The Iceland Breed of Leadersheep

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ABSTRACT

In this paper the unique Icelandic leadersheep is described, their breeding past and present is reviewed and results of both a research project to determine the leading characteristics and a nationwide survey of the leadersheep population are presented. Leadersheep, formerly regarded as a strain or a sub-breed within the the short-tailed Iceland Breed of Sheep, has been classified as a special breed since 2017. The results of standardized trials carried out in 2007 were uneqivocal in demonstrating the clearly pronounced leading instinct, i.e. to walk or run ahead of other sheep when driven, and that it is genetically based. The total population of 1422 individuals was identified and recorded in 415 flocks in 2008, i.e. 87.7% ewes, 7.5% rams and 8.8% wethers. It is fairly stable but unevenly distributed over the country with the highest numbers in Northeast-Iceland from whence most of the breeding leaders originate, both through ewe- and ram lamb sales and adult rams acquired for AI services. According to more up-to-date information the population has been growing slightly throughout the country in recent years. Most of the sheep are horned (97%) and a high level of genetic diversity is maintained in the breed, for example, in colours. The basic colours are black and brown and their genes appear to be virtually equal in the population. Piebald patterns are very common and the gene for two colours, black, grey or brown with white, respectively, (i.e., spotting) has the frequency of 0.92 in leadersheep. In fact 98.9% were found to be coloured. The overall mean inbreeding coefficient (F) was 0.0274 of those individuals having sufficient pedigree data to enable its calculation, namely 961 fulfilling the PEC-value of 0.25 or higher. These results indicate that inbreeding in leadersheep has been successfully controlled during the last few decades. Moreover, looking at the leadersheep population as a whole, it seems to represent an example of a sheep breed which has been conserved quite well in spite of small numbers. Although modern sheep management practices in Iceland have severely eroded the practical value of leadersheep, its unique characteristics could fit into new roles in the future, both in its native country and overseas. To make progress on those lines further research is required into their behaviour patterns and the genes involved need to be determined.

Keywords: behaviour, breed diversity, conservation, genetic structure, inbreeding, leadersheep

1. INTRODUCTION

The Iceland breed of sheep belongs to the North European short-tailed group. According to a recent survey, where 34 breeds were identified within this group of sheep, the Iceland breed represented the largest purebred population (Dýrmundsson & Niznikowski, 2010). According to Aðalsteinsson (1981a) Icelandic sheep are most closely related to native Norwegian breeds and this has been confirmed by DNA studies (Tapio et al., 2005). Presumably the sheep, as other livestock, were brought to Iceland by the settlers before 900 A.D. Leadersheep, known for their genetically-based behavioural characteristics of leading the flock when driven, are referred to in the oldest Icelandic texts written in the 12th and 13th centuries, namely the Icelandic Sagas and in both Jónsbók and Grágás, the first Icelandic law books (Aðalsteinsson,1981b). Their existence was thus documented and confirmed soon after the settlement of Iceland. In the past the unique leadersheep have been looked upon as a strain or a sub-breed within the Iceland breed of sheep (Aðalsteinsson, 1981b; Ryder, 1983; Jónmundsson et al., 1994; Dýrmundsson, 2002). However, recently Jónmundsson, Birgisson, Jóhannesdóttir, Eyþórsdóttir, Kristjánsson & Dýrmundsson (2015) proposed that the leadersheep should be classified as a special breed and this was approved in 2017 by the Agricultural Genetic Resources Committee and the Board of the Farmers Association of Iceland. In this paper, Icelandic leadersheep will, therefore, be referred to as a breed. Purebred leadersheep are not found outside Iceland, but due to exports of semen from leaderrams during the last 20 years upgrading is taking place in Icelandic sheep in Canada and the USA (Barkus-Lofton, 2003, 2005).

Unfortunately, no documentation in writing has been found in archives and libraries as to how leadersheep were bred and maintained in small numbers for hundreds of years. Although records of livestock numbers have been available in Iceland since the beginning of the 18th century, leadersheep numbers *per se* have not been known because they are included in the totals of winterfed sheep. The leaders, as other livestock, clearly survived bottlenecks in livestock populations, presumably dropping to very small numbers at times as did the sheep population as a whole (Dýrmundsson, 2011). Certainly, when sheep in Iceland were seriously threatened by imported diseases before the middle of the 20th century, resulting in the slaughter of all sheep in some 70% of the country due to a nationwide Maedi-Visna and Jaagziekte eradication policy (Friðriksson, 1970; Pálsson, 1976, 1990) many belived that leadersheep could possibly not be saved from extinction. One of those who expressed this concern wrote, in fact, the first article promoting the conservation of leadersheep (Eldjárn, 1946). Fortunately, at that time many stories on leadersheep were collected and written nationwide and published in a book, unique on a world scale (Jónsson, 1953). This book has recently been republised in an enlarged edition (Jónsson, 2016). Amongst new material in this book is an overview of the breeding and maintenance of the leadersheep breed from the middle of the 20th century to the present time (Jónmundsson, 2016). Both these books are in Icelandic and the only book on leadersheep available in languages other than Icelandic is a small book with a text in German and a large number of photographs (Mende, 2015).

2. BREED DESCRIPTION

Apart from the distinct and unique behavioural characteristics of leadersheep, they differ substantially in body conformation and several physical attributes from sheep of the Iceland breed, which have been primarily selected for meat characteristics and to a lesser extent for wool. On the contrary, selection criteria applied to leadersheep have been mainly based on their intelligence to show leadership in the herd or in groups of varying numbers. Jónmundsson et al. (2015) have summarized the main points of the breed standard, revised and supplemented by the authors of this paper, as follows:

Icelandic leadersheep is a hardy, medium-sized North European short-tailed breed with a fluke-shaped tail. It has a light frame, is upstanding and alert, keeping watchful and attentive eyes on the flock and its surroundings. They have quick movements and quickly attract attention in the flock or in any number of sheep in a group. The eyes are big, often darker than in other sheep and their look is both alert and searching. The head is normally slender and so is the body as a whole: narrow and high at the withers. Muscles are thinner and there is much less fat in the body than in sheep of the Iceland breed. The belly is also considerably lighter, being not as wide, extended and large, and less prominent. The feet are long, slender, and straight, the pasterns are strong and the hooves are well shaped; cannon bones are of less circumferance than in the Icelandic breed. They have a distinct and firm walk, carrying their feet high with a passage resembling a trot, and even occasionally tölt, as in horses.

Several body shape measurements have confirmed the great differences in conformation between leadersheep and other Icelandic sheep. The leaders are also lighter, adult leader ewes and rams commonly weighing 15-20 kg or approximately 20-25% less. However, there is a considerable variation in their size. The dual coated fleece is normally lighter, the outercoat (tog) with rather coarse and straight hairs while the undercoat (þel) is lighter due to the fineness of the hairs thus giving it certain spinning qualities. Most of the leadersheep are coloured and horned. Such physical characteristics will be reported on in some detail later in this paper.

Although, as stated above, there are great differences in the visual appearance and body conformation between leadersheep and the Iceland breed of sheep, it is the inherent leading behavour pattern of the former which has placed them in a unique breed category. Before describing further their behaviour attributes it should be made clear that so far there has been no evidence of any genetic linkeage between the leading behavior and physical characteristics such as conformation and colour.

When leading the flock the leadersheep selects the best route and exhibits determination, vigour and robustness in paving the way for the other sheep, often in bad weather. It has in fact often been claimed that leaders can sense sudden and

unexpected changes in the weather, for example, before a snowstorm breaks. When several leadersheep are in the same group as, for example, when sheep in large numbers from several farms are being driven from common rangeland pastures for sorting in autumn, a pecking order is established amongst the leaders. Then the same leader (a ewe, ram or wether) assumes the honorary role of being always the very first one in the drove.

When winterhoused, the leadersheep are normally docile, attentive and with fixed habits. However, they may vary in their behaviour patterns but good leaders are pleasant and easy to handle as , for example, to take them on a lead. Thus leaderrams, normally very sexually active, are popular as teasers in flocks where oestrus detection is needed for controlled hand-mating by other rams, or for the preparation of AI. Leaderewes generally show clear signs of oestrus, seek the ram actively and have good conception and lambing rates. Thus, the fertility of leadersheep is normally excellent. As a general rule the ewes give birth easily and they have a reputation of being good mothers, caring extremely well for their lambs, without being aggressive against the lambs of other ewes. After birth their lambs are quick to get up and on their legs and they follow their mothers very closely, compared to other lambs, from spring to weaning in autumn. Lambs born to leaderewes seem to play more actively than other lambs after birth in spring. Opinions vary as to the usefulness of leadersheep when sheep are gathered from the rangelands in autumn under the present farming practices. Then some of the leaders are very agile, move quickly, tend to run too fast, and may be difficult to control. Some claim that crossbred leaders are more commonly causing such problems and thus it is generally recommended that only purebred leadersheep should only be kept.

It is abundantly clear that the role and usefulness of leadersheep has changed substantially as a consequence of major changes in Icelandic sheep farming practices over recent decades, by and large during the last 50-60 years. This particularly applies to wintering practices. Thus, winter grazing with supplementary feeding during housing has been replaced by full feeding indoors throughout the winter. Another important change, diminishing the useful role of leadersheep, is that road transport of sheep, normally by trucking, has in most cases replaced long-distance droving, for example, when taken to rangeland pastures in early summer and when transported both from sorting places and to slaughterhouses in autumn. Leadersheep, therefore, have now much fewer opportunities to express their intelligence than a few decades ago.

Compared to sheep of the Iceland breed leaders are known for their greater longevity. Thus, leaderewes are commonly kept to higher ages than other ewes, even up to 17 years. As indicated above, their slender and somewhat primitive body shape and conformation, generally with thin muscles and little fat, places their carcases in another category than those of sheep primarily selected for meat production with shorter legs and much more compact bodies. Thus, the EUROP meat classification system operated in Iceland for the last 20 years is very unfavourable to leadersheep carcasses with many of them going into the P class. Although leadersheep are lighter than other sheep they are normally taller and thus may look bigger due to longer bones and a more slender build (Birgisson, 1993, 1994). So far, no research has been carried out on wool from leadersheep but it is claimed that the undercoat (thel) is exceptionally soft due to its fine hairs.

In concluding this overview on breed characteristics, it is worth noting that genetic defects are rare in leadersheep and if occurring they seem to be linked to too much inbreeding.

3. BREEDING PAST AND PRESENT

As indicated above little is known about leadersheep breeding centuries ago. It seems that some farmers were actively breeding small populations of these

A leaderewe with her ewe lambs

A leaderram (Strumpur 14-815)

A leaderewe heading a large flock driven into a fold

A leaderwether heading a small flock driven across a bridge

unique sheep and that they would often sell and even give them to other farmers. According to Aðalsteinsson (1981b), citing a source from the 13th century, leaders, particularly proven leaderwethers, were normally more highly priced than other sheep due to their wisdom and outstanding behavioural qualities.

Looking at leadersheep breeding in more recent times it is important to keep in mind some historical facts in order to understand the development and the situation at present. It seems that in the past these sheep were always unequally distributed within the country, possibly due to local differences in grazing practices in winter. However, during the middle of the 20th century, when the country was divided into several isolation zones and all sheep were killed in large parts of the country under the successful Maedi-Visna and Jaagziekte eradication scheme (see Introduction above), the majority of the leadersheep was lost. Moreover, there was, and still is in most cases, a total ban on the sale of live animals between most of these zones, now mainly because of efforts to eradicate the Scrapie Disease in Iceland. Many of the zones were restocked by sheep from districts in other zones where no leadersheep could be found. The consequences of these massive operations were that nearly all leadersheep now kept in the country, and for some past decades, can be traced back to the Northeast corner of the country.

Just after the middle of the 20th century when regular Artificial Insemination services were established, leaderrams were included and thus interested breeders could obtain semen from them for AI. In fact several farmers in zones without leadersheep have been initiating leadersheep breeding through upgrading over a number of years with semen from AI-rams, normally two per year, one at each AI-station. Thus AI has proved invaluable in maintaining the small leadersheep population. In recent years these efforts have been strengthened by allowing keen leadersheep breeders to buy live leaders in the autumn from certain isolation zones, both purebred ewe- and ram lambs.

It is difficult to evaluate and measure the genetic traits which characterize the leadersheep. Furthermore, as pointed out above, there has been a lack of nationwide population data on the breed *per se*, apart

from other sheep in the country. Therefore two research projects were undertaken in 2007 and 2009, respectively, in order to enhance the knowledge base. They are described and their results are presented in the following sections.

4. LEADERSHEEP RESEARCH PROJECTS

4.1 Trials to determine leading characteristics

4.1.1 Materials and methods

Standardized trials were carried out in the autumn of 2007 in five flocks where leadersheep are kept in order to determine the willingness of such sheep to walk or run in front of groups of sheep of the Iceland breed driven a certain distance from and to sheep houses known to them. The trials took place on 25 and 26 October in four of the flocks, all in NE-Iceland, and on 16 November in one flock in W-Iceland, just before the onset of winter housing. The same two observers recorded behavioural events in all five trials and one of them was filmed. A total of 15 leadersheep were tested, including 13 ewes, 1 ewe lamb and 1 ram, 2 - 4 leadersheep in each flock. Each leadersheep was tested with a group of 5 sheep of the Iceland breed, all carrying large numbers on the flanks clearly visible from a distance, the leaders always being number 1 but the others number 2-6 at random. In each test the group (1+5) was driven from respective sheep houses for a distance of 210 - 400 m, in most cases 250 m, then returned and driven back from the endpoint, the same way, by one to four persons from each farm and thus known to the sheep. Each of the two external observers was located 50-75 m from the sheep house and the endpoint, respectively. They recorded the number of each individual sheep in the order it walked or ran by and each test run was carried out twice. Thus four observations were recorded per sheep, namely on the way from the sheep house and on returning x 2. Thus a total of 60 x 2 = 120 group observations were recorded in the trials. Within flocks where more than 1 leader was tested, the 5 ewes running with each of them were the same individuals and thus their numbers were not totally at random.

4.1.2 Results

The leadersheep ranked first in all test runs (30 x 2) except in the first run when the leader ranked once 3rd, otherwise always number one, and in the second run the leader ranked twice 2nd, otherwise always number one. The mean numbers observed for each number in the trial flocks are shown in Table 1. They show that the repeated tests were virtually unequivocal in demonstrating the clearly pronounced and intrinsic leading instinct.

Table 1. Results of recorded observations showing means of sheep numbers in ranks 1-6, respectively. In all the trials the leadersheep had the flank number 1.

Rank	First test run	Second test run
1	1.033	1.033
2	3.317	3.267
3	4.100	3.933
4	4.817	4.600
5	3.833	4.183
6	3.900	3.983

4.2 Survey of the population of leadersheep

4.2.1 Materials and methods

In the autumn of 2008 a survey was initiated on the total population of leadersheep in the country. At the onset the two following forms were sent by mail to all farmers known to have such sheep in their flocks:

First, a form for individual registration, identified by number, and also by name if available (common in Iceland), followed by sex (almost all wethers in Iceland are leaders), colour and whether horned or polled. Secondly, a form for pedigree information for individual leadersheep in the flock.

It should be mentioned that until recent years farmers have commonly not registered their leadersheep in the Icelandic Sheep Recording Scheme. Thus most of the pedigree information had to be obtained direct from farmers keeping leadersheep and this

information has been rather fragmented and imperfect. The main reason has been a lack of individual recording on the ram side and this has been so because most of the leaderrams sire only one or two progeny in the flock per year. Moreover, most of these rams, normally used for mating at 7 months of age, are castrated after the first mating season or are culled the following autumn. Progeny resulting from AI are recorded in much more detail.

Due to the fact that the authors know most sheep farmers in the country, information on leadersheep could to be obtained to a large extent by telephone calls followed by e-mail exchanges. However, a few farmers were visited to complete the data. All the data from the survey were entered into a database, the pedigree information going into SRS. Most of the results were obtained by counting and by the help of EXCEL but results from the genetic part were condensed by applying the EVA package (Berg, 2008).

4.2.2. Results

4.2.2.1 Population size

The total number of leadersheep recorded in the survey was 1422. Based on our knowledge of sheep breeding in the whole country we claim that the survey, when conducted, included at least 97-98% of the total number of leadersheep in Iceland. Out of the total population 1190 (83.7%) were ewes, 107 (7.5%) were rams and 125 (8.8%) were wethers.

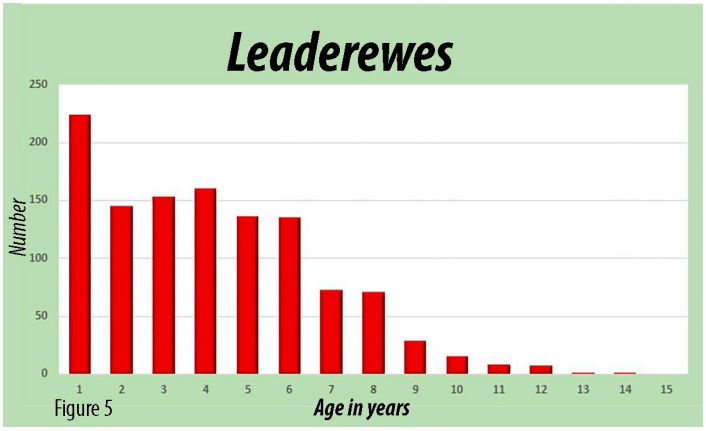
4.2.2.2 Geographical distribution

Leadersheep were found in all districts except one (Vestur- Barðastrandarsýsla) in the Westfjords of Iceland. In fact, in the Westfjords, and also in Southeast Iceland, leadersheep are and have always been rare while these sheep are most numerous in the Northeast corner of Iceland. Further details on the distribution are mainly of local interest but can be seen in Jónmundsson et al. (2015).

4.2.2.3 Age distribution

Seventy percent of the leaderrams were one or two year old and their mean age was 2.5 years. The leaderwethers and the leaderewes had the same mean age, 4.4 years. The age distribution of the ewes is shown in Figure 5.

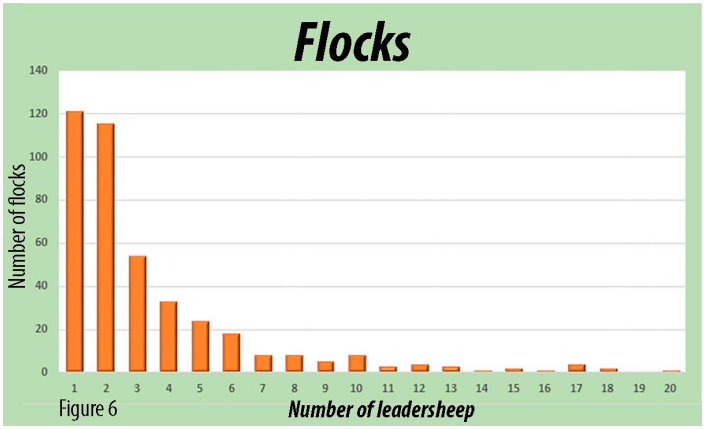
4.2.2.4 Flock numbers and distribution



Age distribution of leaderewes

Leadersheep were found in a total of 415 flocks in the country, i.e. in approximately 20% of all sheep flocks in Iceland in 2008. Figure 6 shows the distribution of flocks by numbers of winterfed leadersheep. It highlights the fact that in most of the flocks only one or very few leadersheep are kept.

4.2.2.5 Colours and their frequency



Distribution of flocks by numbers of leadersheep

Most of the leadersheep showed non-white colours (98.9 %) compared to only 1.1 % white. The main basic colours were black and brown with a very high ratio of piebald patterns (broken colour). The frequency of different colour alleles as described by Aðalsteinsson (1970) was estimated. Assuming that all individuals in the A-locus of colours, a homozygotic and heterozygotic mix, were set to be heterozygotic, this assumption was obviously not always correct. Frequencies at the B- and S-locus were estimated

from numbers of recessive homozygotic individuals. In the same way the estimated frequencies in the A-locus were; Aa 0,870, At 0.064, Ab 0,038, Ag 0,022, Awt 0,006. In the B-locus Bb is estimated at 0,499 and in the S-locus Ss was found to be 0,916.

4.2.2.6 Hornedness

Most of the leadersheep were found to be two-horned (97%) while the remaining 3% were equally distributed between scurred (miniature horns), four-horned and polled sheep.

4.2.2.7 Pedigree values and inbreeding coefficients

As mentioned before the pedigree information was not dense. Measured by the PEC-coefficient (MacCluer, Boyce, Dyke, Weitkamp, Pfennig & Parsons (1983), calculated for five generations, it rose from 0.41 to 0.67 for the 2000 born individuals in the age classes born in 2008. The overall mean inbreeding coefficient was calculated as 0.0274 for 961 individuals having fulfilled the PEC-value of 0.25 or higher. The coefficient was slightly higher for rams (0.040) than for ewes and the wethers (0.026 and 0.028, respectively). The highest individual inbreeding coefficient calculated was 0.45 and very high coefficients were rare. Calculations on changes in the inbreeding coefficient, of utmost importance in such small populations, showed very low values. The yearly increase of this value was calculated as 0.0012 per year. It should be mentioned that the mistake was made in the beginning of this century to use one of the AI-rams and his sons too extensively for some years. This resulted in a years class with approximately 18% genetic contribution from this one ram which is unacceptable in a small population.

5. DISCUSSION

The driving trials for determining leading characteristics (4.1 above) showed clearly the genetically based behavioural ability of leadersheep to walk or run in front of sheep from the same flock. Such behavior has been well documented as indeed experienced on sheep farms but these were the first controlled experiments to verify this unique leading behaviour. These results have recently been supported by preliminary findings of a research project where the alertness of leadersheep was monitored during human-, dog- and drone tests (Brunberg, Gröva, Eythórsdóttir and Dýrmundsson, 2018). As far as the nationwide survey of the leadersheep population is concerned (4. 2 above) only one older survey is comparable, at least to a certain extent (Birgisson, 1993, 1994; Jónmundsson et al., 1994). The main difference in the populations included in the present survey and the previous one 16-17 years before is that we included only purebred leadersheep, according to the information from the owners, whereas in the previous study, crossbred individuals (hybrids) were also included. At that time crossbred leadersheep were much more common than now-a-days the reason being that upgrading was still commonly practiced on some farms in certain districts. Since the turn of the century upgrading has become rare. Those who want to own and/or breed leadersheep are now allowed to buy purebred leadersheep, both ewe- and ram lambs, from farms in four disease-free zones approved by the Food and Veterinary Authority. These include Northeast Iceland where most of the "elite" herds of leadersheep breeding are located. No research has been carried out on crossbred leadersheep but based on practical experience and observations F_1 individuals are normally less alert, even withdrawn, and are not likely to express clear leading instincts, though with some well known exceptions (Birgisson, 1993; 1994; Sveinbjarnardóttir-Dignum, 2000, 2004; Barkus-Lofton, 2003, 2005). In the F_2 and following generations, upgraded individuals show increasingly leading characteristics. Those failing to do so are normally culled.

The results of the past survey (Birgisson,1993, 1994) showed that the population of leadersheep numbered approximately 1.000 in 1991-1992 assuming that some 90% of the population had been accounted for. Thus the results of the present survey indicate a slight increase in numbers and the data on the number of leaders in different year classes support this trend. It can be stated that in recent years the leadersheep population is growing in size although total sheep numbers in the country have shown a gradual decline.

It is worth commenting on the age structure as a large proportion of the leadersheep are in very small numbers in most flocks where they are kept, namely 1-3 individuals, mainly ewes. Leaderewes are normally kept to high ages and they are usually culled because of age. Thus they are normally old, compared to other ewes in the flock, when the replacement takes place. The generation interval is

therefore long or nearly six years and in the data set of the survey we have two examples of a generation interval of 17 years on the dam side. Longevity is certainly amongst the characteristics of leadersheep.

Characteristics such as horns and colours do not show any significant changes between the two surveys. In the older study there were much more polled leadersheep but many of them were crossbreds. The relatively few polled leadersheep found in recent times can be traced back to blood lines of polled leadersheep known for centuries, mainly in Northeast Iceland. Fourhornedness has never been associated with leadersheep breeding but it is known to have been introduced through upgrading during recent decades. In comprison with the Iceland breed which has identical colour diversity, a much higher proportion of leadersheep are coloured, namely almost 99% compared with 17% in the former (Dýrmundsson, 2014). As far as colours are concerned we consider that their diversity can be easily managed although some of them have low frequency. An example of this is the badgerface colour which is known to have risen considerably in frequency since our survey was carried out due to the use of rams of that colour at the AI-stations in recent years. We believe that the white colour is not innate to leadersheep but has been introduced through upgrading. Some of the piebald patterns with only minor black or brown colourations may have been mistakingly classified as white by some farmers.

Although the prominent leading characteristics of leadersheep have been severely devalued due to changes in sheep management, primarily the abandonment of wintergrazing, new roles are being considered and even tested. These may include the driving of sheep between fields and enclosures, in Iceland particulary in autumn, flock management under extensive pastoral conditions and the protection of the flock against predator attacks due to the alertness of the leaders (Birgisson, 1993, 1994, Sveinbjarnardóttir-Dignum, 2000, 2004, Dýrmundsson, 2002, Barkus-Lofton, 2003, 2005). Certainly their unique genetic traits constitute enormous conservation value. Thus it is noteworthy that the breeding and management of leadersheep has by and large been successful during the last few decades, perhaps one of the best examples of conservation known in such small populations. Fortunately the increment in inbreeding within the breed is rather small but without going into detail we can state that this has been brought about by several attributes in the population structure and breeding practices. By obtaining more complete pedigree information than was possible in our study the montoring of inbreeding will certainly become more reliable.

Since the application of AI in leadersheep breeding during the last 60 years has been important in conserving and distributing the breed, it is worth addressing a few facts in this respect. Roughly 40% of the annual replacement in the leadersheep population constitute ewe-and ram lambs sired by AI-rams. District variation shows that in areas where only a few leaderewes are kept in the flock, leaderrams are normally absent. As mentioned before, the generation interval on the dam side is high as the ewes are normally replaced at an old age. Thus AI is common in such flocks and renewal on the male side is mainly due to rams bred in the Northeast corner of Iceland and sold to the AI-stations. In that area the breeding practices of leadersheep differ considerably from those in other districts of the country and many of the most numerous leadersheep groups are found within flocks there. In fact most of the leadersheep are bought from there for breeding in other parts of the country, in addition to most of the AI-rams as previously pointed out by Jónmundsson(2016). Our survey results highlight 6-10 “elite” leaderflocks in the Northeast and in that area AI in leadersheep is only practiced to a very limited extent. Instead the farmers exchange rams, often originating from the “elite” flocks. The rams may even be rotated, bought or borrowed, and are normally used for only one or two years on each farm, often leaving only one or two progeny in the flock. Such breeding practices have clearly resulted in lower levels of inbreeding than usually found in small populations. Its diversity in both behavioural and physical characteristics seems to have been maintained. Therefore, the future outlook for a desirable genetic management of the leadersheep population appears good. In that context it is vitally important not to use individual rams too extensively. As far as AI-rams are concerned the rule established a decade ago not to use each leaderram for more than two years, one year at each of the two AI-stations, seems to work quite well.

In view of the fact that the leadersheep breed constitutes a unique and valuable reasource it is worth undertaking research on the whole genetic structure of the breed. This is interesting both in light

of its long breeding history and also in order to determine the genes responsible for the special characteristics of the breed. It seems clear that very few genes are involved. Moreover, in the international perspective it is of interest to establish future possibilities for applying leadersheep characteristics under practical conditions in overseas sheep populations.

6. CONCLUSIONS

The overview presented here on the short-tailed Icelandic Breed of Leadersheep, based on experimental work, nationwide surveys of the population and historical evidence, has confirmed beyond doubt that the leading instinct is genetically based. By and large, the genetic diversity in the breed has been maintained and increased inbreeding has been successfully controlled in its small population. Improved progeny recording and monitoring of data, combined with studies on the genetic structure of the breed, and determination of the genes involved, will strengthen the management and the conservation of this unique genetic resource. Possible novel forms of leadersheep utilization, both in Iceland and abroad, are worth considering.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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About the Authors:

1) **Dr. Jón Viðar Jónmundsson** was born in 1947. He has a farming background and studied agricultural sciences in the Agricultural University of Norway, Ås, Norway, where he majored in animal breeding and genetics wih an emphasis on sheep. Early in his career he worked in the Agricultural Research Institute and the Hvanneyri Agricultural College (both now incorporated into the Agricultural University of Iceland). However, most of his working time was spent in the Farmers Association of Iceland where he was a national advisor on both cattle and sheep recording and breeding until retirement a few years ago. Jón Viðar has written extensively about agricultural subjects with emphasis on cattle and sheep breeding and has in addition to his extension work been involved in several research projects, for example on leadersheep. He was the first one to suggest that leadersheep should be classified and recorded as a special breed of sheep. As a pensionist he is still involved in some agricultural projects, including a thorough investigation of the genetics of Icelandic sheep by studying individual sheep records kept for several decades.

2) **Dr. Ólafur R. Dýrmundsson** was born in 1944. With a farming background he studied agricultural sciences at the University College of Wales, Aberystwyth, Wales, UK, where he majored in sheep reproduction. His first position was in the Hvanneyri Agricultural College where he was involved in teaching, research and administration. However, for nearly 40 years he was a national advisor in the Farmers Association of Iceland, mainly involved in grassland management, sheep and goat production and organic farming. Although mainly working in the extension sector he has always been, also after retirement, involved in research projects and has been a prolific writer in both Icelandic and English. Ólafur was and still is, involved in much international activity such as in the EAAP (European Federation for Animal Production), IFOAM (the World Organic Movement) and Slow Food where he specializes in the conservation of rare breeds such as the Icelandic leadersheep, goats and poultry. He chaired the Leadersheep Society of Iceland for several years and keeps a few leaders in his small flock of sheep, one of the few left in the City of Reykjavik.