Policies to decrease inbreeding in the Cinta Senese pig

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SUMMARY - Inbreeding in the Cinta Senese pig rapidly increased during the last 15 years to the current level of 0.172. Several observations suggest severe inbreeding depression on fertility and survival to weaning. This paper discusses a breeding scheme to reduce inbreeding in the very short term. Management criteria include: optimization of population effective size, minimum kinship selection of boars and sows and minimum inbreeding mating. A mean inbreeding of 0.043 is expected in the next generation, which is 67% lower than under the hypothesis of no management.

Key words: Inbreeding, minimum kinship selection, pig, conservation.

RESUME - *"Hypothèse de gestion pour réduire la consanguinité dans la race porcine Cinta Senese". La consanguinité dans la race porcine Cinta Senese a augmenté rapidement au cours des dernières années jusqu'à la valeur moyenne actuelle de 0,172. Plusieurs observations indiquent un fort effet négatif de la consanguinité sur la fertilité et la survie au sevrage. L'article propose une utilisation des reproducteurs pour réduire la consanguinité à court terme. Les critères de gestion adoptés comprendront un nombre effectif adéquat, la sélection des mâles et des femelles par la minimisation de leur parenté, la minimisation de la parenté d'accouplement. On attend dans la prochaine génération une consanguinité de 0,043, avec une réduction de 67% en comparaison à l'absence de gestion génétique.*

Mots-clés : *Consanguinité, sélection pour le minimum de parenté, porc, conservation.*

Introduction

During the last decades the Cinta Senese pig has strongly reduced in size. A very narrow bottleneck was experienced in the 1980's due to only 3.6 animals registered per year. Thanks to the engagement of several breeders, of the local Breeders Association and to the incentives of the Tuscany Region, the breed survived. More recently we are observing a growing interest for the Cinta Senese: the number of sows and farms is steadily increasing, marketing of typical products has been developing, several research activities are in progress and the herd book was established in 1997. Recent studies show severe erosion of genetic variation and high rates of inbreeding during the last 15-20 years (Gandini *et al.,* 1996; Campodoni *et al.*, 1997). Because lack of data, inbreeding effects on performances can not be estimated, nevertheless several observations suggest severe inbreeding depression on fertility and survival to weaning. It is therefore urgent to adopt a genetic management programme. As a first step, this paper presents a breeding scheme to reduce in the very short term the high inbreeding.

Materials and method

Genealogical data

A pedigree data set of 318 living animals, 257 females and 61 males, and their ancestors, for a total of 437 animals, was used. The pedigree of the breed can be divided into 13 generations. From the first generation, which refers to the animals with no progeny, to the 13th generation the number of founders (animals with both parents unknown) and non-founders is respectively 250 and 0, 69 and 0, 38 and 1, 19 and 0, 10 and 3, 6 and 3, 7 and 0, 5 and 2, 6 and 0, 8 and 2, 1 and 5, 1 and 1, 0 and 2. The living population is distributed among 24 farms.

The breeding scheme

The proposed breeding scheme includes four steps: (i) analysis of the genetic structure of the population; (ii) selection of parent females; (iii) selection of parent males; and (iv) mating structure. These four steps were implemented by means of the software *Minbreed,* recently developed for the genetic management of small farm animal populations (Gandini and De Filippi, 1998).

Step (i). Inbreeding, additive relationship among males, females, males and females, number of founders and effective number of founders (Lacy, 1989) were computed in the living population by pedigree analysis.

Step (ii). The rapid demographic growth of the last few years took place without any genetic management and consequently resulted into unbalanced genetic contributions of boars and sows and high mean relationship. Many females are routinely crossbred to produce pigs for slaughter. A set of female was then selected as pure-bred parents by minimizing relationship as _ relationship among selected females + _ relationship among selected females and living males.

Step (iii). Because no artificial insemination is used, the number of boars is firstly determined by the number and the size of herds; then we consider one boar per herd and per a maximum of 15 sows. Moreover, the number of boars (and sows) must guarantee an adequate effective population size (Ne); the rate of inbreeding per generation (ΔF) is in fact function of Ne, as ΔF = 1/(2Ne). Ne was computed following the Wright equation (Wright, 1931) Ne = 4MF/(M+F), where M and F are the breeding males and females respectively. A coefficient (Ne*0.7) was adopted to take into account possible deviations from the Wright model, e.g., the presence of phenotypic selection. A maximum rate of inbreeding of approximately 0.015 per generation was considered acceptable. M males were then selected as parents among the 61 living males, by minimizing relationship among selected males (weight _) and among selected males and the previously selected females (weight _).

Step (iv). Selection of parents and effective population size affect the rate at which inbreeding increases over generation. Mating structure affects the level of inbreeding in the progeny. Because the high inbreeding, it was assumed to modify the mating structure by moving boars across herds but not sows. The software *Minbreed* still does not provide a function to minimize inbreeding mating, nevertheless a few mating hypothesis, aimed to reduce inbreeding mating, were evaluated.

Results and discussion

Inbreeding in the living population is very high and equal to 0.172 (±0.143; range 0-0.5). Mean additive relationship among females, males and females and among males is also high and equal to 0.270, 0.261 and 0.275 respectively. Number of founders and effective number of founders are respectively 29 and 9.54.

Three sets of 200, 150 and 100 parent females were alternatively selected among the 257 living females by minimizing relationship. In Table 1 additive relationship, number of founders and effective number of founders are given for the 257 living females and for three selected sets. Under the hypothesis "100 parent females" 15 herds (63%) participate in the conservation programme and mean relationship among females and among females and the 61 living males is reduced by 40% and 32% respectively. Number of founders does not change, effective number of founders increases by 31%.

Table 1. Mean additive relationship among females, females and the 61 living males, and numbers of founders for four sets of females (see text)

No. females (in No. herds)	Relationship among females	Relationship among females and the living males	No. founders	Effective No. founders
257 (24)	0.270	0.261	27	9.6
200 (20)	0.224	0.235	27	10.6
150 (20)	0.189	0.207	27	11.4
100 (15)	0.162	0.177	27	12.6

Considering that 15 herds are included in the programme and that one herd has more than 15 sows, 16 males were selected as parents among the 61 living males, by minimizing relationship. The hypothesis "16 sires and 100 dams" corresponds to an effective population size of 39, i.e., a rate of inbreeding per generation of 0.013.

In Table 2 the relationship among males, males and females and the numbers of founders for the hypothesis of 16 selected parent males and for the 61 living males are given. The hypothesis "16 parent males" reduces mean relationships among males, and among males and the 100 selected females, by 25% and 43% respectively, and increases the effective number of founders by 53%.

Table 2. Mean additive relationship among males, males and 100 females, and numbers of founders for 2 sets of males (see text)

No. males (in No. herds)	Relationship among males	Relationship among males and 100 females	No. founders	Effective No. founders
61 (18)	0.275	0.261	25	9.2
16 (9)	0.206	0.149	25	14.1

Under the hypothesis "100 dams and 16 sires", assuming random mating, an average inbreeding of 0.075 is expected (additive relationship among 100 dams and 16 sires = 0.149) in their progeny. Conversely, under the hypothesis of random selection of parents, expected inbreeding is 0.13. In the following generation, assuming random mating and random selection, an inbreeding of 0.167 is expected, to be compared with an inbreeding of 0.267 under the hypothesis of no management. The frequency distribution of relationship coefficients among the 16 selected males and the 15 selected female herds has a mean of 0.155 (±0.176) and 40% of observations range from 0 to 0.1. The skewness of the distribution suggests to adopt a mating scheme for inbreeding avoidance. The best mating scheme, among those evaluated, yields a reduction of inbreeding mating and of expected inbreeding in the progeny respectively to 0.085 (±0.42) and to 0.043.

Conclusions

The proposed management policy yields a marked reduction of the actual high inbreeding. The scheme can be somehow modified in terms of participating herds, number of male and female parents and mating plans with no consistent changes in the expected results. Management criteria are aimed to reduce inbreeding in the very short term, however they are not in conflict with policies to control inbreeding rate in the long term.

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