Eur J Wildl Res
DOI 10.1007/s10344-017-1080-y

ORIGINAL ARTICLE

Assessing hunters' ability to identify shot geese: implications for hunting bag accuracy

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Received: 18 July 2016 / Revised: 5 January 2017 / Accepted: 6 January 2017

Abstract Reliable hunting bag statistics are a prerequisite for sustainable harvest management. Recently, Internet-based hunting bag reporting systems have been introduced in some European countries, e.g. Denmark, which may enable faster and more detailed reporting. However, reporting of waterfowl bags on a species-specific level may be biased from the individual hunters' ability to correctly identify species, particularly because juvenile birds can only be identified from subtle differences. We assessed hunters' ability to identify the five goose species huntable in Denmark. Identifications were made from a line-up of ten full-bodied geese including adults and juveniles. From a total of 2160 identifications made by active hunters, 85.5% were correct while 14.5% were assigned to a wrong species. Active hunters had on average an identification accuracy of 76.0%, highest for Canada goose (99.1%) and lowest for white-fronted goose (74.6%) and bean goose (73.7%). Identification accuracy was significantly lower for juvenile than for adult individuals of white-fronted and bean geese. Correcting the official Danish Bag Record (2013/2014) for identification accuracy, the bags of white-fronted and bean geese increase by 56.5 and 104.4%, respectively, while the bags of greylag and pink-footed geese decrease by 6.7 and 9.0%; the bag for Canada goose remains unchanged. Although identification accuracy is probably higher under field conditions, the study documents that inaccurate species identification is a source of bias in national bag statistics. Hence, improving identification skills by hunters is important to improve bag data accuracy when based on Internet reporting.

Keywords Hunting · Bag size · Waterfowl · Goose hunting · Species identification

Introduction

For wildlife populations subject to hunting, information of hunting bags and of population sizes and trends are of key importance to ensure sustainable exploitation (Brainerd 2007, European Commission 2008). For migratory species, clear population and/or flyway delineation is likewise needed, in order to define the population unit subject to exploitation and the geographical range of exploitation (see Scott and Rose 1996, Boere and Stroud 2006).

Internationally coordinated inventories on the wintering grounds (Nagy et al. 2014, 2015) provide estimates of most populations of migratory waterfowl in the West Palaearctic region which are otherwise difficult to obtain via surveys in the vast breeding areas in northern Scandinavia and Russia. However, with few exceptions, internationally coordinated bag statistics do not exist, making total hunting exploitation difficult to assess properly, especially for trans-border migratory species. National bag statistic programs exist in most European countries, but these are not harmonized and differ in geographical and species coverage, methodology and timing, often with years of delay between sample year and reporting. So far, relatively few studies have attempted to provide a full overview of hunting exploitation of waterfowl within the European Union (Tamisier 1985, Hirschfeld and Heyd 2005, Mooij 2005), but such data need to be standardized and reported on a regular and up-to-date basis if international management of migratory species shall be effective and

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Published online: 13 January 2017

adaptive (cf. Beintema et al. 2005, Madsen and Williams 2012, Madsen et al. 2015).

Implementation of Internet-based platforms for bag reporting, that allow individual hunters to report their bag at the end of the hunting season, may greatly improve national bag statistics and data accessibility. Such Internet-based reporting systems are already in place in several European countries (see the Artemis portal of FACE, the European Federation of Associations for Hunting and Conservation: www.artemis-face.eu). The benefit of Internet reporting is potentially an increase in hunter reporting rates and species coverage, more precise bag totals and a relatively fast and regular (annual) post-season reporting (but see Vaske 2011). Hunter-derived bag statistics may, however, be biased for several reasons, and some countries supplement or extend their hunting bag schemes with mail surveys, professional species determination or Wing Surveys, as seen in North America and some European countries (e.g. Raftovich et al. 2009, Christensen 2016, Alhainen et al. 2010). Some countries perform random questionnaires to obtain data used to correct bag statistics for known biases related to survey method and design, hunter characteristics and memory loss, rounding of bagged numbers and missed reports (e.g. Chu et al. 1992, Beaman et al. 1998, Asferg 1996, 2008, Miller and Anderson 2002). Basically, most reporting systems depend on the hunters' ability to make accurate species determination, but the effect of the identification ability of hunters on bag reporting has, however, not attracted much attention (see Atwood 1956, Sen 1973, Wilson and Rohwer 1995). Consequently, there is a lack of knowledge on how capable hunters are to determine or differentiate between many of the look-a-like species, which is a particular problem in juvenile and female Anatidae (AEWA 2015).

In the present study, we examine the ability of Danish hunters to correctly determine the five species of geese that are huntable in Denmark. With a mandatory Internet-based bag reporting system in place since 2012, hunters have to report their bag by species. Although educational material for new licence applicants, including species identification, has been updated recently, no assisting guides providing detailed information of how to identify and age goose species based on plumage characteristics have been produced. Given these conditions, the overall aim is to assess and quantify the potential bias in the data reported to the national Danish Bag Record (Strandgaard and Asferg 1980) resulting from inaccurate species determination made by individual hunters. As species determination may be affected by correct classification of goose age and with adults dominating the annual goose bag, we also included hunters' determination accuracy of goose age classes (adults and juveniles) in the assessment of the reported totals of species-specific bag sizes.

Methods

Dead geese were identified by visitors at the annual Danish outdoor and hunting fairs in the cities of Ålborg (in 2013) and Odense (in 2014) and at courses in goose shooting held for groups of goose hunters, including both novice and experienced persons, in two local areas in western and northern Jutland, Denmark, in 2013 and 2014. On all occasions, respondents were presented to ten full-bodied dead geese, representing two specimens of the five goose species huntable in Denmark: greylag goose *Anser anser*, white-fronted goose *A. albifrons*, pink-footed goose *A. brachyrhynchus*, bean goose *A. fabalis* and Canada goose *Branta canadensis*. In 2013, all species were represented by one adult and one juvenile bird, except for pink-footed goose, which was represented by two adults. In 2014, greylag and Canada geese were represented by two adult birds of each species, all other species by one adult and one juvenile bird.

The ten dead geese were lined up on a table, and each goose was tagged with a reference number. Before species identification of geese, respondents were informed that the identification array contained two of each of the five goose species huntable in Denmark presented in random order. They were informed that most species were represented by both an adult and a juvenile bird but that ageing was optional. In addition to writing their identifications of species on a form (full species name), respondents were asked to inform about their personal age, hunting experience (years holding a hunting licence), lifetime total goose bag (0, <10, 10–50, 50–100 and >100 geese) and if they shot geese last season (yes, no).

In total, 253 persons filed an identification form, each enclosing between four and ten identifications. Positive identifications as well as identification errors were assessed for each species/age constellation separately, providing figures of identification accuracy and the proportions erroneously assigned to other species. Identification scores were calculated as the sum of points given for correct identification (1) and wrong identifications (0), hence ranging between 0 and 10. The resulting scores (sum of correct determinations) can be treated as a multinomial distribution function. The relative figures of identification of the separate species/age constellations were subsequently used to assess the accuracy of the overall bag size in the official Danish Bag Record for the hunting season 2013/2014 (Strandgaard and Asferg 1980, Asferg 2014). This was done by calculating corrected bag sizes from the hunter identifications obtained in this study from the species-specific bag sizes reported to the official, Internet-based, Bag Record. To take into account differences in hunter identification accuracy between adult and juvenile geese, the official Bag Record data was divided into age groups, based on data from the Danish Wing Survey. The Danish Wing Survey processes on average 621 goose wings annually (average for the 2012/2013 and 2013/2014 hunting

seasons) which are determined to species and age, separating juveniles and older birds (Clausager 2004, Christensen 2016), and separated on a regional scale (14 counties previously used as administrative units) to deal with geographical differences in species distribution. To avoid inflation of inter-annual variation in reproduction and relative small numbers for some species, we calculated, however, species-specific age distributions from goose wings collected during the seasons 2009/2010–2013/2014.

Species-specific bag size based on the hunters' determination of geese was calculated as follows:

$$\text{Hunter BAG}_x = \sum_{y=1}^{10} \text{IA}_{(x|y)} \times \text{Bag}_y$$

where identification accuracy $\text{IA}_{(x|y)}$ is the frequency determined as species x when identifying species y (i.e. the identification accuracy value in Table 3), y is the ten possible species and age combinations and Bag_y is the age-specific bag size for y.

Statistical analyses include correlation analyses, general linear model, chi-square and ANOVA (Sokal and Rohlf 1981). We used the non-parametric Kruskal-Wallis test to test for changes in identification accuracy with experience, expressed as hunter age and years holding a hunting licence (data lumped into 10-year intervals). A generalized linear model using a multinomial distribution with a logit link function (GENMOD procedure; SAS Enterprise Guide 2013) was used to determine differences in identification accuracy between hunters that have bagged geese and hunters that have not bagged geese. In all analyses, significance level was set at 5%.

Results

The respondents

Of the 253 hunters that filed an identification form, 221 reported they were active hunters, 21 were not hunters or not active hunters (of these, 6 were in the process of achieving a hunting licence and 2 had previously been hunting) and 11 did not respond to this question. Of the active hunters that reported on personal goose bag ($N = 218$), 21.7% had never shot geese, 33% had shot 1–9 geese, 27.1% had shot 10–49, 8.7% had shot 50–100 and 9.6% had shot >100 geese in their lifetime, respectively. The average age of active hunters was 40.9 years (±16.0 SD, $N = 211$), and for these, the average number of years with a hunting licence was 20.3 (±16.9 SD, $N = 211$). The average age of all other respondents was 32.7 years (±11.8 SD, $N = 24$). The age distribution of respondents in this study differed from the age distribution of hunters that have reported a positive goose bag to the official Bag Record in the hunting season 2014/2015 averaging an age of 48.6 years (±15.4 SD, $N = 13{,}297$). Hence, the respondent group showed a higher representation of young hunters (age 15–30 years) and lower numbers of older hunters (>50 years of age) (Fig. 1).

Goose identification by hunters

As only few respondents made age determination, hunters' age determination accuracy could not be assessed by the data collected in the present study. If not explicitly stated, the following results only include the group of active hunters.

Out of 2210 potential identifications made by active hunters, 50 were left blank, leaving 2160 identifications in total. The numbers of responses per species and age are given in Table 1. Of these, 1847 (85.5%) represented correct species identifications, while 313 (14.5%) identifications were assigned to a wrong species. In identifying the five huntable goose species, greylag goose, white-fronted goose, pink-footed goose, bean goose and Canada goose, hunters showed the highest accuracy in identifying Canada geese (99.1%), followed by greylag geese (92.2%), pink-footed geese (86.9%), white-fronted geese (74.6%) and bean geese (73.7%).

Of the 14.5% wrongly identified geese, 12.2% ($N = 264$) were assigned to one of the other four huntable goose species, while 2.3% ($N = 49$) were assigned to non-huntable goose species (barnacle goose *Branta leucopsis* 6, lesser white-fronted goose *A. erythropus* 28 and brent goose *B. bernicla* 15). Despite that respondents were informed that there were two individuals of each of the five huntable species, 83 respondents (32.8%) made unbalanced identifications, e.g. one individual of one species and three of another species.

On average, individual active hunters had correct identifications on 76.0% (±9.9 SD) of their species determinations, regardless of number of IDs (range 60.0–86.1% among 4 to 10 given IDs). The average identification score in relation to numbers of IDs made for active hunters, persons not hunting and persons with unknown status are shown in Fig. 2. Among those that made all ten goose IDs within these three respondent groups, identification score did not differ significantly (ANOVA: $F_{2,228} = 1.94$; $p = 0.147$), although identification accuracy tended to be lower in the group with unknown hunting status (average score 7.4) compared to the identification score of active (score 8.6) and non-active hunters (score 8.6).

Identification accuracy when separating species into adult and juvenile birds is shown in Table 2. For greylag goose, pink-footed goose and Canada goose, there were no difference in identification accuracy between adults and juveniles, but for white-fronted goose and bean goose, identification accuracy was markedly higher for adults than for juvenile birds. Whereas identification accuracy for adult white-fronted goose was fairly high (89.4%), juvenile white-fronted goose obtained the lowest identification accuracy (59.5%) among all species/age constellations. Table 2 also shows in what proportions wrongly identified adult and juvenile individuals are

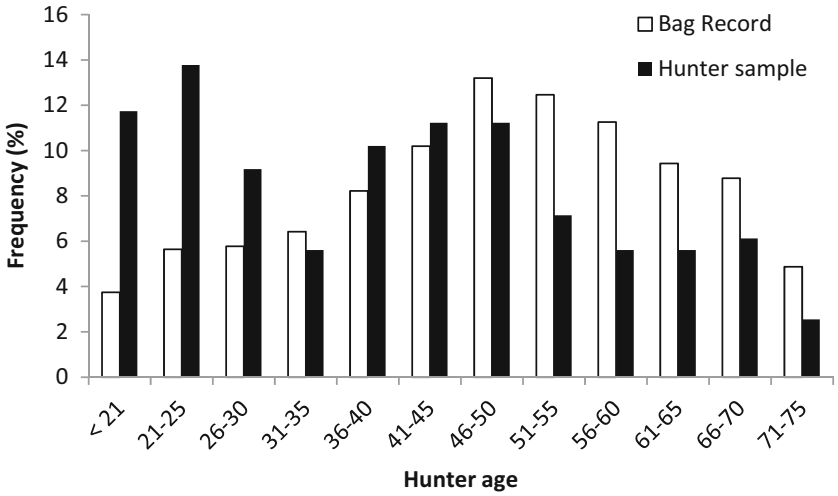

Fig. 1 Age distribution of 196 active hunters that made goose identifications at two hunting fairs and two courses for goose hunters in 2013 and 2014 in Denmark (hunter sample) and the age distribution of 13,297 hunters that have reported at least one bagged goose to the Danish Bag Record in the hunting season 2014/2015

distributed among the other four huntable goose species as well as among non-huntable species.

Among active hunters that made all 10 identifications (N = 194), identification accuracy in relation to experience as a hunter showed significant changes with hunter age (Kruskal-Wallis: χ^2 = 15.55, df = 5, p = 0.008) but not with years holding a licence (Kruskal-Wallis: χ^2 = 9.12, df = 5, p = 0.104). In comparison of hunters that had (N = 151) and had not (N = 43) bagged geese previously (Fig. 3), the effect of hunter age when having/not having a previous goose bag was not significant (χ^2 = 0.64, df = 1, p = 0.423) as was the interaction term of goose bag and age (χ^2 = 8.64, df = 5, p = 0.125). The effect of age was just insignificant (χ^2 = 10.54, df = 5, p = 0.061) (GENMOD procedure). As regression analyses of all respondents that had shot geese likewise showed no significant correlation between identification accuracy and number of geese shot (ANOVA: $F_{1,157}$ = 0.05, p = 0.822), the present analyses give no indications that experience with goose hunting markedly increased identification accuracy, although a slight increase in identification skills generally occurred with age (cf. Fig. 3).

Estimating hunting bag

Age-specific total bag sizes for the five huntable goose species were calculated from species-specific bag totals in the Bag Record and age ratios in the annual Wing Surveys (Table 3). With the exception of Canada goose, all species showed no significant annual variation in the age ratios of received wings (χ^2 tests, $p > 0.05$).

The total bag size of goose species calculated from the hunters' species determination (hunter sample; see formula in "Methods"), taking into account those lost to wrong identifications and those added from wrong determinations of other species, is shown in Fig. 4a. Compared to the official Bag Record, hunter determinations lead to a reduction in the numbers of bagged greylag and pink-footed geese of 3190 (−6.7%) and 794 (−9.0%), respectively, when corrected for misidentifications among all species. For white-fronted and bean geese, the net results showed an increase of 1419 (+56.5%) and 2008 (+104.4%), respectively, while Canada goose only showed a minor deficit of 77 individuals (0.8%).

Figure 4b shows the number of misidentifications for all species separated into adult and juvenile birds (negative scale) and how these are distributed among other species (positive scale). Incorrect determinations of the numerically dominating greylag geese (N = 3446) are the major source for increasing the bag sizes of white-fronted and bean geese, while wrongly determined pink-footed geese (N = 1156) contribute less.

Discussion

Species identification

The present assessment of hunter identification accuracy of huntable geese in Denmark showed an average individual

Table 1 Number of identification responses made by Danish hunters on adult and juvenile geese of the five different goose species at two hunting fairs and two goose hunting courses in Denmark in 2013 and 2014

	Greylag goose	White-fronted goose	Pink-footed goose	Bean goose	Canada goose	Total
Adult	309	218	341	210	313	1391
Juvenile	127	215	86	212	129	769

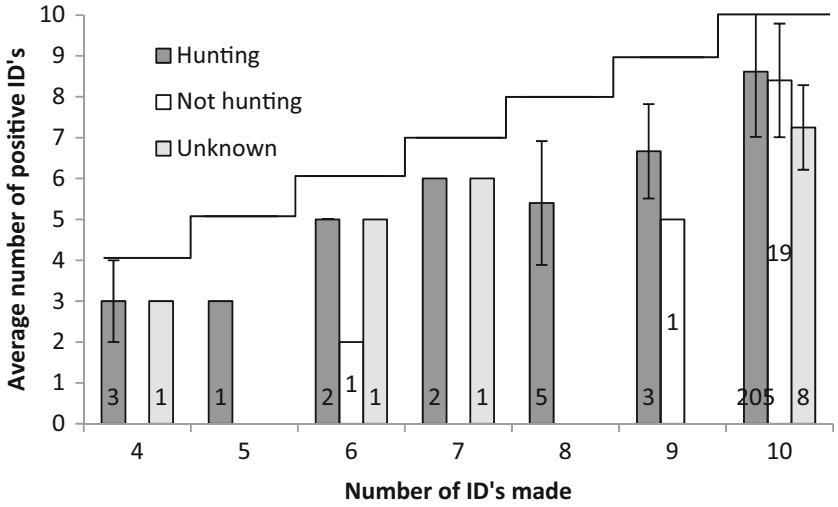

Fig. 2 Average identification score (±SD) in relation to number of identifications made by 221 active hunters, 21 non-active hunters and 11 respondents with unknown hunting status recorded at two hunting fairs and two courses for goose hunters in 2013 and 2014. The number of respondents is shown *inside the bars*. The *black line* shows maximum number of correct IDs that can be given

hunter identification accuracy of 76.0%. Despite a relatively high species-specific identification accuracy for the most common species, misidentifications of the numerically dominant species lead to marked increases in bag sizes of species bagged in smaller numbers and hence suggest that national hunting bags are somewhat biased in relation to the present identification skills of individual hunters.

We know no other study of hunter identification skills with respect to geese to which we could compare the present results. In North America, an assessment of hunters in-hand identification of duck species has been made by Wilson and Rohwer (1995), showing an average of 4.6 (~57.5%) correct identifications out of 8 ducks, including males and females selected among 13 species. Hence, higher identification accuracy seems to exist for goose identification compared to ducks, which follows expectations from both the monomorphic appearance of geese and the lower number of species.

Not surprisingly, we found that identification accuracy was highest regarding Canada goose, approaching almost completely accurate identifications (>99% for both adults and juveniles). This species shows conspicuous plumage characteristics (black and white head/neck pattern) different to the other four species, and only superficially resembling the non-huntable 'black goose' barnacle goose. Among the other species, identification accuracy was highest for the most commonly bagged species, the greylag goose, followed by pink-footed goose, and with the lowest identification accuracy in white-fronted goose and bean goose. Identification accuracy was markedly lower for juvenile birds than for adult birds in white-fronted and bean geese, but not differing in the other three goose species. This pattern is comparable to identification accuracy among American duck hunters, showing the highest identification ability with species they regularly encountered and lowest with females of uncommon species (Wilson and Rohwer 1995).

Table 2 Identification accuracy (in percent) made by 221 active hunters on full-bodied adult and juvenile geese of the five huntable goose species at two hunting fairs and two goose hunting courses in Denmark in 2013 and 2014 (*GrG* greylag goose, *WFG* white-fronted goose, *PFG* pink-footed goose, *BeG* bean goose, *CaG* Canada goose) as well as three protected species (*BaG* barnacle goose, *LWG* lesser white-fronted goose, *BrG* brent goose)

	Huntable					Protected		
	GrG	**WFG**	**PFG**	**BeG**	**CaG**	**BaG**	**LWG**	**BrG**
GrG ad	**92.9**^{ns}	3.2	0.4	3.2	0.0	0.0	0.0	0.3
GrG juv	**92.1**	3.1	0.0	3.9	0.0	0.0	0.9	0.0
WFG ad	0.5	**89.4*****	3.7	2.7	0.0	0.5	2.7	0.5
WFG juv	1.4	**59.5**	13.5	15.3	0.0	0.5	8.4	1.4
PFG ad	0.6	2.3	**86.8**^{ns}	8.2	0.0	0.0	0.6	1.5
PFG juv	1.2	1.2	**87.1**	6.9	0.0	1.2	1.2	1.2
BeG ad	9.5	4.8	4.8	**79.0****	0.5	0.0	0.0	1.4
BeG juv	5.2	20.3	5.6	**68.4**	0.0	0.0	0.0	0.5
CaG ad	0.0	0.0	0.0	0.0	**99.0**^{ns}	1.0	0.0	0.0
CaG juv	0.0	0.8	0.0	0.0	**99.2**	0.0	0.0	0.0

Bold figures mark correct identifications; incorrect determinations are assigned to both huntable and non-huntable goose species. Differences in identification accuracy within species were tested by chi-square: *ns* non-significant
**$p < 0.025$; ***$p < 0.01$

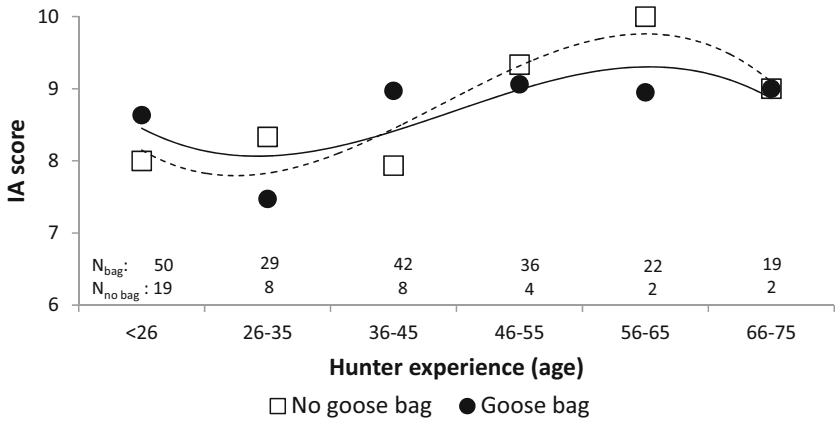

Fig. 3 Identification accuracy score (IA score) for hunters that have bagged geese and hunters that not have bagged geese in relation to hunter experience, expressed as hunter age (number of hunters in each age class is shown). Only respondents with ten identifications are included. Data were collected at two hunting fairs and two courses for goose hunters in Denmark in 2013 and 2014

The lower identification accuracy for the four species in the family *Anser*, often referred to as 'grey geese', is most probably related to more subtle species-specific differences that should be specifically known in order to make accurate identifications (Cramp and Simmons 1977, Madge and Burn 1988 and various field guides). The pattern of wrong determinations is largely what could be expected when considering plumage and other species-specific characteristics normally used in the identification of geese. It also follows an expected inability of most hunters to age geese, using mainly adult bird characteristics as identification clues, especially evident in the determination of juvenile white-fronted goose lacking the white forehead pattern of adults; probably, this mistake led to the lowest identification accuracy among all species examined. As geese in general are difficult to age from plumage characteristics, because accurate ageing depend on specific knowledge of moult pattern and feather shape (cf. Carney 1962, 1992, 1993, Boyd et al. 1975, Ogilvie 1978), hunters are only rarely assumed to know how to age shot geese, as also reflected in the lack of ageing in the present study.

Showing the highest identification accuracies probably also reflects that the greylag goose is the most common and widespread goose species in Denmark and the dominating species in the national goose bag (cf. Table 3, Fig. 4a). White-fronted geese have a high identification accuracy for adults and a low identification accuracy for juveniles. For both sexes, however, incorrect determinations are mainly, and in equal proportions, assigned to pink-footed goose and bean goose, suggesting that hunters at least are able to distinguish the white-fronted goose from the common greylag goose.

Of the 14.5% misidentified geese, only 2.3% were assigned to non-huntable and protected species such as lesser white-fronted goose, brent goose and barnacle goose. Resampling white-fronted goose, the majority of 'identified' lesser white-fronted geese were actually white-fronted goose, and with a surprisingly larger fraction of wrongly identified juveniles rather than adult birds. This indicates that although juvenile birds of both species lack the white forehead pattern, hunters positively identified the 'white-fronted species group' but were probably mistaken due to the small size of the juvenile white-fronted goose. The wrongly identified brent geese originated from all four 'grey goose species', while barnacle geese originated from white-fronted, pink-footed and Canada geese.

In general, the relatively low percentage of incorrectly identified geese reflects that hunters possess a relatively good knowledge of goose species occurring in Denmark. In addition, the low percentage of hunters incorrectly 'identifying' non-huntable species suggests that a small fraction of hunters

Table 3 Total bag size of geese reported by hunters to the Danish Bag Record for the hunting season 2013/2014, the Wing Survey data (numbers of adult and juvenile wings and percentage of age class) and the calculated age-specific total bag. No annual variation in age ratios was found (chi-square tests, non-significant (ns), except for Canada goose)

	Bag size	Wing Survey data (2009–2013)				Age-specific bag	
		N (ad)	*N* (juv)	Ad %	Juv %	Ad	Juv
Greylag goose	47,403	2,097^{ns}	523	80.0	20.0	37,940	9463
White-fronted goose	2513	181^{ns}	50	78.4	21.6	1969	544
Pink-footed goose	8833	566^{ns}	207	73.2	26.8	6468	2365
Bean goose	1924	71^{ns}	9	88.8	11.3	1708	216
Canada goose	9282	206*	64	76.3	23.7	7082	2200

*$p < 0.05$

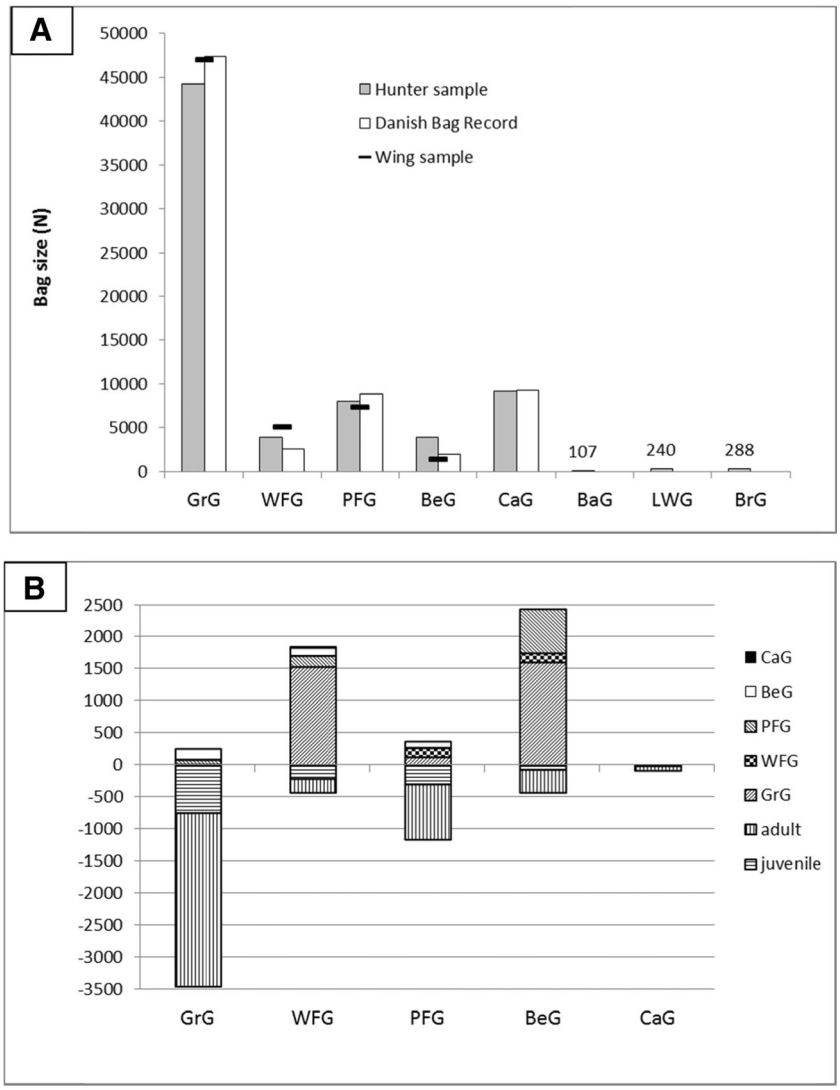

Fig. 4 **a** Total bag sizes of geese obtained from the sampled hunter identification accuracy (hunter sample; this study) and the official Bag Record (mandatory annual reporting). For the hunter sample, the number of incorrect identifications assigned to non-huntable goose species is shown. For the grey geese, *black horizontal lines* mark the total bag sizes estimated from the relative county-wise distribution of wings forwarded to the Wing Survey and the county-wise goose bag (calculation not shown). **b** The number of incorrect determinations expressed as the deviation between the Bag Record and the hunter sample (*negative scale*) separated into adult and juvenile birds and the species-specific allocation of these to other species (*positive scale*). For example, 3446 misidentified greylag geese (2701 adults and 745 juveniles; *negative scale*) are wrongly identified as 1526 white-fronted geese, 123 pink-footed geese and 1600 bean geese (*positive scale*)

are not fully aware of which species are legal to hunt and which are not but likewise indicates that hunters have knowledge of even generally rare species, such as the lesser white-fronted goose. It is, however, possible that some of the hunters identifying non-huntable species in the identification array for some reason did not trust or had not taken notice of the information given, that only huntable species were present in the array.

It can be argued that, with an overall identification accuracy for individual hunters of 76%, there is room for improvement in the determination of goose species. In the present study, however, identifications were made at hunting fairs or at field courses. This contrasts the normal situation, with goose hunting mainly taking place in traditional areas, and where many hunters may have a long experience and, hence, clear expectations of which goose species they are hunting and which species that may be present. Likewise, experienced hunters may even use species-specific calls of geese heard prior to the kill as a clue in their identifications. Thus, in the field, species misidentification may possibly be lower than recorded in the present study due to site-specific knowledge of goose occurrence and/or help in species identification from fellow hunters.

Identification accuracy tended to increase with hunter age, and this pattern was apparent regardless of hunters having shot geese previously or not. This suggests that identification skills increase with general experience and are not specifically linked to experience with goose hunting. Furthermore, hunters older than 50 years are underrepresented in the present study compared to the overall goose hunter population (cf. Fig. 1). This age class has a relatively high identification score and constitutes 46% of successful goose hunters in Denmark, compared to 27% in the present study. Therefore, if the results of this study were to be used to adjust the Danish Bag Record, a further weighting might be applied which adjusts the hunter identification accuracy from the hunter sample for the actual hunter age distribution of the Bag Record.

However, to what extent hunter age influences identification accuracy in the field is still questionable. The general tendency of identification accuracy to slightly decline during the first years of experience and subsequently increase to a higher and rather stable level found in the present study (Fig. 3) could reflect that lower identification accuracy naturally occurs at some point between the learning process of hunting (demanding species differentiation from plumage characteristics of huntable waterfowl species in textbooks) and before some personal experience with goose hunting is build up.

That the present study probably underestimates hunter identification accuracy compared to field conditions is also related to the fact that if hunters make one misidentification within the array of 10 geese, this automatically leads to at least one additional incorrect determination, if all 10 geese were responded to in the right balance (2 × 5 species). To some extent, this effect is outbalanced, as with 9 given correct identifications, there will be no room for a mistake on the last identification, despite any existing doubt. That hunters making less than 10 identifications in many cases probably stopped as a result of recognition of identification mistakes and from emerging confusion is also indicated by a marked decline in average identification accuracy from 86% among hunters with 10 identifications to 74 and 67% among hunters giving 9 and 8 identifications, respectively. A high identification accuracy among hunters making 6 (83%) and 7 (86%) identifications indicate that many have made identifications of personally known species and then stopped the ID process when in doubt.

Biases in the Bag Record

With an Internet-based bag reporting system in place in Denmark since 2006 and this being mandatory for all persons holding a hunting licence since 2012, the national bag size of specific goose species in the Bag Record is fully based on the species identifications made by individual hunters and hence subject to biases due to misidentifications.

From the identification accuracy found in the present study, it is clear that for Canada geese, no significant bias is expected in the numbers bagged, identified and reported by hunters to the Bag Record. For the 'grey' *Anser* species, however, identification accuracy of hunters was less accurate and variable between age classes, resulting in clear deviations between bag sizes estimated from the hunters' identifications and the numbers of reported shot through the Bag Record.

The identification accuracy provides an estimate of the uncertainty of the national hunting bag. Using this to correct the bag statistics, the information should be used with caution. Being based on a relatively small number of hunters, the bag size estimates obtained from the identification array are sensitive to even small differences in identification accuracies, as small deviances would be magnified in the calculation of the total bag. Likewise, the magnitudes of the deviations between the estimated and reported bag sizes of geese are affected by the large differences in the bag size of the different goose species. Being numerically dominating in the total goose bag (see Fig. 4a), the c. 8% misidentified greylag geese is the major potential source of bias in the national bag statistics of geese. Correcting for this leads to large increases in the bag sizes of white-fronted goose and bean goose. Hence, assessed from the present hunter identifications, the combined effect of (i) the observed difficulties in species identification among the 'grey geese', (ii) the numerical differences in species-specific bag size and (iii) the study design (e.g. dealing with more species than under normal situations and out of normal context) potentially leads to an unbalanced pattern in the distribution of wrongly identified geese. This suggests that bag sizes based on the present hunter determination should be considered as the worst possible case, hence representing the maximum deviation expected from misidentification of species.

Based on data compiled by the Danish Wing Survey, the age ratios of bagged geese showed a consistent higher proportion of adults compared to juveniles, with the average proportion of juvenile birds ranging between 22 and 26% for the last 10 years (2005–2014), except for bean goose, which had an even lower average juvenile proportion of 14% (Christensen 2016). In the calculation of bag sizes corrected for identification accuracy, the relatively low proportion of juveniles in the bag dampens the effect of higher rate of misidentification of juveniles, observed in bean goose and especially white-fronted goose. Hence, the observed bias in the hunting bag due to the misidentification by hunters will be dominated by the misidentification of the more numerous adult birds.

As discussed above, the bias in the Bag Record is most probably less than indicated from the identification accuracy in the hunter sample, as hunters to a large extent have site-specific knowledge and hence are aware of both local and regional differences in the occurrence of geese. In comparison with bag size estimates tentatively calculated from the Wing Survey data (including only 'grey goose' species) and where identification errors should be close to none (accuracy rate >99.9% for duck species determination by experienced biologist, Pearse et al. 2014), the bag sizes obtained for both the hunter sample and Bag Record are both higher for pink-footed goose and bean goose, while lower for white-fronted goose. For greylag goose, the bag size estimated from the Wing Survey is comparable to the Bag Record, but higher than the hunter sample estimate (see Fig. 4a). These results support the interpretation that hunters most probably tend to assign doubtful identifications to the most numerously occurring and well-known species, the greylag goose, and to a lesser extent the pink-footed goose, when reporting their bag to the Bag Record.

Comparison of the Bag Record and Wing Survey bag sizes should take into account that it is difficult to assess to what

extent misidentifications partly counterbalance each other in the Bag Record and that biases exist relating to representability of the contributions to the Wing Survey. However, the underestimation of white-fronted goose in the Bag Record is logically linked to the relatively high rate of misidentification. Most likely, this is due to the recent expansion and increase in occurrence of this species in Denmark (Pihl et al. 2015), being more frequently bagged, but prone to be misidentified as it is unknown and unexpected by many hunters that previously have not bagged this species. On the other hand, the slight overestimation of bean goose in the Bag Record is probably related mainly to misidentifications of other species, as bean goose only occurs very locally in southeast Denmark and with very restricted hunting opportunities (reduced season, Anonymous 2014), in order to protect the threatened populations of the taiga bean goose. Hence, tundra bean goose *A. f. rossicus* is presently bagged in low numbers and by relatively few hunters, as evident in both the Bag Record and in the Wing Survey estimates. Given these considerations, the present comparisons of bag size estimates verify that the present mandatory Internet-based reporting system provides relatively reliable figures of the actual numbers harvested. Having said that, biases in the Bag Record persist from a combination of misidentifications related to basic species identification, local knowledge and expectations of goose occurrence and, potentially, from the actual age distribution of goose hunters.

A general weakness of bag size estimation based on subsamples or non-repraisal semi-voluntary hunter reports is a large and variable proportion of non-response or missing reports as well as effects from hunter memory loss or rounding of bag numbers, that may lead to inflated numbers if not included or not managed using proper corrections (Wright 1978, Barker 1991, Barker et al. 1992, Anderson et al. 1996, Beaman et al. 2005a, 2005b, Laborde et al. 2014, Schmidt et al. 2015). Internet bag reporting does not circumvent these problems, but a recent change in administrative procedures (submission of the annual bag report before next year's hunting licence can be issued) has raised the reporting rate from c. 70 to 95% (Asferg 2016) eliminating errors originating from the estimation of the bag of non-respondents.

In the present study, we have shown that hunters' average identification accuracy for geese is 76%. Although this figure most probably is higher under field conditions, it nevertheless indicates that national harvest estimates for individual species, when based on hunters own identifications, are biased from inaccurate species identification. Such a bias may be even larger among the more diverse dabbling duck assembly, where identification of juvenile and female birds may be of particular challenge to hunters (cf. Wilson and Rohwer 1995). So far, the aspect of accurate species identification by hunters in national hunting bag statistics has not received much attention and may be referred to as 'fairly accurate' (Sen 1973, Wilson and Rohwer 1995). However, with increasing use of Internet-based reporting, with an associated potential reduction of non-responses, misidentifications may be a dominant bias in national bag statistics. And although many countries have mandatory training courses which include species identification before acquiring a hunting licence, the present results strongly indicate that the identification skills of hunters can be improved. On the one hand, it is clear that emphasis should be put on correct identification of the most numerously hunted species within a relevant species complex, as even small improvement in identification accuracy will markedly reduce the number wrongly assigned to other species and, hence, improve the overall accuracy of the national bag records. On the other hand, from a conservation point of view, it is of course important that hunters are able to identify the rare and protected species. Increased focus on species identification in training courses, supplemented by booklets, online information sheets and reoccurring magazine articles on identification of target species, may quickly enable hunters to make more accurate identifications and improve the confidence in bag statistics of waterfowl.

Acknowledgements We are grateful to all volunteers making species determination in the "goose array". Bjarne Frost is thanked for his hunting effort providing most of the full-bodied geese used in this study, and Thorsten J.S. Balsby is thanked for guidance on statistical procedures. The study was financially supported by the Danish Nature Agency.

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