The loss rates of web tags applied to day-old *Anas* and *Aythya* ducklings

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We double-marked 4,569 day-old ducklings of five species with web tags and plasticine-filled rings in 1991 and studied tag loss over 3-month, 1-year, 2-year and 3-year periods. The web tag loss for Anas was higher than that for Aythya and occurred primarily during the 3-month period following marking. Loss rates after this period were low and could not be distinguished between the two genera. Higher loss rates for Anas v Aythya might be explained by differences in web durability and duckling behaviour during the early posthatch period. We recommend that plasticine-filled rings (Blums et al. 1994) be used in place of web tags because these rings have high retention rates, greater visibility to hunters and permit additional inferences about duckling survival rates.

Keywords: Anas, Aythya, Tag Loss, Tag Retention, Web Tags, Plasticine-filled Rings, Model Selection, Latvia.

Web tags were first applied for marking newly-hatched Wood Ducks *Aix sponsa* in Massachusetts, USA, in the 1950s (Grice & Rodgers 1965) and since then have often been used to study recruitment and natal philopatry of Wood Ducks in North America (reviewed by Bellrose & Holm 1994). However, the technique has been seldom used for marking over-water and ground-nesting ducks (e.g. Alliston 1975, Lokemoen *et al.* 1990, Dawson & Clark 1996), primarily because ducklings of these species are difficult to capture prior to their exodus. Furthermore, loss rates of web tags for most duck species are unknown. There is some circumstantial evidence on tag loss for Wood Ducks (Grice & Rodgers 1965; Haramis & Nice 1980; Hepp *et al.* 1989), however, in these studies ducklings were not double-marked and loss rates were assessed based on the existence of holes in the webs of recaptured juveniles or adults. This information may be misleading because our experience shows that small slots cut in the webs of day-old ducklings may disappear later when ducklings fledge. On the other hand, holes and tears may occur in the webs of fullgrown ducks that were not previously web-tagged.

Blums *et al.* (1994) estimated loss rates of web tags applied to newly-hatched ducklings of the genera *Aythya* and *Anas* during the three months following application and found evidence of higher loss rates for *Anas*. Because of our interest in possible changes in loss rates over time, we obtained additional information about web tag retention by recapturing these double-marked ducks during three subsequent breeding seasons. Our purpose here is to extend the results of Blums *et al.* (1994) by testing hypotheses about possible changes over time in web tag retention probabilities.

Methods

We double-marked day-old ducklings of Pochard *Aythya ferina*, Tufted Duck *A.*

fuligula, Shoveler *Anas clypeata*, Mallard *A. platyrhynchos* and Gadwall *A. strepera* with web tags (Haramis & Nice 1980) and plasticine-filled rings (Blums *et al.* 1994) in May-June 1991 as part of a long-term population study conducted on Engure Marsh, Latvia (57°15'N, 23°07'E). To minimize the loss, tags were attached in the interior of the web at the base of the digits as close as possible to the metatarsus. Marked birds were reported subsequently either as direct recoveries of ducks shot during the 1991 autumn hunting season, or as recaptures of incubating females during the 1992, 1993 and 1994 breeding seasons. We used only those recoveries obtained by experienced observers during August-September bag checks on Engure Marsh. All ringed birds were examined carefully for the presence of web tags.

We modelled tag loss data using conditional (on birds recaptured with rings) binomial models parameterized with 3-month web tag retention (survival) probabilities. Because tag loss is a cumulative process, we defined four different web tag retention parameters for use in modelling recoveries/recaptures occurring during the three different periods. Let θ_i^1 denote the probability that a bird of species i web-tagged at hatching in 1991 and alive three months later during the hunting season retained its web tag until that time. Let θ_i^2 denote the probability that a bird of species i web-tagged at hatching in 1991 and still possessing the web tag 3-9 months after being tagged will retain the tag the subsequent three months, given that the bird itself survives this period. Let θ_i^3 denote the probability that a bird of species i web-tagged at hatching in 1991 and still possessing the web tag 12-21 months after being tagged will retain the tag the subsequent three months, given that the bird itself survives this period. Let θ_i^4 denote the probability that a bird of species i web-tagged at hatching in 1991 and still possessing the web tag 24-33 months after being tagged will retain the tag the subsequent three months, given that the bird itself survives this period.

Let n_i^1 be the number of birds of species i ringed and web-tagged at hatching in 1991 and recovered (and examined for presence of web tags) three months later during the hunting season. Let m_i^1 be the number of these still retaining their web tags. Let n_i^2 be the number of birds of species i ringed and web-tagged at hatching in 1991 and recaptured (and examined for presence of web tags) for the last time at the approximate time of hatching in 1992. Let m_i^2 be the number of these birds still retaining their web tags. Let n_i^3 be the number of birds of species i ringed and web-tagged at hatching in 1991 and recaptured (and examined for the presence of web tags) for the last time at the time of hatching in 1993. Let m_i^3 be the number of these still retaining their web tags. Let n_i^4 be the number of birds of species i ringed and web-tagged at hatching in 1991 and recaptured (and examined for the presence of web tags) for the last time at the time of hatching in 1994. Finally, let m_i^4 be the number of these still retaining their web tags.

The numbers of birds in each recovery/recapture sample that retained web tags, m_i^j, were modeled as conditional (on the n_i^j) binomial random variables using the web tag retention probabilities defined above. In the most general model, web-tag retention probabilities were specific to both species and time periods. This model is defined by the following four expectations:

$$
\begin{aligned}
&E(m_i^1/n_i^1) = \theta_i^1, \qquad (1)\\
&E(m_i^2/n_i^2) = \theta_i^1(\theta_i^2)^3,\\
&E(m_i^3/n_i^3) = \theta_i^1(\theta_i^2)^3(\theta_i^3)^4,\\
&E(m_i^4/n_i^4) = \theta_i^1(\theta_i^2)^3(\theta_i^3)^4(\theta_i^4)^4.
\end{aligned}
$$

Hypotheses about similarity of the 3-month tag retention probabilities were modeled by constraining parameters of the above model to be equal. For example, we developed a model in which 3-month tag retention probabilities differed among the three time periods (first three months after tagging, 3-12 months after tagging, 12-24 months after tagging) as in the general model, but the time-specific probabilities were assumed to be similar for all five species, $\theta_i^j = \theta^j$ for all i. We developed some models in which we set retention probabilities to be equal within a

genus but different between the two tested duck genera, *Aythya* and *Anas*. We also tried models in which 3-month retention probabilities were set equal for two or three of the time periods after initial tagging. We tried nine models in addition to the most general model (defined by equation 1) and the simplest model in which all retention probabilities were modeled with a single parameter, $\theta_i^j = \theta$ for all i and all j.

Model selection was accomplished using Akaike's Information Criterion (AIC, Akaike 1973) as recommended by Burnham & Anderson (1992). Use of this criterion treats the problem of model selection as a problem in optimization, with the objective function including aspects of model fit (the better the fit, the more appropriate the model) and number of model parameters (the fewer parameters, the better the model). Lower AIC values reflect better models with respect to these two criteria. Formal tests between competing, nested (one model can be obtained by constraining parameters of the other) models were conducted using likelihood ratio tests (e.g., Lebreton *et al.* 1992). Goodness-of-fit of the models to the data was assessed using the statistic computed by program SURVIV (White 1983).

Results

In total, 4,569 day-old ducklings of five species were double-marked with both rings and web tags immediately after hatching in 1991. Two hundred and ten of these birds were recovered three months (range 2.5 - 3.5 months) after hatching during the hunting season of 1991, and 86 others were recaptured during the breeding seasons of 1992, 1993 and 1994 (**Table 1**). Information about time-specific loss rates of web tags after the first three months came from these recaptured birds.

The model with the lowest AIC included only two parameters, one for 3-month tag retention for members of genus *Anas* the first three months after hatching ($\hat{\theta}$ = 0.916, $\hat{SE}$= 0.0375) and another for 3-month tag retention for *Aythya* during all time periods and for *Anas* after the initial 3-month period ($\hat{\theta}$ = 0.998, $\hat{SE}$= 0.0015). The likelihood ratio test between the model with only a single tag-retention parameter and this low-AIC model provided strong evidence that tag loss during the first three months for *Anas* was higher than all other loss rates ($\chi^2_1 = 14.6$, $P < 0.01$). The 2-parameter model with the low AIC fits the data adequately ($\chi^2_{15} = 13.4$, $P = 0.58$).

Table 1. Results of double-marking experiment with *Aythya* and *Anas* ducklings on Engure Marsh, Latvia, 1991[a,b]

	Ducklings double-marked in 1991	Direct recoveries after 3 months		Last recaptured					
				after 1 year		after 2 years		after 3 years	
Species (i)		n_i^1	m_i^1	n_i^2	m_i^2	n_i^3	m_i^3	n_i^4	m_i^4
Pochard	2595	128	128	28	28	7	7	9	9
Tufted Duck	756	45	45	3	2	8	8	11	11
Shoveler	441	10	8	6	5	3	3	5	4
Mallard	702	18	17	4	4	0	0	1	1
Gadwall	75	9	9	1	1	0	0	0	0
Total	4569	210	207	42	40	18	18	26	25

[a] n_i^j= the number of 1991-ringed birds of species i recovered with rings during the hunting season of 1991 (j = *1*), or recaptured for the last time the approximate time of hatch in 1992 (j = *2*), or 1993 (j = *3*), or 1994 (j = *4*).

[b] m_i^j= the number of n_i^j recovered/recaptured with rings and web tags.

Discussion

There are two classes of mechanistic explanations for the relatively high tag loss rates of *Anas* ducklings during the few months following tagging. The first corresponds exactly to the manner in which tag retention was handled in our models. All ducks of similar age have the same tag-retention probability, and this probability is low for *Anas* for up to three months following tag application for some reason (perhaps the web is especially thin and easily torn during this period; perhaps some behaviour typical of this early post-hatch period promotes tag loss).

The other possibility involves heterogeneity of tag loss and is only approximated by our models. Heterogeneity can be most easily visualized if we think of two groups of ducklings, one with high probabilities of losing tags and the other with low probabilities of losing tags. Those with high loss rates will tend to lose their tags early, so that birds still retaining tags after the initial three months are primarily those birds with low loss rates. This ability of heterogeneity to give the appearance of time- or age-specific differences in rates and probabilities has been discussed by Vaupel & Yashin (1985) and Johnson *et al.* (1986). The possible source of heterogeneity in the case of web tag loss is subject to speculation and could involve characteristics of the individual ducklings (e.g. variation in web thickness or toughness, or in early behaviour) or characteristics of tag placement. The uniformity of tagging procedures leads us to view the latter possibility as very unlikely. In any case, the data analyzed here do not permit separation of these possible explanations for relatively high tag-loss rates of post-hatch *Anas* ducklings.

We conclude that *Anas* ducklings showed a higher loss rate of web tags during the three months following marking than did *Aythya* ducklings. Reasons for this difference are not known but might involve differences in web durability and duckling behaviour during the post-hatch period (e.g. dabbling ducks likely spend relatively more time out of the water than diving ducks). *Anas* and *Aythya* ducklings that still had their web tags three months after marking showed similar, low rates of tag loss from that time on.

Web tags are not as visible as conventional rings and are not readily reported by hunters. Because of the problem associated with detection, studies of population dynamics using web-tagged birds have relied mainly on recaptures by investigators. We recommend that plasticine-filled rings (Leins 1964, Blums *et al.* 1994) be used in place of web tags because these rings have high retention rates, greater visibility to hunters and permit additional inferences about duckling survival rates (Mihelsons et al. 1986, Blums *et al.* 1996). The value of this ringing method is apparent from the wealth of information generated from more than 110,000 day-old ducklings of 16 species marked with plasticine-filled rings in Latvia and Estonia during 1961-1994. In total, more than 6,000 ducks ringed as day-old ducklings were later recovered by hunters, and about 2,000 females were recaptured by investigators in subsequent years when they returned to breed for the first time on their natal wetland.

Ducklings of over-water and ground-nesting species are difficult to capture because they are relatively immobile for only three or four hours after hatching. We recommend that pipping eggs of noncavity nesters be placed in synthetic fibre net sacks (7 mm mesh) of sufficient size to allow ducklings to have adequate freedom of movement during the hatching process (Blums *et al.* 1994). The sack prevents ducklings from scattering or leaving nests prior to ringing. There is some concern among waterfowl biologists that ducklings banded with plasticine-filled oval bands may exhibit higher mortality than those marked with web tags. The null hypothesis that there was no difference in survival rates between two cohorts of Wood Duck ducklings marked with (1) plasticine-filled rings and (2) web tags was tested in two U.S. locations, Kentucky and Mississippi (Blums 1995). The test provided no evidence that ducklings marked with plasticine-filled rings exhibited higher mortality.

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