statistical analyses, and mean values ± 1 standard error are presented.

## RESULTS

**Weather conditions.** Surveys conducted on overcast days, determined as 100% cloud cover, did not differ significantly from those conducted on clear days during the same time period and season on the same section of river ($F_{1,12} = 0.47$, $P = 0.51$). However, significantly fewer macaws were encountered in surveys conducted during the colder days of a Friaje (mean

Table 1. Three-way ANOVA with general linear model on log-transformed data of encounter rates for three species of macaw along all four sections of the Rio Manu in the dry season and the rainy season of 1989.

| Source | df | *F* value |
|---|---|---|
| Macaw species | 2,132 | 8.82** |
| Time band | 3,132 | 2.66, ns |
| Season | 1,132 | 10.06** |
| Species × time band | 6,132 | 1.17, ns |
| Species × season | 2,132 | 1.13, ns |
| Time band × season | 3,132 | 1.41, ns |
| Species × time band × season | 6,132 | 0.32, ns |

Significance level: * = $P < 0.05$, ** = $P < 0.01$, ns = $P > 0.05$.

0.67 ± 0.33 large macaws/h) compared to those conducted on warmer days (4.2 ± 1.59) for the same time period and river section ($F_{1,12} = 5.00$, $P < 0.05$). Due to the effect of these cold weather fronts on encounter rates of macaws, surveys on the days of a Friaje were removed from further analyses.

**Seasonal variation.** Encounter rates of macaws along the Rio Manu varied significantly between seasons and with macaw species (Table 1). Overall, fewer large macaws were encountered in one-hour surveys during the dry season compared to the rainy season (Table 2). This seasonal variation in encounter rate was demonstrated for both Red-and-green and Scarlet Macaws, though not for Blue-and-yellow Macaws (Table 2).

Counts of Blue-and-yellow Macaws at the palm swamp roost site indicated that, as with the other two species, a greater number of Blue-and-yellow Macaws were observed during the rainy season than the dry season. An average of 179 ± 6.0 Blue-and-yellow Macaws were counted at the roost site over two nights during the rainy season in March 1989. This number dropped four-fold in the dry season to an average of 38.5 ± 3.5 Blue-and-yellow Macaws at the roost site over two nights in September 1989.

One-hour surveys conducted during the dry-season months of July–September in 1990 recorded a mean/h of 1.2 ± 0.64 Blue-and-yellow, 0.7 ± 0.28 Red-and-green, 1.2 ± 0.49 Scarlet, and 3.2 ± 0.92 total large macaws. This did not differ significantly from dry-season surveys conducted in 1989 ($F_{1,122} = 2.7$, $P = 0.10$).

## DISCUSSION

One-hour surveys along the Rio Manu demonstrated a significant three-fold decline in the number of large macaws encountered during the dry season compared to the rainy season. The low number of macaws encountered during the dry season was also consistent between years, and coincides with a sharp decline in plant energy production of the floodplain forest during the dry season months of May to August (Terborgh 1983, 1986; Janson and Emmons 1990).

The increased number of macaws encountered during the rainy season also coincides with the macaw breeding season in December to April (K. Renton, pers. obs.). River floodplains may provide important nesting sites for large macaws (Iñigo-Elias 1996). Hence, macaws may utilize these habitats more intensively during the rainy season due to the availability of nest sites and food resources in floodplain forest.

Variation in soil types, habitats, and microclimates in tropical forests results in heteroge-

Table 2. Encounter rates and two-sample *t*-test analyses on log-transformed data for three species of macaw in one-hour surveys along the Rio Manu during the rainy season and the dry season of 1989.

| Species | Encounter rate (mean ± SE)/h | | Two-sample *t*-test significance level |
|---|---|---|---|
| | Rainy season (January–April) | Dry season (July–September) | |
| Blue-and-yellow Macaw | 1.9 ± 0.41 | 1.8 ± 0.59 | $t_{61} = 1.18$, ns |
| Red-and-green Macaw | 4.1 ± 1.49 | 1.0 ± 0.28 | $t_{61} = 2.11$* |
| Scarlet Macaw | 7.7 ± 1.74 | 1.8 ± 0.31 | $t_{60} = 3.47$*** |
| Total large macaws | 13.8 ± 2.56 | 4.7 ± 0.73 | $t_{63} = 3.57$*** |

Significance level: * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$, ns = $P > 0.05$.

neity in the availability of plant resources between areas (Foster 1980). Parrots in tropical dry forests of western Mexico may track seasonal fluctuations in food resource availability through dietary switching, habitat shifts, and migration (Renton 1998, 2001). The survey results along the Rio Manu suggest that large macaws in Amazonian rainforest may also alter their use of forest areas and exhibit seasonal variations in abundance.

The variation in encounter rate among species suggests that there may be some degree of habitat differentiation among macaw species. Of the three large macaws in Manu, only the Blue-and-yellow Macaw forms communal roosts (K. Renton, pers. obs.) and frequently occurs in palm swamps (Forshaw 1989). This tendency may be more marked during the rainy season when palm swamps provide both roosting and nesting sites for the Blue-and-yellow Macaw and could influence the probability of encountering this species in surveys along the river. A palm swamp roost site was located along Section 1 of the Rio Manu between Romero Guard Post and Manu Lodge. Roost counts at this palm swamp indicated seasonal variation for the Blue-and-yellow Macaw even though river surveys failed to demonstrate this. The low number of surveys along Section 1 of the river, combined with the behavioral preference of Blue-and-yellow Macaws for palm swamps in the breeding season, may account for the lower numbers of Blue-and-yellow Macaws and the lack of seasonal variation in river surveys for this species.

The ranging pattern of rainforest psittacines is poorly understood, although parrots are capable of moving hundreds of kilometers between areas and may exhibit seasonal variations in diet and movements (Saunders 1980; Smith and Moore 1992; Renton 2001). Potential seasonal variation in the occurrence of rainforest psittacines along rivers suggests that a variety of habitats and forest types may be required to sustain healthy populations. Areas adjacent to the main habitat and range of a species may be important as alternative resources at critical times of the year (Foster 1980). Seasonal variations in psittacine populations may also reduce the potential for sustainable management due to the difficulties of assessing the effect on population viability of habitat changes outside the management area (Beissinger and Bucher 1992). In particular, rapid survey procedures, used to determine the status of species or establish quotas for international trade, may be susceptible to biases and inaccuracies resulting from behavioral characteristics of psittacine species and potential seasonal variations in movements, area requirements, and habitat use.

A limitation of river surveys is that they are restricted to forests along the river edge and do not reveal what may be occurring in tierra firme forest away from the river. Point-count surveys may be more appropriate for determining habitat associations of species (Marsden 1999); however, all survey techniques may be susceptible to biases due to seasonal variation (Drapeau et al. 1999). Hence, surveys of psittacines may need to be conducted throughout the year, or in different seasons, in order to account for potential seasonal variation in abundance or detectability.

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