Health of the Critically Endangered white-winged guan *Penelope albipennis* and implications for its reintroduction and conservation in Peru

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Abstract The white-winged guan *Penelope albipennis* (Cracidae) is endemic to the dry forests of northwestern Peru and considered Critically Endangered due to hunting and habitat destruction. Efforts to conserve this species included captive breeding and reintroduction. Before release, birds were screened for avian diseases to ensure the reintroduction of healthy guans. This work describes the efforts carried out during the years 2000 – 2007, to determine which diseases occur in captive guans and in backyard fowl surrounding the breeding centre, and to establish a pre-release health protocol. A health study was carried out in 95% of the captive population and sick backyard fowl, looking for Galliformes diseases: Avian Influenza (AI), Newcastle Disease Virus (NDV), Infectious Bursal Disease (IBD), Infectious Bronchitis Virus (IBV), Avian Leucosis Virus (ALV), Reticuloendotheliosis Virus (REV), *Mycoplasma gallisepticum* (MG), *Mycoplasma sinoviae* (MS), *Salmonella* Enteritidis (SE) and *Salmonella* Pullorum/Gallinarum (SP/SG). We report for the first time avian pathogens in white-winged guans. Released guans have successfully bred, indicating viability of the reintroduction programme. The species showed positive titers to Infectious Bursal Disease, Infectious Bronchitis, *Mycoplasma synoviae, Salmonella* Enteritidis and *S*. Pullorum/Gallinarum. Backyard fowl were additionally positive to Newcastle Disease and *Mycoplasma gallisepticum*. Future reintroductions should follow the pre-release health protocol. At the breeding centre, periodical health screenings would allow the detection of new pathogens and would monitor the incidence of the known ones. The extension of the screenings in the released and wild guans would compare the prevalence and presentation of avian pathogens. Future conservation of the white-winged guan depends partially on the captive population and should incorporate the health component.

Keywords Conservation, cracids, health, *Penelope albipennis*, reintroduction, white-winged guan.

Introduction

The white-winged guan *Penelope albipennis* is one of the 15 species of cracids that inhabit Peru (Schulenberg et al., 2007). It is categorised as Critically Endangered at both the Peruvian and global level (El Peruano, 2004; Birdlife, 2010) due to overhunting and habitat destruction. The total wild population has been estimated at 200 birds (Angulo, 2008).

The species is endemic to the dry forests of the Tumbesian region (Stattersfield et al., 1998) and of Peru (Schulenberg et al., 2007). Spreading along a narrow band on the western slope of the Andes from 05°25'S/79°55'W North to 06°39'25'S/79°22'30'W South (see Fig. 1), between 300 and 1100 m a.s.l. (Diaz & Del Solar, 1997), it is found in a strip approximately 175–190 km long and 5–40 km wide occupying small ravines and adjacent wooded hillsides (Angulo, 2008).

The species was described in 1878 by Taczanowski; however due to lack of reports, it was considered extinct in the 1960s. It was rediscovered in 1977 in Lambayeque by Gustavo del Solar and John O`Neill (De Macedo, 1979). Following this event, direct conservation actions for the species were initiated with the establishment of a breeding programme in 1981, for the purpose of obtaining enough individuals for reintroduction. This breeding programme was carried out in the 'Bárbara D`Achille' breeding centre (BDBC). In June 1986, the first chick in captivity was hatched and the captive population by 1987 was fourteen guans. In 1990, there were twenty-four guans, in 1995 sixty guans and by 2000 there were around 120 birds.

Since the year 2000, the first population reinforcement actions were taken, with the long-term goal to return this species to its historical habitat (Angulo, 2003). Several IUCN documents were followed such as the Guidelines for translocation of living organisms (IUCN, 1987), the Guidelines for reintroductions (IUCN, 1998) as well as the Galliformes reintroduction guidelines (WPA – RSG, 2009). Ideally, a viable white-winged guan population would be re-established, able to breed successfully in the wild and connect with wild populations in the surroundings, facilitating genetic exchange (Angulo, 2003; Angulo, 2004). The first 16 guans were reintroduced between September and October 2001 at Chaparri Private Conservation Area (CPCA). Prior to the release, birds were kept in semi-captivity to enhance survival possibilities (Angulo, 2003).

The first wild chick was born in year 2002. To date, more than fifty chicks have been born in the wild. Also, since 2006, supplementation works were initiated in Laquipampa Wild Refuge (LWR) - see previous feasibility study by Angulo & Beck (2004). In early 2007, eight guans were released and to date six chicks have been hatched and all the adults have survived in the wild. These results confirm the success of the programme (Angulo, 2003; Angulo, 2008). Further releases in LWR are expected to take place in the coming years.

Sanitary studies tell us about the health status of a species, as well as its exposure to disease and the possible impact on the population (Deem et al., 2001). Defining which diseases impact on endangered wildlife is fundamental in captive breeding programmes designed to re-establish healthy animals to the wild (Mörner et al., 2002).

These releases involve the movement of the bird itself and of those diseases which are brought on by bacteria, virus, parasites and vectors (Woodford & Kock, 1991) as well as potential pathogens for the guans and other organisms that they come in contact with. Moreover, being such a small population, relevant sanitary information should be used in the species' population viability analysis, because this is an inseparable aspect of its health (Karesh & Cook, 1995).

Disease occurrence in Cracidae was described in previous works (Silvino, 1993; Apellaniz & Merino, 1997; Tello & Pedraglio, 1997; Drew, 2003). In general, cracids are resistant birds, not prone to getting sick (Tello & Pedraglio, 1997; Tocidlowski unpublished data 2003). Regarding *Penelope albipennis*, background serological information was found for the guans destined for reintroduction (n = 43) in the years 2000-2002.

In the year 2003 and with reintroductions in full activity, the study '*Sanitary evaluation of the white-winged guans of Bárbara D´Achille breeding centre*' was started, in order to know the health status of the captive population, to identify specific avian pathogens and, if necessary, to take actions to minimise the direct and indirect effects over the captive and wild populations as well as sympatric species of the dry forests. No viable reintroduction programme should be designed without considering the biosecurity aspects of the species involved (Woodford & Kock, 1991), since it is a pre-condition for a successful reintroduction that birds are healthy and not carrying any infectious or contagious diseases (WPA – RSG, 2009). To compare the same diseases occurring in the area, after surveys, samples were taken from domestic birds in a 5 km radius of the breeding centre.

Materials and methods

Study area

The BDBC is located 10 km north of the town of Olmos, in the province and region of Lambayeque (5º53'36'S/79º46'59'W, 130 m.a.s.l.) (Fig. 1). Within its six hectares, it harbours eight aviaries: two for exhibition of white-winged guans and other cracids and another six for white-winged guan breeders. The latter are circular in shape, with a height of 3.40 m, and divided: one with sixteen, three with eight and two with ten cages, with a total area of 18.7, 37.7 and 34.6 m^2 respectively.

The weather of the dry forest is characterised by long periods with little or no precipitation (120 mm on average), that drastically increase when an "El Niño" Southern Oscillation event occurs (2400 mm on average; September 1997 – August 1998 period; SENAMHI, 2004). Under these circumstances, the impoverished, dry environment flourishes showing a very distinct scenario. After an "El Niño" event and depending on its intensity, some years of high rainfall follow, showing a more constant rainy season between January and April and a dry season between May and December.

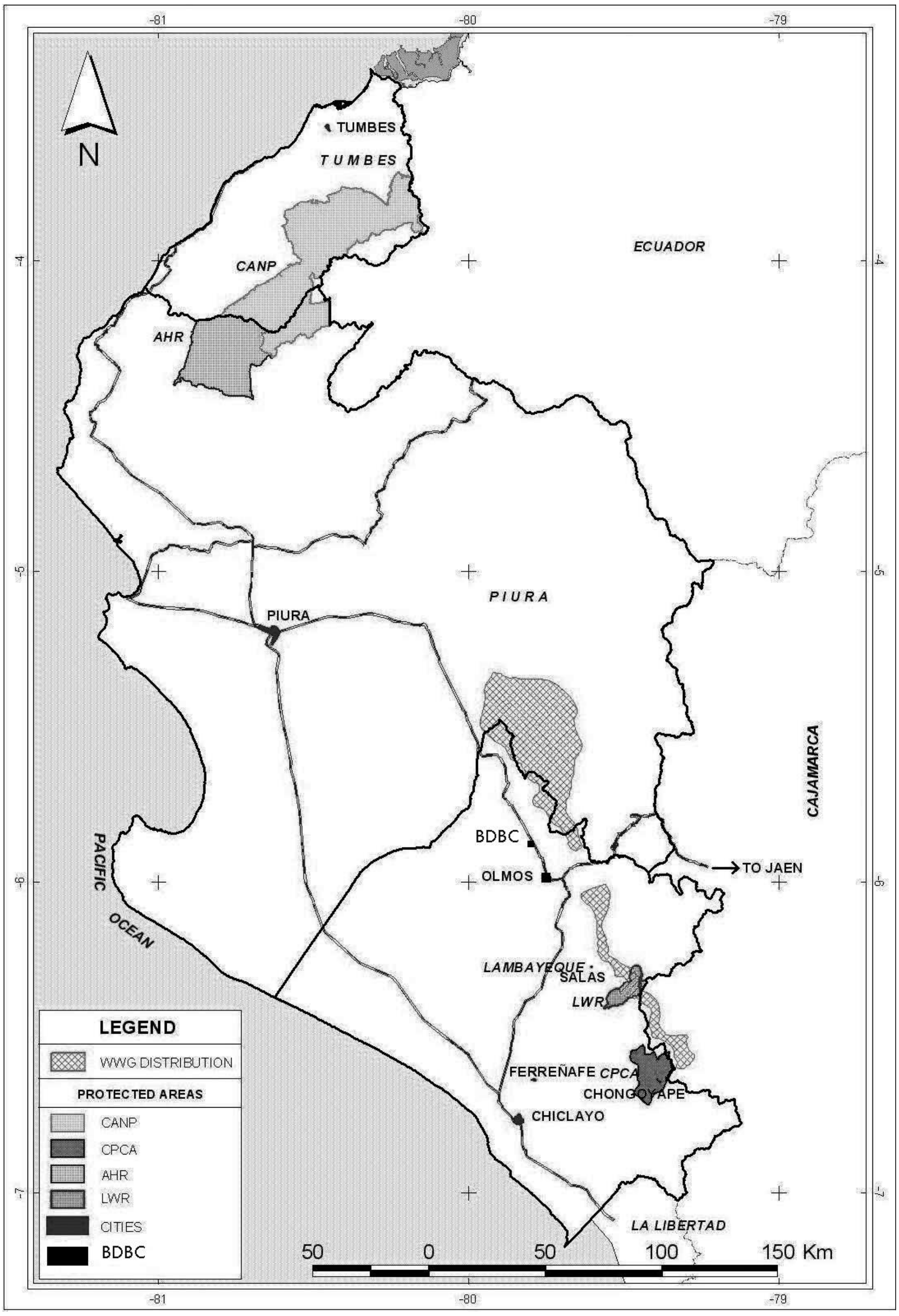

FIG. 1 Map of the distribution area of the white-winged guan showing release sites (Chaparri Private Conservation Area and Laquipampa Wild Refuge), Barbara D´Achille breeding centre (BDBC) and other protected areas in northwest Peru.

Temperatures fluctuate between 13 °C and 37°C according to date taken by personnel at the BDBC.

Selection of individuals for release

The white-winged guan reintroduction programme aims to maximise the long-term survival possibilities of released birds in the wild. For this, a strict individual selection is carried out, that includes the conformation of a group with the same sex ratio (1:1) due to the species' monogamy; the lowest consanguinity between individuals; and to have an excellent external and internal condition (Angulo, 2003). Also, individuals should belong to F1 and F2 generations and must be raised by their own parents or with double imprinting (Angulo, 2006).

Sample collection and storage

Data collection took place in December 2003 and July 2004 and the follow-up analyses in those individuals to be supplemented were taken in February, August and October 2006 (n = 26). In 2003 a total of 87 of 90 white-winged guans (95.5% of the captive population) were studied. Individuals were distributed in three age groups: a) chicks: up to one year old; b) juveniles: from 1 to 3 years old; and c) adults: more than 3 years old. Selection criteria excluded chicks of too small size which were unable to support enough blood extraction, and also adults in their breeding season. Founder individuals (F0, from the wild) or with a transportation history were of special interest for having had more exposure time to pathogens or the possibility of developing diseases, which could even indicate free-ranging pathogens.

White-winged guans are known for being easily scared and very sensitive to stress, and inappropriate handling can cause death, this being the most common cause of morbidity and mortality (Cavero, 2005). To secure the welfare of the birds, captures were done at night or at dawn, and birds were hand-grabbed by experienced workers of the BDBC. As soon as they were captured, guans were examined and if needed, treatments started. Around 3 ml of blood, which is <1% of body weight (mean weights: chicks 1.43 kg., juveniles 1.5 kg., adults 1.6 kg.) (Cavero, 2005) was drawn from the basilic vein. The long, muscular neck of the guans only shows a pale jugular vein of a certain depth that also constricts with stress. It is possible to get blood in small amounts from the jugular in tame white-winged guans. The basilic vein is ideal for long procedures (Cavero, 2005). Samples were put in tubes with serum separator, set temperature, passed to cryovials within 4 hours and kept cold (4-5ºC). In less than 36 hours, they arrived at the lab in Lima and were kept frozen (at -20ºC).

Sample and data analysis

The serological tests searching for antibodies of infectious diseases are shown in Table 1. They were performed initially in Lab Laser laboratory and then in the National Service of Animal Health (SENASA). All viruses were first analysed with ELISA, a commercially available, highly sensitive screen test, and first choice for Gallinacae (Fudge, 2000). Regarding this matter, DNA hybridisation test classifies Cracidae as a brother group of Phasianidae, which includes chickens, turkeys, quails and pheasants (Sibley & Ahlquist, 1990). This comparative DNA-DNA genetic reciprocity is the basis for the use of commercial diagnostic tests. Around the BDBC there were about 90 rural families whose livelihood was to raise backyard fowl such as chickens and fighting cocks *Gallus gallus*, turkeys *Meleagris gallopavo*, ducks *Cairina moschata*, geese *Anser anser*, and pigeons (Columbidae), among others. Minimal productive parameters were observed for those fowl due to poor sanitary conditions and environmental factors that affect food abundance. The backyard fowl selected to sample was non probabilistic, but for convenience, in which sick ones were chosen, not to determine how many were ill, but to determine those pathogens present. The backyard fowl studies included necropsies.

TABLE 1 Total pathogens and serological tests used for analysis in the white-winged guans and results by sex at BDBC (2003 - 2006*).

Disease	Tests used	POSITIVES			(%)	TOTAL
		♀	♂	TOTAL		
Avian influenza (AI)	ELISA - AGID	0	0	0		113
Newcastle disease virus (NDV)	ELISA, HI	0	0	0		113
Infectious bursal disease (IBD)	ELISA	0	2	2	1.9	107
Infectious bronchitis virus* (IBV)	ELISA	2	2	4	14.3	28
Avian leucosis virus (ALV)*	ELISA	0	0	0		28
Reticuloendotheliosis virus (REV)*	ELISA	0	0	0		28
Mycoplasma gallisepticum (MG)	Plate agglutination	0	0	0		113
M. synoviae (MS)	Plate agglutination	1	0	1	0.9	113
Salmonella Enteritidis (SE)	Plate agglutination	7	1	8	7.20	111
S.Pullorum/S.Gallinarum (SP/SG)	Plate agglutination	5	1	6	5.60	107
TOTAL		15	6	21		

* Tested only in 2006 survey

Results

Previous serological data

In 2000, seven sera were analysed for NDV, IBD, MG, MS and *Salmonella* spp. In 2001, twenty guans were analysed for NDV, IBD, MG and SP/SG. In 2002, eleven sera were analysed for NDV, IBD, MS and SP/SG. All thirty-nine guans tested negative and were moved for their reintroduction in Chaparri.

General serosurvey in BDBC

Most of the examined white-winged guans were in good body condition except fourteen out of 87 (16.1%), see Table 2. Three ear infections were sampled and cultured. Only one guan with recent leg trauma was not sampled. There was no mortality incident due to capture stress.

Serology results showed no antibodies to Avian influenza and *Mycoplasma gallisepticum*. One individual (1.27% ± 0.23%) showed antibodies to NDV, testing negative afterwards with HI. Two male adults (2.53% ± 0.29%) were positive to Infectious Bursal disease; one (1.18% ± 0.21%) to *M. synoviae*; eight (9.64% ± 6.36%) to *Salmonella Enteritidis*, of which seven (87.5%) were females; and six (7.59% ± 5.81%) to *S. Pullorum/S. Gallinarum*, of which five (83.33%) were females (Table 1). Of the positive birds, two females (15.38%) showed mixed infection, one to MS and SE and the other to SE and SP/SG. No seropositive guan showed clinical symptoms.

Regarding the backyard fowl, clinical symptoms included weakness, lethargy, anorexia, ruffled feathers, swollen sinuses, oronasal secretions, diarrhoea, drooping wings, and tilted neck. Mortality events, among others, added to the necropsy findings, suggest more diseases than those studied in the survey. The serological results showed high exposure to all the diseases studied except Avian influenza (Table 3).

TABLE 2 Morbidity in 87 white-winged guans captive population at BDBC (2004)

Morbidity cases	n (%)
Congenital defects	1 (1.15)
Ear infections	3 (3.45)
Leg trauma	1 (1.15)
Toe deformities	9 (10.34)
TOTAL	14 (16.09)

Follow-up serology

Analyses were done for the pathogens studied in 2003-2004 and also for Infectious bronchitis virus (IBV), Avian leucosis virus (ALV) and Reticuloendotheliosis virus (REV) (Table 1). In February 2006, eight guans were analysed as they were destined to supplement the population in Laquipampa. All birds tested negative except 2 females (25%) to IBD. One of them did not present titres in the 2003-2004 study and the other one was positive to Salmonella spp.; both were again in apparently good physical condition, but were not released. In August that same year, 4/12 guans (33.3%) presented positive titres to IBV, and were in apparently good physical condition but were not released (Table 1). In October that year, eight guans were analysed, including the two that presented antibodies to IBD in February; all tested negative and were released.

The white-winged guans of the BDBC showed positive titres to Infectious Bursal Disease, Infectious Bronchitis Virus, *Mycoplasma synoviae*, *Salmonella* Enteritidis and *S. Pullorum/S. Gallinarum*.

The guan positive to Newcastle disease with ELISA had negative results after being tested with HI. The pathogenicity of this virus can vary greatly with the strain and the species of the host bird (Leighton & Heckert, 2007). In ostriches *Struthio camelus*, for example, it does not involve the respiratory tract but only the nervous system, showing such signs. In addition, only a few birds show symptoms during an outbreak, as there is no air transmission and the virus does not even cross separation fences. The virus cannot be isolated at bird culls, suggesting a rapid viral elimination and a short carrier state (Huchzermeyer, 2002). It should be necessary to be aware of the strains of highly pathogenic NDV in the domestic fowl (Leighton & Heckert, 2007) surrounding the breeding centre.

Regarding Infectious Bursal Disease, a total of four males had positive titres. In 2006, the two probable positives caused much speculation due to the potential risks of the supplementations to the wild population. No guans with any positive titre have ever been released. This virus causes clinical disease solely in chicks as it colonises the Fabricius bursae, organs of the immune system of young birds, causing severe acute disease with high mortality or secondary infections due to lymphoid depletion (OIE, 2009). There was no apparent evidence of diminished immune function in the guan chicks.

When the suspicious birds were tested again, they did not present any titre. To evaluate the significance of this agent, a virus neutralisation test would be needed.

Regarding Infectious bronchitis virus, four guans, 2 males and 2 females, showed positive titres. This virus affects the respiratory, genital and renal tracts. The avian species in which IBV has been detected have doubled in the past years. The better known coronaviruses affect the domestic fowl, turkey and pheasant *Phasianus colchicus* (Cavanagh, 2005). This pathogen deserves further study; the guans should be tested again with RT-PCR test and the backyard fowl should be assessed for presence of this disease.

Regarding *Mycoplasma synoviae*, one female was positive with the plate agglutination test. This agent causes respiratory and joint infections, although population declines in wild birds have not been attributed yet to clinical disease; the agent has even been isolated in the mucous surface of healthy birds (Luttrell & Fischer, 2007). An HI test would be needed to confirm the results (OIE, 2009) and to evaluate this organism as a disease factor.

In the case of *Salmonella* spp., a total of 17.2% showed positive titres with the plate agglutination test. Of these, 85.7% were females. Depending on factors such as bacterial serotype, host species, environmental conditions and physiological state of the birds, exposure of a bird to *Salmonella* may result in an asymptomatic carrier state, acute disease or chronic infection. Most *Salmonella* intestinal carriage in wild birds is not associated with clinical illness and, in the absence of re-infection, it is likely to last a few weeks. However, young birds are generally more susceptible to infection, while nestlings and recently fledged birds may be more likely to acquire infection from their parents (Daoust & Prescott, 2007). In domestic hens, vertical transmission is significant in the spread of the disease (Chacana & Terzolo, 1997). It would be interesting to identify individual strains of *Salmonella* serotypes in the captive guan population and phage-type them, as well as to evaluate the host propensity to be a long-term asymptomatic carrier and the potential contribution of transovarian transmission to the persistence of *Salmonella* (Daoust & Prescott, 2007).

TABLE 3. Serological results from backyard fowl*, testing positive for NDV, Infectious Bursal Disease (IBD), *M. gallisepticum* (MG), *M. synoviae* (MS), *S. Enteritidis* (SE) and *S. Pullorum/S. Gallinarum* (SP/SG), Olmos, Lambayeque, 2004.

Backyard poultry	NDV	IBD	MG	MS	SE	SG/SG
Positives (%)	15 (60)	18 (72)	15 (62.5)	12 (75)	3 (17.6)	2 (11.7)
TOTAL sampled	25	25	24	16	17	17

* Chicken, fighting cocks (*Gallus gallus*), turkeys (*Meleagris gallopavo*), ducks (*Cairina moschata*), geese (*Anser anser*), pigeons (Columbidae).

Otitis

Ear infections represented a morbidity of 3.5% in the captive population. All guans with otitis were females. The oldest was 10 years old, captured in the field and part of the founder group. It had chronic unilateral otitis, positive to *S. aureus* and *Proteus* spp. The second one was obtained from a local farmer who captured it in the forest along with two chicks. At two months of age it presented unilateral otitis, positive to *S. aureus, Bacillus* sp. and *E. coli*. The third guan was about six years old and it was released at Chaparri and taken back after 19 months. It was found emaciated and with a serious bilateral otitis, positive to *S. aureus, Proteus* sp. and gram positive non-sporulating anaerobic bacteria. The first guan showed improvements and relapses; the second one was cured completely and the third one recovered its weight and vitality but still had otitis.

The three ear infections were caused by normal bacterial flora of the gastrointestinal, upper respiratory tract, mouth or skin, but they are potential pathogens when anatomical barriers or the integrity of the tissues are implicated, or because of low immunity. Otitis is uncommon in birds, thus the cause of these infections occurring naturally is poorly understood. Both *S. aureus* and *E. coli* produce toxins that contribute to their pathogenicity, causing cellular and vascular necrosis. The normal response to experimental infections on a bird's skin or muscle is of a self-limiting progress, coordinated by antigen-specific responses of lymphocytes T and B, removing completely the antigen in 10 days. Therefore, there would be an immune failure to eliminate the antigen as well as to produce protective memory cells (Satterfield & O´Rourke, 1981).

Release management

Transport of guans to be released from the BDBC towards semi-captivity cages at release sites was done during the night. Each bird was put into individual bags and into the vehicle that would take them to the selected release sites. Arrivals were before dawn and birds 'awoke' at the new enclosure.

In Chaparri, predator management was done. Such species as pampas cats *Leopardus colocolo*, Sechura foxes *Pseudalopex sechurae*, tayras *Eira barbara* and black-eared opossums *Didelphis marsupialis* were captured and relocated. Semi-captivity consisted of a mesh cage around a natural creek with native trees such as *Ficus* sp., *Cordia lutea* and *Muntingia calabura* with a total area of 2100 m^2. Guans received supplemental food. There were also artificial nests to stimulate breeding (Angulo, 2006). The semi-captivity cage in Laquipampa measured 114 m^2 and there was no post-release management. Periods of time in semi-captivity ranged from one to 18 months. Hard releases were done in cases of guan replacements. All released guans were identified with two colour band combination. Ten guans in Chaparri were equipped with AVM transmitter back-packs. All birds were monitored post release (Angulo, 2003).

From the total 72 guans under pre-release management, 52 were released (72%) (Table 4). The main reasons for guans not being released were a) predation, b) transport stress/myopathy c) disease (infectious), and d) ethological aspects. Regarding predation, a total of 12 guans died. In 2000, three guans were attacked. In 2001 two more events occurred, one with a boa constrictor (*Boa constrictor ortonii*) and another with a pampas cat, where six guans died and two survived, although they were taken back to the BDBC because of injuries. Another guan was taken back twenty-three months later with a dislocated leg, most probably due to a predation incident. In 2002, three guans died from predation.

Regarding stress, a total of 3 guans died, two males in 2003 and 1 female in 2004. Regarding disease, one guan was found sick with an ear infection in Chaparri after nineteen months of release. Finally, due to unsuitable behaviour, 2 guans were rejected and taken back, one for aggressiveness and another for being unsuitably tame for the programme objectives.

Discussion

All the health information reported in this article is new and serves as baseline data for this critically endangered species. It can later be used to document changes in disease prevalence as well to monitor trends and to evaluate management actions (Deem et al., 2001).

The epidemiological landscape surrounding the BDBC shows that the backyard domestic fowl are most probably the means for the presentation of immunosuppression and disease in the captive guan population because they are reservoirs of the diseases studied and others which are potentially dangerous. Paradoxically, the sensitivity to stress of the white-winged guans is compensated for by their apparent resistance to disease. It would be interesting to study the guans' natural resistance to pathogens. The low pathogen percentages with no clinical symptoms correspond with information from Tocidlowski (unpublished data 2003), who affirms that few infectious diseases have been diagnosed in living cracids, in which non-infectious diseases are predominant. White-winged guans are monogamous and territorial. Except when they are chicks or young birds in search of a mate or in a time of food scarcity, they spend their life in direct contact with few guans. Being arboreal, contact with their faeces is very low, except during breeding.

Theoretical and empirical evidence suggests that populations restricted to specific ecosystems support impoverished parasite communities because the resident parasites are under those same factors that limit biological diversity; they are exposed to few pathogens during their evolution (Wikelski et al., 2004). The dry forest has environmental factors that restrict pathogen dispersal, like UV rays and dryness, which are not always lethal, but inhibit their multiplication (Thrusfield, 1990). Despite this, the loss of genetic diversity over time can result in a lesser ability to respond to new pathogens (Wikelski et al., 2004). But it is important to mention that this research was conducted during a non "El Niño" event period. We can roughly assume that this stochastic event can happen once every 10 years. With it come subsequent years of rain. In this scenario of high temperatures and rainfall, insect propagation, etc., we have the perfect media for disease transmission. This moment should be very interesting to evaluate the incidence of diseases in the guans as well as to monitor many other topics in the dry forest.

TABLE 4. White-winged guan in the reintroduction programme (2000 – 2007)

Year	Guans destined for reintroduction program	Guans dead during transportation	Guans dead during soft-release	Guans taken back to BDBC	Guans released	Release site
2000*	7	0	3	2	2	CPCA
2001	25	0	6	4	15	CPCA
2002	11	0	3	0	8	CPCA
2003	8	2	0	0	6	CPCA
2004	10	1	0	0	9	CPCA
2005	5	0	0	0	5	CPCA
2006	0	0	0	0	0	CPCA
2007	8	0	0	1	7	LWR
Total	74	3	12	7	52	

*: released in 2001; CPCA: Chaparri Private Conservation Area; LWR: Laquipampa Wild Refuge

Some of the diagnostic tests used were not entirely sensitive or specific, making them difficult to measure and therefore difficult to evaluate the effects of the infectious diseases (Wobeser, 2006). However, that domestic backyard fowl introduce pathogens, is highly likely. These direct or indirect interactions are enough to cause disease and are to be considered a latent threat, causing deleterious effects in this species. Nowadays, with the current trend of human and domestic animal number increase and translocations, combined with the local warming and the subsequent possible emergence of infectious diseases (Greger, 2007), the guans' environment could change at any point.

The national strategy for the conservation of the white-winged guan recognises the risk of disease associated with captive breeding and reintroduction processes and recommends assessing them routinely (Angulo, 2005; Cavero, 2005). It is important that preventive measures as well as health assessments and pre-release protocol become a usual practice where captive white-winged guan populations are held, which should include at least the diseases presented in this study (Table 1). At the breeding centre, we recommend carrying out health screenings periodically in order to detect new pathogens and to monitor the incidence of the known ones. Also, it would be interesting to extend the health screenings in the released and wild birds to compare the prevalence and presentation of avian pathogens in both populations.

Future conservation of the white-winged guan may depend partially on the captive population and it should incorporate a health component. This work aims to show the way to an adequate understanding of the level of the sanitary condition of the captive population at the BDBC, which is the largest genetic stock of the species, and the implications for the wild populations. Other cracid populations in Peru or elsewhere should use this information as a baseline for a health assessment and we encourage other researchers to publish their own experiences in order to have the most complete picture of diseases affecting this threatened family. With the diligent efforts carried out over a period of more than 30 years, we hope to contribute to the conservation of this flagship species of the dry forests of Peru.

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