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Age bias in the bag of pink-footed geese *Anser brachyrhynchus*: influence of flocking behaviour on vulnerability

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Abstract In pink-footed goose (*Anser brachyrhynchus*) wintering in Denmark, The Netherlands and Belgium, the proportion of juveniles in the hunting bag is consistently higher than that observed in the autumn population. Such juvenile bias in the bag is usually ascribed to young geese lacking experience with hunting or disruption of juveniles from families. An alternative explanation may be that flocking behaviour of families make juveniles more vulnerable. Observations of morning flights of pink-footed geese to the feeding grounds from two of the major autumn-staging areas showed that geese were distributed in many small flocks (median flock size=9). This was not significantly different from the flock size distribution shot at by hunters (median=8), suggesting that hunters targeted goose flock size in proportion to the general probability of encounter. The rate at which hunters downed geese was independent of flock size. The ratio between juveniles and adults in flocks decreased with flock size and flocks of <60 individuals primarily comprised family groups. The likelihood of being shot at was 2.4 times higher for juveniles and 3.4 times higher for older birds in small flocks (<10 individuals) compared to larger flocks. The observations suggest that both juveniles as well as successful adult breeding birds were more vulnerable than non-breeding/failed breeding birds as a result of flocking behaviour.

Keywords Flocking · Juvenile mortality · Harvest · Predation risk · Predator swamping

Introduction

Analyses of the bag composition of waterfowl have generally shown that hunter-killed birds do not constitute a random subset of the population. Certain individuals in a population may have a higher vulnerability to being killed by hunters, which can be related to age (Grieb 1970; Martin et al. 1979; Boyd et al. 1982; Wright and Boyd 1983; Francis et al. 1992), sex (Olson 1964; Giroux and Bédard 1986), body condition (Greenwood et al. 1986; Reinecke and Shaiffer 1988; Heitmeyer et al. 1993) and flocking behaviour (Olson 1964; Giroux and Bédard 1986; Dufour and Ankney 1995).

In geese, juvenile bias in the bag is commonly observed and has been ascribed to young birds being more vulnerable than older birds due to their lack of previous hunting exposure (Owen 1980; Wright and Boyd 1983), which will be even more pronounced in case of disruption of social units due to hunting or disturbance (Prevet and MacInnes 1980; Ely 1993). However, because juveniles, except for orphans, are attached to their parents in family groups throughout the open season (e.g. Boyd 1953; Raveling 1969; Owen 1980) and by which they gain from the experience of the parents, inexperience and social disruption are possibly not the only explanations. An alternative hypothesis is that the behaviour of family flocks makes them more vulnerable to hunting than non-breeders. The aim of this study was to test this hypothesis based on observations of flocking behaviour of pink-footed geese (*Anser brachyrhynchus*) in relation to hunting.

Materials and methods

Study population

The population of the pink-footed goose which breeds in Svalbard and winters in Denmark, The Netherlands and

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Belgium has increased in numbers from approximately 35,000 birds in the 1990s (Ganter and Madsen 2001) to more than 50,000 in the recent decade (Fox et al. 2005). The population is open to hunting in Svalbard, on the mainland of Norway and in Denmark. Approximately 3,000 geese are shot annually, of which two thirds are bagged in Denmark (Noer et al. 2007).

Since 1986, productivity estimates have been made annually based on field age ratio counts. Juveniles are distinguishable from older birds by their duller, mottled appearance (Owen 1980). Age ratio counts were performed during a short period in October/November when the majority of the population is gathered in one or two places, either in western Jutland in Denmark (1986–1990) or in Friesland in The Netherlands in combination with western Jutland (since 1991). Age ratios counts were made from all group sizes and, in larger flocks, random samples were made throughout the flocks (Ganter and Madsen 2001). In the 1990s, productivity of the population was on average 15.2% juveniles (Ganter and Madsen 2001). In 1996 and 1997 when this field study was performed, productivity was close to average, viz. 18.4% and 14.4% juveniles, respectively.

Study area

Goose flocking behaviour and hunting performance were studied during September–October 1996 and 1997 at Vest Stadil Fjord and Fiil Sø, two of the major autumn-staging sites used by pink-footed geese in western Jutland, Denmark and also the sites where most pink-footed geese were shot annually. Up to 20,000 geese occurred during late September to mid-October after which only a few hundred were left. At night, the geese roosted on lakes and approximately 1 h before sunrise they flew to adjacent stubble fields (usually within 7 km from the roost) to feed mainly on waste grain (Madsen 2001). The farmland used by the geese at Vest Stadil Fjord and Fiil Sø extend over 14 and 12 km², respectively.

In Denmark, the goose hunting is open from 1 September to 31 December; in 1996, hunters were only allowed to shoot geese from 1.5 h before sunrise to 10 A.M. (in 1997 until 11 A.M.), but with no restrictions on the number of hunting days per season or bag limits. In the study areas, most hunting took place in the early morning when hunters shot at the geese as they passed between roosts and foraging grounds or when geese landed in fields. Single hunters or parties of hunters were hiding in ditches, reeds or scrub and few (less than 10%) used decoys.

Bag statistics

Wing collections of bagged waterfowl have been carried out in Denmark since 1986 to obtain information of sex and

age composition (in geese only age composition) as well as geographical distribution of the bag (e.g. Clausager 2001; see www.dmu.dk/Dyr_planter/Dyr/Vinger/Resultater for an overview of the wing collection programme and data). The sample of pink-footed goose wings has been small throughout; on average, 55 wings (range 12 to 153) were collected per season during 1986–2008. In 1996 and 1997, when the field study was carried out, the proportion of juveniles in the bag was 35.0% and 38.9%, respectively.

Field observations

Observations of morning flights of geese in the two study areas were made from elevated points with the aid of binoculars or telescopes. All sizes of goose flocks flying from the roosts into the farmland were recorded. Flock sizes between one and 10 were counted and flock sizes of >10 were estimated to the nearest 10. Simultaneously, hunters, either single hunters or groups of two to three hunters and up to a total of five hunters at once, were kept under observation, and all shots fired at geese were noted together with the goose flock size fired at. It was recorded whether the hunters successfully downed geese or not. In the vast majority of cases, observations were made on hunters not using decoys. Observations were carried out by one to two observers at a time and a total of three observers were involved in the study. Hunters were not informed about the presence of observers. The distance between the observer and hunters varied between 200 and 600 m. Shortly after the cessation of hunting, the farmland areas were visited and goose flocks were counted. Age ratio counts were made in as many flocks as possible and brood sizes were registered in a random subset of flocks. To ensure that the age composition of flocks in the fields reflected the composition of flying flocks, age ratio counts were primarily performed on flocks shortly after landing.

Results

Age ratios in population and bag

During 1986–2008, the proportion of juveniles in the autumn population varied from 6% to 24% (average 13.8%). During the same period, the mean proportion of juveniles in the hunting bag varied from 10% to 67% (average 34.3%) and was consistently higher than the proportion of juveniles in the population. The proportion of juveniles in the population and in the bag was significantly correlated (Fig. 1).

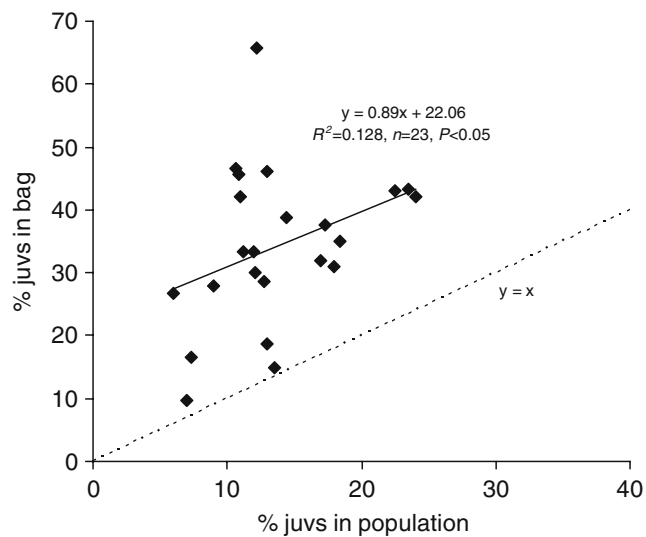


Fig. 1 Relationship between the proportion of juveniles in the autumn population of pink-footed geese and in the hunting bag, 1986–2008, based on age ratio counts and wing collections, respectively. The stippled line shows $x=y$

Flocking and hunting

There was no difference in flock size frequency distribution between years ($\chi^2_{15} = 6.55$, $P > 0.05$) nor areas ($\chi^2_{12} = 2.13$, $P > 0.05$). For the autumns 1996 and 1997 combined, the observed sizes of flocks flying onto the farmlands in the morning ranged from one to 3,000 individuals, with a median of 9 (Fig. 2). Single birds and flocks of two geese made up 4.4% and 7.0%, respectively.

There was no difference in frequency distribution of flock sizes shot at between years ($\chi^2_7 = 2.03$, $P > 0.05$), nor areas ($\chi^2_5 = 8.35$, $P > 0.05$). For 1996 and 1997 combined, flock sizes shot at ranged from one to 900 individuals with a median of 8. Single birds and flocks of two geese made up 7.2% and 7.8%, respectively. There was no difference in flock size frequency distribution of flocks shot at versus flocks not shot at ($\chi^2_{15} = 22.13$, $P > 0.05$).

Out of 156 shots registered fired at geese, 26 shots resulted in successfully downed geese (16.7%). In only three cases, it was observed that more than one goose per flock was downed. There was no relationship between flock size and success (individuals in a given flock downed or not downed), neither on the full range of flock sizes (logistic regression, $\chi^2_1 = 1.03$, $P > 0.05$) nor on flock sizes ranging between 1 and 10 ($\chi^2_1 = 0.962$, $P > 0.05$). Hence, birds in small flocks were more likely to be downed.

In flocks subsequently observed in fields, the ratio between juveniles and adults decreased with flock size (Fig. 3). Average brood size was 1.83 (± 0.33 SD, $n=68$). Assuming that all juveniles were attached to two parents (more than 95% of juveniles fulfilled this assumption in the present study; J. Madsen unpublished data) it can be

calculated from the relationship between flock size and ratio of juveniles/adults (Fig. 3) that, in flocks of <60 individuals, the majority of individuals were family group members. In flocks of <60 individuals (excluding flocks <3), the average proportion of juveniles was 45.5% ($n=41$), while in larger flocks, it was 20.4% ($n=21$), which is significantly lower (Mann–Whitney U test, $U=131$, $P < 0.001$). Out of 12 single individuals observed (excluding individuals which were obviously crippled), 10 were older birds, and out of 15 duos observed, 14 were composed exclusively of older birds.

Discussion

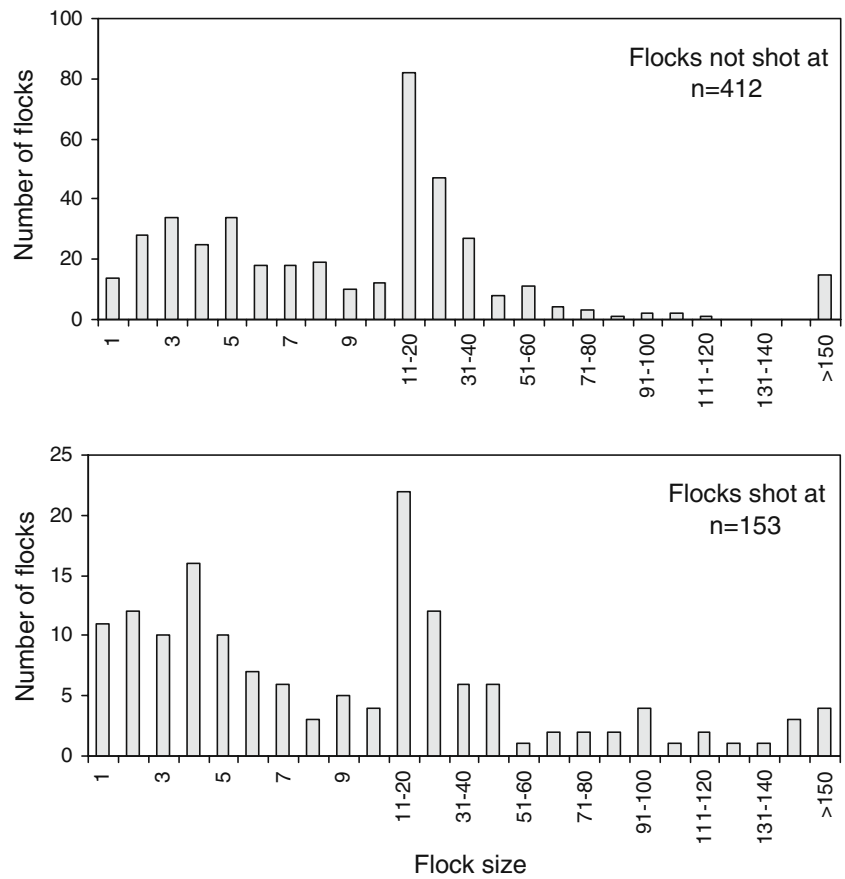
Despite a small sample of wings from bagged pink-footed geese, there was a consistently higher proportion of juveniles shot than observed in the autumn population at large. This result is similar to those found in other goose populations (Grieb 1970; Boyd et al. 1982; Wright and Boyd 1983). That young geese are more vulnerable to hunting than adults has also been shown by age-specific analyses of survival in lesser snow geese (*Anser c. carulescens*) (Francis et al. 1992).

Because there was no difference between the flock size distribution among geese shot at and those generally observed, it can be assumed that hunters shoot at goose flock size in proportion to the general probability of encounter. This is contrary to studies of canvasback (*Aythya valisineria*; Olson 1964) and mallard (*Anas platyrhynchos*) hunting (Dufour and Ankney 1995) where it was found that single birds were more vulnerable than flocking birds. The difference may reflect that the two duck species, in contrast to pink-footed geese, are mostly shot using decoys and that lone birds are more readily attracted to decoys.

The observations demonstrated that the number of shooting opportunities was connected to the flocking behaviour of pink-footed geese. If, theoretically, all geese present in the study area had taken off from the roost in one flock, to land in one flock in the feeding fields, hunters would have had limited shooting opportunities. If, however, as was the case, many small flocks of geese fly around, the hunters get a proportional increase in the number of opportunities to bring down birds.

The combination of the high frequency of encounter of small flocks and small flocks being composed mostly of families (with the exception of single birds and pairs) results in a disproportionately higher likelihood of family units being shot at compared to their general frequency in the population as a whole. It is calculated that 28% of all juveniles and 22% of all older birds occurred in flocks of <10 individuals (median flock size was 9). Given that success to down geese was unrelated to flock size and that

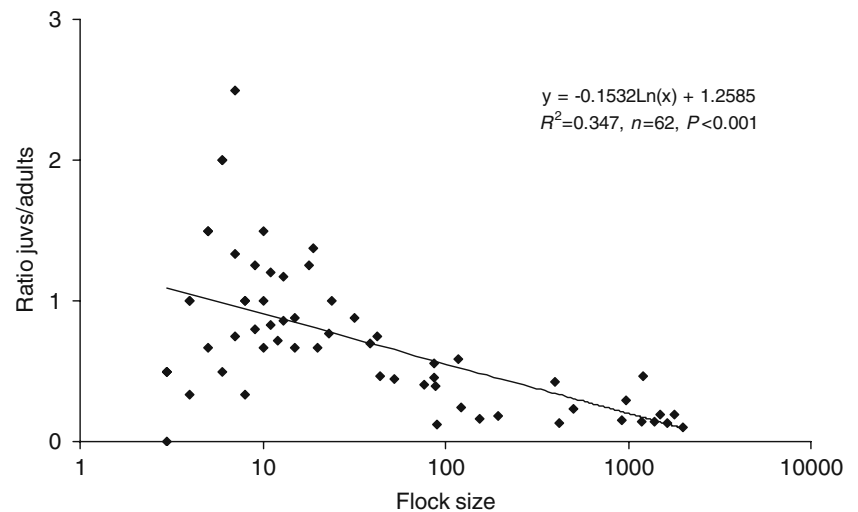
Fig. 2 Distribution of flock sizes of pink-footed geese shot at and not shot at during their morning flight between the roosts and the farmlands



hunters largely only downed one goose per flock, it is estimated that for juveniles occurring in flocks of <10 individuals, the likelihood of being shot at is 2.5 times higher than for juveniles in larger flocks; similarly, for older birds, it is 3.4 times greater. With an arbitrary cut-off flock size of 100 individuals, the exposure to hunting increases dramatically: 24 times higher for juveniles in flocks of <100 individuals compared to larger flocks and 59 times

higher for adults. Even if the assumption about equal shooting opportunities across flock sizes should not hold in all situations, the calculations suggest a major ‘predator swamping’ advantage to members of the larger flocks. The finding that the success to bring down geese was not related to flock size was also reported in a study of duck hunting (Hochbaum and Walters 1984); however, the generality of this requires further study.

Fig. 3 The ratio between juveniles and adults in flocks of pink-footed geese in relation to flock size. Single birds and pairs have been excluded



Single individuals are most likely to be unpaired second-year birds or stray juveniles (Boyd 1953; Raveling 1969). Single juveniles may be more vulnerable to hunting because of inexperience (Owen 1980) or because poor condition makes them more risk prone (Greenwood et al. 1986; Heitmeyer et al. 1993). However, in the present data set, most of the single individuals were not juveniles. Furthermore, there was no sign of a difference between the proportion of single birds observed flying and the proportion of single birds shot at. Therefore, it is unlikely that vulnerability of single juveniles is an important contributor to the juvenile bias in the bag of pink-footed geese. Within the family flock, juveniles may be more vulnerable than parents either because juveniles may react more slowly to a hunter or more readily to decoys because of inexperience (Giroux and Bédard 1986). In the present study, decoys were rarely used, but in other parts of the autumn range of the species, decoys are often used. To substantiate this, more studies are required on individual reactions by geese as well as on the targeting behaviour of hunters.

In summary, the observations suggest that the juvenile bias in the bag of pink-footed geese is to a large extent explained by flocking behaviour, and inexperience by single orphan juveniles seems to be of minor importance. An inference of this conclusion is that there also should be a disproportionate larger bag of parents than of older non-breeding/failed breeding birds. In support of this, Francis et al. (1992) found that adult breeders of lesser snow geese, marked on the breeding grounds, experienced higher hunting mortality than adult, non-breeding birds.

The findings may contribute to explain why pink-footed geese carrying shotgun pellets in their tissues have a lower annual survival probability compared to geese without pellets as described by Madsen and Noer (1996). One causal explanation is that geese with pellets are injured with a consequent poorer condition and hence may experience a reduced survival. However, Madsen and Riget (2007) showed that body condition of birds carrying pellets (X-rayed during spring, i.e. after the hunting season) was not different from that of geese without pellets and, therefore, this hypothesis is unlikely. An alternative explanation for the differential survival is that a certain segment of the population is more vulnerable to hunting than others, i.e. if an individual has been hit once but survives, it is also more likely to be hit (and killed) later on in life. The present study suggests that this may actually be the case, viz. that successfully breeding adults are more vulnerable. In most goose populations, successful breeding is confined to a relatively small proportion of the adults, which are successful year after year (Owen and Black 1990); hence, breeders will also be at a higher risk of being shot at.

Why do families fly in separate small flocks when it incurs a higher risk of predation from hunting? A likely

explanation is that families make different behavioural trade-offs between predation risk and feeding requirements compared to non-breeders (e.g. Abrahams and Dill 1989; Lima and Dill 1990; Suhonen 1993). In the Danish autumn-staging areas, food supplies are limited and waste grain is rapidly depleted by geese (Madsen 2001). The larger flocks deplete the resource most rapidly and involve most aggressive encounters at highest bird densities. Probably due to higher food demands, families often feed on the edges or in the front end of the large goose flocks where the density of food is highest (brent goose *Branta bernicla*, Teunissen et al. 1985; barnacle goose *Branta leucopsis*, Black et al. 1992). In the case of the pink-footed geese, small family parties were often feeding separately and in patches outside areas used by the large flocks (J. Madsen, unpublished data) possibly to avoid the rapid depletion (and perhaps higher interference rates) experienced in the larger flocks. Hence, the underlying mechanism behind the feeding segregation of families may be condition driven; however, it is not poor condition as such which is the explanation of the vulnerability of juveniles but the nature of the flocking behaviour.

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