Nasal saddles and body mass in Eurasian Teal *Anas crecca*

MATTHIEU GUILLEMAIN[1]*, BETTY PLAQUIN[2], JOCELYN CHAMPAGNON[3] & DAVID VALLECILLO[4]

[1]Service Conservation et Gestion Durable des Espèces Exploitées, DRAS, Office Français de la Biodiversité, 13200 Arles, France.
[2]Service Conservation et Gestion Durable des Espèces Exploitées, DRAS, Office Français de la Biodiversité, 85340 Ile d'Olonne, France.
[3]Tour du Valat, Research Institute for Conservation of Mediterranean Wetlands, Le Sambuc, 13200 Arles, France.
[4]CEFE, University of Montpellier, CNRS, EPHE-PSL University, IRD, 34000 Montpellier, France.
*Correspondence author. E-mail: matthieu.guillemain@ofb.gouv.fr

Abstract

Recent capture-mark-recapture analyses have shown that nasal saddles negatively affect Eurasian Teal *Anas crecca* annual survival probability, although the precise mechanism underlying the reduced survival probability remained unclear. It has been hypothesised that greater predation and/or hunting mortality are the primary causes, given that earlier studies found no apparent physiological effects. These studies were however largely conducted in aviaries with an *ad libitum* food supply, or in the field with limited sample sizes, which may have buffered any effects that the markers had on the birds. Here we analysed a large long-term dataset of body mass measurements collected on ringing and recapture for wild Teal in France (713 nasal-saddled individuals over 22 years). We tested whether changes in body mass differed significantly between Teal that initially received a nasal saddle on first being captured, and those fitted with metal rings only. Saddled and metal-ringed only Teal showed the same non-linear trend of body mass change across the season, but saddled birds had lost more weight upon recapture. These results provide some explanation for the observed reduced annual survival probability of nasal-saddled Teal, by indicating that the saddles affect their body condition. Whether the mechanism is physiological (*e.g.* with stress or breathing difficulties causing less efficient fat accumulation), behavioural (*e.g.* through less efficient foraging behaviour), a knock-on effect (*e.g.* energy-stressed birds spending more time exposed to predators or hunters for foraging), or a combination of these remains to be evaluated.

Key words: body mass change, nasal saddles, physiology, survival probability.

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Capture-mark-recapture is a cornerstone of wildlife demographic studies (*e.g.* Lebreton *et al.* 1992; Caswell & Fujiwara 2004; Newman *et al.* 2014; Gimenez 2026). In birds, a century of ringing has allowed major advances in the understanding of migration and population dynamics (Coulson 1993; Greenwood 2009; Gregory *et al.* 2023). Metal leg-rings bearing a unique code make it possible to identify individuals in such studies, yet the very small size of the characters on the ring generally restricts the collection of such information to live recaptures or dead recovery of the bird, when it is in the hand. To overcome this limitation, external markers with larger identification codes have also been used, which provide more information more quickly because data can then be obtained by observers reading the codes from a distance with binoculars or telescopes. These markers however come with their own problems, because they may make the individual more visible or desirable to predators or hunters, or affect the bird's behaviour (review in Calvo & Furness 1992). Among such devices, nasal markers have been widely used in waterfowl studies (*e.g.* Sugden & Poston 1968; Rodrigues *et al.* 2001; Gajdošová *et al.* 2023) but recent research has shown that, despite providing valuable information on movements, and instantaneous confirmation of survival through visual sightings, nasal saddles have a detrimental effect on annual survival probabilities for Eurasian Teal *Anas crecca* (Guillemain *et al.* 2026). Deane *et al.* (2021) obtained a similar result in Lesser Scaup *Aythya affinis* fitted with nasal disks. In both cases, the exact mechanism by which bird mortality increased in nasal-marked ducks could not be ascertained.

On testing the physiological effects of nasal saddles for birds in an aviary, Guillemain *et al.* (2007) found no difference in the body mass dynamics of saddled and unsaddled ducks. Mallard *Anas platyrhynchos* and Northern Pintail *A. acuta* showed the same body mass changes over the 6-week study period, and there were also no differences in mean values recorded for each species in relation to whether or not the birds were fitted with nasal saddles. However, the ducks were fed *ad libitum* and no behavioural observations were conducted to test for a differential foraging efficiency between the two groups. The same study also compared body mass change of Eurasian Teal (hereafter Teal) between capture and recapture in the wild and found that saddled birds lost 4.46g/day whereas metal-ringed only birds lost 2.90g/day. No statistically significant difference was detected, but variance was large and the sample size was very low (consisting of 76 saddled and 98 metal-ringed only birds), which required pooling of age and sex classes and prevented the consideration of a potential site effect.

Here we compare field measurements of body mass in saddled and metal-ringed only Teal at ringing and first recapture using a much larger and longer dataset (713 saddled individuals over 22 years), to assess if the fitting of a nasal saddle is associated with differences in body mass dynamics recorded during the non-breeding season. This permitted use of more robust and powerful statistical analyses, with the objective of determining whether there are differences in

body mass dynamics which could potentially contribute to explaining the lower survival probability of nasal-saddled Teal previously reported. We predicted that if nasal saddles impair body condition, saddled birds should lose more body mass between capture and recapture than metal-ringed only individuals. We therefore tested whether fitting a nasal saddle to Teal on ringing was associated with differences in mean body mass at recapture, whilst taking phenological variation in body mass throughout the winter and potential site effects into account. We also assessed whether fitting a saddle influenced mean daily and overall body mass change, because slight non-significant differences at the daily scale may accumulate over time, and thus affect the body mass change recorded on recapture.

Methods

Ringing dataset

Data analysed in this study were compiled from the long-term national dabbling duck ringing scheme run by the Office Français de la Biodiversité with a network of collaborating parties across France since 2002 (*e.g.* Plaquin *et al.* 2025; Guillemain *et al.* 2026). Here we use data from birds whose sex and age could be determined at capture, or sometimes confirmed at recapture when uncertain at ringing, by plumage examination (Mouronval 2016). Ringing occurred from August to March each year. Only data from the first live recapture at the same site as the ringing site during the same season (*i.e.* direct local recaptures) were considered; birds without body mass records at either ringing or recapture were omitted. A total of 1,332 individuals ringed and recaptured at 22 different locations in France from October 2002 to December 2024 were eventually included in the analyses. Nasal saddles were fitted to 53.5% of them (*i.e.* 713 individuals), randomly selected from the captured birds upon ringing.

Statistical analyses

Given the known sex and age differences in the mean body masses of dabbling ducks in winter (*e.g.* Fox *et al.* 1992), all analyses were conducted separately for each sex (females *vs.* males) and age category (juvenile first-year birds *vs.* adults).

Considering seasonal changes in body condition. The body mass of non-breeding dabbling ducks is known to increase from early to mid-winter, then decrease until late winter (*e.g.* Fox *et al.* 1992; Tamisier *et al.* 1995; Guillemain *et al.* 2010). Nasal saddles may alter this seasonal pattern by reducing individual average body mass and/or affecting the shape of this seasonal pattern. We first ensured that mean body mass at ringing did not differ between birds that were only metal-ringed and those fitted with a nasal saddle during the catch (Table 1), so that birds were in a similar initial condition irrespective of whether or not they were fitted with a nasal saddle. We then tested if the presence of a nasal saddle affected the expected monthly pattern of body mass dynamics – *i.e.* if there was an interaction effect of marking on the non-linear pattern of body mass change through the winter months. The expected non-linear pattern of monthly body mass dynamics was modelled

Table 1. Mean body mass (g) at ringing for Teal with a metal-ring only and those also fitted with a nasal saddle, caught in France during 2002–2024. The *P* values indicate the non-significant association between marking method (Y = fitted with a nasal saddle; N = metal-ringed only) and mean body mass on ringing, for each age and sex category, in linear mixed-effects models. Ringing site was included as a random effect in the models except for adult females, where the lack of variation at some sites prevented the consideration of the random site effect.

Sex	Age	Nasal	*n*	Body mass (mean ± s.d.)	*P*
Females	Juveniles	N	176	302.7 ± 37.3	0.981
		Y	166	304.7 ± 40.6	
	Adults	N	96	317.4 ± 39.7	0.357
		Y	112	312.5 ± 37.2	
Males	Juveniles	N	211	334.9 ± 41.4	0.200
		Y	251	331.2 ± 40.5	
	Adults	N	136	348.3 ± 42.9	0.849
		Y	184	349.4 ± 40.4	

using natural spline functions within linear mixed-effects models (LMMs), following established approaches for capturing smooth non-linear trends in longitudinal ecological data (*e.g.* Welham *et al.* 2006). The model hence tested the effect of recapture month*presence/absence of a nasal saddle, with capture site as a random factor (see below). Three knots were chosen to capture the expected unimodal (bell-shaped) monthly pattern in body mass. Preliminary tests to compare the fit of the natural spline model to that of a model without a month effect, using a likelihood ratio test (ANOVA), confirmed that the spline approach significantly improved model fit to the data (tests were carried out for each age and sex category; $P < 0.05$ in each case; Supporting Material Table S1).

Testing the effect of saddles on mean body mass change through time. We then used these models to test for a potential difference in the change in the mean body mass from ringing to recapture between saddled and metal-ringed only birds. Model structure, both for daily body mass change and for overall body mass change from ringing to recapture, was: Difference in body mass ~ presence/absence of a nasal saddle, with site included as a random factor. The effect of wearing a nasal saddle on the linear relationship between body mass change (grams) and the number of days elapsed was analysed by the model: Difference in body mass ~ Days elapsed*presence/absence of a nasal saddle, with site again included as a random factor. Most birds were recaptured soon after ringing, but there were a few

outliers where recapture occurred up to *c.* 6 months after ringing (7–12 such outlier individuals per age and sex categories; *i.e.* 2.4–3.5% of the initial sex/age datasets). Therefore, these last analyses were restricted to birds recaptured within 60 days of ringing.

Effects of local capture conditions. Local capture methods (*e.g.* baited traps *vs.* mist nets) and habitat conditions are known to affect changes in body mass between capture and recapture in Teal (Guillemain *et al.* 2015). Data from a total of 22 different ringing/recapture sites were used in the study. All analyses therefore were conducted with ringing locality included as a random factor in the LMMs because, whilst we were testing for marker effects on body mass rather than for a site effect, potential geographic differences had to be considered. The only exception was when insufficient variation within some of the sex or age categories at some sites prevented consideration of a random site effect. This occurred on testing for differences in body mass at initial capture between saddled and metal-ringed only adult females, and on the mean time elapsed from capture to recapture between saddled and metal-ringed only adult females and juvenile males. In such cases the model simply ignored the random locality effect, thus acting as a simple linear model with only a nasal saddle effect.

The distribution of residuals, normality and homoscedasticity (QQ-plots, not shown) supported the use of the analytical procedure presented here. All analyses were conducted using R-4.5.2 (R Core Team 2024), with linear mixed-effects models using the lme4 package (Bates *et al.* 2015).

Results

The mean initial body mass at ringing did not differ between birds fitted with metal rings only and those that also received a nasal saddle, for any of the sex and age categories (Table 1; Supporting Materials Table S2). The natural spline analysis did not record any significant interaction between the presence of a nasal saddle and the splines, nor a persistent fixed effect of the saddles on recapture body mass except for adult females ($P = 0.015$ for adult females; $P > 0.097$, n.s. for all other categories; Table S3), with saddled and metal-ringed only birds showing similar mean body mass and body mass dynamics when assessed at a monthly scale (Fig. 1).

Saddled and metal-ringed only birds were recaptured after similar lengths of time on average (Table 2; Table S4). Birds lost body mass daily between capture and recapture, although the variance around the mean was relatively large, so that mean daily body mass change did not differ statistically between saddled and metal-ringed only birds, except for a significant difference found in juvenile females ($P = 0.042$; Table 2; Table S5). However, such small daily differences accumulated over time, so that saddled birds had lost more body mass at recapture than their metal-ringed only conspecifics (mean and *P* values in Table 2), although the slopes of the trend over time did not differ from each other (interaction term: all $P > 0.37$, n.s.; Fig. 2; Table S6).

Discussion

The main result of the study presented here differs from earlier tests on other species

Table 2. Days elapsed and mean body mass change between capture and recapture within the first 60 days for metal-ringed only and nasal-saddled Teal in France, 2002–2024. *P* values for time elapsed and daily body mass change variables refer to the effect of the marker (Y = fitted with a nasal saddle; N = only metal-ringed) in linear mixed-effects models for each sex and age category, with ringing site included as a random effect (except for time elapsed in adult females and juvenile males, where the lack of variation at some sites prevented the consideration of the random site effect). For overall body mass change between ringing and recapture, *P* refers to the marker effect in the linear mixed model, which also included the time elapsed*nasal saddle interaction (the latter being non-significant; all $P > 0.05$), again by sex and age category, with ringing site as a random effect, as illustrated in Fig. 2.

Sex	Age	Nasal	*n*	Parameter (mean ± s.d.)	*P*
Time elapsed (days)					
Females	Juveniles	N	171	9.5 ± 11.9	0.883
		Y	159	9.9 ± 10.3	
	Adults	N	91	9.3 ± 11.5	0.618†
		Y	110	10.1 ± 11.3	
Males	Juveniles	N	206	9.1 ± 11.5	0.655†
		Y	245	8.7 ± 10.5	
	Adults	N	132	9.6 ± 10.7	0.710
		Y	179	10.1 ± 11.3	
Body mass change per day (g/day)					
Females	Juveniles	N	171	–2.4 ± 7.5	0.042
		Y	158*	–3.9 ± 6.4	
	Adults	N	91	–2.9 ± 11.1	0.211
		Y	110	–4.5 ± 7.2	
Males	Juveniles	N	206	–3.1 ± 9.6	0.125
		Y	244*	–4.4 ± 8.6	
	Adults	N	132	–3.6 ± 8.3	0.285
		Y	179	–4.4 ± 7.0	

Table 2 (*continued*).

Sex	Age	Nasal	*n*	Parameter (mean ± s.d.)	*P*
Body mass change between ringing and recapture (g)					
Females	Juveniles	N	171	–7.2 ± 28.2	< 0.0001
		Y	159	–21.1 ± 31.8	
	Adults	N	91	–11.9 ± 31.2	0.002
		Y	110	–24.2 ± 32.7	
Males	Juveniles	N	206	–8.8 ± 32.6	0.005
		Y	245	–17.1 ± 30.6	
	Adults	N	132	–11.6 ± 27.0	0.013
		Y	179	–19.9 ± 31.7	

†Site could not be used as a random effect in this model because time between capture and recapture did not show any variation in some of the sites with limited sample sizes.
*Sample size lower than for other analyses because one bird was recaptured on the same day as ringing, so body mass change per day could not be computed.

held in aviaries (*e.g.* Byers & Montgomery 1981), and also field measurements based on small sample sizes (Guillemain *et al.* 2007), in that Teal fitted with a nasal saddle showed greater reductions in mean body mass between ringing and first recapture than metal-ringed only birds.

Similar to Guillemain *et al.* (2007), Byers & Montgomery (1981) found no significant change in body condition between saddled and unsaddled Mallard fed *ad libitum* in the aviary. Guillemain *et al.* (2007) reported that saddled Teal lost 4.46g/day whereas metal-ringed only Teal lost 2.90g/day, but the large variance around both values yielded non-significant differences between means. We likewise recorded non-significant differences in daily body mass changes between wild Teal with or without a nasal saddle, with saddled birds losing on average 3.9–4.5g/day compared to 2.4–3.6g/day for their metal-ringed only conspecifics (Table 2), a difference which was statistically significant only for juvenile females. Using daily body mass as a response variable without considering the time elapsed since initial ringing can however result in important information being lost, so is not recommended for studying the effects of marker-type on body condition. For instance, non-significant differences between groups at the daily scale can accumulate over time, so that when birds are recaptured (on average after *c.* 10 days, independent of the

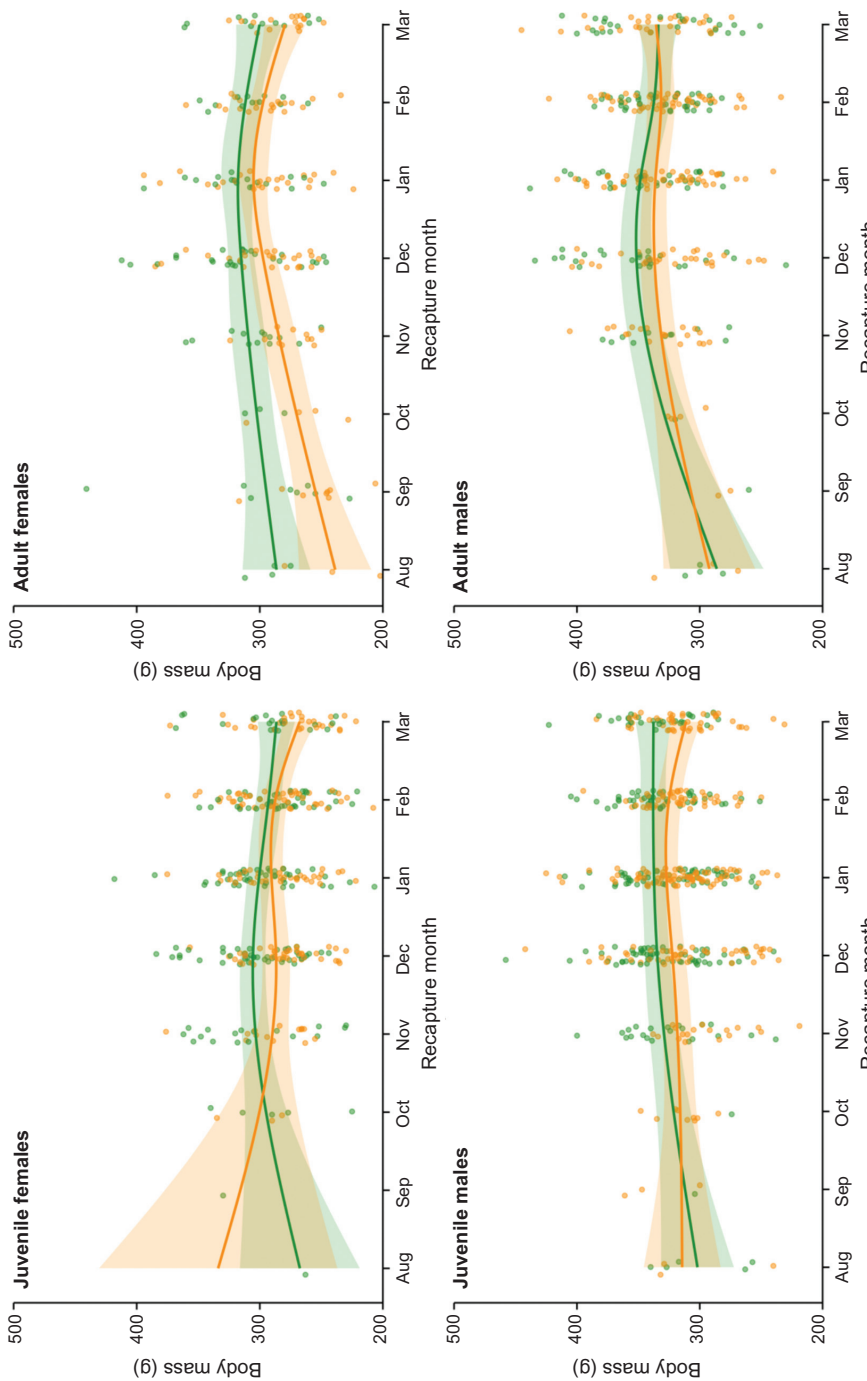


Figure 1. Recapture body mass of saddled (orange) and metal-ringed only Teal (green) across months in France, 2002–2024. Shaded areas show the confidence intervals. Presence of a saddle did not significantly affect the shape of the monthly patterns in body mass, and the overall mean body mass of saddled *vs.* non-saddled birds differed only in adult females (see text).

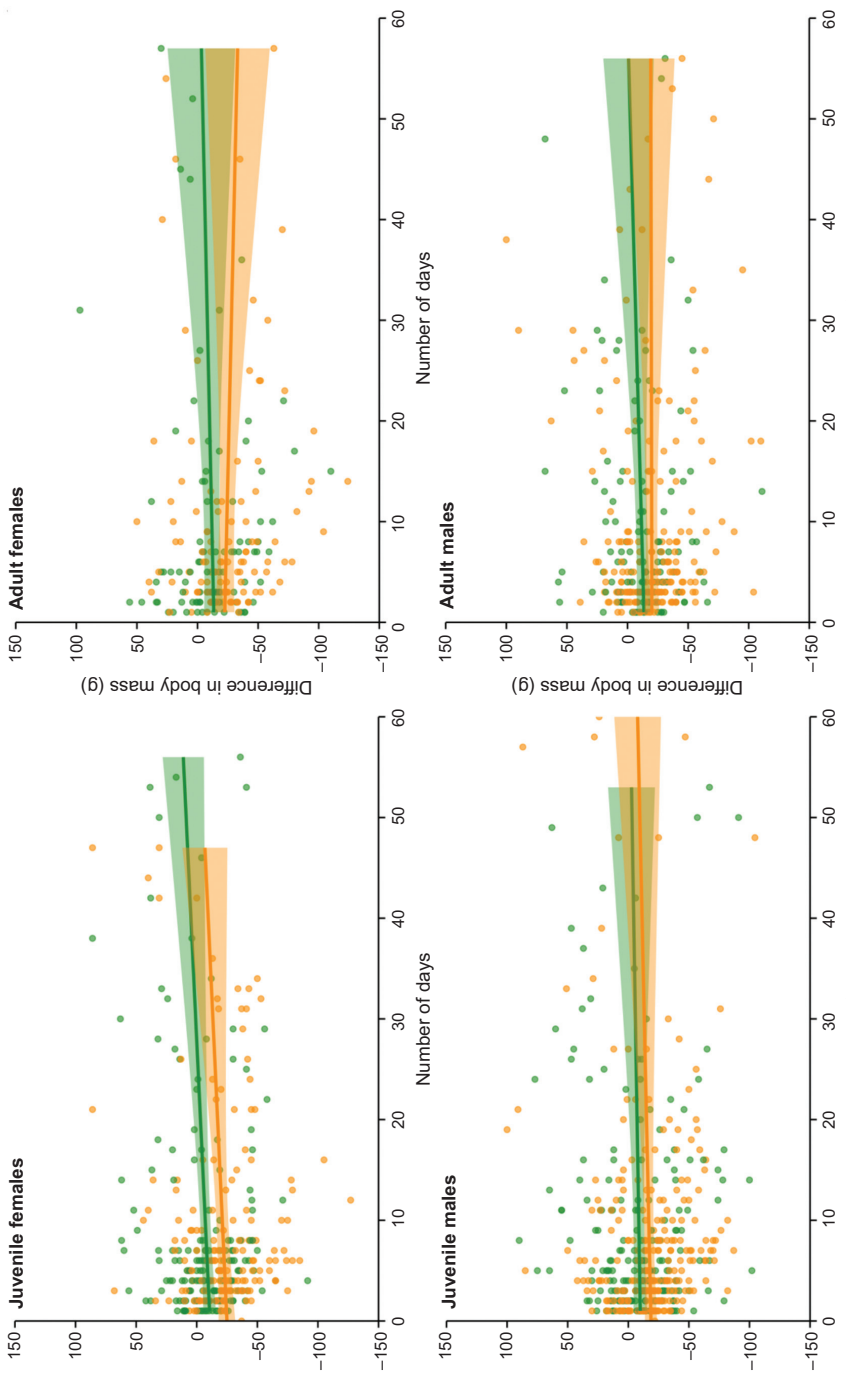


Figure 2. Relationship between change in body mass and the number of days elapsed between capture and recapture, depending on whether Teal were metal-ringed only (shown in green) or were also fitted with a nasal saddle on initial ringing (orange). See text and Table 2 for statistics.

marking method, for Teal in this study), saddled Teal had lost more body mass than unsaddled ones. This was not investigated in Guillemain *et al.* (2007), who only tested for differences in daily body mass change between saddled and metal-ringed only Teal.

The magnitude of the difference in body mass loss from ringing to first recapture (within 60 days) comparing metal-ringed only with saddled birds was two- to threefold, with the greatest mean value being 24.2 g lost by saddled adult female Teal. Given their mean body mass of 312.5 g at ringing, this represents a 7.7% loss. Indeed, the difference may have been *c.* 1 g greater for birds weighed at ringing before being fitted with a nasal saddle, because the saddles themselves weigh *c.* 1 g. These birds can naturally gain 20–40 g between early and mid-winter and lose them again by late winter (Fox *et al.* 1992; Guillemain *et al.* 2010) so the current effect of nasal saddles on body mass, although clearly significant, should not impair overall survival. In the same way, when tested in the natural spline models with several explanatory variables (3 knots plus the saddle effect plus the interaction between the saddle effect and the knots), the effect of nasal saddles on monthly dynamics of body mass at recapture was non-significant except in adult females: saddled and unsaddled Teal kept the same pattern of body mass dynamics through the winter.

The current analysis does not provide any firm explanation as to why saddled Teal lose more body mass between capture and recapture than metal-ringed only birds. There has been a number of previous studies of the effects of nasal saddles, including time-budget analyses. Some of these revealed no effect of the saddles on general behaviour (Bartonek & Dane 1964; Sugden & Poston 1968; Byers & Montgomery 1981), while others showed differences in levels of bill-scratching or preening (McKinney & Derrickson 1979; Evrard 1996). It is possible that the presence of a saddle affixed to the nostrils makes the bird's foraging less efficient, given the complex suction mechanisms in a foraging dabbling duck bill (*e.g.* Kooloos *et al.* 1989) and/or because it makes the individuals less dominant within the group (Guillemain *et al.* 2007). It is also possible that discomfort or stress caused by the saddle leads to more preening or vigilance bouts which, although not affecting the overall time-budget, interrupts foraging sessions and hence reduces foraging efficiency (*e.g.* Fritz *et al.* 2002).

Whatever the mechanism, birds fitted with saddles or some other types of markers can become somewhat energy-stressed during the non-breeding season, a pattern not recorded by Deane *et al.* (2021) for Lesser Scaup fitted with nasal discs nor Babkina *et al.* (2025) for neck-collared Greater White-fronted Geese *Anser albifrons*, but observed by Caswell *et al.* (2012) in neck-collared Ross's Geese *Chen rossii*. See also Geen *et al.* (2019) for a review of the effects of tracking devices on birds. However, the magnitude of the body mass loss for Teal with nasal saddles in our study is similar to that experienced by Teal through their natural body mass dynamics across the winter, so it seems very unlikely that the greater mortality probability recorded in these birds compared to metal-ringed only Teal is directly linked exclusively to starvation.

Conversely, it has been shown recurrently that hunted ducks and geese have a poorer body condition than the average bird (Greenwood *et al.* 1986; Hepp *et al.* 1986; Heitmeyer *et al.* 1993; Pace & Afton 1999; Fowler *et al.* 2020), which is supposed to result from condition-poor individuals being more vulnerable to hunters. It is therefore possible that saddled Teal, owing to a greater body mass loss, more frequently use hunted areas or take more risks, elevating the risk of mortality relative to metal-ringed only individuals. The fact that body mass is already reduced during the few days and weeks following saddling (see Fig. 2) is consistent with the earlier result that mortality of saddled birds is particularly high during the season of ringing compared to later years (Guillemain *et al.* 2026). Apart from greater hunting mortality risk, lower body mass may also have carry-over effects, which might translate into higher mortality probabilities during migration which is energy demanding.

We have already recommended that fitting nasal saddles to Teal should not be used to study long-term demographic parameters for the species, because of the massive impact on survival probability (Guillemain *et al.* 2026). The results presented here provide some insight into the mechanism whereby such detrimental effects may occur, by ruling out direct starvation but suggesting that saddled birds may be more vulnerable to predation, hunting mortality, or other mortality risks. Nasal saddles may still retain utility for studies of discrete life history events or short-term ecological processes, such as breeding season parameters. Attachment methods should however be changed to suture string, which quickly deteriorates in the wild, so that the saddle will fall off after a few weeks. Even so, the present study suggests that the presence of the saddle could affect behaviour and breeding parameters, so the results should be interpreted with caution.

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