Field methods to assess pectoral muscle mass in moulting geese

Authors: Nyeland, Jens, Fox, Anthony D., Kahlert, Johnny, and Therkildsen, Ole R.

Source: Wildlife Biology, 9(2) : 155-159

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/wlb.2003.029

Field methods to assess pectoral muscle mass in moulting geese

Jens Nyeland, Anthony D. Fox, Johnny Kahlert & Ole R. Therkildsen

Nyeland, J., Fox, A.D., Kahlert, J. & Therkildsen, O.R. 2003: Field methods to assess pectoral muscle mass in moulting geese. - Wildl. Biol. 9: 155-159.

In this paper, we report two new simple field methods to assess changes in pectoral muscle mass in live moulting geese. In the first method, transverse chest profiles of Canada geese *Branta canadensis* and greylag geese *Anser anser* were recorded using soldering wire. This standard measure of the chest angle showed a highly significant relationship with actual pectoral muscle mass. Chest angle measures showed a highly significant polynomial correlation with an index of moult stage, i.e. length of the ninth primary (p9). This indicated an initial slight decline in pectoral muscle mass as p9 length increased, followed by an increase in muscle mass in preparation for regaining the ability to fly. In the second method, visual pectoral profile scores from 0 (thin pectoral muscles concave) to 3 (convex bulky) recorded at distances using telescope or binoculars also proved to be useful as a field measure of pectoral muscle mass in moulting geese. Hence, the first method provides a non-consumptive means of predicting pectoral muscle mass in moulting geese without the need to dissect birds, and the second method enables field prediction of muscle mass in moulting geese without resort to capture of birds.

Key words: atrophy, Canada geese, greylag geese, hypertrophy, moult

Jens Nyeland, University of Copenhagen, Department of Population Ecology, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark - e-mail: jny@natur.gl*
Anthony D. Fox, Johnny Kahlert & Ole R. Therkildsen, National Environmental Research Institute, Department of Wildlife Ecology and Biodiversity, Grenåvej 12-14, Kalø, DK-8410 Rønde, Denmark - e-mail addresses: tfo@dmu.dk (Anthony D. Fox); jok@dmu.dk (Johnny Kahlert); oth@dmu.dk (Ole R. Therkildsen)

**Present address: Greenland Institute of Natural Resources, P.O. Box 570, DK-3900, Nuuk, Greenland*

Corresponding author: Jens Nyeland

Received 12 November 2001, accepted 9 August 2002

Associate Editor: Hannu Pöysä

All wildfowl (with the exception of the magpie goose *Anseranas semipalmata* which has a gradual moult of flight feathers) undergo an annual moult period, during which all old primaries and secondaries are shed simultaneously and replaced with new feathers (Batt 1992). During this period, birds are flightless and dependent on habitats offering good feeding sites as well as protection against predators and disturbance (Owen 1980). In geese *Anser* and *Branta* spp., the flightless period lasts ca 3-4 weeks (Owen 1980, Hohman, Ankney & Gordon 1992) during which time the birds have no need for strong and well-developed flight muscles and depend on their legs for locomotion, either swimming or running from potential predators. As an adaptation to this period, the pectoral muscle mass of geese initially gradually decline (atrophy) with a simultaneous increase in the leg muscle mass (hypertrophy). The process is then reversed during late moult in preparation for the regained power of flight (for Canada geese *Branta canadensis* see Hanson (1962) and Raveling (1979); for lesser snow geese *Chen caerulescens* see Ankney (1979); for brent geese *Branta bernicla* see Ankney (1984)).

Assessment of body condition, and in particular major protein reserves such as flight muscles, is an important aspect of many avian studies. Determination of total avian body protein or pectoral muscle mass (e.g. Evans & Smith 1975) is time-consuming, costly and destructive, in the sense that its measurement involves the death of the individual. It is therefore helpful to develop techniques that enable the prediction of pectoral muscle mass from measures derived from live birds in the hand or free-ranging individuals in the field. In this paper, we investigate the correspondence between the shape of the chest profile measured on captured live geese and actual pectoral muscle mass in a sample of dissected greylag geese *Anser anser* moulting in Denmark. We also determine whether a visual field score of chest profile (i.e. one applicable without necessitating capture) was a good predictor of pectoral muscle mass, and apply the first method to a sample of Canada geese moulting in Greenland.

Methods

During a ringing expedition to Isunngua (67°5'N 50° 30'W), West Greenland during 11-29 July 1997, 65 moulting adult Canada geese were herded into corrals and caught during five catches. The total length (mm) of the ninth primary (p9) on the left wing was measured from the remige calamus at the skin surface to the distal tip of the feather (with a ruler placed between the eighth and ninth primaries).

Chest angle was measured perpendicular to the carina (keel) 2 cm from the anterior edge using a modification of the method described by Bolton, Monaghan & Houston (1991). Feathers were gently moistened with soapy water in the measuring area and smoothed away to expose the skin. A 25 cm length of solder wire (1.5 mm diameter) was placed on the bare skin and carefully pressed evenly across the chest on both sides of the keel simultaneously. The solder wire was then placed flat on a piece of paper and the shape of the angle drawn with a pencil directly onto the paper. The narrowest angle between points situated 2 cm from the angle of the wire was measured (Fig. 1). Six birds caught on 18 July were recaptured on 24 July, and their chest angles were remeasured.

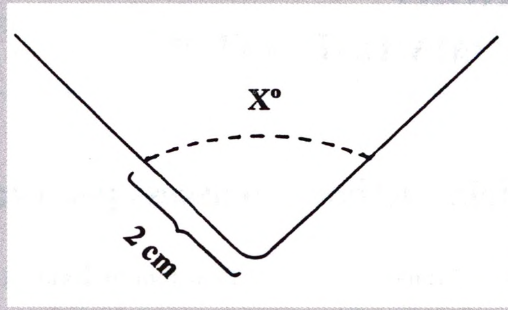

Figure 1. Schematic illustration of the soldering wire used to measure chest angle in moulting Canada geese in Greenland in 1997, and greylag geese in Denmark in 1998. The inner angle (X°) 2 cm from the tip was used as a measure of chest angle.

In addition, 21 moulting greylag geese were caught and sacrificed for diet, stable isotope and body composition studies on the island of Saltholm (50°40'N 12°45'E), Denmark, on 25 May (seven birds, early moult), 11 June (nine birds, mid moult) and 26 June (five birds, late moult) 1998 using cannon nets. This was done with permission from the Danish Forest and Nature Agency, the Ministry of Environment and Energy. Before being sacrificed, ninth primary feather length and chest angle were measured as described above. To relate actual pectoral muscle mass to chest angle (and 'pectoral profile' score, see below) the right and left pectoral muscles (i.e. *pectoralis*, *supra coracoideus* and *coraco brachialis*) were dissected, removed and weighed (total wet weight of left and right pectoral muscles). The pectoral muscles contained only negligible amounts of fat and hence, differences in fat storage could not affect the chest angle.

On Saltholm, during 7-27 June 1998 and 2000, chest angles (pectoral profiles) of moulting greylag geese were scored from a concealed position ca 2.5 m above the ground when birds were facing the observer in a head-up posture. A four-point classification was used (Fig. 2): 0) keel very obvious with thin pectoral muscles making each side of the keel concave, 1) keel obvious with more pectoral muscle tissue giving the chest a tri-

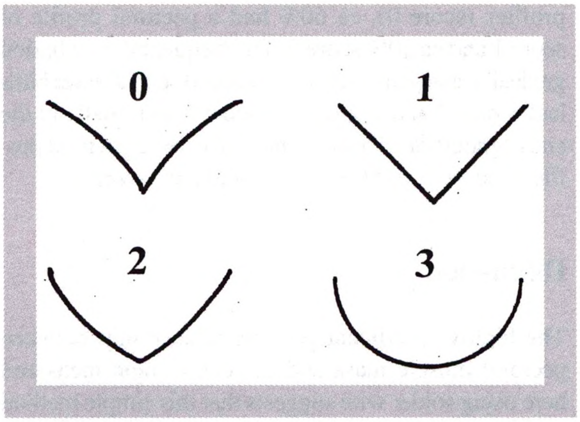

Figure 2. Classification of point values (0-3) used to score pectoral profiles in moulting greylag geese; 0: keel very obvious with thin pectoral muscles making each side of the keel concave; 1: keel obvious with more pectoral muscle tissue giving the chest a triangular shape; 2: keel not visible with pectoral muscles large enough to make the chest profile look slightly rounded; 3: large pectoral muscles making the chest profile look very bulky and concave.

angular shape, 2) keel not visible with pectoral muscles large enough to make the chest profile look slightly rounded, and 3) large pectoral muscles making the chest profile look very bulky and concave. All assessments were carried out on birds ca 10-200 m from the observer, using binoculars (10x) or telescope (20-60x). Unfortunately, data were not obtained in the very beginning of the moult. To assess the usefulness of this scoring system, before being sacrificed, each of the greylags that were caught in 1998 were placed separately in a 1-m^2 pen constructed of chicken wire, the pectoral profile was scored as described above at a distance of >30 m, and the scores were correlated with actual pectoral muscle mass.

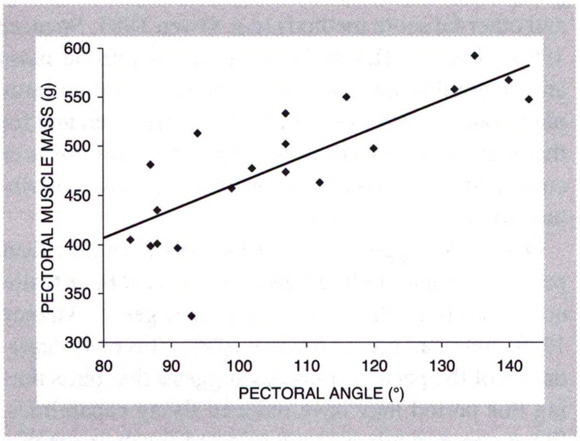

Figure 3. Relationship between pectoral muscle mass (in g wet weight) and chest angle (in °) of moulting greylag geese. The pectoral muscle mass = 2.7805 * chest angle + 184.45; r^2 = 0.63, N = 21, P < 0.0001.

Table 1. Relationship between the dependent variable chest angle in greylag geese and Canada geese and the four independent variables: length of ninth primary (p9), p9*p9, sex and species. The analysis was carried out using multiple regression, N = 88; r^2 = 0.74 (all variables included).

	Coefficient ± SE	t-ratio	P
Constant	95.52 ± 3.205	29.804	< 0.0001
p9	-0.221± 0.053	4.198	< 0.0001
p9*p9	0.001± 0.0002	7.262	< 0.0001
Sex	-1.145± 1.774	0.6453	0.5205
Species	3.037+ 2.042	1.487	0.1407

Results

There was a highly significant linear relationship between actual muscle mass and chest angle (Fig. 3). There was also a significant linear relationship between muscle mass and the length of p9 (r^2 = 0.51, N = 21, P = 0.003), however, this explained less of the variation than did chest angle (p9: r^2 = 0.51 vs chest angle: r^2 = 0.63), making this measure a better predictor of muscle mass.

A multiple regression model showed a highly significant polynomial relationship between length of p9 and chest angle amongst live moulting Canada geese and greylag geese, reflecting the change in pectoral muscle mass during moult (Table 1). However, there was no difference between the species and sexes. In the data pooled from Canada geese and greylag geese chest angle decreased slightly as the length of p9 increased until ca 90 mm length after which an increase in chest angle occurred with continued growth of p9 (Fig. 4). The pattern suggests that chest angles (and therefore muscle mass) started to decline even before the flight feath-

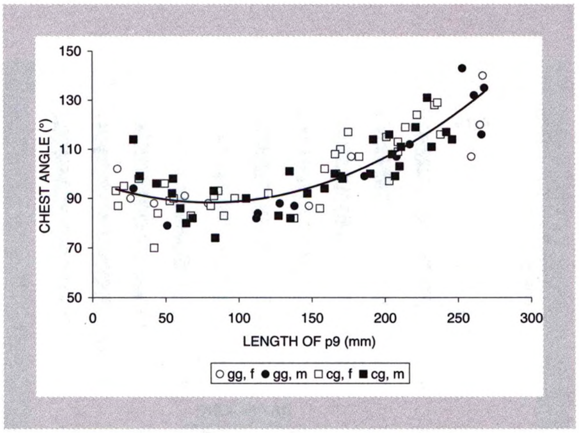

Figure 4. Relationship between chest angle (in °) and moult stage expressed as length of the ninth primary of Canada geese in Greenland and greylag geese in Denmark. The chest angle = 0.001 * $p9^2$ - 0.21 * p9 + 96.7; r^2 = 0.73. The abbreviations in the figure are: gg, f = female greylag geese; gg, m = male greylag geese; cg, f = female Canada geese; cg, m = male Canada geese. The fitted polynomial regression is based on all data pooled.

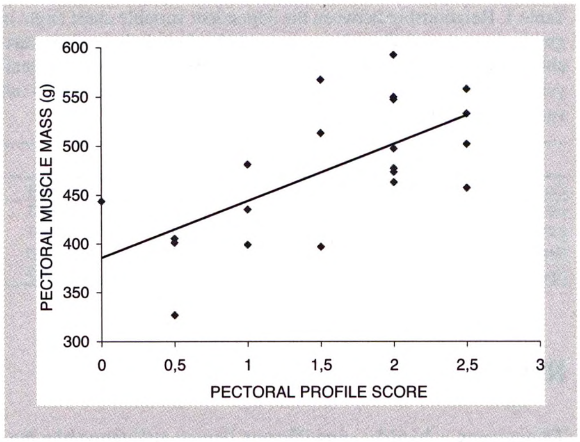

Figure 5. Relationship between pectoral muscle mass (in g wet weight) and chest profile score of greylag geese according to the scoring classification given in Figure 2. The pectoral muscle mass = 58.332 * pectoral profile score + 385.54; $r^2 = 0.43$, N = 21, P = 0.0014.

ers were shed. The six Canada geese that were recaptured after six days showed a significant increase in chest angle (from 96.17° ± 7.19 to 101.67° ± 5.68 (average ± SD); pairwise t-test: t = 3.422, df = 5, P = 0.018). This equates to an average increase of 2.55 g ± 1.82 (SD; wet weight) muscle mass per day as based on the relationship between pectoral muscle mass and chest angle; see Fig. 3).

There was a significant positive correlation between pectoral score and muscle mass amongst the caught sample of greylag geese ($r^2 = 0.43$, N = 21, P = 0.0014; Fig. 5).

The pectoral profiles of greylag geese scored in the field changed according to moult stage (Fig. 6). In the early moult stage ca 20% of the birds had concave pectoral profiles (score 0), ca 60% had a pectoral profile of score 1 and ca 20% score 2. The frequency distribution gradually changed as moult progressed so that fewer birds had scores 0 and 1 and more score 2 and finally at the end of moult ca 25% of the birds showed a pectoral profile of score 1, ca 50% score 2 and 25% score 3.

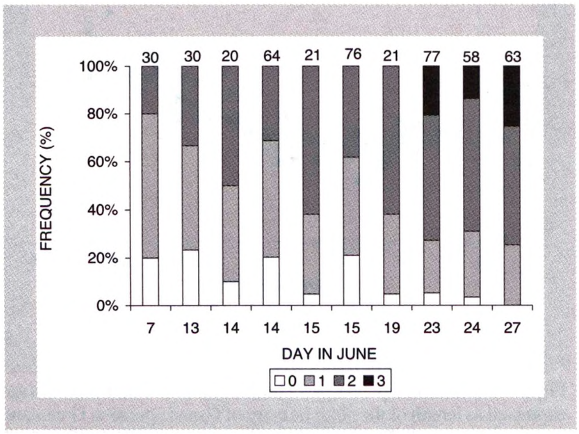

Figure 6. Frequency distribution (in %) of pectoral profile scores (0-3) during moult in greylag geese on 14, 15, 23, 24 and 27 June 1998 (N = 338), and 7, 13, 14, 15 and 19 June 2000 (N = 122). The profile scores follow Figure 2.

Discussion

The highly significant positive relationship between pectoral muscle mass and the chest angle measured here using solder wire suggests that this simple method can be used to predict pectoral muscle mass in live moulting geese, explaining some 63% of the variation in muscle mass. Although the relationship between pectoral muscle mass and length of the ninth primary was also significant, it explained less of the variance than did chest angle. The curvilinear relationship between muscle mass (chest angle) and moult stage and the increase of muscle mass with progressing moult is consistent with the pattern of atrophy/hypertrophy described for moulting geese and other waterfowl elsewhere (Hanson 1962, Ankney 1979, Raveling 1979, Young & Boag 1982, Ankney 1984, Bailey 1985, Piersma 1988).

Furthermore, the visual scoring of pectoral profiles of moulting greylag geese also demonstrated a significant relationship with pectoral muscle mass. This method offers a field technique that obviates the need to capture birds to estimate muscle mass of moulting geese. However, there was inevitably greater variation using this more crude visual scoring system, which nevertheless explained 43% of the variation in pectoral muscle mass. This method should therefore be used with the same caution as when using other subjective proxy field methods such as abdominal profile scores and other fat score methods (e.g. Owen 1981, Spencer 1995). The correlation between actual muscle mass and pectoral score in this analysis was based on birds placed and scored in a small chicken wire pen and for that reason often were in unnatural and odd postures compared to wild conditions and this may have contributed to the overall variation.

Our results suggest that the geese began to reduce their pectoral muscles before they actually shed their feathers, as has been shown for lesser snow geese (Ankney 1979) and brant geese (Ankney 1984). This early degradation of the pectoral muscles suggests that birds during this period may have reduced flying capabilities. Since goose moult sites are selected for their specific characteristics (providing good feeding opportunities and protection against predators) it is important that they arrive at these sites well before they lose the powers of flight. If, for some reason, local conditions are unsuitable for moulting in any one season, the geese must be able to fly to another moult site (as occurred for greylag geese at the Oostvaadersplassen, the Netherlands in 1988, 1989 and 1990 (van Eerden, Loonen & Zijlstra 1998)) before commencing wing moult. The potential reduction in flight capability prior to moult might therefore be crucial. Such a finding has implications for the management of disturbance in areas supporting moulting geese if these birds are less tolerant of predator-like stimuli two or more weeks before the onset of the flightless phase of moult.

The methods presented here proved to be useful to predict muscle mass in moulting geese without recourse to dissection of birds (i.e. the chest angle method) or resorting to the capture of birds (i.e. the pectoral profile index method). These methods are likely to be useful studying other waterfowl such as diving and dabbling ducks which undergo similar morphological changes in pectoral and leg muscles during moult but are less well known (Young & Boag 1982, Bailey 1985). Prior to migration some long-distance wader species undergo large morphological changes degrading their internal organs such as the gizzard and intestine and allocate resources to pectoral muscles (Piersma 1998). The field methods presented in this paper could potentially be useful tools to study these birds during their preparation for long-distance migrations. It is not known whether long-distance migratory geese and other waterfowl show similar adaptations in preparation to migration, however, measuring chest angles either using solder wire or by visual scoring of live birds could provide information on this matter in the future.

Acknowledgements - we sincerely thank the whole team of the 1997 Greenland White-fronted Goose Ringing Expedition for their help during this study, and are especially indebted to Stephanie Warren and Nigel Jarrett for measuring and ageing the birds, and Guy Thompson, Henning Ettrup and Barbara Ganter for their help during the chest profile measuring. We thank Ebbe Bøgebjerg, Torbjørn Eriksen and Flemming Hansen for their help during the cannon netting on Saltholm 1998 and for measuring and ageing the birds. Timme Nyegaard is thanked for scoring chest angles in 2000, Hugh Boyd for commenting on an earlier draft and Gösta Nachman for statistical advice. Permission to kill a number of greylag geese was given by the Danish Forest and Nature Agency, the Ministry of Environment and Energy. Finally, the owners of Saltholm, the Greenland Home-rule Authority and the Danish Polar Centre are thanked for permission to carry out the fieldwork.

References

Ankney, C.D. 1979: Does the wing molt cause nutritional stress in lesser snow Geese? - Auk 96: 68-72.

Ankney, C.D. 1984: Nutrient reserve dynamics of breeding and molting brant. - Auk 101: 361-370.

Bailey, R.O. 1985: Protein reserve dynamics in postbreeding adult male redheads. - The Condor 87: 23-32.

Batt, B.D.J. 1992: Introduction - The waterfowl. - In: Batt, B.D.J., Afton, A.D., Anderson, M.G., Ankney, C.D., Johnson, D.H., Kadlec, J.A. & Krapu, G.L. (Eds.); Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis, 635 pp.

Bolton, M., Monaghan, P. & Houston, D.C. 1991: An improved technique for estimating pectoral muscle protein condition from body measurements of live gulls. - Ibis 133: 264-270.

Evans, P.R. & Smith, P.C. 1975: Studies of shorebirds at Lindisfarne, Northumberland. 2. Fat and pectoral muscle as indicators of body condition in the Bar-tailed Godwit. - Wildfowl 26: 64-76.

Hanson, H.C. 1962: The dynamics of condition factors in Canada geese and their relation to seasonal stresses. - Acta Institute of North America, Technical Paper No. 12, 68 pp.

Hohman, W.L., Ankney, C.D. & Gordon, D.H. 1992: Ecology and management of postbreeding waterfowl. - In: Batt, B.D.J., Afton, A.D., Anderson, M.G., Ankney, C.D., Johnson, D.H., Kadlec, J.A. & Krapu, G.L. (Eds.); Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis, pp.128-189.

Owen, M. 1980: Wild geese of the world: Their life history and ecology. - B.T. Batsford, London, 236 pp.

Owen, M. 1981: Abdominal profile - a condition index for wild geese in the field. - Journal of Wildlife Management 45: 227-230.

Piersma, T. 1988: Breast muscle atrophy and constraints on foraging during the flightless period of wing moulting great crested grebes. - Ardea 76: 96-106.

Piersma, T. 1998: Phenotypic flexibility during migration: optimisation of organ size contingent on the risks and rewards of fuelling and flight? - Journal of Avian Biology 29: 511-520.

Raveling, D.G. 1979: The annual cycle of body composition of Canada geese with special reference to control of reproduction. - Auk 96: 234-252.

Spencer, R. 1995: The ringers' manual. - The British Trust for Ornithology, Thetford, UK, 138 pp.

van Eerden, M.R., Loonen, J.J.E. & Zijlstra, M. 1998: Moulting greylag geese Anser anser defoliating a reed marsh Phragmites australis: seasonal constraints versus long-term commensalism between plants and herbivores. - In: van Eerden, M.R. (Ed); Patchwork: patch use, habitat exploitation and carrying capacity for waterbirds in Dutch freshwater wetlands. Published PhD thesis, Rijkswaterstaat, Lelystad, the Netherlands, pp. 239-264.

Young, D.A. & Boag, D.A. 1982: Changes in physical condition of male mallards Anas platyrhynchos during moult. - Canadian Journal of Zoology 60: 3220-3226.