Ringing does not appear to have an adverse effect on body mass immediately following capture in Eurasian Teal *Anas crecca*

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Abstract

Studies of waterbirds rely to a large extent on ringing and resighting or recapture data, whilst assuming that ringed birds are broadly representative of the population as a whole. This may not be the case if the capture process may in itself have an influence on the birds. The analyses presented here showed that the body mass of ringed ducks often decreases between capture and recapture if the latter occurs within a few days or weeks. This could possibly reflect stress caused by handling, which would be problematic if it causes ringed birds to behave in a way that differs from the population as a whole. Alternatively, body mass measurements could also be biased by the general use of bait to attract birds to the trap. Initial and subsequent body mass data recorded for Eurasian Teal *Anas crecca* caught then recaptured within three weeks were compared between sites where the birds were attracted to traps with bait or with live decoys. When bait was used individuals had a greater body mass at ringing but were lighter at recapture at all but one site, where only a marginal difference was found. Conversely, when using live decoys, body mass remained constant at the next capture event. This suggests that mass loss commonly observed between capture and recapture is not caused by handling, but is potentially an artefact linked to duck hyperphagia in the presence of abundant food at ringing. It also implies that most available duck body mass data, which are usually obtained from birds ringed at baited traps, may be artificially inflated. The present results are based on one single unbaited site, however, and experimental manipulative studies (alternating the use of bait and live decoys to trap birds) are needed to confirm the findings.

Key words: *Anas crecca*, bait, bird banding, body mass, handling stress, live decoys.

Data from bird ringing has supported major advances in ornithology and avian ecology over the last century (*e.g.* Coulson 1993; Rees & Bowler 1996; Wernham *et al.* 2002; Balmer *et al.* 2008; Peterjohn 2011). For wildfowl, important findings include delineation of flyways (Scott & Rose 1996) and assessment of demographic rates, which have led to a better understanding of population dynamics (*e.g.* Bell & Mitchell 1996). Potentially, catching and handling can affect condition and therefore fitness of wild birds, so ringing is only allowed by trained ornithologists in most countries (*e.g.* North American Banding Council 2001; Balmer *et al.* 2008). Ringing operations have been shown to cause body mass loss (*e.g.* Castro *et al.* 1991; Refsnider 1993; Duarte 2013) and rapid rises in stress hormone levels following capture (*e.g.* Romero & Romero 2002). For these reasons all efforts are generally made to reduce stress at capture and keep ringing operations as brief as possible (see also Casas *et al.* 2015).

During analysis of long-term Eurasian Teal *Anas crecca* (hereafter Teal) ringing data from Tour du Valat, ducks apparently lost body mass immediately, for the first three weeks after ringing (Fig. 1). Survival and breeding success have been considered dependent on individual body mass in dabbling ducks (*e.g.* Heitmeyer *et al.* 1993; Guillemain *et al.* 2008; see however Guillemain *et al.* 2014), so post-ringing body mass loss was potentially problematic. Such body mass loss could be linked with capture stress, causing deterioration of individual body condition following ringing (*e.g.* Rogers & Odum 1966; Leberman & Stern 1977; Clausen & Madsen 2014; reviews in Clark 1979; Duarte 2013). The Tour du Valat traps used seed bait to attract ducks (see description of the Camargue technique in Bub 1991), however, so an alternative

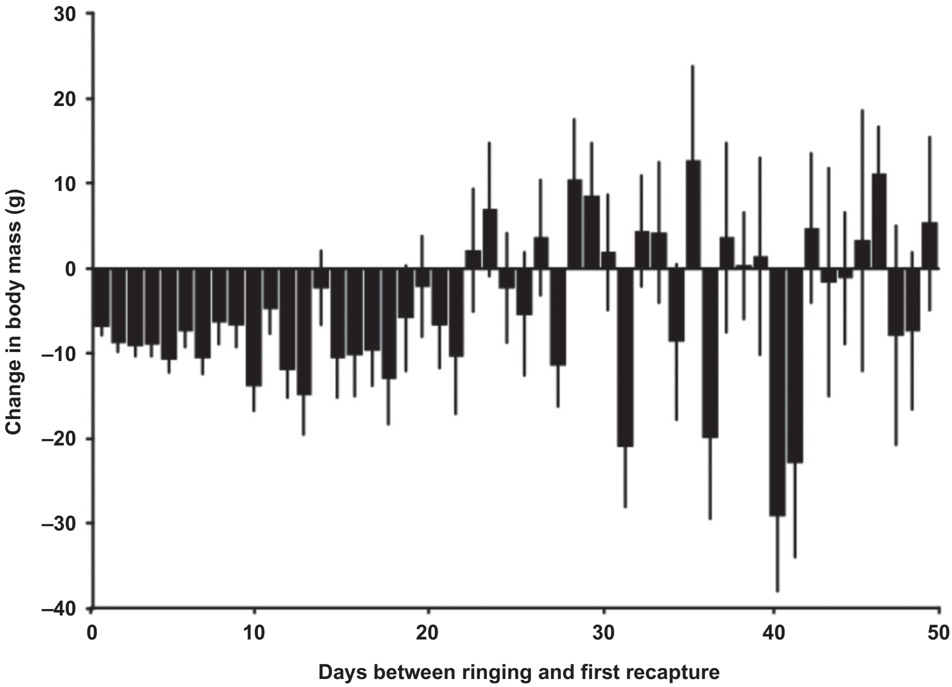

Figure 1. Mean change in body mass between ringing and first recapture for 4,442 different Teal individuals at Tour du Valat, Camargue, France, between 1953 and 1973. Both sexes and age classes (first-year and adults) are combined. Vertical lines show standard errors. Only birds recaptured for the first time within 50 days of ringing are included. Sample size for a given time lag between ringing and first recapture ranges from 10 individuals (50 days) to 507 individuals (2 days). Bait was used to trap the birds throughout the study period.

hypothesis could be that body mass loss was caused by an abundance of artificial food not utilised to the same extent by the birds immediately after capture. Teal may ingest more upon first encountering an abundant and unexpected food source (*i.e.* bait), whereas this may not be so beneficial on recapture, by which time the birds have realised that the availability of such food is actually predictable (see *e.g.* Witter & Cuthill 1993). Irrespective of temporal changes in body mass across the winter (*e.g.* Tamisier *et al.* 2015), their body mass would therefore be artificially inflated by their filled oesophagus and crop at ringing, while this would not be the case at recapture.

This paper tests these competing hypotheses by comparing body mass change between initial ringing and first live recapture among catching sites with and without baiting (in the latter case using live duck decoys). There would be support for the capture stress hypothesis if body mass at capture did not differ between the decoy and the baited sites, and if body mass change between first capture and recapture was similar between sites using different methods to attract the birds. Conversely, if the mass loss was associated with use of bait, ringing body mass would be greater at baited than decoy sites, and body mass would only decrease (or decrease more) between capture and recapture at baited sites.

Methods

Between winters 2002/03 and 2013/14, 772 individual Teal were captured and subsequently recaptured at the same site at seven ringing stations throughout France (Fig. 2). Capture relied on traditional baited traps or nets at six of the sites. All such sites were shallow and relatively small wetlands (of a few hectares in general), *i.e.* small ponds, lakes or marshes. They were however part of very different wetland systems, ranging from an isolated dammed site at the foot of the Pyrénées in Puydarrieux to the extensive Mediterranean marshland system of the Camargue Rhône Delta in Arles. Food availability in the landscape hence likely differed around the trapping sites, although this was not quantified. For instance, ducks used crop leftovers in corn fields at Puydarrieux, and baiting in Camargue hunting areas around the trapping site likely provided superabundant food compared to more natural surroundings at the other sites (*e.g.* Guillemain *et al.* 2010). Local numbers of Teal differed markedly between sites, but all were selected for trapping because these regions attract several thousand individuals in winter. All trapping sites were protected areas free from human disturbance, or nocturnal foraging grounds adjacent to such reserves. Traps were usually active and checked daily throughout the autumn and winter. Net catches were more intermittent and concentrated around periods considered favourable for this caching method, *e.g.* dark moonless nights. Seed bait was spread in great quantities and could be considered as an *ad libitum* source of food. Bait differed between sites; wheat was the most common, but corn was used in Puydarrieux and rice was used in Camargue. In Sainte-Opportune-la-Mare, Normandy, a large funnel trap was set up in a lake above an underwater spring (where the water did not freeze significantly and birds could be captured even during cold weather). Water depth at Sainte-Opportune-la-Mare was too deep for Teal to reach the bottom of the pond (*i.e.* 1.2 m), so baiting was not an option for attracting the birds into the trap. At this site, and only there, wild ducks were instead attracted by live duck decoys kept in the trap, and the body mass of the captured individuals therefore was not biased by the ingestion of bait.

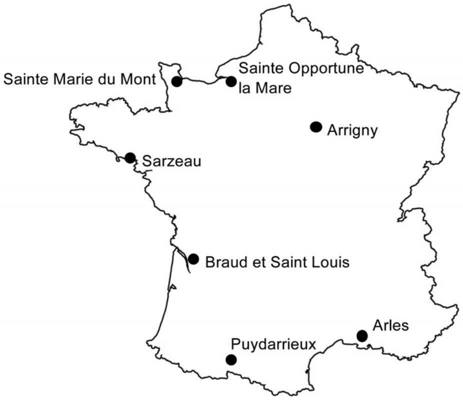

Figure 2. The seven sites in France where Teal were caught for ringing in winters 2002/03 to 2013/14.

All Teal were sexed and aged at first capture, in accordance with plumage criteria (*e.g.* Mouronval 2014), then fitted with a metal ring engraved with a unique code. All birds were weighed to the nearest gram (nearest 2 g at Sainte Marie du Mont) at capture and recapture using a Pesola© spring balance or a variety of kitchen or letter scales. Equipment differed between sites but was consistently the same at capture and recapture for a given site. Some birds were recaptured several times, but only the weight and date of the first recapture are considered here. There is no guarantee that first capture corresponded to the first time an individual used the trapping area in any region, because some Teal may have come and fed where bait was available around the traps without being caught. However, as this could also hold true for recaptures, estimation of body mass change between first capture and first recapture should not be biased.

Only birds recaptured within three weeks of initial ringing were included in the analyses, because Tour de Valat data showed this to be the time period over which recaptured Teal lost mass (Fig. 1). Because birds may differ in initial weight (*e.g.* males *versus* females, first-year *versus* juveniles, and also within a given sex and age class), the response variable used in the analyses was the proportional change compared to initial body mass at ringing. We used Generalised Linear Models with a normal distribution and identity link function to assess how this variable was affected by Year (winters 2002/03 to 2013/14, included as a categorical variable), Site (seven ringing sites), Age (first-year *versus* adults), Sex (males *versus* females), days elapsed between capture and recapture (Days) and ringing date (Date). Dabbling ducks show seasonal patterns of body mass change through the winter in response to energy and mating requirements (Tamisier *et al.* 1995; Guillemain *et al.* 2005), so body mass change will differ between early, mean or late winter. We here used a modified Julian date, set to zero for 1st January, with positive values from January to the end of July and negative values from the end of December to the beginning of previous August (*e.g.* Guillemain *et al.* 2013). Only two continuous predictor variables (Days and Date) were used, and these did not show collinearity (r^2_{770} = 0.003, $P > 0.05$). Both variables were thus considered simultaneously in the analyses (Graham 2003). All additive combinations of the above variables and factors were tested in separate models, plus the interaction between Site and Days to assess if any temporal effect after capture potentially differed between sites. Site*Year could not be tested because we lacked catch data from some sites during some years. A total of 127 different models were hence constructed and compared. The relative support for the different models was assessed using Akaike Information Criterion (AIC, Burnham & Anderson 2002). Models within 2 AIC units of the lowest AIC value were considered as being equivalent, but the most parsimonious (*i.e.* those with fewer parameters) model(s) was/were considered the best one(s). Residuals from such best model(s) were confronted to predicted values to check for homogeneity of variance (Zuur *et al.* 2010).

In parallel to this Information Theoretic Approach, simple ANOVAs or *t*-tests were also used to compare mean body mass at ringing between sites and whether mean proportional body mass change per site differed from zero, respectively. Analyses were performed on arcsine-transformed proportional change in body mass between ringing and first recapture, but untransformed percentages are used throughout the paper to ease reading and interpretation. All statistical analyses were performed using Statistica 10 (Statsoft 2011).

Results

On average, Teal lost 4.6% (s.e. ± 0.3%) of their body mass between ringing and first recapture. Seven models were within 2 units of the lowest AIC value, but the model with only a Site effect had the lowest number of parameters, and was thus considered the best (Table 1). The predominant role of Site among the explanatory variables was also highlighted by its cumulative AIC weight (sum of the AIC weights of all models where Site was included) being 0.956, and the Site effect was present in most low AIC models of body mass change between capture and recapture. The next highest cumulative AIC weight, for Site*Days, was only 0.473, and values for the other variables were even lower (Date = 0.348, Days = 0.315, Sex = 0.285, Age = 0.281, Year = 0.001).

If only the model with only the Site effect was considered, *post-hoc* Tukey tests indicated that the effect was due to Sainte-Opportune-la-Mare (*i.e.* the only site without bait), which was significantly different from all other sites except Braud-et-Saint-Louis. No significant difference was detected by any other pairwise comparisons (Fig. 3). Furthermore, site-

Table 1. Model selection for changes in mean body mass between capture and recapture of wintering Teal in France. Only the 10 best models are presented.

Model	df	AIC	ΔAIC	AIC weight
Site	6	6264.930	0.000	0.117
Site + Site*Days	12	6265.255	0.325	0.100
Site + Date	7	6266.265	1.335	0.060
Site + Days	7	6266.292	1.362	0.059
Site + Date + Site*Days	13	6266.370	1.440	0.057
Site + Sex	7	6266.714	1.784	0.048
Site + Age	7	6266.812	1.882	0.046
Site + Days + Site*Days	13	6267.041	2.111	0.041
Site + Sex + Site*Days	13	6267.122	2.192	0.039
Site + Age + Site*Days	13	6267.124	2.194	0.039

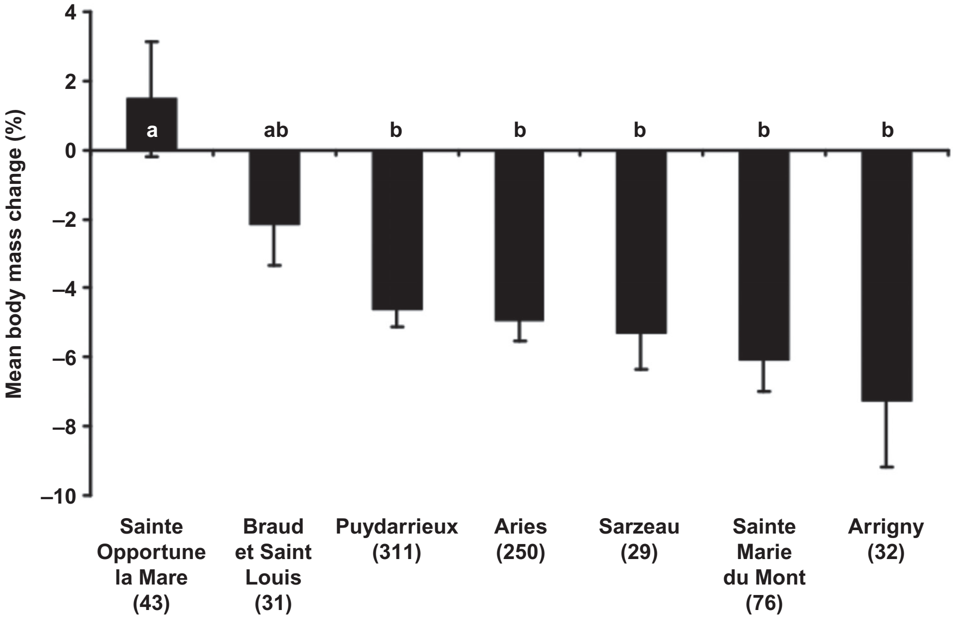

Figure 3. Mean change in body mass between ringing and first recapture within 3 weeks for Teal in France, winters 2002/03 to 2013/14. Vertical lines show standard errors, numbers in brackets are sample sizes, and columns with different letters differ significantly from each other. While no statistically significant change was recorded for Sainte-Opportune-la-Mare, birds tended to lose body mass between capture and ringing at the other sites (*t*-tests; see text).

specific analyses indicated that the mean change in body mass at recapture at Sainte-Opportune-la-Mare did not differ significantly from zero (*t*-test: t_{42} = 0.68, P = 0.500), while it was significantly negative at all other sites except for Braud-et-Saint-Louis (all t < –4.23, all P < 0.002) where it approached significance (t_{31} = –2.02, P = 0.053 for Braud-et-Saint-Louis). Hence, mean body mass did not change between ringing and first recapture where live decoys were used, but decreased (or showed a tendency to decrease) where captures relied on bait.

Teal body mass at first ringing also differed significantly between sites (ANOVA: $F_{6,765}$ = 18.88, P < 0.001), with those caught at Sainte-Opportune-la-Mare being lighter than those caught elsewhere (Fig. 4).

Discussion

Teal ringed in France over the last twelve years showed a decrease in body mass between capture and recapture, averaging a 4.6% loss in body mass when recapture occurred within three weeks, confirming patterns observed between the 1950s and the 1970s during the long-term ringing programme in the Camargue where bait was used to trap the birds (Fig. 1). Marked variation between sites on body mass

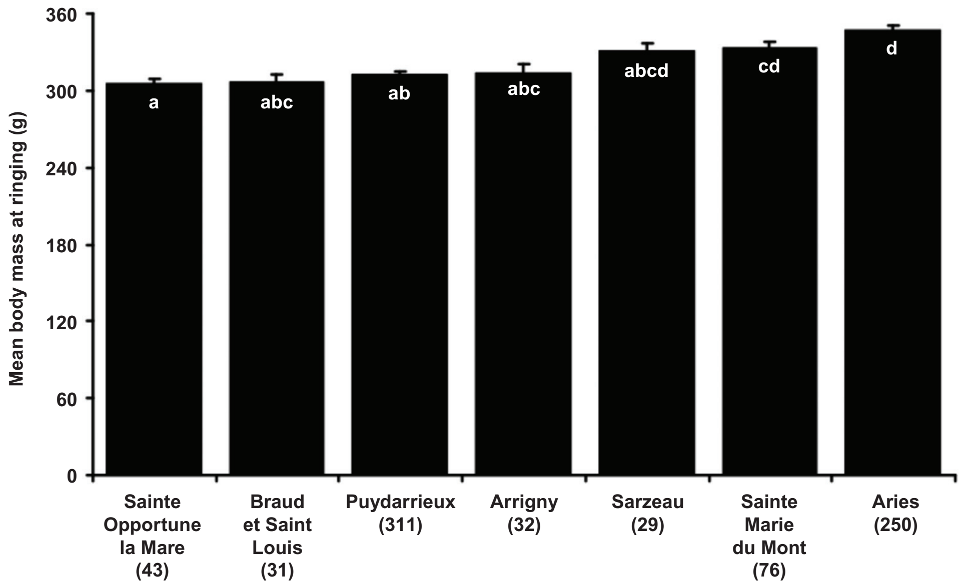

Figure 4. Mean body mass at ringing for Teal in France, winters 2002/03 to 2013/14. Vertical lines show standard errors, numbers in brackets are sample sizes, and columns with different letters differ significantly from each other (ANOVA; see text).

decrease was attributable to lower initial body mass and a lack of mass loss between capture and subsequent recapture at the one site where baiting did not occur (Sainte-Opportune-la-Mare). In contrast, birds lost body mass between capture events at the six baited sites, although marginally so at one of them (Braud Saint Louis).

It should be noted that the present results are based on one single site with live decoys, and that the results from this site were not that different from one of the baited sites. It is also true that the site effect could be due to other differences between sites rather than just the capture method. For example, lower temperatures could lead to greater mass loss between capture events (*e.g.* Castro *et al.* 1991), and this may partly explain why it was greatest at the most continental site, at Arrigny. However, body mass loss did not occur at the northernmost site (Sainte Opportune la Mare, in Normandy), and body mass loss in Arrigny was similar to that in Arles, along the Mediterranean coast, so there was no apparent link between body mass loss and climate harshness. Similarly, food availability outside the trapping area may differ between sites. Body mass at ringing at Arles was greater than at most other sites, reflecting baiting at hunting estates in the Camargue, especially around the site where Teal were caught (Guillemain *et al.* 2010). However, despite such plentiful food, Teal lost body mass in the Camargue to a similar extent as those at other baited sites. Although it could not be quantified, there is no reason to believe that Sainte Opportune la Mare provided more abundant or better quality food than the other sites to explain maintenance of body mass between capture events. Live decoys were actually used in Sainte Opportune because water depths put bait and other food sources beyond the reach of foraging birds.

The use of live decoys at Sainte-Opportune-la-Mare could select for leaner birds (see Greenwood *et al.* 1986 for Mallard *Anas platyrhynchos*, although Sheeley & Smith 1989 did not observe such a difference in Northern Pintail *Anas acuta*). Leaner birds could show a lower propensity to lose mass subsequently, in comparison with fatter conspecifics at other sites. However, if anything it would seem more likely that bait attracts lean and hungry rather than satiated Teal.

Due to the limited availability of environmental (particularly food abundance) data, and with only one site using live decoys instead of bait, the present results cannot be considered a conclusive demonstration that the decrease in duck body mass commonly observed between capture and recapture is attributable to the use of bait (*e.g.* Bub 1991), rather than to stress associated with catching, handling and ringing the birds. A manipulative experimental study with simultaneous or successive use of bait and live decoys at the same sites is required to assess the situation more rigorously. Such experiments should be designed to measure the likelihood of actually catching the ducks as they come to the baited area around the traps (*e.g.* with automatic cameras). If ducks are genuinely very likely to be caught when they first approach the traps, the observed pattern of body mass change between capture events could be linked with ducks trying to benefit as much as possible from a novel food resource upon first encounter (*i.e.* at initial ringing), while the benefit of ingesting vast amounts of food would decrease as this becomes more predictable, for instance at recapture (*e.g.* Witter & Cuthill 1993).

Whatever the mechanism that explains bait apparently causing changes in food ingestion behaviour, the present results from the decoy site suggest that catching and handling did not seem to cause Teal to lose body mass. Earlier studies documenting such handling traumatism causing reduction in body mass often concerned small passerines (*e.g.* Rogers & Odum 1966; Leberman & Stern 1977), but a recent study documented similar temporary loss of body condition after marking in Pink-footed Geese *Anser brachyrhynchus* (Clausen & Madsen 2014). Whether or not birds loose mass due to stress after handling may therefore be species-specific, and not simply related to body size (see also Casas *et al.* 2015). It should however be kept in mind that the present analysis is restricted to birds that could be recaptured at least once after ringing. It cannot be excluded that some other birds were more acutely stressed, and in response developed trap-shyness which reduced the ability to capture them again.

On a less positive note, another conclusion of the present study is that body mass of Teal at ringing was generally inflated owing to bait ingestion; the present data suggesting a 5% bias. Given that bait is the most common mean of attracting waterfowl to traps or nets outside the moulting season (*e.g.* Bub 1991; Whitworth *et al.* 2007), this means that most body mass data for ringed ducks may be biased. This may not be a problem when comparing amongst ringed birds (*e.g.* in demographic analyses based on capture-mark-recapture methods). However, this should be taken into account when comparing body mass of birds from different origins, in particular ringed *versus* hunted birds (since hunting may already show bias towards leaner birds in the population, Heitmeyer *et al.* 1993). While this bias may be modest, recapture body mass should perhaps be used instead of ringing body mass to estimate lean mass of Teal and likely other wildfowl.

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