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Population Growth and Seasonal Abundance of the Neotropic Cormorant (*Phalacrocorax brasilianus*) at Highland Lakes in Ecuador

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Abstract.—Population growth of piscivorous species raises concerns when it could affect aquaculture activities. In this study, an increase of the Neotropic Cormorant (*Phalacrocorax brasilianus*) population in the Ecuadorian Andes was documented using census data from three high Andean lakes (Yahuarcocha, San Pablo and Yambo) for 2004-2010. In the 20th Century, only one record of the species existed for the study area. From 2005 onward, the species occurred regularly at all three lakes. At Yahuarcocha, the wintering population (October-February) grew at an annual rate of 0.382 ± 0.05, reaching 307 in 2010. The population consists mainly of non-breeding migrants, and at the present time, the wintering distribution range of cormorant populations in Ecuador includes the high Andes. Given reports of cormorant predation at fish farms, potential conflicts on account of cormorant expansion are discussed. *Received 21 December 2010, accepted 18 July 2011.*

Key words.—freshwater fishery, phenology, piscivorous birds, population growth.

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Population increases of piscivorous birds in regions where humans depend on fish can raise problems of wildlife management (Harris *et al.* 2008). In many cases, the proportion of the resource that the birds consume is minor, and the problem is more sociological-the fear that a new, increasing predator may reduce income-than economic (e.g. Zydelis and Kontautas 2008). Nonetheless, ecologists may be tasked to monitor the dynamics of piscivorous species as an early warning of population and/or distribution increases that could generate conflicts between species conservation and fish-based, local socioeconomies (Nisbet 1995; Trapp *et al.* 1995).

In Ecuador, fish farms are numerous in the coastal lowland regions, where conflicts with piscivorous species occur locally (see hereafter). During the 20th century, exotic fish species have been introduced in the high-Andean provinces to increase fish production (Ministerio de Recursos Naturales y Energéticos 1978), as in the rest of South America (Fitzsimmons 2000). In coastal Ecuador, the Tilapia (*Tilapia mossambica*) harvest increased from 18 t in 1990 to 2,318 t in 1997, and was predicted to reach 20,000 t by 2010. The number of introductions and harvesting were the highest in the provinces of the northern Andes, i.e. Pichincha, Cotopaxi and Imbabura (Ministerio de Recursos Naturales y Energéticos 1978). To our knowledge, prior to the present study, no potential conflict between fishing activities and piscivorous species has been considered for the high Andes (Fjeldså and Krabbe 1990).

In the Americas, the Neotropic Cormorant (*Phalacrocorax brasilianus*) is widely distributed, from Tierra del Fuego to the southern United States. The species dwells in a wide range of wetland habitats, from fresh to salt water, where it mainly preys on fishes, although its foraging techniques and prey selection are remarkably flexible (Barquete *et al.* 2008). The distribution range and/or population size are locally increasing, especially in the United States (Telfair 1995; Coldren *et al.* 1998; Gawlik *et al.* 1998). In the high Andes, the Neotropic Cormorant is rare in the northern region but it is becoming common southward, from Peru to northwest Argentina (Fjeldså and Krabbe 1990). In

Ecuador, the species was restricted to coastal lowlands (Ridgely and Greenfield 2001) and until recently was extremely rare in the Andes (one record of one individual collected at Yahuarcocha, Ridgely and Greenfield 2001). However, over the past decade, the species has apparently expanded its range into the Andes, as suggested by the increasing number of reports at several high elevation Andean lakes (elevation range 2,200-3,600 m a.s.l.; Henry in press.). Since this apparent range extension is partly confounded by increases in bird observation effort, only a rigorous statistical analysis of count data can diagnose the actual status of the species.

In this paper, we provide the first analysis of population trend and seasonal fluctuations of abundance of Neotropic Cormorants at three high Andean lakes of Ecuador. We rely on annual systematic censuses carried out from 2004 to 2010 to estimate population growth rates. In addition, we used monthly censuses over a period of 24 months to assess the phenology of occurrence of the species.

METHODS

Bird censuses were carried out in February and July 2004-2010 at three high Andean lakes: Yahuarcocha, San Pablo, and Yambo (Santander *et al.* 2006). Censuses were performed in the morning (08.00 h), lasting from two to three hours. Additionally, from November 2007 to November 2009, bird censuses were carried out on a monthly basis at Yahuarcocha (except in January 2009). There was no census at San Pablo in 2009 and at Yambo in 2005. Observations were conducted from a boat that toured the wetlands perimeter at a constant velocity, remaining at 60-100 m from the shore to avoid massive take off of birds. Whenever a flock of birds was found, we stopped the boat and counted the birds with the help of binoculars. When two observers counted cormorants simultaneously the highest value was considered.

To estimate the temporal trend in population size, we used a log-linear regression model (appropriate for count data; e.g. Henry *et al.* 2008), adjusted for overdispersion. Explanatory variables were the linear effect of the year to quantify the population growth rate, the effect of the season (July *versus* February) and of the sites to account for seasonal and site-specific variations in the number of counted individuals, and the two-way interactions among these effects. Significance of the temporal trend in the number of individuals, and its variation among sites and among seasons (i.e. hypotheses formulated before the study) were tested by model comparisons. For other effects, their statistical support was assessed by comparisons of nested models with the quasi-Akaike Information Criteria (QAIC). A difference of QAIC (DQAIC) higher than two indicated that the effect had a statistical influence on the counts (Burnham and Anderson 1998).

The phenology of occurrence of the species at Yahuarcocha was characterized with monthly counts for 2007-2009 using a generalized additive model with a quasi-Poisson distribution. We used the spline function of the month to obtain the most parsimonious smoothed description of the phenological variation in numbers of individuals. Analyses were performed with software R ver. 2.8.1 (R Development Core Team, Vienna, Austria).

Study Area

Monitoring data were collected at three lakes. (i) The Yahuarcocha lake, located in the dry inter-Andean valley of northern Ecuador (Imbabura province, 00°22'N 78°06'W, 2,210 m a.s.l.). The lake is large (230 ha), permanent, shallow, and of fresh alkaline water. The maximum depth is 7.9 m, with a seasonal decrease of the flow rate between July and September (Consejo Provincial de Imbabura 1997). Rainfall runoff through adjacent ravines is the sole water supply. Yahuarcocha is surrounded by introduced tree species, such as Monterey Pine (*Pinus radiata*) and Southern Blue Gum (*Eucalyptus globulus*) that cormorants occasionally use for roosting. (ii) The San Pablo lake is 20 km southward of Yahuarcocha (Imbabura province, 0°13' N, 78°14° W, 2,660 m a.s.l.). With an area of 670 ha and a maximum depth of 35 m, it is one of the largest Andean lakes in Ecuador (Santander *et al.* 2006). The Itambi river contributes 90 % of the water supply to the lake. (iii) The Yambo lake lies in the inter-Andean valley, in Central Ecuador, within one of the most arid regions in the inter-Andean plateau (Cotopaxi province, 1º05'S 78°35'W, 2,600 m a.s.l.). The lake is small (16 ha), with 25 m of maximum depth, and surrounded by steep hills and cliffs (Steinitz-Kannan *et al.* 1993). Cormorants roost on dead trees standing in the water.

RESULTS

At the start of the study, the cormorant had already expanded in the Ecuadorian Andes (Fig. 1), with marked differences in population size between the three studied lakes. The number of cormorants differed between seasons, with a much higher number of birds during the non-breeding season (February, Fig. 1a) than during the breeding season (July, Fig. 1b; additive month effect, DQAIC = 194.2). Seasonal difference was the same at all sites (Site * Month interaction, DQAIC = -3.9).

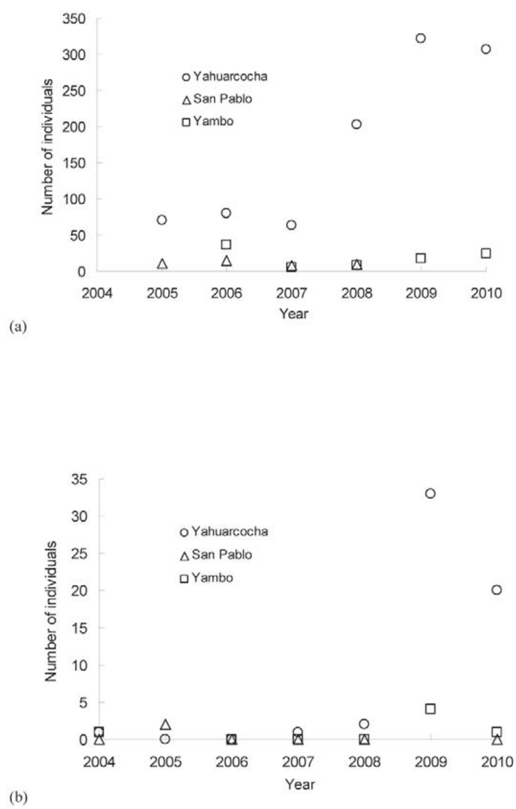

Figure 1. Annual (a) February and (b) July counts of the Neotropic Cormorant at the Yahuarcocha, San Pablo and Yambo lakes. Note the scale difference for the Y-axes.

The number of cormorants significantly increased over the years (linear Year effect, $F_{1,30}$ = 41.584, P < 10-4,) with no difference between seasons (Year * Month interaction, $F_{1,24}$ = 2.52, P = 0.126). Annual counts did not increase equally between sites (Fig. 1a,b; Year * Site interaction, DQAIC = 0.6). At Yahuarcocha lake, the population growth rate was estimated at 0.382 ± 0.05 individuals per year. For the San Pablo and Yambo lakes, there was no significant, linear temporal trend in the number of cormorants (respectively, -0.131 ± 0.312, and -0.024 ± 0.172; Fig. 1). At least for Yambo lake, the interannual variations of the number of cormorants were high (Fig. 1).

The phenological pattern of occurrence of the species at Yahuarcocha suggests that the birds are using this site as an over-wintering location and not to breed (Fig. 2). Cormorants were almost absent in May-June and numbers rapidly in-

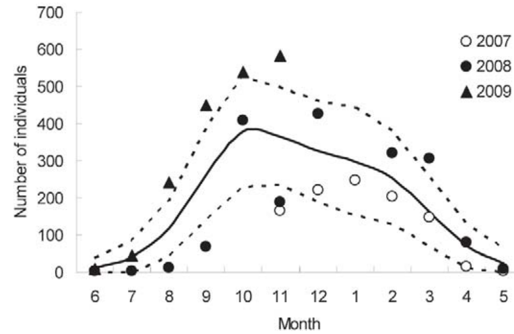

Figure 2. Phenology of occurrence of the Neotropic Cormorant at the Yahuarcocha lake, in 2007-2009. Month 1 holds for January. Symbols differ between years. The solid line represents the number of individuals per month estimated with a spline smoothing function for the effect of the month, and the dashed lines delimit the 95% confidence interval.

creased, reaching a maximum in October and remaining numerous until February.

DISCUSSION

The rise in abundance of cormorants in several parts of the world has raised concerns due to their potential impacts on local fish stocks of economic value (Nisbet 1995; Frederiksen *et al.* 2001; Harris *et al.* 2008). We provide the first quantification of the increase of the Neotropic Cormorant for the Andes. Numbers of cormorants rapidly increased over the survey period at Yahuarcocha. For the two other monitored lakes, the number of individuals was stable, indicating among-site variation in the temporal dynamics of the species. Nonetheless, considering that all three lakes have regularly been visited by birdwatchers over the past decades (Fjeldså and Krabbe 1990) but that only one single Neotropical Cormorant had been recorded until the 21st century (Ridgely and Greenfield 2001), these figures indicate a recent increase of the species at high-Andean wetlands in Ecuador. Also, anecdotal indications of increase of occurrence are available for the Andean provinces of Napo, Tungurahua, Chimborazo, Azuay and Loja (Henry in press). If we consider densities of cormorants, the Yahuarcocha and the Yambo lakes hosted many more individuals (respectively, a maximum of 140 and 231 ind.km^{-2}) than the San Pablo lake (2 ind. km-2). Assuming an individual daily prey consumption of 0.425 kg.day^{-1} (Barquete *et al.* 2008), the seasonal fluctuations represent variations in fish demand from 5.95 kg.km^{-2}.day^{-1} in July to 59.5 kg. km^{-2}. day^{-1} in February for Yahuarcocha in 2009.

From the monthly phenology of occurrence (Fig. 2), and the low number of individuals counted in July (Fig. 1b), we infer that observed cormorants are mainly non-resident individuals that migrate to the high Andes during the non-breeding season. Although suitable habitats for reproduction are available, such as sedges or leafless trees, the species is not known to breed in the Ecuadorian Andes (Ridgely and Greenfield 2001).

Reasons for an increasing usage of highland lakes by non-breeding Neotropic Cormorants are unknown. Three non-mutually exclusive mechanisms can be considered: the demography hypothesis, the behavioral change hypothesis, and the food availability hypothesis. First, the demography of the species may have changed in its original range. For example, if coastal breeding colonies have experienced a significant population growth, the number of individuals dispersing during the non-breeding season in search of suitable habitats should have increased, and may have resulted in an increase of the non-breeding distribution range of the species. The hypothesis is not supported by a preliminary analysis of cormorant censuses from coastal wetlands (N = 17 sites, 2004-2008), which found no indication of temporal change in July counts (-0.041 ± 0.142, t = -0.286, P = 0.778). Secondly, for an unknown reason, cormorants of some populations may have changed their non-breeding dispersal behavior, now including the highland lakes in their wintering range. The decrease of the number of cormorants counted at coastal wetlands during the non-breeding season supports this hypothesis (February censuses: -0.574 ± 0.144, t = -3.971, P < 10-3). Thirdly, food availability and therefore the carrying capacity of highland lakes for the species may have increased.

The fish composition of highland lakes is likely to have changed in the past decades. Tilapiine cichlid fishes (*Oreochromis niloticus* or *Tilapia mossambica*) have been introduced in lake Yahuarcocha for sport fishing and self consumption (Jahn *et al.* 2010). The introduction pressure was particularly high in the study area (Ministerio de Recursos Naturales y Energéticos 1978; Fitzsimmons 2000). The recent occurrence of other piscivorous birds (such as Cocoi Heron *Ardea cocoi,* Tricolor Heron *Egretta tricolor*; Santander *et al.* in press), in addition to the Neotropic Cormorant, is suggestive of an increase in fish availability. Elsewhere in the Andes, the introduction of exotic fish (trout *Salmo gairdneri*; Pejereyes *Odonthestes* sp.) has already been proposed as a reason favoring the local occurrence of cormorants (Fjeldså and Krabbe 1990, Bechard and Márquez-Reyes 2003, Henry in press). To further explore the relationship between food availability and cormorant abundance, data on fish abundances, fish community composition and local fish landings are needed.

Recently, in 2009-2010, Neotropic Cormorants has been reported to forage at commercial fish ponds (*Tilapia mossambica* from northwestern Andean Ecuador, province of Pichincha; 00°09'N, 78°50'W, 400 m a.s. l.). Owners have started culling activities to keep cormorants away from their ponds (Rolando Hipo pers. comm.; see also Bechard and Márquez-Reyes 2003). These ponds are 90 km from Yahuarcocha. To prevent further rise of local conflicts between piscivorous birds' conservation and fishing activities, environmental managers should monitor the abundance and local impact of cormorants, and the relationship with fish abundances, in collaboration with fish producers. If management actions are required by local people, techniques that deter cormorants from foraging at and roosting close to fish ponds would be more efficient than trying to reduce the entire cormorant population (Mott and Boyd 1995; Frederiksen *et al.* 2001). Properly planned disturbances at roosting sites may be a sound control option.

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LITERATURE CITED

Barquete, V., L. Bugoni and C. M. Vooren. 2008. Diet of Neotropic Cormorant (*Phalacrocorax brasilianus*) in an estuarine environment. Marine Biology 153: 431-443.

Bechard, M. J. and C. Marquez-Reyes. 2003. Mortality of wintering Ospreys and other birds at aquaculture facilities in Colombia. Journal of Raptor Research 37: 292-298.

Burnham, K. P. and D. R. Anderson. 1998. Model selection and inference: A practical information-theoretic approach. Springer-Verlag, New York, New York.

Coldren, M. K., C. L. Coldren, K. G. Smith and S. S. Lacy. 1998. First Neotropic Cormorant, *Phalacrocorax brasilianus* (Aves: Phalacrocoracidae), breeding record for Arkansas. Southwestern Naturalist 43: 496-498.

Consejo Provincial de Imbabura. 1997. Manejo sustentable de la laguna de Yahuarcocha. Consejo Provincial de Imbabura, Ibarra, Ecuador.

Fitzsimmons, K. 2000. Future trends of Tilapia aquaculture in the Americas. Pages 252-264 *in* Tilapia Aquaculture in the Americas Vol. 2. (B. A. Costa-Pierce and J. E. Rakocy, Eds.). World Aquaculture Society, Baton Rouge, Louisiana.

Fjeldså, J. and N. Krabbe. 1990. Birds of the High Andes. Zoological Museum, University of Copenhagen and Apollo Books, Svendborg, Denmark.

Frederiksen, M., J. D. Lebreton and T. Bregnballe. 2001. The interplay between culling and density-dependence in the Great Cormorant: A modeling approach. Journal of Applied Ecology 38: 617-627.

Gawlik, D. E., R. D. Slack, J. A. Thomas and D. N. Harpole. 1998. Long-term trends in population and community measures of colonial-nesting waterbirds in Galveston Bay estuary. Colonial Waterbirds 21: 143-151.

Harris, C. M., J. R. Calladine, C. V. Wernham and K. J. Park. 2008. Impacts of piscivorous birds on salmonid populations and game fisheries in Scotland: A review. Wildlife Biology 14: 395-411.

Henry, P.-Y. 2005. New distributional records of birds from Andean and western Ecuador. Cotinga 23: 27-32.

Henry, P.-Y. In press. Distributional and altitudinal range extensions for birds from Ecuador. Boletín SAO.

Henry, P.-Y., S. Lengyel, P. Nowicki, R. Julliard, J. Clobert, T., Čelick, B. Gruber, D. S. Schmeller, V. Babij and K. Henle. 2008. Integrating ongoing biodiversity monitoring: Potential benefits and methods. Biodiversity and Conservation 17: 3357-3382.

Jahn, O., P. Cosgrove, C. Cosgrove, T. M. Cevallos and T. Santander. 2010. First record of Brown Pelican (*Pelecanus occidentalis*) from the Ecuadorian highlands. Cotinga 32: 108.

Ministerio de Recursos Naturales y Energéticos. 1978. Plan Nacional de Piscicultura. Dirección General de Pesca y Fomento Pesquero, Guayaquil, Ecuador.

Mott, D. F. and F. L. Boyd. 1995. A review of techniques for preventing cormorant depredations at aquaculture facilities in the southeastern United States. Colonial Waterbirds 18: 176-180.

Nisbet, I. C. T. 1995. Biology, conservation and management of the Double-crested Cormorant: Symposium summary and overview. Colonial Waterbirds 18: 247-252.

Ridgely, R. S. and P. Greenfield. 2001. The Birds of Ecuador. Cornell University Press, Ithaca, New York.

Santander, T., B. Haase and J. R. Hidalgo. 2006. Advancing a range-wide approach to waterbird conservation at priority sites throughout the Neotropics, Capítulo Ecuador. Report to BirdLife International and U. S. Fish & Wildlife Service. Aves&Conservación, Quito, Ecuador.

Santander, T., K. Terán, T. Mueces, A. Lara, C. Llumiquinga and E. Guevara. In press. Registros inusuales de aves costeras en lagunas Altoandinas de Ecuador. Cotinga.

Steinitz-Kannan, M., M. Nienber, M. Riedinger and R. Kannan. 1993. The fossil diatoms of Lake Yambo, Ecuador. A possible record of el Niño events. Bulletin de l'Institut Français d´Etudes Andines 22: 227-241.

Telfair, R. C. 1995. Neotropic Cormorant (*Phalacrocorax brasilianus*) population trends and dynamics in Texas. Bulletin of the Texas Ornithological Society 28: 7-16.

Trapp, J. L., T. J. Dwyer, J. J. Doggett and J. G. Nickum. 1995. Management responsibilities and policies for cormorants: United States Fish and Wildlife Service. Colonial Waterbirds 18: 226-230.

Zydelis, R. and A. Kontautas. 2008. Piscivorous birds as top predators and fishery competitors in the lagoon ecosystem. Hydrobiologia 611: 45-54.