Estimates Of Inbreeding Rates In Ancient Belgian Chicken Breed Populations

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Introduction

In addition to experimental lines and commercial stocks, contributing to the range of chicken genetic diversity, traditional chicken breeds are still highly connected to cultural values, geographical origins and adapted to local environments. A survey evaluating breeding population size of 49 ancient poultry breeds in this country showed, however, that most of these existing genetic resources are under critical or endangered status (Larivière and Leroy (2007). A similar situation is observed in Europe (Zanon and Sabbioni (2001), Woelders, H., Zuidberg, C. A., and Hiemstra, S. J. (2006), Hermanns, A., Stock, K. F., and Distl, O. (2008), Larivière and Leroy (2008) and the World (Hoffmann (2005)). Awareness of the need to conserve such resources has led to initiate an integrated strategy for conserving chicken genetic resources in Europe (Larivière, J.-M., Weigend, S., Vieaud, E., et al. (2007)). Proposed strategies for conserving these resources include their genetic management, requiring awareness on practices that may increase inbreeding coefficients. It is strongly emphasize that control of inbreeding should be given high priority in animal breeding (Kristensen and Sørensen (2005)). Obvious consequences of high inbreeding rates in poultry are associated with a reduction in performance that will reduce the number of progeny hatched per hen, thus decreasing reproductive efficiency and increasing production costs at breeding and hatching levels. Studies showed that inbreeding affects fertility, hatchability, embryonic mortality and egg production (Ibe, S. N., Rutledge, J. J., and Mcgibbon, W. H. (1983), Hagger, C., Steiger-Stafl, D., and Marguerat, C. (1986), Nordskog and Cheng (1988), Flock, D. K., Ameli, H., and Glodek, P. (1991), Sewalem and Wilhelmson (1999), Sewalem, A., Johansson, K., Wilhelmson, M., et al. (1999), Christensen (2001). The present study aims to evaluate inbreeding rates in Belgian traditional chicken breeds populations.

Material and methods

Data on populations from ancient breeds. Data was collected from a previous realized survey (Larivière and Leroy (2007). Individuals listed in the poultry fanciers membership directory (2005) indicated the number of breeding males (N_m) and females (N_f) for each traditional Belgian chicken breed conserved.

Effective population size. The effective population size (N_e) is the number of individuals from a population randomly selected and randomly mated that would expect to have the same rate of inbreeding as the population itself. It may be unrealistic to assume that these populations, mainly from fanciers, are under random mating or random selection but the N_e of chicken populations estimated here aims to give an approximate idea of the upper limit. Calculations are based on the formula given by Wright (1931):

$$N_e = \frac{4N_f N_m}{N_f + N_m}$$

where: N_f is the number of breeding females, N_m is the number of breeding males.

Effective population size over total population size and male: female ratios. The ratio of the effective population size to census population size (N_e/N) is an indicator of the extent of genetic variation expected in a population. Male: female ratio (N_m/N_f) is defined as the number of breeding males upon the number of breeding females in a population.

Inbreeding rates within populations. Inbreeding rate (ΔF) was calculated for 40 existing ancient chicken breed populations. The variation in ΔF is inversely proportional to the number of individuals contributing equally to the gene reservoir:

$$\Delta F = \frac{1}{2N_e}$$

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Results and discussion

Effective population size, effective population size over total population size and male: female ratio. Estimated N_e, N_e/N and N_m/N_f are given in Table 1. The N_e/N and N_m/N_f ratios (excluding breeds with N_e of less than 50) varied widely from 57-89% and from 23-51%, respectively.

Table 1: Number of breeding males (N_m) and females (N_f), male: female ratio (N_m/N_f), total breeding population (N), effective population sizes (N_e), Ne/N ratio of breeders contributing efficiently genes to the population and hypothetical rates of inbreeding per generation (ΔF) of Belgian chicken breeds existing in Belgium in 2005.

Breed	N_m	N_f	N_m/N_f (%)	N	N_e	N_e/N (%)	ΔF (%)
Dwarf							
Ardennaise naine	75	209	36	284	221	78	0.23
Barbu d'Anvers	393	1078	36	1471	1152	78	0.04
Barbu de Boitsfort	5	14	36	19	15	78	3.33
Barbu de Grubbe	40	99	40	139	113	82	0.44
Barbu de Waes	13	41	32	54	39	73	1.28
Barbu de Watermael	162	455	35	617	477	77	0.10
Barbu d'Everberg	11	15	73	26	25	98	2.00
Barbu d'Uccle	163	412	40	575	467	81	0.11
Bassette	123	358	34	481	365	76	0.14
Belge naine	73	185	40	258	209	81	0.24
Bleue de Lasnes	10	28	36	38	29	78	1.72
Brabançonne naine	20	56	36	76	59	78	0.85
Braekel naine	8	21	36	29	22	78	2.27
Combattant de Liège nain	73	190	38	263	211	80	0.24
Combattant de Tirlemont nain	8	14	54	22	20	91	2.50
Famennoise naine	9	24	35	33	25	77	2.00
Fauve de Méhaigne	23	63	36	86	66	78	0,76
Herve naine	34	94	36	128	99	77	0.51
Malines naine	19	80	23	99	60	61	0.83
Sans queue des Ardennes nain	15	42	36	57	44	78	1.14
Tournaisis	40	108	37	148	116	78	0.43
Normal							
Aarschot	11	38	29	49	34	70	1.47
Ardennaise	134	548	25	682	431	63	0.12
Brabançonne	56	181	31	237	171	72	0.29
Braekel	192	639	30	830	589	71	0.08
Combattant de Bruges	13	54	24	66	42	63	1.19
Combattant de Liège	61	216	28	277	191	69	0.26
Combattant de Tirlemont	7	20	34	27	20	76	2.50
Coucou des Flandres	12	41	29	53	37	70	1.35
Coucou d'Izegem	75	242	31	316	229	72	0.22
Famennoise	19	79	24	98	61	63	0.82
Fauve de Hesbaye	14	46	30	59	42	71	1.19
Herve	96	356	27	452	303	67	0.17
Malines	553	1085	51	1637	1465	89	0,03
Malines tête de dindon	62	208	30	269	190	71	0.26
Poule de la Zwalm	3	9	33	12	9	75	5.56
Poule de Zingem	20	96	21	115	66	57	0.76
Poulet de Zingem	1	1	100	2	2	100	25.0
Sans queue des Ardennes	17	59	29	76	53	70	0.94
Zottegem	17	44	39	60	49	81	1.02

Inbreeding rates within populations. Estimates of inbreeding rates are also presented in Table 1. Inbreeding rates of 0.03%-0.94% per generation were estimated in ancient Belgian chicken breeds populations with N_e of more than 50. As an example, ΔF of 0.1% means that 0.1 percent of heterozygosity is lost in one generation. Assuming 1.5 hatches per generation every year, this will represent a total loss of 7.5% after 50 years.

Conclusion

Effective population size, effective population size over total population size and male: female ratios. The N_e/N and N_m/N_f ratios in some European populations (with N_e of 70-2285), varied from 33-82% and from 8-25%, respectively (Spalona, A., Ranvig, H., Cywa-Benko, K., et al. (2007). Wang, J., Hill, W. G., Charlesworth, D., et al. (1999) demonstrated that fitness declines with N_e of 50 because of detrimental mutations fixation despite natural selection. Meuwissen and Wooliams (1994) suggested, from theoretical predictions, that N_e between 30-250 is needed for natural selection to counteract inbreeding depression. According to Lynch, M., Conery, J., and Burger, R. (1995), N_e should exceed 500 animals otherwise this accumulation of slightly deleterious mutations will deem the population to extinction. It is important to monitor N_e, because it can be smaller than expected due to any effect increasing variance of the family size of an animal (e.g. selection, unequal survival rates). A rapid strategy to minimize inbreeding would be therefore to maximize the effective population size in flocks and increase the male: female ratio in some breeds.

Inbreeding rates per generation. In Belgian chicken breeds, only populations with N_e of less than 50 showed ΔF over 1% per generation. Estimates in populations with N_e of more than 50 were within the range (0.03-0.94%) of other studies on small chicken flocks in Europe. Moreover, a study on population size of 37 local chicken breeds conserved in institutions of five European countries demonstrated relatively low ΔF (0.02-0.71%) (Spalona, A., Ranvig, H., Cywa-Benko, K., et al. (2007)).

Management practices and recommendations to limit inbreeding. Maximizing the number of individuals contributing to the genetic pool is required to limit effects of genetic drift (Wright, 1931) and of inbreeding in limited effective populations. Small flocks with no pedigree would need to be supported through genetic management assistance to limit inbreeding levels. In Lower-Saxonny, pedigree recording is encouraged but represents only 5% of total poultry fanciers in Germany. The use of a herd book and the systematic recording of the origin and performance are practices that are not so frequent in Europe because trapnesting is laborious and time consuming. Procedures for the establishment and an efficient conservation of a chicken breed flock, as a case study, are summarized by Weigend, S., Stricker, K., and Röhrßen, F.-G. (2009). In practice, mating of a male from a unique farm to a large number of females is to be avoided. A constant number of females with as high as possible number of males (although keeping large number of males can be a management problem), achieving a rotation of males (via hatching eggs) between families and assuring a slow change of males to increase the generation interval is strongly suggested. However, the suggestions in circulating males between breeders may be unrealistic for fanciers who have precise selection criterias and who will not choose a male from a neighboor.

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