

Multiple tests of the effect of nasal saddles on dabbling ducks: combining field and aviary approaches

MATTHIEU GUILLEMAIN^{1*}, MAUD POISBLEAU², LÉOPOLD DENONFOUX², MICHEL LEPLEY³, CORALINE MOREAU², GRÉGOIRE MASSEZ⁴, GILLES LERAY⁵, ALAIN CAIZERGUES⁵, CÉLINE ARZEL^{1,6,7}, DAVID RODRIGUES⁸ and HERVÉ FRITZ²

¹Office National de la Chasse et de la Faune Sauvage, CNERA Avifaune Migratrice, La Tour du Valat, Le Sambuc, 13200 Arles, France, ²Centre d'Etudes Biologiques de Chizé, CNRS, 79360 Beauvoir sur Niort, France, ³Station Biologique de la Tour du Valat, Le Sambuc, 13200 Arles, France, ⁴Association des Amis des Marais du Vigueirat, Mas Thibert, 13200 Arles, France, ⁵Office National de la Chasse et de la Faune Sauvage, CNERA Avifaune Migratrice, 53 Rue Russeil, 44000 Nantes, France, ⁶Department of Mathematics and Natural Sciences, Kristianstad University, SE-291 88 Kristianstad, Sweden, ⁷Laboratoire d'Ecologie des Hydrosystèmes, Université Paul Sabatier, 118 route de Narbonne, 31062 Toulouse, France and ⁸Departamento Florestal, Escola Superior Agrária de Coimbra, 3040-316 Coimbra, Portugal

Capsule Nasal saddles have no negative consequences apart from, under some circumstances, a potential bias in social relationships.

Aims To test the effect of nasal saddles on Teal *Anas crecca*, Wigeon *A. penelope*, Mallard *A. platyrhynchos* and Pintail *A. acuta*.

Methods The following features were compared between saddled and unsaddled individuals: body mass change of wild Teal between ringing and first live recovery, pairing probability of wild Teal through the winter, wild Teal and Wigeon time-budgets, captive Mallard and Pintail body mass fluctuations, testosterone levels and dominance in the aviary.

Results We generally found no significant difference between values for birds with nasal saddles and control birds. Exceptions were for pairing probability, which was lower for marked Teal during one of the winters, and the proportion of aggressive interactions won by Pintail, which decreased after they were fitted with saddles, while this did not happen in Mallard.

Conclusions Nasal saddles are an appropriate general method for marking dabbling ducks. However, saddles may not be appropriate for the study of social relationships in some conditions.

Many research topics in ecology require the use of individually marked animals. Many marking methods have been developed for birds, from feather-dyeing to electronic devices (Bibby *et al.* 2000). Not all methods can be used on all species, and all methods have drawbacks; for example, they may be harmful or disturbing to the birds under some circumstances, the number of possible codes may be limited, marks may be difficult to detect or read, or the method may be very expensive (Calvo & Furness 1992).

Ducks, especially dabblers, are a group of species on which many different marking methods have been

developed. Metal ringing has been, and continues to be, extensively used: by the end of 2003, close to 310 000 dabbling ducks had been ringed in Britain and Ireland (Clark *et al.* 2004); between the 1950s and the mid-1970s, more than 75 000 had been ringed at the Station Biologique de la Tour du Valat in the Camargue, southern France (Johnson 1975); and more than 5 500 000 Mallard *Anas platyrhynchos* had been ringed in North America by the end of 1998 (USGS 1999). In addition to metal rings, web tags (Blums *et al.* 1997), coloured leg rings (Giroux *et al.* 1990, Mitchell 1997), patagial tags (Anderson 1963, Weeks 1972, Gilmer *et al.* 1974), markers pinned through the skin (Gullion 1951), wing rings (Jeske *et al.* 1993), nasal marks (Bartonek & Dane 1964, Sudgen & Poston

*Correspondence author.
Email: m.guillemain@oncfs.gouv.fr

1968, Doty & Greenwood 1974, Greenwood 1977, Lokemoen & Sharp 1985, Howerter *et al.* 1997, Guyn & Clark 1999) and even freeze-branding of feather tracts (Greenwood 1975) or dyeing of feathers (Evans 1951, Winston 1955, Giroux *et al.* 1990) have all been used.

Individual markers other than metal rings have seldom been used for dabbling ducks in Europe. In contrast, in North America nasal markers are the most widely used of such methods (Derrickson 1978, Blohm 1978, Burns *et al.* 1980, Rohwer 1985, Sorenson 1994, Evrard 1996, Dzus & Clark 1997), and are accepted as such a natural method that these are fitted to birds when testing for potential effects of other devices, such as radio-transmitters (Pietz *et al.* 1995, Guyn & Clark 1999, Garretson *et al.* 2000).

Attempts to test the potential effects of nasal saddles have, however, produced a range of results, from the lack of any detectable effect on body condition, behaviour or reporting rates (Bartonek & Dane 1964, Sudgen & Poston 1968, Sjöberg & Danell 1977, Byers & Montgomery 1981, Davey & Fullagar 1985, Rodrigues *et al.* 2001), to limited effects on behaviour (more bill scratching: McKinney & Derrickson 1979), significant impacts on time-budget and breeding behaviour and success (Doty & Lee 1974, Evrard 1996, Howerter *et al.* 1997), and more dramatic observations of birds being injured or dying (Greenwood & Bair 1974, Byers 1987, Lokemoen & Sharp 1985, Evrard 1986). The inconsistencies between some of these results are likely to be because: (i) most studies only tested the effect of marking on one or two parameters; and (ii) they were conducted for sometimes quite different nasal marking methods (e.g. soft saddles over the top mandible versus more rigid discs on both sides of the bill), or at least for devices differing in shape, weight, or fitting method to the bird.

As a group of duck researchers, we all had to use individual marking of ducks for our studies (Rodrigues *et al.* 2001, Guillemain *et al.* 2002, Poisbleau *et al.* 2005a, 2005b). We decided to use the same type of nasal saddles on several duck species, which allowed comparison of the potential effects of these marks in different geographic areas, in the wild and in the aviary, for a set of individual parameters. In particular, we assessed the effect of saddles for: (i) body mass change of wild Teal *Anas crecca* between ringing and first recapture; (ii) body mass fluctuation in captive Mallard and Pintail *Anas acuta* in the aviary, before and after fitting of nasal saddles; (iii) time-budgets of wild Teal and Wigeon *Anas penelope*; (iv) pairing probability of

wild Teal; (v) testosterone levels and dominance hierarchy of captive Mallard and Pintail.

METHODS

Nasal saddles

The nasal saddles used here were similar to those used by Rodrigues *et al.* (2001). Saddles had the shape of those developed by Greenwood (1977), and were cut into Allflex® cattle ear tags in three sizes (Rodrigues *et al.* 2001) for Mallard (large), Wigeon and Pintail (medium) and Teal (small). Following Greenwood's (1977) terms, dimensions for the three respective saddle sizes were: *a* (distance between holes for nylon): 20 mm, 18.5 mm and 16 mm; *b* (saddle length): 50 mm, 43 mm and 33 mm; and *c* (saddle width): 23 mm, 20 mm and 16 mm. The saddles were fitted to the bird using a nylon fishing line of 1 mm diameter, beaded on both sides. Identification signs (numbers and letters, one or two similar on each side of the bill, plus one on the front on some of them) were handwritten with a pen sold with the ear tags by the same company. Saddles were heat-formed to a V-shape prior to fitting on the birds.

Teal body mass change in the field

Teal were captured using funnel baited traps, plus occasionally vertical nets (Bub 1991), at four sites: the Marais du Vigueirat in the Camargue, southern France (43°33'N, 4°43'E), the Réserve de Chasse et de Faune Sauvage du Massereau, Loire Estuary, western France (47°14'N, 1°56'W), the Réserve de Chasse et de Faune Sauvage de la Grand'Mare, Seine Estuary, northern France (49°25'N, 0°32'E), and Le Marais de la Présidente in Braud et Saint Louis, Gironde, southwest France (45°14'N, 0°37'W). A total of 2017 Teal were ringed at these sites between 23 November 2001 and 2 February 2005, of which 219 different individuals were then subsequently recaptured alive at least once. In total, 175 birds were sexed, aged and weighed twice (to the nearest gram), and constituted the sample of this study (for birds recaptured more than once, data from the first recapture event at which the individual was also weighed were considered). In total, 98 of these birds received only a metal ring from the French National Museum of Natural History, and 76 were both ringed and fitted with a nasal saddle. After comparing the average body mass at ringing between saddled and unsaddled birds with bilateral *t*-tests, and testing for potential differences in age- and sex-ratios between the

two samples using χ^2 tests, we tested for differences between average number of days between capture and recapture and between body mass changes at the four sites using ANOVAs (we could not include the site effect in the analyses because of small sample size). We then used backward stepwise (at $P = 0.05$) GLMs to test if the number of days between capture and recapture and body mass change differed significantly between sexes, ages and saddle status (plus all two-way interactions). Analyses were run with Statistica (Statsoft, Inc. 2002).

Teal pairing probability in the field

In the Camargue, we observed the mating behaviour of Teal from 21 November 2002 to 26 February 2003, 1 October 2003 to 25 February 2004, and 20 October 2004 to 23 February 2005. At weekly intervals we recorded, from a sample of 30 males and 30 females picked up randomly, how many individuals were mated. Only when too few birds were present or when meteorological conditions made it impossible were these observations not performed. During all visits, marked Teal were also sought and, whenever possible, their mating status was determined. Mating status was determined from the birds' behaviour, i.e. proximity and coordination of movements of the two mates (Wishart 1983, Guillemain *et al.* 2003).

A total of 56 mating checks of 60-bird samples were performed, and a total of 760 nasal-saddled Teal observations were performed with the mating status determined. Mating status of marked birds was recorded once per day. Data were pooled for ten-day periods over the three winters, and we used logistic regression to determine, separately for males and females, if the probability of being paired varied across time and showed the same trend over time in saddled and unsaddled Teal. The same analysis was then run again for 2003–04 and 2004–05 separately (it was not possible to run it for 2002–03 alone because nasal marking started only in December that year). Analyses were run with Statistica (Statsoft, Inc. 2002).

Wigeon and Teal time-budgets in the field

A total of 100 Teal and 13 Wigeon were captured with a cannon-net (Bub 1991) and ringed at the Réserve Naturelle de Saint Denis du Payré in Vendée, western France (46°24'N, 1°15'W) on 11, 16 and 20 December 2003, of which 51 Teal and 11 Wigeon were fitted with a nasal saddle. Diurnal observations of behaviour with ten minutes' scan sampling (Altman 1974) were then

performed simultaneously by two observers on one saddled and one unsaddled individual of the same species, sex and broad category of behaviour in the same flock. Each change in behaviour was recorded to the nearest second. Seven behaviour categories were distinguished: aggressive interactions, foraging, resting, preening, movement (swimming, walking or flying), displaying and vigilance. A total of 98 pairs of such focal samples were recorded between 2 January and 16 March 2004. We used paired *t*-tests to compare average proportions of time spent in each behaviour, separately for each species and sex, between saddled and unsaddled birds. Data are presented as percentages in the text to ease reading, but we used arcsine-transformed proportions in the statistical analyses, which were run with Statistica (Statsoft, Inc. 2002).

Mallard and Pintail body mass, testosterone level and dominance in the aviary

Aviary conditions

Experiments were carried out between September and November 2003 at the Centre d'Etudes Biologiques de Chizé (CEBC), western France, using adult ducks descended from individuals caught in the wild. This programme was approved by the Ministry of the Environment and satisfied the requirements of the Animal Welfare regulations from the Ministry of Research and Higher Education. During the day, Mallard and Pintail were usually kept in separate 110-m² enclosures (50 m² grass, 60 m² concrete) equipped with a 10 m² pool. At night, ducks were caged in two different 200-m² aviaries (100 m² grass, 100 m² concrete), one per species, equipped with a 25 m² pool. Food in aviaries (*ad libitum*) was composed of a mixture of crushed corn, wheat and commercial duck food. The birds were kept at the CEBC and were together for at least four months before the experiments. They were therefore accustomed to their aviary environment and their group. In this context, the hierarchy between individuals would have had time to be well established and, if stable, well conserved. No pairs were identified prior to or during the experiment. For the experiments, we randomly selected ten adult males and ten adult females for both species. However, one male Pintail died for unknown reasons before being fitted with a nasal saddle, which reduced the sample size to nine males in this species. During the experiments, birds were kept apart in two separate 10 × 10 m grass areas during the day and in 5 × 10 m concrete aviaries during the night, all equipped with a 10 m² pool.

Effect of nasal saddles on body mass

To test for a potential effect of the saddles on duck body mass, the 39 birds were weighed weekly from 15 September to 27 November 2003. Nasal saddles were fitted on 15 October to half of the birds (five of the nine male Pintail; see below for method of selection for birds to be saddled). We first compared the initial body mass on 15 September between birds that subsequently would and would not be saddled, separately for each species and sex, using Mann–Whitney *U*-tests. We then used repeated-measures ANOVAs separately for each species and sex with time as the repeating index and individuals as repetitions to determine if body mass patterns differed significantly between saddled and unsaddled birds. Analyses were run with Statistica (Statsoft, Inc. 2002).

Effect of nasal saddles on dominance hierarchy

To establish initial rank order, ducks were observed in the morning (for two hours) in two three-day sessions, from 17 to 19 and 23 to 25 September 2003. During each period, all interactions were noted, near the resources or elsewhere in the enclosure. For each aggressive encounter we determined the winner and the loser identities. Interactions between birds were organized in sociometric matrices from which we calculated Kendall's coefficient of linearity *K*, Landau's index and the index of linearity *h'* (De Vries 1995), using MatMan 1.0 (Noldus Information Technology 1998, De Vries *et al.* 1993). Each index varies from 0 (no linearity) to 1 (complete linearity). Index *h'* is based on *h* and takes into account the existence of unknown relationships, when two members of a dyad have not been observed to perform any agonistic interaction. Statistical significance of *K* is provided by a χ^2 test. For the *h'* index, a sampling process using 10 000 randomizations is performed (De Vries 1995). When the dominance hierarchy was significantly linear, individuals were reordered by a two-step iterative procedure (10 000 sequential trials), finding the rank order most consistent with a linear hierarchy by minimizing the number of inconsistencies and then minimizing the total strength of the inconsistencies (De Vries 1998). The birds were ranked from 1 (most dominant) to 20. We then ranked males and females (ranks from 1 to 10) separately. To assess the effects of the nasal marks, we divided the ducks into two groups (saddled and unsaddled), assigning individuals alternately to each lot following the order of the social hierarchy: nasal saddles were put on individuals of rank 1, 3, 5, 7 and 9 for both males and females in the two species.

After fitting nasal saddles, ducks were observed in the morning (for one hour) on 20 different days, from 17 to 21 October, from 3 to 12 and 22 to 26 November. During each session, the birds were placed in a 2 × 4 m arena and videotaped. No observer was visible to the ducks after the camera was positioned. The camera field (2 × 2 m) included a bowl containing 400 g of wheat and a bowl of water with a surface area of 700 cm². All interactions were noted in order to record all agonistic encounters. For each of these we determined if the winner and the loser had a nasal mark. We obtained a distribution of encounter outcomes between and within marked and unmarked birds, which we then compared with a similar set of data from the sessions carried out before the marking.

Effect of nasal saddles on testosterone levels

Blood samples were first collected on 15 September 2003 for the pre-marked period, and 7 November 2003 for the marked period. Birds were captured one after another. Immediately after capture, we drew 600 µl of blood from the brachial vein into a 1 ml heparinized syringe using a 25 gauge needle. We completed the entire capture and handling process as quickly as possible to minimize the effects of handling stress on circulating hormones. Handling time, i.e. time between capture and completed blood sampling, never exceeded 354 seconds (mean = 97.1 ± 6.0 se). All ducks were bled in the afternoon (14:00 to 18:30 hours) to minimize the effect of diurnal fluctuations in testosterone (Balthazart 1976). Samples were centrifuged immediately. The plasma was decanted and frozen at -20°C until it was dosed. Plasma testosterone levels were determined at the CEBC laboratory by radioimmunoassay using a specific antibody for testosterone (Lormée *et al.* 2000, Poisbleau *et al.* 2005a). Testosterone antiserum was provided by Dr Gérald Picaper (Medecine nucléaire, CHU la Source, Orléans, France). Testosterone was extracted from a 50 µl plasma sample with diethyl-ether with a recovery rate above 95%. The extracts were redissolved in 0.01 M phosphate-buffered saline (pH 7.4) containing 0.1% bovine albumin serum (PBS-BSA) and incubated overnight at 4°C with about 9000 cpm of the appropriate ³H-testosterone (Amersham Pharmacia Biotech, F-91898 Orsay, France) and antiserum. The bound testosterone fraction was separated by addition of dextran-coated charcoal and counted in a Packard scintillation spectrometer. Only one assay was performed and the intra-assay coefficient of variation was 6.5% (*n* = 3 duplicates). The lowest concentration

detectable was 0.15 ng/ml. We first compared the average initial testosterone levels on 15 September between birds that would and would not be subsequently saddled, separately for each species and sex, using Mann–Whitney *U*-tests. We then computed for each bird the difference between post- and pre-marking testosterone levels, and the average was compared between saddled and unsaddled birds using Mann–Whitney *U*-tests.

RESULTS

Teal body mass change in the field

The initial body mass at ringing did not differ significantly between birds that were and were not subsequently saddled: the average initial body mass was 357.3 g (± 5.2 se, $n = 98$) for saddled birds, and 353.0 g (± 5.1 se, $n = 76$) for unsaddled birds ($t = -0.63$, $df = 172$, $P = 0.53$). There were 36 females and 62 males in the unsaddled sample, and 25 females and 51 males in the saddled sample, which did not represent a significant difference in sex ratio ($\chi^2 = 0.28$, $df = 1$, $P = 0.60$). The unsaddled sample comprised 35 adults and 63 first-year Teal, while the saddled sample comprised 34 adults and 42 first-year birds: the age ratio did not differ significantly between them ($\chi^2 = 1.46$, $df = 1$, $P = 0.23$).

The number of days between the two weighing events (i.e. ringing and recapture) did not differ between sites (ANOVA: $F_{3,171} = 0.69$, $P = 0.51$). The final model of the stepwise procedure to fit this number of days using sex, age and saddle status kept only 'Age' as an explanatory factor, but did not fit the data ($F_{1,172} = 0.67$, $P = 0.41$): on average, there were 15.32 ± 1.33 days between ringing and recapture.

Body mass change between the two weighing events did not differ between sites (ANOVA: $F_{3,171} = 2.41$, $P = 0.07$). The final model of the stepwise procedure to fit this number of days using sex, age and saddle status kept only 'Saddle status' as an explanatory factor, but did not fit the data ($F_{1,172} = 2.12$, $P = 0.15$): on average, saddled birds lost 4.46 g/day (± 0.81 se) and unsaddled birds lost 2.90 g/day (± 0.71 se), which was not significantly different.

Teal pairing probability in the field

The logistic regression for the probability of being paired in female Teal with saddle status and time (i.e. ten-day periods) as factors fitted the data (goodness-of-fit: $\chi^2 = 1841.98$, $P > 0.05$); it revealed both a

significant increase across ten-day periods ($P < 0.01$) and a significant interaction between time and saddle status ($P = 0.01$), but saddle status alone did not have a significant effect ($P = 0.35$). Although at the beginning of winter the probability of being paired was similar between saddled and unsaddled females, this probability then increased at a higher rate in unsaddled birds (Fig. 1). In males, the model with saddle status, time and saddle status–time fitted the data (goodness-of-fit: $\chi^2 = 2180.44$, $P > 0.05$), all the factors having a significant effect (P values: 0.03, <0.0001 and 0.0002, respectively): saddled males were more likely to be paired than unsaddled ones at the beginning of winter, but then their probability increased at a slower rate with time (Fig. 1).

When the same analyses were run separately for the 2003–04 and 2004–05 winters, however, results were more contrasted: though the models fitted the data in both winters and for the two sexes (all $\chi^2 > 675.98$, all $P > 0.05$) a significant effect of the saddle status (but only via the saddle status – ten-day period interactions) was only apparent in the first winter (females: $P = 0.04$; males: $P < 0.01$). In 2004–05, the logistic regression revealed no effect of saddle status alone or through the saddle status–ten-day period interactions, in either males or females (all $P > 0.15$).

Wigeon and Teal time-budgets in the field

The average percentage of time spent by Teal and Wigeon of the two sexes in each behaviour is presented in Fig. 2 for saddled and unsaddled birds. In no species and no sex was the difference significant for any

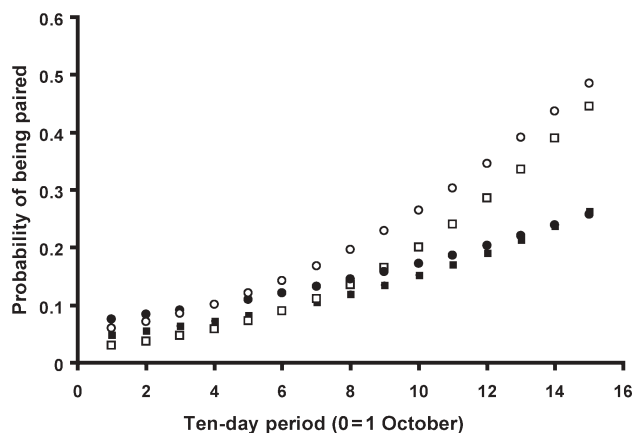


Figure 1. Probability of saddled (closed symbols) and unsaddled (open symbols) Teal being paired versus time, expressed in ten-day periods from early October to late February. Squares, males; circles, females. See text for statistics.

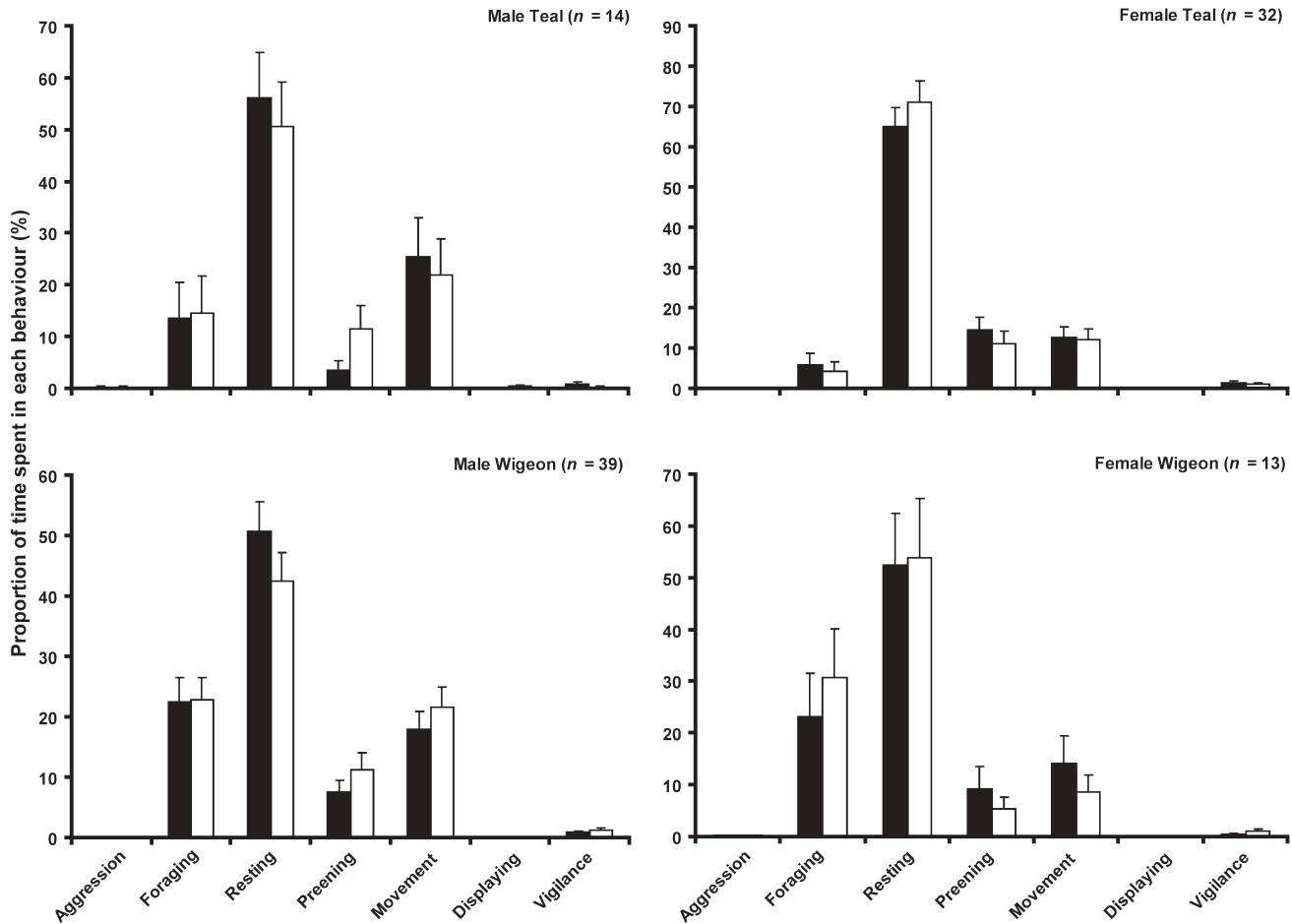


Figure 2. Average time-budgets of saddled (■) and unsaddled (□) Teal and Wigeon after paired focal observations at the Réserve Naturelle de Saint Denis du Payré. Vertical lines indicate standard errors. Only the percentage of time spent resting by female Teal differed significantly between saddled and unsaddled individuals. See text for statistics.

behaviour (all $P > 0.05$) except female Teal, which spent less time resting if saddled (paired t -test: $t = -2.29$, $P = 0.03$). However, one of the only marginally significant tests ($P = 0.06$) was also for resting in male Wigeon, but this time the pattern was the opposite, i.e. marked birds rested more.

Mallard and Pintail body mass variation in the aviary

Initial body mass on 15 September 2003 did not differ significantly between birds that were subsequently saddled or not, in either species or sex (Table 1). Body

Table 1. Initial body mass (\pm se) of subsequently saddled and unsaddled captive Mallard and Pintail on 15 September 2003, at the beginning of the experiment.

Species	Sex	Subsequently saddled	Body mass (g)	Number of individuals	Mann–Whitney test	
					z	P
Mallard	Male	Yes	1209.0 \pm 74.4	5	1.15	0.25
		No	1089.8 \pm 52.0	5		
	Female	Yes	1081.0 \pm 24.5	5	-1.78	0.08
		No	982.8 \pm 35.7	5		
Pintail	Male	Yes	756.0 \pm 46.0	5	-0.24	0.81
		No	788.2 \pm 44.1	4		
	Female	Yes	750.2 \pm 10.8	5	-1.47	0.14
		No	687.8 \pm 44.5	5		

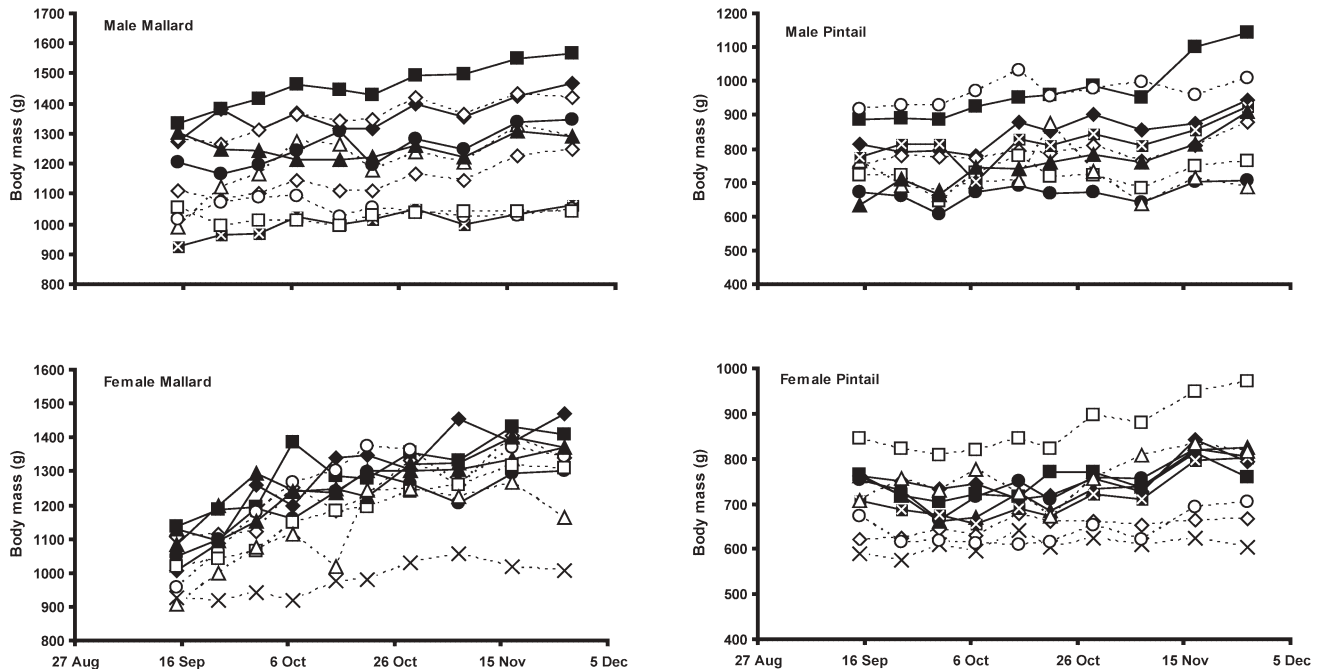


Figure 3. Body mass change of captive Mallard and Pintail at CEBC from 15 September to 27 November 2003. Different symbols represent different individuals. Birds that had a saddle fitted on 15 October are indicated by closed symbols and plain lines, birds that did not are indicated by open symbols and dashed lines.

mass changes over a two-month period are shown in Fig. 3. Repeated-measures ANOVAs did not reveal any significant difference in body mass during this period between marked and unmarked individuals, of either sex in the two species (male Mallard: $F_{1,8} = 1.31$, $P = 0.29$; female Mallard: $F_{1,8} = 4.57$, $P = 0.07$; male Pintail: $F_{1,7} = 0.02$, $P = 0.89$; female Pintail: $F_{1,8} = 0.50$, $P = 0.50$).

Mallard and Pintail dominance in the aviary

The analysis of the Mallard sociometric matrix comprised 536 interactions and revealed a clear linear hierarchy (Kendall's linearity index $K = 0.66$, $\chi^2 = 112.72$, $df = 27$, $P < 0.0001$). The values of Landau's index and the corrected index were high ($h = 0.66$, $h' = 0.67$, improved linearity test using h' , $P < 0.0001$) and clearly indicated that Mallard ranking was linear. The matrix of Pintail comprised 88 interactions and clearly revealed a significant linear hierarchy ($K = 0.35$, $\chi^2 = 62.22$, $df = 27$, $P < 0.0002$; $h = 0.35$, $h' = 0.36$, improved linearity test using h' , $P < 0.0002$).

Prior to saddling, Mallard not to be saddled won 47.03% ($n = 557$ interactions) of aggressive interactions compared to 53.20% ($n = 515$) for birds that were to be saddled. Pintail not to be saddled won

42.62% ($n = 711$) of their aggressive interactions compared to 57.99% ($n = 857$) for birds that were to be saddled. After saddling, unsaddled Mallard won 48.24% ($n = 3074$) of their aggressive interactions compared to 52.45% ($n = 2208$) for saddled ones; unsaddled Pintail won 45.58% ($n = 3023$) of their aggressive interactions compared to 53.63% ($n = 3679$) for saddled ones. The difference between both winning percentages before and after fitting nasal saddles was not significant in Mallard ($\chi^2 = 1.1885$, $df = 1$, $P = 0.28$), but was significant in Pintail ($\chi^2 = 20.6000$, $df = 1$, $P < 0.0001$).

Mallard and Pintail testosterone levels in the aviary

In no sex and no species did the testosterone levels differ significantly on 15 September 2003 (Mann-Whitney U -tests: all z absolute values < 1.57 , all $P > 0.11$; Fig. 4). Only in male Pintail did the change in testosterone between the two sampling dates (before and after fitting of the nasal saddles) differ significantly ($z = -2.45$, $P = 0.01$): unmarked male Pintail lost 0.15 ng/ml (± 0.29 se, $n = 4$). This was the only sex and species group to lose testosterone, while marked male Pintail gained 0.31 ng/ml (± 0.08 se, $n =$

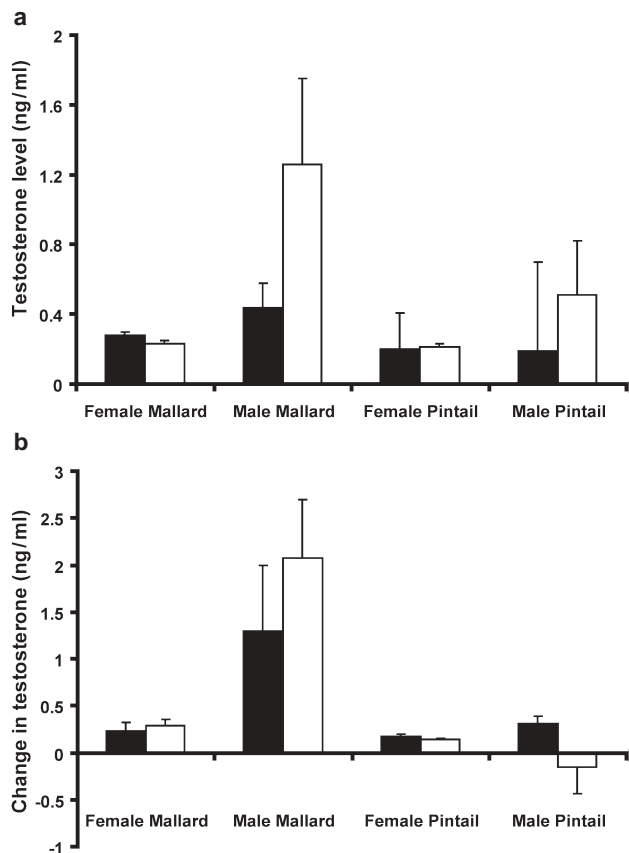


Figure 4. Average testosterone levels on 15 September 2003 (a) and change in testosterone levels between initial sampling and second sampling on 7 November 2003 (b) of captive Mallard and Pintail. Black bars, saddled birds; white bars, unsaddled birds. Vertical lines indicate standard errors. All $n = 5$ except for unsaddled male Pintail ($n = 4$). See text for statistics.

5), a pattern more similar to what was observed in the other cases (Fig. 4).

DISCUSSION

Duck body mass

Nasal saddles did not affect body mass, either in the field for Teal or in the aviary for Mallard and Wigeon. In the field, Teal lost body mass between ringing and first live recapture, a common observation in wild birds often attributed to the stress of handling (Ens *et al.* 1990). While marked Teal lost 4.5 g per day on average, unmarked Teal lost 3.0 g per day. However, the variance was large and the difference was not statistically significant.

In the aviary, neither Mallard nor Pintail appeared to be affected in their body mass patterns by the presence

of nasal saddles. In both species body mass increased from September to November, as has been demonstrated for wild Teal too (Guillemain *et al.* 2005).

Given the common use of this marking method in North America, there have been surprisingly few tests of the effect of nasal saddles on duck body mass. Sjöberg & Danell (1977) and Byers & Montgomery (1981) weighed simultaneously nasal-marked and control ducks in the aviary or fenced areas, and found no significant difference. The present study corroborates these results.

Duck time-budget

There have been a number of previous studies of the effects of nasal saddles, including time-budget studies. Some of these revealed no effect of the saddles on behaviour, at least a few days after the saddle was fitted (Bartonek & Dane 1964, Sudgen & Poston 1968, Byers & Montgomery 1981), while other studies showed differences in levels of bill-scratching or preening (McKinney & Derrickson 1979, Evrard 1996). We found no consistent difference between the behaviour of marked and unmarked Teal and Wigeon. It is true that saddles may induce more occasional bill-scratching in the field (M. Guillemain pers. obs.), but this does not translate into an altered broad time-budget. Nocturnal data were not available, but given the nocturnal foraging habits of most dabbling ducks, the comparison of foraging time of saddled and unsaddled birds during the night would be welcome in the future.

Duck pairing probability

The pairing probability test was the only one to show a clear effect of nasal saddles on birds in the field. Marked Teal paired at a slower rate through the winter than unmarked ones. However, this result was only observed in one of the winters when data from the two field seasons were analysed separately, while no effect of the saddle was detected in the other one.

Most earlier tests of the effects of nasal saddles on pairing in dabbling ducks were anecdotal, e.g. they reported the presence of all combinations of marked and unmarked mates (Evrard 1996, Rodrigues *et al.* 2001), or did not provide quantified data (Bartonek & Dane 1964). Conversely, Howerter *et al.* (1997) measured a delay in first nest initiation by marked female Mallard, which they hypothesized may have been due to a negative response of males to nasal-

marked females, and Koob (1981) reported that paired male Ruddy Duck *Oxyura jamaicensis* fitted with a nasal saddle generally lost their mate to unmarked males. Regehr & Rodway (2003) also observed a lower pairing probability in marked than unmarked male Harlequin Duck *Histrionicus histrionicus*, while no significant difference could be observed in females. Marked females, nonetheless, were less likely to reunite with previous mates. Results in Teal here were always similar between the two sexes, and were not as extreme as in the Ruddy Duck case. We observed marked Teal of the two sexes to pair, though the fact that in some cases pairing may occur at a slower rate than for unmarked birds calls for caution in the use of nasal saddles for studies including social parameters.

Duck dominance hierarchy and testosterone

A clear significant stable linear hierarchy was observed in both Mallards and Pintails prior to marking. In Mallards, the proportion of aggressive interactions won by marked individuals did not differ before and after fitting of the saddle (52–53%). Pintails, conversely, won only 54% of their interactions after marking, while they won 58% before. Though not large, the difference was significant. The biological significance of these changes in dominance is difficult to assess. However, our results call for caution when using nasal saddles for studies of the social structure in dabbling ducks.

To our knowledge this is the first time that the effect of nasal saddles on duck hormone levels has been tested, which precludes any comparison with other studies. However, according to the 'challenge hypothesis', plasma testosterone levels should be elevated only when needed during social challenge, including reproductive events (Wingfield *et al.* 1990). Consequently, if putting nasal saddles on ducks leads to a destabilization of dominance relationships, we would expect an increase of plasma testosterone for newly challenged marked birds. This did not seem to occur in this study since blood testosterone concentration was initially low and similar between marked and unmarked Mallard and Pintail in both sexes. We suggest that the stable dominance hierarchy and associated low levels of testosterone were probably maintained by 'social inertia' (Guhl 1968, Archawaranon *et al.* 1991, Wiley *et al.* 1999). As in other studies (Poisbleau *et al.* 2005a), and consistent with the fact that pairing behaviour starts around mid-winter (Heitmeyer 1988), we found that testosterone levels

generally increased between September and November except among unmarked male Pintails. Nevertheless, marked and unmarked birds showed a similar testosterone level increase.

Conclusion

We conclude that nasal saddles do not have a general negative impact on dabbling ducks. The only caution concerns social relationships between ducks, as we observed a significant effect on pairing and on the outcome of aggressive interactions. However, in both cases these results only held for some species or some periods and so do not have a general effect. Despite the fact that we studied many aspects of dabbling duck ecology during winter, we were not able to study all aspects of these birds' biology. In particular, a test of the effect of nasal saddles on life-history traits would also be valuable. Earlier work (Evrard 1996) has revealed no difference in reporting rates between saddled and ringed-only ducks but we could not test this directly, as we use the back of the saddles to write a phone number for hunters to report shot ducks. The difference in methodology therefore makes reporting of saddled birds easier than for individuals simply ringed. However, we only mark half to two-thirds of the ducks we catch with nasal saddles, so that it will be possible within a few years to compare survival rates of marked and unmarked ducks. We conclude that nasal saddles are an appropriate marking method for dabbling ducks for most research topics, and we hope that their use will help promote individual-based studies of these birds in Europe.

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