Wear and Opening as Sources of Band Loss in the White Stork

ROGER JOVANI AND JOSÉ L. TELLA

Department of Applied Biology, Estación Biológica de Doñana (C.S.I.C.), Avda. Mª Luisa s/n, E-41013 Sevilla, Spain
Internet: jovani@ebd.csic.es

Abstract.—Butt-end and lock-on aluminum band loss and wear were studied in the White Stork (*Ciconia ciconia*) banded in Spain. The risk of loss of butt-end bands increased from 0% to 85% in bands of 0 to 12 years. However, no loss occurred when storks were banded on the tibia rather than in the tarsus. Lock-on metal bands showed a low band loss rate throughout. The results indicated that band loss was mainly caused by the band opening, probably because of frequent contact with mud and water on the tarsus. Aluminum bands should be completely discarded to avoid important biases in analyses of population dynamics, dispersal and survival of storks and other groups. This is currently already done in many banding schemes, but should be applied more generally worldwide.

Key words.—band corrosion, band shape, banding, *Ciconia ciconia*, individual identification, ring, Spain, White Stork.

Individual bird identification through banding started as a way of studying "where birds go", and rapidly evolved to the main way of studying bird migration (Berthold 1993). Nowadays, the results from bird banding have gone much further, becoming an indispensable tool for the study of many important issues in avian biology. Much of this has been developed from mark-recapture statistical methods applied to band recovery/recapture data to estimate movement and survival rates and those factors affecting them (Lebreton and North 1993).

Among band types, metal bands are considered the most durable, and they are used as virtually permanent identifiers for many bird species (Huyvaert and Anderson 2004). However, detailed studies, mainly on seabirds, have reported a limited life of some metal bands (Coulson and White 1955; Ludwig 1967; Marion and Shamis 1977). This obviously constrains the longest lifespan that we are able to record from a wild bird species, but perhaps more relevant, the progressive loss of bands with aging is a major biasing factor for estimating survival rates even within low age classes for a species (Coulson and White 1957; Furness 1978; Ludwig 1981). Banding groups are aware of this problem, and continuous improvements are made in the materials and types of bands used from a long time ago (Coulson 1976; Furness 1978; Marion and Shamis 1977; Forsman *et al.* 1996). Simultaneously, efforts are focused to counteract the negative statistical effects of band loss (e.g., Coulson and White 1957), such as estimating band loss rate by double-banding some individuals (e.g., Bradley *et al.* 2000). However, band loss may not follow a linear pattern through time (this study), nor have the same rate for all the band series even for the same band model (Coulson 1976; Ludwig 1981; Nisbet and Hatch 1985). Thus, even small band loss rates could be a major problem for studies dealing with survival and movement rates of individuals, and it merits further studies.

This study deals with aluminum bands on White Storks (*Ciconia ciconia*) in Spain during the last 18 years. This metal is known to be inappropriate because of being prone to corrosion, leading many banding schemes to avoid its use (Coulson 1976; Furness 1978). We also address how band shape could change with time, an additional problem that has attracted less interest.

METHODS

Since 1986, more than 19,000 White Storks (mainly nestlings) have been banded with both a metal and a plastic band in Spain. Metal bands have been made of an alloy of aluminum with a small content of manganese and magnesium. The numerical code of the metal band is extremely difficult to read from distance, but plastic bands are large enough to be read at distance with spotting scopes. During the first years of plastic banding, a lock-on metal band (model "G") was used, but it was rapidly replaced by a butt-end aluminum band (model

"9"). Plastic and metal bands were initially located on the tibia, but since about 1990 metal bands have been attached to the tarsus (L. García, pers. comm.).

In a long-term study on population dynamics of this species (see e.g. Jovani and Tella 2004), plastic bands on White Storks were read at distance with spotting scopes from May 2000 until July 2004 at refuse dumps, rice fields and breeding colonies near the Doñana National Park (SW Spain). When both legs of a plastic-banded stork were visible in good light conditions, whether the stork had retained the metal band and its position (tibia or tarsus) was recorded. Since band opening was a potential cause of band loss in the study population, whenever the junction of the band was clearly visible, the gap at the butt end was estimated in four categories: 0, 1, 2, and 3 mm or more. Thus, within the last category there were bands with gaps from 3 to 8 mm. (the width at which a ring could fall off because is the approximate width of a stork's tarsus). For each individual bird seen more than once, we used only the last record for each year of band age. Those birds banded with lock-on and butt-end bands were analyzed separately. Information concerning the code, the type of metal band and the banding date was extracted from the files of the Estación Biológica de Doñana. A few storks that were initially banded only with a plastic band were excluded from the analyses.

The minimum width (nearest 0.01 mm) and weight (nearest 0.0001 g) was measured for 14 metal bands from dead storks, for one metal band lost by one bird and found on the ground, and for ten unused new bands.

RESULTS

A total of 910 band-year records from 688 different White Storks banded with plastic bands, and known to be banded with a metal band, were used. Band "ages" were from 36 days after banding up to 6,578 days (c. 18 years), within a median of 1,901 days (c. 5 years; see Fig. 1 for sample sizes at different age classes). For butt-end bands (model "9") the earliest band loss was detected 509 days after banding, and the probability of band loss increased from 0% to 28% in an almost linear way until 10 years, then rapidly increased to 85% at 12 years-old, and dropped abruptly afterwards to 0% (Fig. 1). This decline over 12 years old coincided with a change in the location of bands from the tarsus to the tibia of birds. In fact, of bands >12 years-old, 12 out of 13 (92%) were attached to the tibia, while among bands <13 years-old only 41 out of 600 (7%) were on tibia. For lock-on bands the probability of band loss was always low and only one loss was detected (Fig. 1). Of those lock-on band records, nine bands were on the tarsus and six on the tibia.

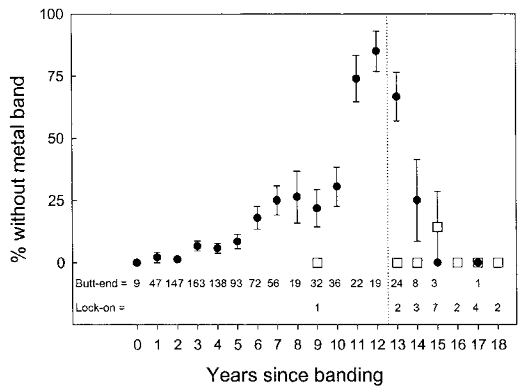

Fig. 1. Proportions of storks that lost aluminum butt-end bands (black dots) or lock-on bands (white squares). Numbers indicate sample size. The vertical dotted line divides the time when bands were normally located on the tibia (<13 years-old) *vs.* tarsus (>12 years-old). Error bars indicate standard error of the proportion.

For 14 birds, it was possible to record the loss of a butt-end metal band between successive sights of the bird. This occurred for one bird with its band being one year of age, and then absent at age three years [abbreviated: 1 year-3 years (1 bird)]; and also 2-3 (1); 3-4 (1); 4-4 (1); 4-5 (3); 4-6 (2); 5-6 (2); 6-8 (1); 7-7 (1); 10-11 (1).

Band opening of butt-end bands placed on the tarsus rapidly increased with the age of the band ($r_{64} = 0.44$, $P < 0.001$; Fig. 2). For example, the band seen at four years old, but absent at age five, was seen at year four with a 6 mm opening. The most worn band in Fig. 3 had a 9.8 mm gap when found, and the individual stork was repeatedly seen alive afterwards (i.e., its plastic band was read). However, band opening was much slower for butt-end bands located on the tibia ($r_8 = 0.71$, $P < 0.02$; note the lower trend in Fig. 2).

Bands became narrow and lighter through time, although it was only appreciable on bands of more than 10 years of age (Fig. 3). Even the most worn band had its inscription (number and remittent) perfectly readable, wear occurred principally on the inside of the band.

DISCUSSION

White Stork metal bands were lost starting the following year of banding and reach-

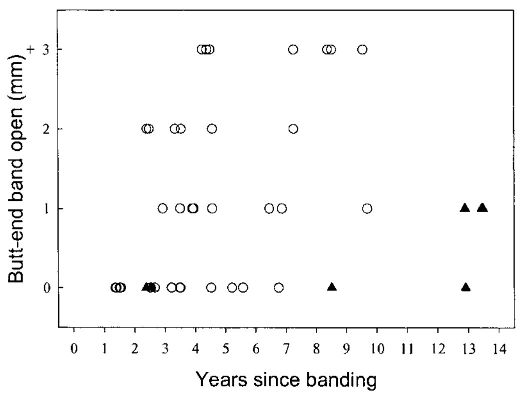

Fig. 2. Opening of butt-end bands located on the tarsus (white dots) and tibia (black triangles) of White Storks in Spain.

ing 85% at 12 years of age. Given that the White Stork can live more than 20 years (Cramp and Simmons 1977), the longevity of these bands is clearly insufficient.

Bands located on the tarsus are more exposed to the mud and water than bands on the tibia while storks forage on rice fields and wetlands. Accordingly, butt-end bands on the tarsus showed a more rapid opening than those located on the tibia (Fig. 2). Moreover, although loss rate increased through aging of bands from 0 to 12 years, this abruptly decreased from 13 to 17 years, coinciding with the time that banding shifted from the tibia to the tarsus (Fig. 1). Band wear seems not to be the cause of band loss because band slimming evolved much more slowly than band loss rate (Figs. 1 and 3), and even the most

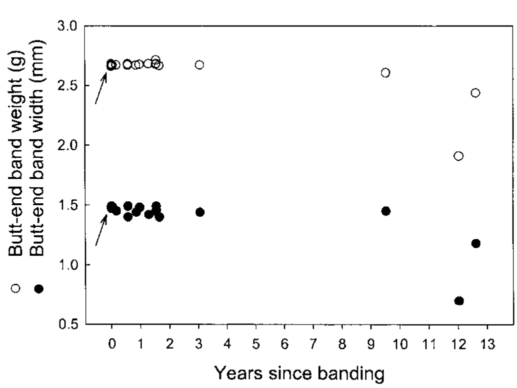

Fig. 3. Weight and width of butt-end bands at different ages since being banded. The arrow indicates the data for the ten unused new bands.

worn bands were entire enough to remain on the leg apart for the pronounced band opening. Moreover, more than half of the lock-on bands recorded still remained on the tarsus for more than 12 years, clearly suggesting that band loss is greatly lowered if band opening is precluded.

Lock-on bands are normally used for bird species with powerful beaks (e.g., owls) that could remove their bands (Berthold 1993). However, we have shown here that band loss by band opening is also possible for aluminum bands in constant contact with mud and water, but that lock-on bands do not suffer from this problem. Aluminum bands should be completely discarded to avoid important biases in analyses of population dynamics, dispersal and survival of birds. This is currently already done in some banding schemes, but should be done worldwide.

ACKNOWLEDGMENTS

We want to thank Juan Manuel Terrero, and Rosa Rodríguez, for help in the field. Luis García, Manolo Vázquez and Francisco Gabriel Vilches provided valuable discussion. Eric Öhman kindly provided information about band materials. Funds were provided by the Project B0S2002-00857 of Ministerio de Ciencia y Tecnología y Fondos Feder, Telefónica Móviles S.A., and Junta de Andalucía.

LITERATURE CITED

Berthold, P. 1993. Bird migration. A general survey. Oxford University Press. Oxford, UK.

Bradley, J. S., R. D. Wooller and I. J. Skira. 2000. Intermittent breeding in the short-tailed shearwater *Puffinus tenuirostris*. Journal of Animal Ecology 69: 639-650.

Coulson, J. C. 1976. An evaluation of the reliability of rings used on Herring and Lesser black-backed gulls. Bird Study 23: 21-26.

Coulson, J. C. and E. White. 1955. Abrasion and loss of rings among sea-birds. Bird Study 2: 41-44.

Coulson, J. C. and E. White. 1957. Mortality rates of the Shag estimated by two independent methods. Bird Study 4: 166-171.

Cramp, S. and K. E. L. Simmons. 1977. Handbook of the Birds of Europe, the Middle East and North Africa. Vol. 1. Ostrich to Ducks. Oxford University Press, Oxford-New York.

Forsman, E. D., A. B. Franklin, F. M. Oliver and J. P. Ward. 1996. A color band for Spotted owls. Journal of Field Ornithology 67: 507-510.

Furness, R. 1978. Movements and mortality rates of Great skuas ringed in Scotland. Bird Study 25: 229-238.

Harris, M. 1964. Band loss and wear of bands on marked Manx shearwaters. Bird Study 11: 39-46.

Huyvaert, K. P. and D. J. Anderson. 2004. Limited dispersal by Nazca boobies *Sula granti*. Journal of Avian Biology 35: 46-53.

Jovani, R. and J. L. Tella. 2004. Effects of weather on environmental sensibility and nestling mortality in white storks. Ecography 27: 611-618.

Lebreton, J. -D. and P. M. North. 1993. Marked individuals in the study of bird population. Birkhäuser Verlag, Basel, Switzerland.

Ludwig, J. P. 1967. Band loss—its effect on banding data and apparent survivorship in the Band-billed gull population of the Great Lakes. Journal of Field Ornithology 38: 309-323.

Ludwig, J. P. 1981. Band wear and band loss in the Great Lakes Caspian tern population and a generalized model of band loss. Colonial Waterbirds 4:174-186.

Marion, W. R. and J. D. Shamis. 1977. An annotated bibliography of bird marking techniques. Bird Banding 48: 42-61.

Nisbet, C. T. and J. J. Hatch. 1985. Influence of band size on rates of band loss by Common terns. Journal of Field Ornithology 56: 178-181.