CURRENT RAPTOR STUDIES IN MÉXICO

Edited by

Ricardo Rodríguez-Estrella

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Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
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PREFACE

Biological diversity of México, raptors and scientific research

México is one of the most biologically diverse countries on the planet, as a result of its very complex geological history, geographic position, and environmental heterogeneity, among other factors. Its biological diversity is such, that together with 17 other countries such as India, China and Brazil, it is referred to as Megadiverse. Together, these countries sustain more than 70% of all living organisms, including plants, animals and microorganisms, México ranking first for its diversity of reptiles and amphibians, third for its mammalian diversity, fourth for its diversity of vascular plants, and eleventh for its diversity of birds. Moreover, a high percentage of the species, up to 65% in amphibians, are endemic to México; i.e. with geographic ranges restricted to the country.

The biological diversity of México has been part of the geographic and natural settings that have accompanied its inhabitants since they first settled in the country more than 12,000 years ago. The legendary diversity of the country has astonished scientists such as Baron Alexander Von Humbolt, who described México as a biological paradise. Unfortunately, this impressive natural diversity of the country is practically unknown by most Mexicans, who instead should be proud of their biological inheritance.

Nowadays, the biological diversity of México is seriously threatened. Hundreds of species and thousands of populations are endangered, mainly because of human population size and social inequity. México's population size is expected to become stable around 145 millions, but only in three decades. The loss of biological diversity has severe consequences at a biological and social level, because populations and species are the basis for the structure and functioning of biological systems, which provide us for free with environmental goods and services. These goods and services, which include the maintenance of a proper atmospheric gas composition, the ozone layer, soil fertility and quality and quantity of water, among others, generate the environmental conditions that allow life on Earth. They are the basis of our existence. Paradoxically, their continuance depends on our activities.

The only way to understand the complex relationships of living organisms with their environment, their role in providing environmental services, and better management of these living organisms to reconcile their use with their conservation, is through a solid investment in scientific research. However, many governments, including the Mexican government, surrender to the temptation of investing little in scientific and technological research, focusing on other approaches to fight social and economic problems. Those governments ignore that one of the few ways out of poverty is through the generation of scientific and technological knowledge, which is fundamental to the development of any country.

That is why I have received with great satisfaction this volume addressing the ecology and conservation of raptors – one group of species very sensitive to anthropogenic disturbances. As top predators, with low population sizes, raptors are susceptible to environmental changes that can affect them negatively, and thus increase the risk of their extinction. That is precisely why their status is an indication of environmental conditions, much like canary birds long ago used to indicate the presence of toxic gases to miners. The results presented by researchers working with raptors in México can have an immediate application in conservation.

The careful editing of the editor has produced an interesting book of high scientific quality. I am sure that time will be the best test of the benefits of this type of publications, which are essential to maintain the welfare of our society.

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High infestation by blood parasites (Haematozoa) in nestlings of colonial ospreys (*Pandion haliaetus*) from Baja California, México

Jesús A. Lemus
Guillermo Blanco
Ricardo Rodríguez-Estrella

ABSTRACT

Despite the cosmopolitan distribution of the osprey (*Pandion haliaetus*) and interest in its study and conservation, there is limited information on pathogens, parasites and diseases negatively affecting health and survival rates in their populations. In this work, we describe parasitism by blood parasites in nestlings of colonial ospreys from Baja California, México. A very high prevalence of infection with blood parasites (53%) in nestling ospreys was found, especially for *Leucocytozoon toddi* (39.2%) and for *Plasmodium polare* (13.7%). The intensity of haematozoan infections was very high (mean: 128 parasites/2,000 erythrocytes), which ranged from 40 to 320 parasites per 2,000 erythrocytes. A preliminary assessment of the effects on nestling health of blood parasites and their possible vectors was conducted to establish their potential role in the declining of this population. This is the first intensive survey of blood parasites in nestling ospreys from breeding colonies and the first record of both parasite species in ospreys.

Key words: osprey, blood parasites, coloniality, Laguna San Ignacio, B.C.S.

RESUMEN

A pesar de la distribución cosmopolita del águila pescadora (*Pandion haliaetus*) y del gran interés en su estudio y conservación, existe muy poca información sobre los parásitos, patógenos y enfermedades que pueden estar afectando negativamente a la salud y las tasas de supervivencia en sus poblaciones. Describimos el parasitismo por hematozoos en pollos de águilas pescadoras coloniales en Baja California, México. Se encontró una alta prevalencia de infección por hemoparásitos (53%), especialmente para *Leucocytozoon toddi* (39.2%) pero también para *Plasmodium polare* (13.7%). La intensidad de infección fue muy elevada (media: 128 parásitos/2,000 eritrocitos), variando desde 40 hasta 320 parásitos por 2,000 eritrocitos. Se ofrece una valoración preliminar de los efectos de los parásitos sanguíneos y sus vectores potenciales sobre la salud de los pollos para establecer su posible papel en la regresión de la población. Este es el primer estudio sobre parásitos sanguíneos en pollos de águila pescadora nidificando de forma colonial, y los primeros registros sobre infección por ambos hemoparásitos en esta especie.

INTRODUCTION

Parasites may have important negative effects on behavior and fitness of their avian hosts (Møller *et al.* 1990, Loye and Zuk 1991). Among the most common

endoparasites of birds, blood parasites (Haematozoa) have become of great interest because of their potential effects on host fitness (Atkinson and van Riper 1991) and their implications on parasite-mediated sexual selection (Clayton 1991). Haematozoa may reduce the fitness of their hosts due to their negative effects on health, especially listlessness and loss of condition (Atkinson and van Riper 1991, Bennett *et al.* 1993, Valkiūnas 1993) that indirectly may decrease survival rates and breeding output (Møller *et al.* 1990). Prevalence and intensity of infection with haematozoa have shown to vary between species, populations, seasons and years presumably because of ecological factors that affect both host condition and vector abundance (Tella *et al.* 1999). Host condition is a main component of individual quality determining fitness (Clutton-Brock 1988), and it may influence the response of the immune system to the wide array of parasites generally infecting birds (Gershwin *et al.* 1985). The development and expression of immunity against parasitic infections may be modulated by additional factors such as stress, age, sociality or a combination of these and other factors (Lloyd 1995). The study of prevalence and intensity of infection by haematozoa may be of interest to understand the role of parasites in ecology and conservation of their hosts. In fact, parasites, especially blood parasites, have been involved in the decline and extinction of several bird populations (Warner 1968, van Riper *et al.* 1986, van Riper 1991, Savidge *et al.* 1992, Work *et al.* 2000). Here, we describe parasitism by blood parasites in nestlings of colonial ospreys (*Pandion haliaetus*) from Baja California, México. A preliminary assessment of the effects on

nestling health of blood parasites and their possible vectors was conducted to establish their potential role in the declining of this population (Rodríguez-Estrella *et al.*, in this publication).

Despite the cosmopolitan distribution of ospreys and interest in their study and conservation, there is limited information on pathogens, parasites and diseases that negatively affect health and survival rates of their populations (Schmidt and Huber 1985, Kinsella *et al.* 1996, Miller *et al.* 1997, Dennis *et al.* 2000). Baja California peninsula together with its adjacent islands is one of the main strongholds of ospreys in the world. In this region, ospreys reach the densest concentration of breeding pairs worldwide (Henny and Andersson 1979, Reitherman and Storer 1981, Danemann 1994). In contrast with other populations, ospreys in Baja California nest in colonies at high densities, although the species is not strictly colonial in the area, some pairs nesting isolated or in loose groups (Danemann 1994, Castellanos and Ortega 1995, Cartron 2000). High breeding density may impose costs for individual birds such as higher transmission of parasites although the particular life histories of parasites and their strategies of transmission may shape this relationship (Tella 2002). Studies on the effects of parasites with different life strategies are needed to assess whether coloniality is associated with a greater risk of parasitism in this species. This knowledge may be helpful to assess the potential costs that derive from the evolutionary transition from solitary to colonial nesting (Rolland *et al.* 1998, Tella 2002), which may have implications for management and conservation. In addition,

differences in risk of blood parasitization between solitary and colonial nesting (Tella 2002) might have implications on the evolution of certain hosts traits (Clayton 1991), such as the reduced sexual dimorphism in plumage showiness found in the study population of ospreys (Blanco and Rodríguez-Estrella 1999).

Almost nothing is known about prevalence and intensity of parasites on birds inhabiting the peninsula of Baja California (Tella *et al.* 2000), especially blood parasites (Blanco *et al.* 2001). In this paper, we present the results of a survey of blood parasites on osprey nestlings from colonies located in Baja California. This is, to our knowledge, the first sampling for avian haematozoa in nestlings of a raptor species in Baja California and the first intensive survey of blood parasites in nestling from breeding colonies of this species.

STUDY AREA

The study was conducted in Laguna San Ignacio located in the middle portion of the Baja California peninsula. The lagoon is shallow with an average depth of 2 to 4 m; with some channels 26 m deep. The climate is warm and dry with annual average temperatures that oscillate between 18 and 22°C. Precipitation occurs in the summer and is less than 150 mm per year (Reitherman and Storrer 1981, Danemann 1994). The breeding population we studied constructed their nests in two small islands, Isla Garzas and Isla Pelicanos (both are also known as Whale Island). During low tide, both islands connect and can be reached by foot. The total area of both islands is 1.3

km^2. In this area, ospreys nest at high densities although abundance of breeding pairs greatly varied every other year in the last decades. The study area and osprey colonies were described in detail in another work (Rodríguez-Estrella *et al.* in this publication).

MATERIAL AND METHODS

During the breeding season of 2001, osprey colonies were monitored as described in Rodríguez-Estrella *et al.* (in this publication). Nests were accessed during nestling banding operations in May and June 2001 at breeding colonies established in Isla Pelicanos and Isla Garzas. Nestlings were sampled on average at 45 days old (range: 32-59 days), that is, when they were feathered but before fledging. The age of nestling ospreys at sampling fairly exceeds the minimum prepatent period reported for some blood parasites in nestlings of other raptor species (13 and 14 days for sparrowhawks *Accipiter nisus* and Goshawks *Accipiter gentilis,* respectively (Peirce and Marquiss 1983, Toyne and Ashford 1997). Nestlings were bled from the brachial vein and a thin smear was made using a drop of blood. Blood smears were air dried, fixed with ethanol in the field, and stained in the laboratory with Giemsa. We searched for extracellular parasites (trypanosomes, microfilariae) by scanning whole smears under low magnification (X40). Intraerythrocytic parasites were quantified under oil at 1,000X by counting the number of parasites per 2,000 erythrocytes, i.e. 40 microscope fields (Godfery *et al.* 1987). The smears were examined at least four different times by the same observer. Prevalence was defined as the proportion of

hosts with slide-positive infections. The intensity of infection was presented and analyzed excluding samples in which no blood parasites were detected. Parasites were identified by comparing their color, morphology and size with descriptions of known species. Overall, we sampled 51 nestlings from 37 nests. Ectoparasites were systematically searched on the nestling body and counted. Several specimens were collected and stored in ethanol to be identified in the laboratory later on. A drop of blood was used for sexing the nestlings through molecular procedures after DNA extraction (Fridolfsson and Ellegren 1999).

RESULTS

Two haematozoan species were identified: *Leucocytozoon toddi* and *Plasmodium polare*. The identification of the *Plasmodium* species is preliminary and needs to be confirmed by further examinations. No extracellular parasite was found although the inspection of blood smears is not the best method to detect them. Haematozoan prevalence varied depending on parasite species (Table 1). Overall, 53% of nestlings (n=51) were infected with haematozoan parasites. No nestling presented concurrent infections, i.e. with the two parasite species. Prevalence of haematozoa as well as prevalence of each parasite species did not differ between nestling from Isla Garzas and Isla Pelicano (G test, all P >0.26). There was no significant difference between sexes in the prevalence of *Leucocytozoon toddi*, *Plasmodium polare*, and total prevalence (pooling both species) (G test, all P>0.48). The intensity of haematozoan infections, excluding

samples in which no parasite were detected, was very high (average of 128 parasites/2,000 erythrocytes), ranging from 40 to 320 parasites per 2,000 erythrocytes (Table 1). There were no significant differences in the intensity of infection between island and sexes (Mann-Whitney *U* test, all $P > 0.48$). There was a higher intensity of infection of *Leucocytozoon toddi* than of *Plasmodium polare* when sexes and island were pooled (Mann-Whitney *U* test, $z = 2.397$, $P = 0.017$, Table 1).

Table 1. Prevalence (percentage of individuals with parasites) and intensity of infection with hematozoa (parasites per 2,000 erythrocytes) in nestling ospreys from Baja California, México

	prevalence		intensity of infection		
	% positive	*n*	mean ± SE	range	*n*
Hematozoa (total)	52.9	51	128.15 ± 13.30	40-320	27
Leucocytozoon toddi	39.2	51	144.00 ± 15.67	40-320	20
Plasmodium polare	13.7	51	82.86 ± 16.57	60-180	7

Most sampled nestlings were weakened, dehydrated or with pale mucous membranes on physical examination. Many of them were apparently affected by malnutrition and anemia or had suffered development constraints (Rivera and Rodríguez-Estrella unpublished data); several died before fledging, which promoted a low breeding success and productivity of the colonies in the study breeding season (Rodríguez-Estrella *et al.*, in this publication). The only ectoparasite found in high numbers was the louse fly *Olfersia fumipennis*, Hippoboscidae (Rodríguez-Estrella and Rivera unpubl. data).

DISCUSSION

We found a very high prevalence of infection with blood parasites (53%) in nestling ospreys, especially for *Leucocytozoon toddi* (39%). This protozoan species is a common blood parasite of Falconiformes and Accipitiformes around the world (Greiner and Kocan 1977, Bennett *et al.* 1982, Ashford *et al.* 1991). To our knowledge, this is the first report of *L. toddi* in the osprey. The other parasite species found that was preliminary identified as *Plasmodium polare* has been previously reported for several raptor species (Greiner *et al.* 1981, Bennett *et al.* 1982) but it has never been found in ospreys. The prevalence of blood parasites reported here may be considered very high according to the published information for raptors (Greiner *et al.* 1975, Peirce 1981, Tella *et al.* 1999). A study that searched for hematozoan parasites on a significant number of nestling ospreys (n=30) sampled in nests from Ontario, Canada found no parasite (Miller *et al.* 1997). Other less extensive surveys in ospreys have shown no blood parasite in samples from Europe and North America (Greiner *et al.* 1975, Greiner and Kocan 1977, Bennett *et al.* 1982, Peirce and Marquiss 1983, Krone *et al.* 2001).

The high values of prevalence reported here were found associated with average intensities of infection of 128 parasites per 2,000 erythrocytes, which can be considered severe infections according to the available information for other species (Tella *et al.* 1996, Dawson and Bortolotti 1999, Stuht *et al.* 1999, Krone *et al.* 2001). These data suggest that blood parasites may be causing health problems to nestlings

probably associated to low condition and depressed immunity (Atkinson and van Riper 1991, Bennett *et al.* 1993, Valkiünas 1993). Low condition and anemia are typically associated with leucocytozoonosis in birds (Atkinson and van Riper 1991, Bennett *et al.* 1993) and it may cause high morbidity and mortality (Hunter *et al.* 1997). Avian malaria caused by *Plasmodium* infections may be associated to health problems, including anemia, splenomegaly and myocarditis (Atkinson and van Riper 1991), and may cause death in species or birds not commonly infected with this parasite (Warner 1968, Bennett *et al.* 1993). However, under conditions of abundant food supply, most infections with blood parasites may cause no severe effects on health, as the immune system may be able to successfully fight infection (Atkinson and van Riper 1991). Therefore, the severe infections and associated symptoms of low condition found in osprey nestlings may indicate reduced food availability during the breeding season of 2001 and possibly other related factors such as high breeding density (Tella *et al.* 2001). The fact that no mixed infection with the two blood parasite species was recorded is remarkable because it may indicate competence between intraerythrocytic parasites, which need further examination and research.

The high prevalence and intensity of infection found is not expected according to the potential scarcity of vectors due to the marine environment and the dry conditions around the colonies (Piersma 1997, Jovani *et al.* 2001). The lack of suitable vectors in marine environments or open and arid areas has been argued to explain the absence of blood parasites in several bird species (Blanco *et al.* 1997, Tella

et al. 1999, Martínez-Abrain and Urios 2002) but it failed to explain presence of blood parasites in other species and particular localities (Bosch *et al.* 1997). The only previous survey of avian blood parasites in Baja California found geographical differences in the prevalence of infection by *Haemoproteus coatneyi* in wintering white-crowned sparrows (*Zonotrichia leucophrys*). These differences were argued to be associated to contrasting environmental conditions affecting both the vectors and the hosts in coastal and inland oases where birds were respectively sampled (Blanco *et al.* 2001). The studied osprey colonies were located far from any source of fresh water where the potential vector of *L. toddi* and *Plasmodium*, such as black flies (Simulidae) and *Culicoides* spp. mosquitoes (Ceratopogonidae) may breed. However, these and other appropriate vectors may be common in mangroves that are about 10 km far from the colonies (pers. obs.). Though the effects of salinity on rates of infection by haematozoa may be less significant compared to those from areas with fresh water (Figuerola 1999), salinity levels in mangroves may be lower than in open sea and suitable vectors may also breed in dead and humid vegetation (Atkinson and van Riper 1991).

As mentioned before, the only ectoparasite found on nestlings in high numbers was the louse fly *Olfersia fumipennis* (Hippoboscidae). Louse flies are blood-sucking parasites that may cause a reduction in their host's body condition (Bize *et al.* 2004) and transmit blood parasites (Sol *et al.* 2000). Several species of *Olfersia* louse flies have been cited as potential vectors of avian protozoan parasites in Hawaiian

birds (van Riper 1991). The emergence and abundance of these and other potential vectors need to be assessed in the future to determine their effects on nestling ospreys. Assessing whether louse flies, high blood parasites infestation or both are involved in low condition or depressed immunity of nestling ospreys in Baja California is worthy of further investigation. Given the absence of haematozoa in nestlings from populations where osprey nest solitarily (Miller *et al.* 1997, Krone *et al.* 2001), the role that parasites may play in the transition from colonial to solitary nesting or *vice versa* in this species may be a good study model of the costs associated to the evolution of coloniality in birds.

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LITERATURE CITED

Ashford, R.W., E.E. Green, P.R. Holmes, and A.J. Lucas. 1991. *Leucocytozoon toddi* in

British sparrowhawks *Accipiter nisus*: patterns of infection in nestlings. *Journal of Natural History* 25:269-277.

Atkinson, C.T. and C. van Riper. 1991. Pathogenity and epizootology of avian haematozoa: *Plasmodium*, *Leucocytozoon*, and *Haemoproteus* Pages 19-48 *in* J.E. Loye and M. Zuk (Eds.) Bird-Parasite Interactions: Ecology, Evolution, and Behavior. Oxford University Press, Oxford.

Bennett, G.F., M. Whiteway, and C. Wood-worth-Lynas. 1982. A host-parasite catalogue of avian haematozoa. *Memorial University of Newfoundland Occasional Papers in Biology* 5:1-243.

Bennett, G.F. and M.A. Peirce. 1988. Morphological form in the avian Haemoproteidae and an annotated checklist of the genus *Haemoproteus* Kruse 1890. *Journal of Natural History* 2:1683-1696.

Bennett, G.F., R.A. Earlé, H. Du Toit, and F.W. Huchzermeyer. 1992. A host-parasite catalogue of the haematozoa of the sub-saharan birds. Onderestepoort *Journal of Veterinary Research* 59:1-73.

Bennett, G.F., M.A. Peirce, and R.W. Ashford. 1993. Avian Haematozoa: mortality and pathogenicity. *Journal of Natural History* 27:993-1001.

Bize, P., A. Roulin, J.L. Tella, L. Bersier, and H. Richner. 2004. Additive effects of ectoparasites over reproductive attempts in the long-lived alpine swift. *Journal of Animal Ecology* 73:1080-1088

Blanco, G., S. Merino, J.L. Tella, J.A. Fargallo, and A. Gajón. 1997. Hematozoa in two populations of the threatened red-billed chough in Spain. *Journal of Wildlife Diseases* 33:642-645.

Blanco, G. and R. Rodriguez-Estrella. 1999. Reduced sexual plumage dimorphism in Ospreys from Baja California Sur, Mexico. *Ibis* 141:489-506

Blanto, G., R. Rodríguez-Estrella, S. Merino, and M. Bettellotti. 2001. Effects of spatial and host variables on hematozoa in white-crowned sparrows wintering in Baja California. *Journal of Wildlife Diseases* 37:786-790.

Bosch, M., J. Figuerola, F.J. Cantos, and R. Velarde. 1997. Intracolonial differences in the infestation by *Haemoproteus lari* on Yellow-legged Gulls *Larus cachinnans*. *Ornis Fennica* 74:105-112.

Carron, J.L. 2000. Status and productivity of Osprey along the eastern coast of the Gulf of California: 1992-1997. *Journal of Field Ornithology* 71:298-309.

Castellanos, A. and A. Ortega. 1995. Artificial nesting sites and Ospreys at Ojo de Liebre and Guerrero Negro lagoons, Baja California Sur, Mexico. *Journal of Field Ornithology* 66:117-127.

Clayton, D. 1991. The influence of parasites on host sexual selection. *Parasitology Today* 7:329-334.

Clutton-Brock, T.H. 1988. Reproductive success. Chicago: University of Chicago Press.

Danemann, G.D. 1994. Biología reproductiva del águila pescadora (*Pandion haliaetus*) en Isla Ballena, Laguna San Ignacio, Baja California Sur, México. Unpublished M. Sc. Thesis. CICIMAR, Instituto Politécnico Nacional, México.

Dawson, R.D. and G.R. Bortolotti. 1999. Prevalence and intensity of hematozoan infections in a population of American kestrels. *Canadian Journal of Zoology* 77:162-170.

Dennis, P.M., D.J. Heard, and W.L. Castleman. 2000. Respiratory distress associated with pulmonary fat emboli in an osprey (*Pandion haliaetus*). *Journal of Avian Medicine and Surgery* 14:264-267.

Figuerola, J. 1999. Effects of salinity on rates of infestation of waterwbirds by haematozoa. *Ecography* 22:681.685.

Fridolfsson, A.K. and H. Ellegren. 1999. A simple and universal method for molecular sexing of non-ratite birds. *Journal of Avian Biology* 30:116-121.

Gershwin, M.E., R.S. Beach, and L.S. Hurley. 1985. Nutrition and immunity. Orlando Florida: Academic Press.

Greiner, E.C., G.F. Bennett, E.M. White, and R.F. Coombs. 1975. Distribution of the

avian hematozoa of North America. *Canadian Journal of Zoology* 53:1762-1787.

Greiner, E.C. and A. Kocan. 1977. *Leucocytozoon* (Haemosporidia: Leucocytozidae) of the falconiformes. *Canadian Journal of Zoology* 55:761-770.

Greiner, E.C, D.J. Black, and W.O. Iverson. 1981. *Plasmodium* in a bald eagle (*Haliaetus leucocephalus*) in Florida. *Journal of Wildlife Diseases* 17:555-558.

Henny, C.J. and D.W. Anderson. 1979. Osprey distribution, abundance, and status in western North America: III. The Baja California and Gulf of California population. *Bulletin Southern California Academy of Sciences* 78:89-1060.

Hunter, D.B., C. Rohner, and D.C. Currie. 1997. Mortality in fledgling great horned owls from black fly hematophaga and leucocytozoonosis. *Journal of Wildlife Diseases* 33:486-491.

Jovani, R., J.L. Tella, M. Forero, M. Bertelloti, G. Blanco, J.A. Donázar, and O. Ceballos. 2001. Apparent absence of blood parasites in the Patagonian seabird community: is it related to marine environment? *Waterbirds* 24:430-433.

Kinsella, J.M., R.A. Cole, D.J. Forrester, and C.L. Roderick. 1996. Helminth Parasites of the Osprey, *Pandion haliaetus*, in North America. *Journal of the Helminthological Society of Washington* 63:262-265.

Krone, O., J. Priemer, J. Streich, P. Sömmer, T. Langgemach, and O. Lessow. 2001. Haemosporida of birds of prey and owls from Germany. *Acta Protozoologica* 40:281-289.

Lloyd, S. 1995. Environmental influences on host immunity. Pages 327-361 *in* B.T. Grenfell, and A.P. Dobson (Eds.). Ecology of infectious diseases in natural populations. Cambridge: Cambridge University Press.

Loye, J.E. and M. Zuk (Eds.). 1991. Bird-parasite interactions: Ecology, evolution, and behavior. Oxford University Press, Oxford.

Martinez-Abraín, A. and G. Urios. 2002. Absence of blood parasites in nestlings of the Eleonora's falcon (*Falco elenorae*). *Journal of Raptor Research* 36:139-141.

Miller, M.J.R., P.J. Ewins, and T.D. Galloway. 1997. Records of ectoparasites

collected on ospreys from Ontario. *Journal of Wildlife Diseases* 33:373-376.

Møller, A.P., K. Allander, and R. Dufva. 1990. Fitness effects of parasites on passerine birds: a review. Pages 269-280 *in* J. Blondel, A. Gosler, J.D. Lebreton, and R.H. McCleery (Eds.). Population biology of passerine birds: an integrated approach. Springer-Verlag, Berlin.

Peirce, M.A. 1981. Distribution and hos-parasite check-list of the haematozoa of birds in Western Europe. *Journal of Natural History* 15:419-458.

Peirce, M.A. and M. Marquiss. 1983. Haematozoa of British birds. VII. Haematozoa of raptors in Scotland with a description of *Haemoproteus nisi* sp. Nov. from the Sparrowhawk (*Accipiter nisus*). *Journal of Natural History* 17:813-821.

Piersma, T. 1997. Do global patterns of habitat use and migration strategies co-evolve with relative investment in immunocompetence due to spatial variation in parasite pressure? *Oikos* 80:623-631.

Reitherman, B. and J. Storrer. 1981. A preliminary report on the reproductive biology and ecology of the Whale Island Osprey (*Pandion haliaetus*) population, San Ignacio Lagoon, Baja California Sur, México. Western Foundation Vertebrate Zoology, Los Angeles, CA.

Rolland, C., E. Danchin, and M. Fraipont. 1998. The evolution of coloniality in birds in relation to food, habitat, predation, and life-history traits: a comparative analysis. *The American Naturalist* 151:514-529.

Savidge, J.A., L. Sileo, and L.M. Siegfried. 1992. Was disease involved in the decimation of Guam's avifauna? *Journal of Wildlife Diseases* 28:206-214.

Schmidt, G.D. and P.M. Huber. 1985. Two rare helminths in an Osprey, *Pandion haliaetus*, in Mexico. *Journal of the Helminthological Society of Washington* 52:140-141.

Sol, D., R. Jovani, and J. Torres. 2000. Geographical variation in blood parasites in feral pigeons: the role of vectors. *Ecography* 23:307-314.

Stuht, J.N., W.W. Bowerman, and D.A. Best. 1999. Leucocytozoonosis in nestling bald eagles in Michigan and Minessota. *Journal of Wildlife Diseases* 35:608-612.

Tella, J.L. 2002. The evolutionary transition to coloniality promotes higher blood parasitism in birds. *Journal of Evolutionary Biology* 15:32-41.

Tella, J.L., M.G. Forero, M. Bertellotti, A. Gajón, F. Hiraldo, and J.A. Donázar. 1996. Absence of blood-parasitization effects on lesser kestrel fitness. *The Auk* 113:253-256.

Tella, J.L., G. Blanco, M.G. Forero, A. Gajón, J.A. Donázar, and F. Hiraldo. 1999. Habitat, world geographic range and embryonic development of hosts explain the prevalence of avian hematozoa at small spatial and phylogenetic scales. *Proceedings of the National Academy of Sciences USA* 96:1785-1789.

Tella, J.L., R. Rodríguez-Estrella, and G. Blanco. 2000. Louse flies on birds of Baja California. *Journal of Wildlife Diseases* 36:154-156.

Tella, J.L., M.G. Forero, M. Bertellotti, J.A. Donázar, G. Blanco, and O. Ceballos. 2001. Offspring and body condition and immunocompetence are negatively affected by high breeding densities in a colonial seabird: a multi-scale approach. *Proceedings of The Royal Society Biological Sciences* 268:1455-1461.

Toyne, E.P. and R.W. Ashford. 1997. Blood parasites of nestlings Goshawks. *Journal of Raptor Research* 31:81-83.

Valkiünas, G. 1993. Pathogenic influence of haemosporidians and trypanosomes on wild birds in the field conditions: facts and hypotheses. *Ecologia* 1:47-60.

Van Riper III, C., S.G. van Riper, M. Lee Goff, and M. Laird. 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. *Ecological Monographs* 56:327-344.

Van Riper III, C. 1991. The impact of introduced vectors and avian malaria on insular passeriform bird populations in Hawaii. *Bulletin of the Society for Vector Ecology* 16:59-83.

Warner, R.E. 1968. The role of introduced diseases in the extinction of the endemic

Hawaiian avifauna. *The Condor* 70:101-120.

Work, T.M., J.G. Massey, B.A. Rideout, C.H. Gardiner, D. Ledig, and J.P. Dubey. 2000. Fatal toxoplasmosis in free-ranging endangered 'alala (*Corvus hawaiiensis*) from Hawaii. *Journal of Wildlife Diseases* 36:205-212.