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Recent and Chronic Exposure of Wild Ducks to Lead in Human-modified Wetlands in Santa Fe Province, Argentina

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ABSTRACT: Poisoning of waterfowl due to ingestion of lead pellets is a worldwide problem in areas that are subject to hunting. No studies have assessed exposure of waterbirds to this heavy metal in Argentina, in spite of intense hunting activity, and the fact that only lead ammunition is commercially available. The objective of this study was to evaluate duck exposure to lead by examining gizzard and bone samples collected from 30 wild ducks, 16 Rosy-billed Pochard (*Netta peposaca*), and 14 Fulvous Whistling-Duck (*Dendrocygna bicolor*), provided by hunters in northern Santa Fe Province, Argentina, in July 2007. Radiographs, followed by dissection of the gizzards, showed that 31% of the Rosy-billed Pochards and 29% of the Fulvous Whistling-Ducks had ingested lead pellets (between one and four per animal). Lead in bone was found at concentrations associated with detrimental health effects. In spite of the small number of samples in this project, these results indicate high levels of lead exposure (both recent and chronic) in these species. This is the first report of a problem in Argentina that could represent a threat to the health and conservation of native aquatic species, their predators, and the wetlands they inhabit.

Key words: Argentina, bone, ducks, gizzard, hunting, lead, rice fields, wetlands.

Lead poisoning in wild birds has been documented in many parts of the world, with waterfowl and birds of prey being those most frequently affected (Clemens et al., 1975; Friend, 1987; Pain, 1996). Aquatic environments subject to intense hunting and/or fishing activity have been identified as high-risk areas, because hundreds of lead pellets or fishing weights are introduced each season.

The most frequent mode of exposure for waterbirds is through accidental ingestion of lead pellets that they confuse for seeds or grit (Hall and Fisher, 1985; Suarez and Urios, 1999; Mateo et al., 2001; De Francisco et al., 2003; Figuerola et al., 2005; Svanberg et al., 2006). Pellets may be evacuated immediately after ingestion, with minimal or no lead absorption, or they can be retained in the digestive tract from 18 to 20 days on average (Jordan and Bellrose, 1951). Stomach acids dissolve the lead, which is then absorbed into the bloodstream from the intestine in the form of lead salts (Pain, 1996; De Francisco et al., 2003). The observation of radiodense pieces of metal in radiographs of the gizzard or proventriculus is suggestive of the presence of ingested lead pellets (recent exposure; Hall and Fisher, 1985; Rupley, 1997), which can then be confirmed by dissection. Lead absorption by bone tissue is rapid, but its liberation is slow; thus, this measurement is used to evaluate lifetime accumulation of lead (chronic exposure; Guitart et al., 1994; De Francisco et al., 2003; Svanberg et al., 2006).

Reports of mortality of aquatic birds from lead poisoning are frequent in environments contaminated by lead (Blus, 1994; Guitart et al., 1994; Mateo et al., 1997, 2001; Fisher et al., 2006). This implies an additional problem for avian conservation efforts, particularly for threatened or vulnerable species.

Large areas of wetlands in Argentina have been modified for rice cultivation. These environments harbor a variety of resident and migratory birds (Blanco et al., 2006) that use the areas for feeding, reproduction, or both. Ducks, geese, swans, and in particular the Whistling-Ducks (*Dendrocygna viduata*), Fulvous

Whistling-Ducks (*D. bicolor*), Rosy-billed Pochards (*Netta peposaca*), Yellow-billed Pintails (*Anas georgica*), and Brazilian Teal (*Amazonetta brasiliensis*), are considered pests due to their consumption of plant parts, damage of rice shoots and seeds, or both (Bucher, 1983; Menegheti et al., 1990; Zaccagnini, 2002). Thus, sport hunting is authorized in rice fields to limit duck populations and mitigate crop damage (e.g., R.P. 0306, 2007). In addition, regular sport hunting is permitted for 4 mo each year across an extensive region, including rice cultivated areas and natural wetlands in Santa Fe Province, Argentina (e.g., R.P. 0124, 2007).

Despite intense hunting activity using lead pellets, no previous studies have been conducted to examine lead exposure in birds using these wetlands. Our objective was to evaluate recent and cumulative lead exposure in wild ducks in modified wetlands in the northeast of Santa Fe Province. The study site spanned approximately 17,000 ha and is composed of a mosaic of rice fields, natural wetlands and marshes, native forests, and patches of land within the floodplain of the Paraná River (30°41′S, 60°02′W). Avian fauna present in this area are abundant and diverse (Blanco et al., 2006), and duck hunting occurs from February to August each year.

In July 2007, 16 Rosy-billed Pochards (nine males and seven females) and 14 Fulvous Whistling-Ducks (seven males and seven females) were provided by licensed hunters. Species, weight (±20 g), sex, and age class (based on plumage) were recorded for all individuals. Collected samples included gizzards and pneumatic wing bones (humerus), which were preserved in a 10% formalin solution and frozen at −20 C, respectively. Radiographs were later obtained from all the gizzards and those showing images compatible with pellets were dissected to collect the pellets. Stomachs perforated by pellets during hunting were discarded ($n = 8$) to avoid inclusion of any pellets not consumed during feeding. Lead concentration in bone samples was determined by atomic absorption with electrothermic atomization (atomic absorption spectrophotometer, Perkin Elmer Analyst 700 with Autosampler AS 800). Nondetectable levels of lead were estimated as 0.01 ppm (0.01 μg/g), with the mean between 0 ppm and the detection limit of 0.02 ppm. Therefore, values below detectable limits were estimated to be 0.01 ppm.

Radiograph evidence of lead pellets in the gizzard lumen was observed in 31.3% of *N. peposaca* and 28.6% of *D. bicolor* examined (Tables 1 and 2). Size of recovered lead pellets was highly variable, ranging between 1 mm (flat, coin-like shape) and 2.9 mm (spherical).

Levels of lead concentration in bone are shown in Tables 1 and 2.

Our preliminary results demonstrate high lead exposure and accumulation in the sampled species. Based on dry weight results, Pain (1996) and Svanberg et al. (2006) considered a range of 10 to 20 ppm of lead in waterfowl bones as subclinical to clinical exposure, whereas values of more than 20 ppm were associated with severe clinical symptoms. To compare our values to those published, we made a rough estimate of dry weights in our samples using the average measure of the humidity of 15% of the samples (a mean humidity of 37.4% was determined by drying 4 g of bone samples at 105 C until weight remained constant). Using these estimated dry weight values, 7% of *N. peposaca* bone samples would fall in the range of 10 to 20 ppm of lead, and 40% would show concentrations of more than 20 ppm (Table 1). In *D. bicolor*, 15% would have lead concentrations between 10 ppm and 20 ppm, as well as more than 20 ppm (Table 2). Given that this study used hunter-killed specimens, the sampled individuals probably do not represent those incapacitated by lead exposure, and this selection bias could underestimate the

TABLE 1. Presence of lead pellets in gizzards and bone lead concentrations in hunter-killed Rosy-billed Pochard (*Netta peposaca*) from waterfowl hunting in central Argentina.

Weight (g)	Sex	Age class	Presence of lead pellets in radiographs	No. of lead pellets recovered	Lead in bone wet weight (ppm)	Estimated lead in bone dry weight (ppm)
1,050	Female	Adult	Negative	0	0.01	0.016
900	Female	Adult	Positive	1	76.3	126.53
1,000	Male	Juvenile	Negative	0	0.01	0.016
1,000	Male	Juvenile	Positive	1	18.4	30.51
640	Male	Juvenile	Positive	1	3.6	5.97
1,150	Female	Adult	Negative	0	3.5	5.80
980	Male	Juvenile	Negative	0	0.01	0.016
1,100	Female	Adult	Negative	0	10.7	17.74
1,050	Male	Adult	Negative	0	0.01	0.016
1,250	Male	Adult	Positive	2	16.7	27.69
1,400	Male	Adult	Negative	0	2.0	3.31
1,050	Female	Adult	Negative	0	15.5	25.7
1,100	Male	Juvenile	Negative	0	33.1	54.89
900	Female	Adult	Positive	3	20.07	33.28
1,050	Male	Juvenile	Negative	0	5.2	8.62
1,200	Female	Adult	Negative	0	N/A[a]	N/A[a]

[a] N/A = not analyzed.

extent of lead exposure in these populations.

This study is the first to report exposure of waterfowl to spent lead shot in Argentina. Wetlands in the northern zone of Santa Fe Province of Argentina are major global locations for duck hunting (Hartmann, pers. comm.). Replacement of the region's wetlands by rice fields is accelerating, and the attraction of these fields to large concentrations of waterbirds tends to magnify damage to crops and a subsequent demand for more hunting as a control on duck populations. This situation could lead to increased lead contamination. Studies conducted in the wintering grounds of Rosy-billed Pochard in Brazil suggest that their populations could be

TABLE 2. Presence of lead pellets in gizzards and bone lead concentrations in Fulvous Whistling-Ducks (*Dendrocygna bicolor*) from waterfowl hunting in central Argentina.

Weight (g)	Sex	Age class	Presence of lead pellets in radiographs	No. of lead pellets recovered	Lead in bone wet weight (ppm)	Estimated lead in bone dry weight (ppm)
850	Male	Adult	Negative	0	0.01	0.016
850	Female	Adult	Negative	0	2	3.31
1,100	Male	Adult	Negative	0	1.8	2.98
800	Female	Adult	Negative	0	0.3	0.49
950	Male	Adult	Negative	0	13.3	22.05
800	Female	Adult	Negative	0	5.5	9.12
780	Male	Adult	Positive	2	N/A[a]	-
900	Female	Adult	Negative	0	0.2	0.33
800	Female	Adult	Negative	0	0.01	0.016
700	Female	Adult	Negative	0	0.01	0.016
760	Male	Adult	Positive	1	10.02	16.61
600	Male	Adult	Positive	4	0.9	1.49
700	Male	Adult	Positive	2	7.7	12.76
920	Female	Adult	Negative	0	12.8	21.22

[a] N/A = not analyzed.

decreasing, possibly due to excessive hunting, among other reasons (Menegheti, 1999). The effects of chronic lead exposure on fitness and reproductive success should also be considered as possible contributing factors.

At least 18 of the 38 duck species from Argentina use the study area (Zaccagnini, 2002), and could be exposed to lead. Nonetheless, lead toxicity probably expands beyond the aquatic bird community. Lead ammunition ingestion has been documented in 59 terrestrial species, including raptors, galliforms, and gruiforms (Fisher et al., 2006), and representatives of these taxa also use the study site. Long-term persistent pollution by lead threatens the sustainability and resilience of this human-impacted ecosystem. Given the current magnitude of duck hunting in the Parana River floodplain, our results suggest that the replacement of lead pellets with nontoxic ammunition is both necessary and urgent.

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LITERATURE CITED

Blanco, D. E., B. Lopez-Lanus, R. A. Dias, A. Azpiroz, and F. Rilla. 2006. Use of rice fields by migratory shorebirds in southern South America. Implications for conservation and management. Wetlands International, Buenos Aires, Argentina, pp. 56.

Blus, L. J. A. 1994. Review of lead poisoning in swans. Comparative Biochemistry and Physiology C 108C: 259–267.

Bucher, E. H. 1983. Las aves como plaga en la Argentina. *In* D. J. Elias (coord.): Symposium, Zoología económica y vertebrados como plagas de la agricultura. IX Congreso Latinoamericano de Zoología, 9–15 October 1983, Arequipa, Peru, Arequipa, Peru, pp. 74–90.

Clemens, E. T., L. Krook, A. L. Aronso, and C. E. Stevens. 1975. Pathogenesis of lead shot poisoning in the mallard duck. Cornell Veterinarian 62: 248–285.

De Francisco, N., J. D. Ruiz Troya, and E. I. Aguera. 2003. Lead and lead toxicity in domestic and free living birds. Avian Pathology 32: 3–13.

Figuerola, J., R. Mateo, A. J. Green, J. Y. Mondain-Monval, H. Lefranc, and G. Mentaberre. 2005. Grit selection in waterfowl and how it determines exposure to ingested lead shot in Mediterranean wetlands. Environmental Conservation 32: 226–234.

Fisher, I. J., D. J. Pain, and V. G. Thomas. 2006. A review of lead poisoning from ammunition sources in terrestrial birds. Biological Conservation 131: 421–432.

Friend, M. 1987. Lead Poisoning, Chapter 18. *In* Field guide to wildlife diseases, general field procedures and diseases of migratory birds, M. Friend (ed.). US Department of the Interior, Fish and Wildlife Service, Washington, D.C., pp. 175–189.

Guitart, R., J. To-Figueras, R. Mateo, A. Bertolero, S. Cerradelo, and A. Martinez-Vilalta. 1994. Lead poisoning in waterfowl from the Ebro Delta, Spain: Calculation of lead exposure thresholds for mallards. Archives of Environmental Contamination and Toxicology 27: 289–293.

Hall, K. L., and F. M. Fisher. 1985. Heavy metal concentration of duck tissues in relation to ingestion of spent shot. Bulletin of Environmental Contamination and Toxicology 35: 163–172.

Jordan, J. S., and F. C. Bellrose. 1951. Lead poisoning in wild waterfowl. Illinois Natural History Survey Biological Notes 26: 1–27.

Mateo, R., J. Carles Dolz, J. M. Aguilar Serrano, J. Belliure, and R. Gultart. 1997. An epizootic of lead poisoning in greater flamingos (*Phoenicopterus ruber roseus*) in Spain. Journal of Wildlife Diseases 33: 131–134.

———, A. J. Green, C. W. Jeske, V. Urios, and C. Gerique. 2001. Lead poisoning in the globally threatened marbled teal and white-headed duck in Spain. Environmental Toxicology and Chemistry 20: 2860–2868.

Menegheti, J. O. 1999. Mais sobre o marrecão: Sua caça esportiva no Cone Sul das Américas. Caça & Conservação, Porto Alegre 4: 11–12.

———, F. Rilla, and M. I. Burger. 1990. Waterfowl in South America: Their status, trends and

distribution. *In* G. V. T. Matthews (ed.). Managing waterfowl populations. *In* Proceedings of the International Waterfowl Research Bureau Symposium, Astrakhan USSR, 2–5 October 1989. International Waterfowl Research Bureau Publication 12, pp. 97–103, Slimbridge, Gloucester, UK.

Pain, J. D. 1996. Lead in waterfowl. *In* Environmental contaminants in wildlife: Interpreting tissue concentrations, W. N. Beyer, G. H. Heinz, and A. W. Red-Norwood (eds.). Lewis, Boca Raton, Florida, USA, pp. 251–264.

R.P. 0306, 2007. "Habilitar la caza deportiva del PATO en los predios arroceros de los Departamentos Garay y San Javier". Secretaría de Estado de Medio Ambiente y Desarrollo Sustentable. Gobierno de la Provincia de Santa Fe.

R.P. 0124, 2007. "Habilitación de caza deportiva, temporada 2007". Secretaría de Estado de Medio Ambiente y Desarrollo Sustentable. Gobierno de la Provincia de Santa Fe.

Rupley, A. E. 1997. Toxicoses. *In* Manual of avian practice. W. B. Saunders Company, Philadelphia, Pennsylvania, USA, pp. 302–303.

Suarez, C. R., and V. Urios. 1999. La Contaminación por saturnismo en aves acuáticas del Parque Natural de El Hondo y su relación con los hábitos alimenticios. Sehumed, Humedales Mediterráneos, Valencia, Spain 1: 83–90.

Svanberg, F., R. Mateo, L. Hillosträm, A. J. Green, M. A. Taggart, A. Raab, and A. A. Meharg. 2006. Lead isotopes and lead shot ingestion in the globally threatened marbled teal (*Marmaronetta angustirostris*) and white-headed duck (*Oxyura leucocephala*). Science of Total Environment 370: 416–424.

Zaccagnini, M. E. 2002. Los patos en las arroceras del noreste de Argentina: ¿plagas o recursos para caza deportiva y turismo sostenible? *In* Primer Taller sobre la Caza de Aves Acuáticas. Hacia una estrategia para el uso sustentable de los recursos de los humedales, D. E. Blanco, J. Beltrán and V. de la Balze (eds.). Wetlands International, Buenos Aires, Argentina, 152: pp. 35–57.

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