Rubber Band Ingestion by a Rubbish Dump Dweller, the White Stork (*Ciconia ciconia*)

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Abstract.—The health of wildlife can be affected by the ingestion of non-edible, anthropogenic debris that mimic prey. First evidence of localized, massive ingestion of rubber bands is provided for an earthworm consumer, the White Stork (*Ciconia ciconia*), using nest contents and necropsies recorded in France. In 2003-2004, the prevalence of rubber bands and other debris in nests (N = 227) differed between the nine regions analyzed and decreased as distance from the nearest rubbish dump (*distRD*) increased. Hence, ingestion of rubber bands would occur only at some rubbish dumps. Nests with rubber bands contained 6.5 ± 2.5 units (max: 27; independent of *distRD*). The number of chicks was not related to the presence/absence of rubber bands in their nest. In 2008-2010, 26% of necropsied storks (N = 57: Alsace region) had rubber bands in their digestive tract. Seven instances of death due to gut occlusion by rubber bands are reported. Immature birds may be more exposed to rubber band ingestion than adults because of their lower ability at discriminating and regurgitating non-edible items, as well as their higher frequentation of rubbish dumps. The disposal of used rubber bands in a form that prevents ingestion by earthworm consumers is recommended. *Received 14 April 2011, accepted 29 June 2011.*

Key words.—diet, elastic thread, environmental contamination, foraging behavior, plastic debris, pollution, refuse tip, waste management.

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Contamination of the environment with non-edible items that mimic food can cause health problems in invertebrates, fishes, reptiles, birds and mammals (Gregory 2009). The high prevalence of plastic debris ingestion by marine predators, such as sea turtles (e.g., Bugoni *et al.* 2001), seals (Eriksson and Burton 2003), cetaceans (Jacobsen *et al.* 2010) and seabirds (Moser and Lee 1992; Ryan 1988a; Gregory 2009) has attracted much attention from environmental researchers and conservationists (Thompson *et al.* 2009). Accounts of the effects of debris in terrestrial habitats are rarer (Thompson *et al.* 2009).

The effects of ingestion of non-edible debris are controversial (Gregory 2009), with some evidence of minimal or no impact (e.g., Ryan and Jackson 1987, Moser and Lee 1992). Studies that found a deleterious impact suggest that ingestion of debris disturbs the digestive process by affecting the absorption and assimilation of nutrients (Mee *et al.* 2007; reviewed in Gregory 2009). Also, masses of indigestible items may artificially induce satiety, causing animals to stop feeding before having acquired the energy necessary for self-maintenance (Ryan 1988b). Accumulation of debris can also block the transit of food through the digestive tract. Another deleterious effect is the release of toxic chemicals (Thompson *et al.* 2009). Eventually, impacts can be intergenerational, when adults feed their chicks by regurgitating pellets of food that contain indigestible items (Ryan 1988a).

Rubber bands are one of the commonest anthropogenic items ingested by birds foraging on worms, likely because their shape and color mimic prey such as earthworms (Lumbricidae). Rubber band ingestion has been reported for Ardeidae (Gómez-Tejedor *et al.* 1994), waders (Jackson 1954), insectivorous raptors (Little Owl *Athene noctua, Union Française des Centres de Sauvegarde de la faune sauvage, in litt.*), and terns (Hocken 1960). Researchers have even used the ingestion of rubber bands in corvids (Soler *et al.* 1990) and gulls (Hüppop 1999) to characterize foraging range. Bands of different colors were deposited at foraging sites, and the proportion of bands in each color that were regurgitated at the colony served to identify foraging-site frequentation.

In the present study, we provide the first evidence of localized, massive ingestion of rubber bands by White Storks (*Ciconia ciconia*) in France, with potentially deleterious impact on their health. Earthworms compose a large part of their diet (Antczak *et al.* 2002). During the breeding seasons of 2003 and 2004, we asked stork banders to record the number of rubber bands present in the nests, the number of other anthropogenic items, and the linear distance from the nearest rubbish dump for each nest visited. We expected that if: (i) storks mainly find rubber bands when foraging at rubbish dumps (Peris 2003), the prevalence of rubber bands per nest should depend on the distance of the nest from the nearest rubbish dump; (ii) if rubber bands are more concentrated in rubbish dumps than other anthropogenic debris, this dependence of the prevalence on the distance from the nearest rubbish dump should be stronger for rubber bands than for other debris; and (iii) rubber band ingestion has a major impact on energy acquisition, the number of fledglings per nest should be lower in nests with rubber bands than in other nests.

METHODS

Only one observation per nest is used in analyses (the maximal number for counts in 2003 and 2004). The prevalence of occurrence of items per nest and numbers were analyzed respectively with comparisons of nested logistic regression models and Poisson regression models (adjusted for over-dispersion if necessary), and the significances of effects were assessed with likelihood ratio-tests (or F-tests in case of overdispersion). Statistical analyses were carried out with R ver. 2.8.1 (R Development Core Team, Vienna, Austria).

The prevalence of rubber band ingestion by White Storks was assessed by compiling the results of systematic necropsies undertaken in Alsace (2008-2010) by the Departmental Veterinary Service of Haut-Rhin. Corpses of storks found dead, or that died in rehabilitation centers, were examined for external and internal indications of trauma. Their digestive tracts were searched for helminthic parasites, and gut contents were collected. All body cavity organs were dissected. *Salmonella* sp. and *Escherichia coli* were searched for with standard culture assays.

RESULTS

Over the two years of the survey, 227 different nests were examined. The prevalence of rubber bands and other indigestible anthropogenic debris per region are presented in Table 1. The prevalence of rubber bands was significantly less than for other debris (χ^2_1 = 201.7, P < 10-4). The prevalence of both types of anthropogenic items differed significantly between regions (for rubber bands, χ^2_8 = 28.0, P < 10-3; for other debris, χ^2_8 = 279.0, P < 10-4). Rubber bands were frequent in only two regions (Languedoc and Dombes: Fig. 1) whereas other debris were more or less frequent in all regions. The prevalence of both rubber bands and other debris in nests decreased as distance from the nearest rubbish dump increased (effect of the log of the distance expressed in km: for rubber bands, χ^2_1 = 9.8, P = 0.002, slope -0.742 ± 0.236 [SE], Fig. 2a; for other debris, χ^2_1 = 162.5, P < 10-4, slope -4.224 ± 0.554, Fig. 2b).

Nests with at least one item contained 6.5 ± 2.5 [SD] rubber bands (maximum: 27) and

Table 1. Prevalence (and sample size) of White Stork nests with rubber bands and/or other indigestible anthropogenic debris for nine regions in France.

Region	Rubber bands	Other debris
Alsace	0.050 (20)	0.350 (20)
Bourgogne	0 (9)	0.667 (9)
Camargue	0 (6)	0 (2)
Charente-Maritime	0.017 (60)	—
Dombes	0.158 (38)	0.579 (38)
Languedoc	0.750 (4)	1.000 (4)
Normandie	0.016 (62)	0.274 (62)
Pays-de-la-Loire	0 (18)	0.222 (18)
Picardie	0 (10)	—
Total	0.053 (227)	0.392 (153)

Figure 1. Nest of White Stork containing rubber bands (Languedoc, France, 28 May 2003). Photo by P.-Y. Henry.

2.8 ± 0.5 (maximum: 19) other items of debris per nest. The number of items per nest differed between regions for other debris ($F_{5,51}$ = 5.677, P < 10-3) but not for rubber bands ($F_{3,7}$ = 1.066, P = 0.422), and the number of items per nest decreased as distance from the nearest rubbish dump increased for other debris (effect of the log of the distance, $F_{1,49}$ = 14.824, P < 10-3, slope -0.409 ± 0.097) but not for rubber bands ($F_{1,9}$ = 0.435, P = 0.526, slope -0.26 ± 0.389; Fig. 2b).

The number of chicks was not related to the presence/absence of indigestible items in their nest (for rubber bands, χ^2_1 = 0.957, P = 0.328; for other debris, χ^2_1 = 0.067, P = 0.796, Fig. 2c), nor to the number of items (for rubber bands, χ^2_1 = 0.727, P = 0.394; for other debris, χ^2_1 = 0.284, P = 0.594).

From 2000-2004, we received seven reports of White Storks that had been found dead with rubber bands in their stomachs: three from Alsace (including a juvenile for which a veterinarian identified stomach occlusion as the likely cause of death: Fig. 3), two from Dombes (out of four necropsies, J.-Y. Fournier, *in litt.*), and two from Languedoc (a juvenile with 50 bands in its stomach, P. Mayet, *in litt.*, and an adult with the "stomach full of rubber bands"). For the years 1995-2005, all of the 20-25 dead White Storks that were analyzed in the Dombes region had ingested rubber bands (or similar items), but none would have died of gut occlusion (E. Bureau, veterinarian at the Bird Center of the Dombes, *in litt.*). During the necropsy survey 2008-2010 (N = 57; Alsace region), 15 storks (26%) had rubber bands in their digestive tract (11 in gizzard, 3 in esophagus and 1 in both). In seven of the 15 storks, rubber bands were numerous and had become compacted into a massive pellet. The cause of death was diagnosed as gut occlusion due to the rubber bands and subsequent starvation for five storks (9%: all immatures or adults). Among the 52 storks that did not die of gut occlusion, ten (19%) had rubber bands in their digestive tracts.

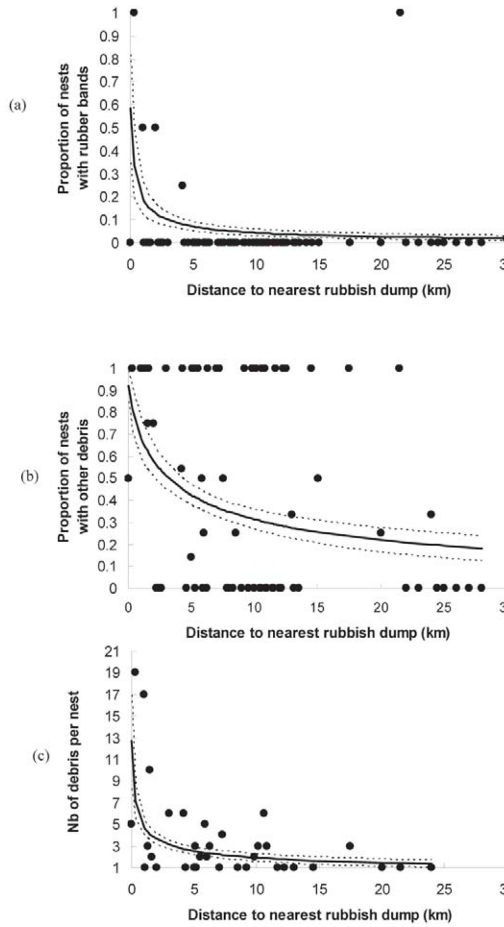

Figure 2. Decrease in (a) prevalence of rubber bands and (b) other debris, and (c) number of other debris in nests of White Storks according to distance to the nearest rubbish dump.

DISCUSSION

Our study provides the first quantitative assessment of the ingestion of rubber bands

Figure 3. Mass of rubber bands collected from the gizzard of a dead White Stork (Alsace, France, 27 October 2003). Photo by G. Wey.

by a terrestrial animal. White Storks mainly collect rubber bands when foraging at rubbish dumps (also see Gómez-Tejedor *et al.* 1994). The prevalence of rubber bands in nests of White Storks rapidly decreased as distance to the nearest rubbish dump increased, becoming less than 10% for nests that were three km or more from rubbish dumps. The distance corresponds to the usual maximal foraging distance of breeding storks (1.5 km in Denac 2006; 3-5 km in Cramp and Simmons 1977). Note that the 'other debris' category included several items that were similar in shape or texture to rubber bands (e.g., a feeding-bottle tip 'proving that storks rear human babies', J.-Y. Fournier, *in litt.*). Hence, we provide a conservative estimate of the attraction to worm-like debris. The quantity of rubber bands varied among rubbish dumps, with highest prevalence in stork nests in Languedoc and Dombes regions. In June 2011, five years after the closure of the dump in Languedoc, rubber bands were absent from all seven visited nests, thus confirming that rubber bands had come from the rubbish dump. The occurrence of other debris in the nests was also related to distance to the nearest rubbish dumps, but average prevalence remained high even far from rubbish dumps (>20% at 20 km). Consequently, rubbish dumps appear to play a greater role as a provider for rubber bands than for other debris. Some of the rubber bands may have been ingested in agricultural fields, particularly in those with vegetable crops (Languedoc, Dombes) and vineyards (Alsace), where they are used for attaching plants. However, our results suggest that the major part of rubber band ingestion takes place at rubbish dumps, and rubbish dumps have now become a major foraging habitat for White Storks (Tortosa *et al.* 2002; Archaux *et al.* 2004; Ciach and Kruszyk 2010). While foraging at dumps, storks also ingest all sorts of other non-edible items of anthropogenic origin, which are also found in large quantities in their stomachs (Peris 2003).

We obtained only a rudimentary notion of the impact that rubber band ingestion may have on reproductive output or survival. The lack of relationship between the occurrence of rubber bands or other debris in nests and the number of nestlings suggests that rubber band ingestion is not strongly deleterious for nestlings (also see Ryan 1988a). But, if rubber bands accumulate slowly in their digestive tracts, the negative impact may be delayed to after fledging and, therefore, would not be detected by reproductive success parameters. According to necropsies in Alsace, one stork out of four or five ingests rubber bands, and the ingestion of a large number of rubber bands can cause death. Nonetheless, the ability of storks to regurgitate non-edible items likely protects most individuals from gut occlusion.

Immature birds may be more exposed to rubber band ingestion, and consequent health problems, than adults (Ryan 1988a). Nestlings likely accumulate in their digestive tracts the rubber bands fed to them by their parents (Ryan 1988a), and they are less inclined to regurgitate indigestible items than adults (Hutton *et al.* 2008). Juveniles may also be more prone to making errors when discriminating edible from non-edible items (Ryan 1988a), hence potentially ingesting higher quantities of rubber bands than adults. Finally, juvenile and immature birds forage more often on rubbish dumps than adults (Archaux *et al.* 2008), which should result in a higher rate of ingestion of rubber bands - 63% of freshly dead juvenile storks contained anthropogenic debris *versus* 35% in adults (Peris 2003).

The western European population of White Storks is increasing (Peris 2003; Archaux *et al.* 2004), hence rubber band consumption most likely does not pose a global conservation problem for the species. However, other earthworm consumers may be more negatively affected by this peculiar type of environmental contamination. When storks regurgitate rubber bands away from rubbish dumps, they are contributing to the diffusion of this contamination by making this fake food available to other earthworm consumers. For instance, in the Dombes region, several nestlings of captive Bald Ibises (*Geronticus eremita*) suffered from gut occlusion after having been fed rubber bands by their parents. These rubber bands had been regurgitated by wild storks nesting on top the aviary (E. Bureau, *in litt.*). We conclude that, whatever the actual prevalence and impact of rubber band ingestion, measures should be taken for disposing of rubber bands in a safe form that prevents ingestion by earthworm consumers, such as waterbirds, raptors and corvids.

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