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Crippling ratio: A novel approach to assess hunting-induced wounding of wild animals

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ABSTRACT

In order to use recreational hunting as a socially acceptable management tool, the practice of this activity should adhere strictly to the ethical standards of animal welfare and the conservation guidelines on sustainable harvest. A key measure in this regard is monitoring the negative side effects of hunting associated with crippling of wild animals. This study introduces "crippling ratio" (the number of individuals crippled for each successfully bagged) as a novel approach to evaluate hunter performance in a way that accounts for differences in population size and harvest pressure, and which therefore can be used to evaluate initiatives launched to reduce wounding of wild game. We demonstrate that crippling ratios of Svalbard-breeding Pink-footed Geese *Anser brachyrhynchus* has been declining steadily over the last 25 years despite an increasing harvest rate. Hence, for juvenile birds that have not previously experienced a hunting season, and therefore can be used as a direct measure of annual variation in the crippling ratio, the number of geese crippled for each goose bagged dropped from 1.00 in 1992–0.11 in 2016. This corresponds to an 89% reduction in crippling frequency. Among adult birds the ratio dropped from 9.75 in 1992–1.99 in 2016, corresponding to a reduction of 80%. This positive development might be ascribed to effective awareness campaigns, training of hunters and adjustment of hunting techniques in both Denmark and, recently, Norway. It exemplifies that monitoring the outcome of management programmes is an important element in ensuring that measures introduced to manage wildlife are socially defensible.

1. Introduction

Waterbird hunting is a widespread recreational activity and a key factor in the management of many waterbird populations. The direct and indirect effects of hunting on harvested as well as protected populations are subject to ongoing debate (Fox and Madsen, 1997; Haig et al., 2014; Nichols et al., 1995; Newth et al., 2011; Norton and Thomas, 1994; Sutherland, 2001). Whether hunting of wild animals serves as a management tool, a source of food, a mere recreational activity or any combination of these, it should be performed sustainably, ensuring the conservation status of populations as well as reducing negative side effects, such as displacement of birds from critical resources due to disturbance, lead poisoning or crippling (European Commission, 2008; Madsen et al., 2015a).

Crippling due to shotgun shooting has for long gained focus in waterbird management (Elder, 1950; Joensson et al., 1985), not only because it constitutes an ethical and animal-welfare problem but also because it may potentially affect population dynamics through reduced survival of inflicted individuals. Mortality due to crippling may happen shortly after injury (within days or weeks), without the injured individual being retrieved by the hunter, or from more subtle long term effects (Madsen and Noer, 1996). Main causes of crippling are shooting at birds at too long ranges, use of suboptimal shotgun ammunition and shotguns and, more generally, lack of experience in shooting at overflying waterbirds (Noer et al., 2006). In Denmark, x-ray investigations carried out in the early 1990s showed high rates of crippling in geese and eider ducks. This led to a national action plan to reduce crippling, organized by the statutory authorities and the Danish Hunters' Association. The plan included annually recurrent awareness campaigns during 1997–2005 and relevant training of hunters. Subsequently, reductions in crippling rates were observed, which could be ascribed to the successful campaign (Noer et al., 2007). A slight increase in crippling rate of Pink-footed Geese during 2009–2011 triggered the need for recommencing these initiatives, and a second round of recurrent campaigns was introduced in 2012 and is still running.

Recently, adaptive harvest management of Svalbard-breeding Pink-footed Geese *Anser brachyrhynchus* has been introduced to regulate the size of this population, as part of the first International Species Management Plan (ISMP) under the auspices of the African–Eurasian

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Migratory Waterbird Agreement (AEWA, Madsen and Williams, 2012). Alongside the long-term aim of maintaining a stable population size around 60,000 birds by means of adaptive harvest management, an important objective is to secure long-term conservation of this species and continued societal accept of hunting as a management tool. To this end, the AEWA Pink-footed Goose International Working Group (constituted by national statutory agencies, stakeholder organizations and experts) has decided that crippling of geese as a result of hunting should continue to be reduced (http://pinkfootedgoose.aewa.info/node/196). This decision gave rise to simultaneous campaigns in Denmark and (from 2014 onwards) Norway, and in recent years the monitoring of crippling has been organized in connection with the management plan to fulfil the objective of continuously declining crippling rates. The objectives of increased harvest and reduced crippling may be conflicting, because, intuitively, increasing the harvest rate on the population will also increase the crippling rate. Thus, if a continued decrease in crippling rates has to be achieved, it requires a continued improvement in shooting performance by the hunters.

Evaluating the level of crippling among waterfowl species is usually done by x-raying individual birds to identify embedded shotgun pellets. X-rayed birds may be either living individuals caught by cannon-netting or similar capture methods (Noer et al., 2007), or individuals killed by means other than standard shotgun shooting (Holm and Haugaard 2013). Crippling levels are usually reported as a "crippling rate", defined as the percentage of birds x-rayed with embedded shotgun pellets. While this measure is a valid proxy of the level of crippling on wild populations, it is also very sensitive to changes in harvest rate of the population in question: a rise in the proportion of a population being shot will (given that the frequency of crippling is unchanged) invariably lead to a corresponding increase in crippling rate. Consequently, crippling rate cannot be used as a direct measure of performance among hunters and long term time series of crippling rate can be difficult to interpret. In order to evaluate appropriately the efficiency of hunters in minimizing crippling frequency, a new approach incorporating harvest rates is therefore necessary.

Here we propose the use of "crippling ratio" as a method to evaluate the quality of hunter performance, and present how crippling rate and crippling ratio have changed in the population of Svalbard-breeding Pink-footed Geese during the period 1992–2016.

2. Methods

2.1. Captures of Pink-footed Geese

Svalbard-breeding Pink-footed Geese migrate via stopovers in Norway to wintering areas in Denmark, The Netherlands and Belgium. During southward migration the population is hunted in Norway (current open season from Aug 10th–Dec 23th; Svalbard Aug 20th–Oct 31st), which accounts on average for 25% of the total bag, and in Denmark (current open season from Sep 1st–Jan 31st), accounting for 75% of total birds shot. Geese are hunted both on inland foraging sites using decoys and blinds and during flights between night time roosts and feeding areas. The species is protected in the Netherlands and Belgium.

The population has been subject to a long-term study of crippling initiated in 1990, and since then a total of 3308 individual geese have been x-rayed to identify embedded shotgun pellets. Geese have been caught by cannon-netting in spring (after the hunting season) in western Jutland, Denmark and in Nord-Trøndelag, mid Norway. At all captures geese were ringed with metal rings and neck-collars, sexed by cloacal examination and aged by use of feather characteristics (divided into juvenile birds having been exposed to one hunting season and older (adult) birds which have survived two or more hunting seasons). All individual geese were screened by x-ray for the presence of shotgun pellets, and the number of embedded pellets recorded.

2.2. Developing crippling ratios

In order to assess hunter performance in a way accounting for changes in harvest rate, we calculated the crippling ratio as:

$$Crippling\ ratio = \frac{Crippling\ rate}{Harvest\ rate}$$

Crippling rate was defined as the proportion of birds with embedded shotgun pellets, and harvest rate as the proportion of the population being shot. The unitless crippling ratio thus indicates the number of geese crippled per successfully bagged goose, and is therefore a suitable measure of hunter performance. While crippling rate is readily available from the x-ray data as:

$$Crippling\ rate = \frac{No.\ ofbirds\ with\ embedded\ shotgun\ pellets}{No.\ of\ \ birds\ x - rayed}$$

harvest rate depends on knowledge of the population size prior to the hunting season and total hunting bag of the species in question:

$$Harvest\ rate = \frac{Hunting\ bag}{Population\ size\ prior\ to\ hunting}$$

Population size of Pink-footed Geese is assessed annually by means of internationally coordinated ground-based surveys organized as part of the AEWA International Species Management Plan of this species (Madsen et al., 2016b; Madsen and Williams, 2012), and to estimate annual population size prior to the hunting season we used the approach described by Clausen et al. (2017). We differentiated between juvenile and adult birds assuming a juvenile bias in the hunting bag of 5.74 and 2.53 for Norway and Denmark respectively (average values reported in Clausen et al., 2017). Annual hunting bags of Pink-footed Geese are available from hunting bag statistics in both Norway and Denmark where this species has an open season, and relies on either hunter reports or a combination of hunter reports and standardized wing surveys (see detailed description in Madsen et al., 2015b). Crippling ratios of adult birds therefore represent a cumulative effect of crippling across several seasons, while crippling ratios of juvenile birds can be thought of as a direct measure of annual conditions. Due to low sample sizes in the early years, and a low number of caught geese in 2014, data samples from 1990 to 1992 and 2014–2015 were pooled as 1992 and 2015, respectively. In both cases the years pooled was very similar in terms of number of embedded shotgun pellets (no significant differences) and estimates of population size. Thus, pooling these years allowed us to include all available data, and secured an appropriate sample size for the important early 1990s data point, without compromising quality of the data used.

3. Results

Although crippling data were available for the early 1990s most were from 1998 onwards (Table 1). Among adults the proportion of crippled birds (the crippling rate) showed a declining trend from 36% in 1992–20% in 2002, after which it more or less stabilized in the following years (Fig. 1). For adult birds annual variation is likely to be dampened by the cumulative effects of hunting over several years. Among juveniles, crippling rate was comparatively high (25%) in the first year of the study (1992), and subsequently dropped to around 10% in the following years (Fig. 1). Although some fluctuation in crippling rate of juveniles exist throughout the study period (from 4% in 2009 and 2016–12% in 2012), sample sizes are generally smaller for juveniles compared to adult birds, and annual estimates are therefore expected to vary to a greater extent (Table 1).

Harvest rates of both adult and juvenile Pink-footed Geese were substantially higher during the last decade of the study compared to previous years, strongly indicating that in recent years a higher proportion of both juvenile and adult birds were shot (Fig. 2).

In contrast to the crippling rate, the crippling ratio accounting for

Table 1
Numbers of birds x-rayed to assess crippling levels throughout the study period.

Year	Adults	Juveniles	Total
1992	278	67	345
1998	258	79	337
2000	134	17	151
2001	171	20	191
2002	227	47	274
2003	176	29	205
2004	219	70	289
2005	322	73	395
2009	159	28	187
2011	121	49	170
2015	334	80	414
2016	252	98	350
Sum	2651	657	3308

differences in harvest rate showed a continuously declining trend throughout the study period. The crippling ratio (number of geese crippled for each goose bagged) of juvenile birds dropped from 1.00 in 1992–0.11 in 2016 (Fig. 3), corresponding to an 89% reduction. Among adult birds (that may have accumulated pellets across several hunting seasons) the ratio dropped from 9.75 in 1992–1.99 in 2016 (Fig. 3), corresponding to a reduction of 80%.

4. Discussion

In order to minimize societal conflicts and secure future conservation, management of natural resources in general and migratory waterfowl in particular should always adhere to the principles of sustainability (see AEWA Conservation Guidelines: http://www.unep-aewa.org/publications/technical-publications?field_publication_type_tid=369). Specifically regarding hunting of wild birds, harvesting practices are subject to recommendations from the Conservation Guidelines on Sustainable Harvest of Migratory Waterbirds (Madsen et al., 2015a), which states that "hunters must be able to use hunting methods in an adequate way to avoid crippling". In this paper we demonstrate the first example of a method that can effectively evaluate hunter performance in terms of game wounding, in a manner taking into account changes in population size and hunting pressure of the desired population. This allows for a direct assessment of the negative side effects associated with hunting, and makes us capable of evaluating the outcome of campaigns to reduce crippling, shooting courses and other means to improve hunting practice. This should in turn enable a better guidance on future policy relying on hunting as a management tool.

Results from this study indicate that crippling of Pink-footed Geese has generally declined during the last 20 years. The development of a crippling ratio reveals that hunter performance (measured as the frequency of crippling) has steadily improved during this period. Consequently, the more or less constant proportion of birds with embedded shotgun pellets in recent years is the result of a substantial increase in harvest rate in conjunction with lower frequencies of goose crippling. The continuous decline in crippling frequency of Pink-footed Geese has taken place in a period of rapid geographical expansion of the population, which could have led to increased exposure to new and inexperienced goose hunters (Clausen and Madsen, 2016; Madsen et al., 2015b). While our data indicate that this exposure has not had negative knock-on effects on the level of crippling, continued improvement of crippling ratios in this species probably rely heavily on dissemination of good goose hunting practices to new hunters and hunters in areas that Pink-footed Geese have only recently started to occupy.

The long periods of recurrent awareness campaigns in Denmark, and the multifaceted nature of the associated initiatives, render causal relationships with crippling ratio difficult to establish. Nonetheless, comparison of crippling levels before and after the first campaign in 1997 strongly suggests a positive effect of this effort (Noer et al., 2007). The first campaign to reduce crippling of Pink-footed Geese was solely targeting Danish hunters who take the majority of the total harvest (on average 75%). Since the implementation of the ISMP for Svalbard-breeding Pink-footed Geese, the focus of reducing crippling has been lifted to an international level for this species (Madsen and Williams, 2012). Subsequently, campaigns to reduce crippling have been initiated in Norway and have been continued in Denmark as well.

Currently there is an ongoing debate in Europe regarding the use of lead vs steel shots for shotgun hunting (Thomas et al., 2015). In Denmark the use of lead-based ammunition for hunting was banned in wetlands in 1986, and a complete ban was imposed in 1996. In Norway

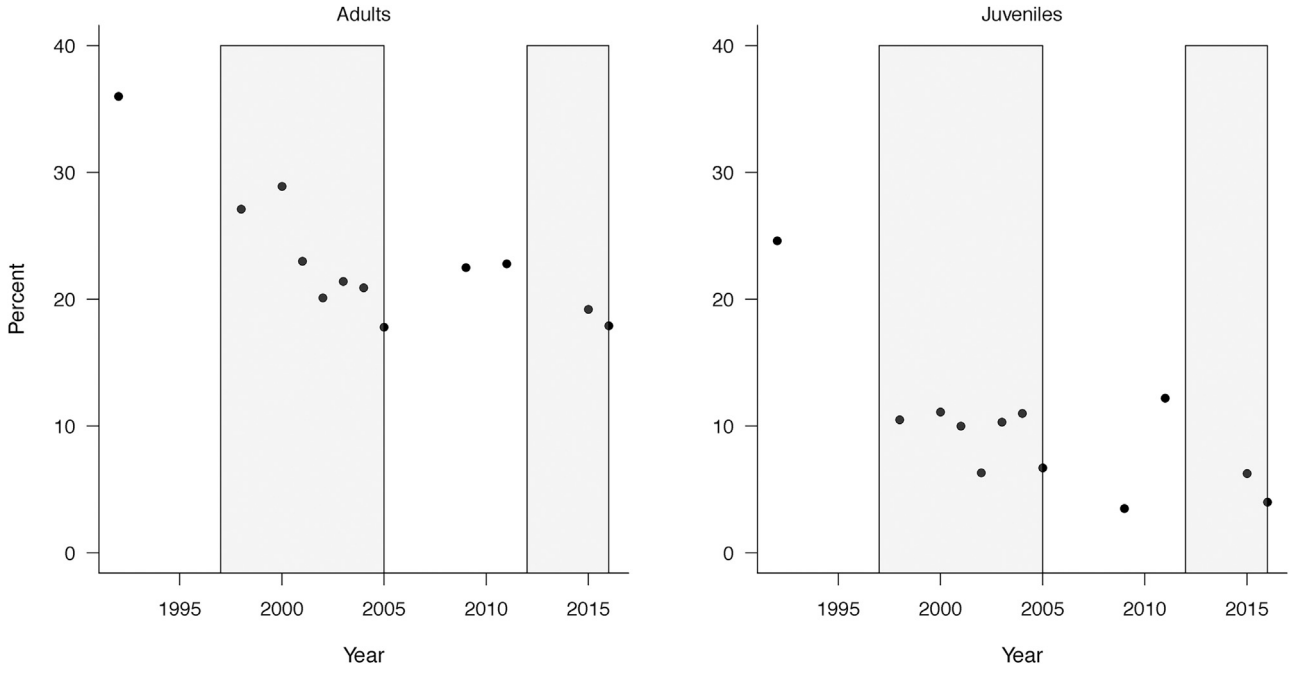

Fig. 1. Crippling rate of adult (left) and juvenile (right) Pink-footed Geese *Anser brachyrhynchus* during the period 1992–2016. Shaded areas indicate periods of recurrent awareness campaigns to reduce crippling.

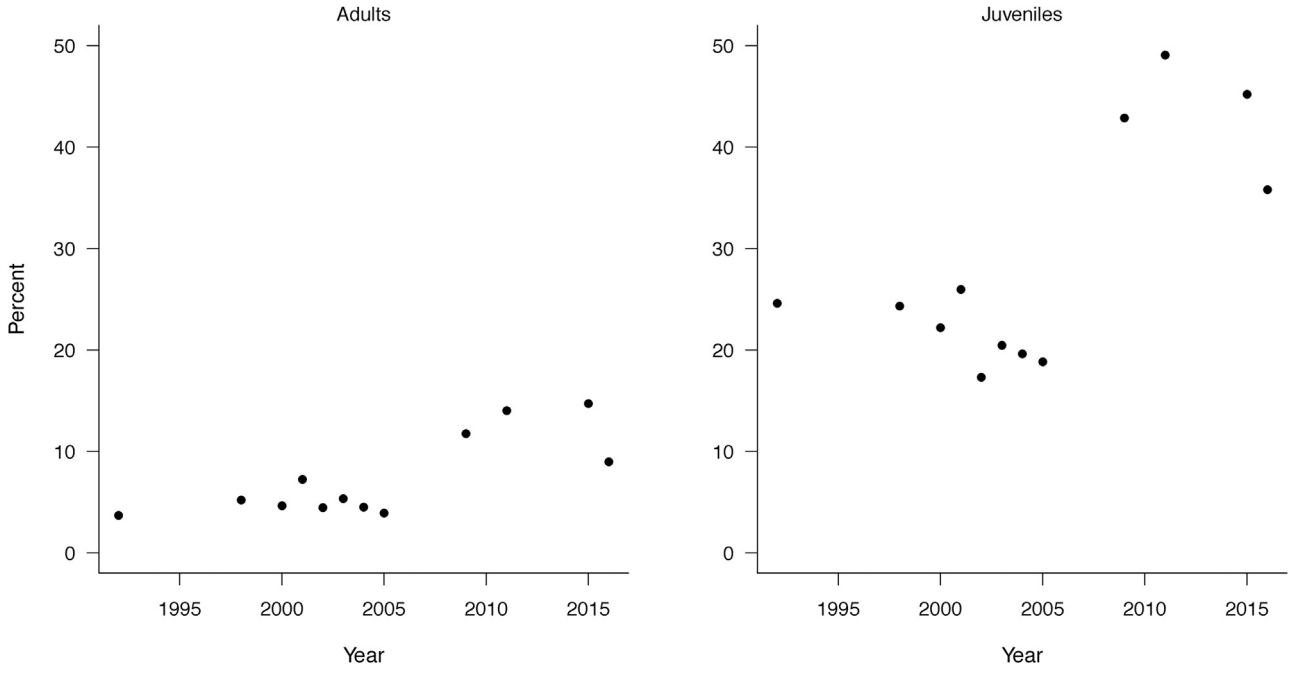

Fig. 2. Harvest rate of adult (left) and juvenile (right) Pink-footed Geese *Anser brachyrhynchus* in years with an assessment of crippling during the period 1992–2016.

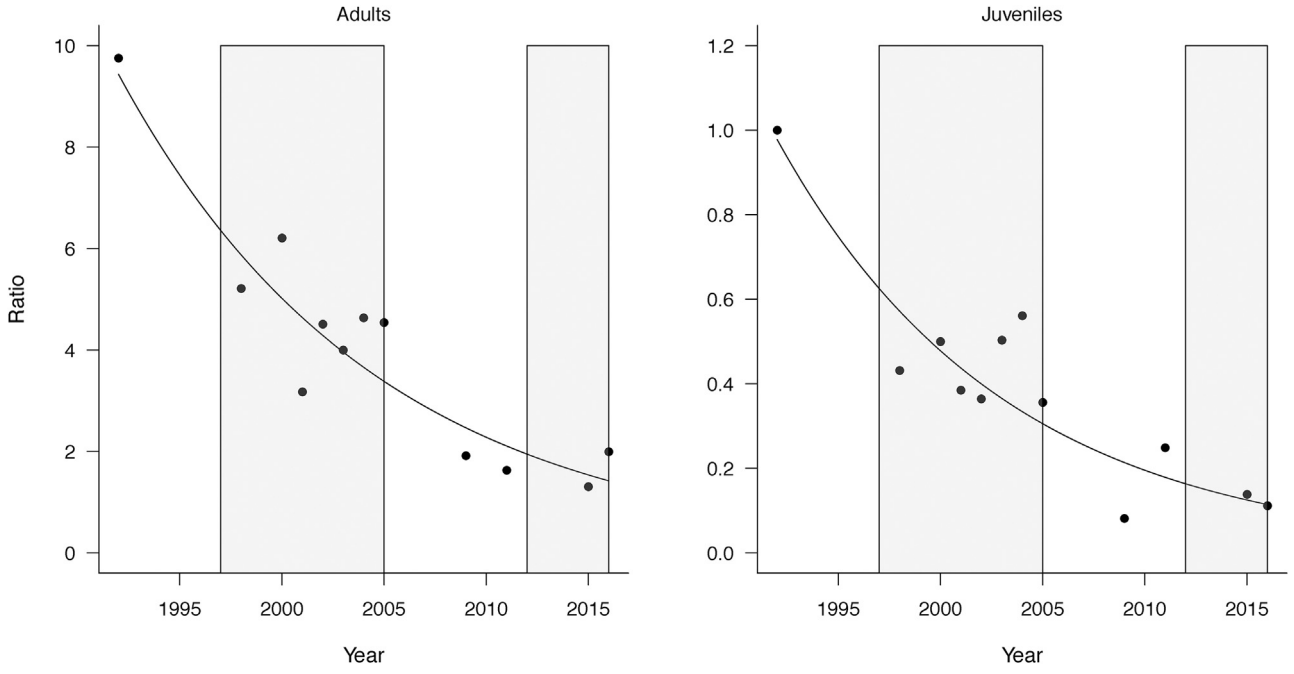

Fig. 3. Crippling ratio of adult (left) and juvenile (right) Pink-footed Geese *Anser brachyrhynchus* during the period 1992–2016. Lines indicate the best exponential fits, corresponding to an annual decrease of 7.6% (adults) and 8.6% (juveniles). Shaded areas indicate periods of recurrent awareness campaigns to reduce crippling.

hunting with lead was banned in 2005, and although partly reopened in 2016 this step was taken after our study period. As the vast majority of Pink-footed Geese are shot in Denmark, it should be safe to regard our crippling data after 1990 as based mainly on hunting with steel, and from 2005 onwards with steel only (alternatively bismuth and tungsten). Based on the development in crippling ratio in this study we have no reason to believe that the ban of lead-based ammunition led to higher levels of crippling.

It follows from the definition of crippling rate that this measure includes only lightly wounded birds that were able to survive with the infliction from shotgun pellets. In addition to these, a number of geese may be wounded to the extent that they die shortly after. These birds cannot be accounted for in the current (or any other) measure of wildlife crippling, but obviously adds to the total negative impact. Nevertheless, the decline in crippling ratio also indicates that the level of severely wounded geese is declining, hence that the overall population impact of wounding is likely to have been reduced.

The ISMP of the Svalbard-breeding Pink-footed Goose currently relies heavily on recreational hunting as a means of regulating population size (Madsen et al., 2016a; Madsen and Williams, 2012). Acknowledging that continued societal acceptance of recreational hunting as a management tool also depends strongly on the adherence to the ethical principles of sustainable harvest, ongoing monitoring of the potential negative effects of hunting – including crippling – is essential to this process.

Ethics statement and funding

Capture and x-raying of geese were performed under license by the Danish and Norwegian Ringing Centres as well as the Norwegian Food Safety Authority. The study was funded by the Danish Environmental Agency, the Norwegian Environment Agency and Aarhus University.

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