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Conference paper

CONSERVATION STRATEGIES FOR ENDANGERED CATTLE BREEDS IN VIEW OF COSTS AND INBREEDING

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Summary

For conservation of endangered cattle breeds the strategies cryoconservation of semen (CS), cryoconservation of embryos plus semen (CE+CS), live animals in reproducing herds (LA) and the combination of live animals plus cryoconserved semen (LA+CS) have been compared with regard to discounted costs and accumulated inbreeding for a simulated conservation period of 50 years. For LA and LA+CS three levels of milk production were assumed. In year 50 a population with an effective population size of Ne = 50 should be available for immediate use. Due to costs of reactivation CS turns out to be one of the most expensive strategies, the combination of LA+CS is the most attractive strategy in respect to costs, inbreeding and important other factors. Cattle breeds which are not used for milk production cause lower costs or subsidies than breeds with low milk production (3000 kg/year).

Introduction

For conservation of endangered breeds several strategies can be used (Brem et al. 1984; Bodo, 1990):

- Live animals in reproducing herds,
- cryoconservation of semen, reactivation of a breed by repeted upgrading of a female population with cryoconserved semen,
- cryoconservation of embryos, reactivation by embryo transfer,
- combination of live animals and cryoconservation of semen.

In cattle the biological conditions allow the application of each of this methods. Conservation by live animals and by cryoconservation have specific advantages and disadvantages; it has been pointed out that a combination of both methods would combine advantages and avoid disadvantages of the individual strategies (FAO 1987; Simon 1993).

Reports on economic evaluations of conservation methods are sparce (Smith, 1984, Brem et al. 1984). Conservation of animal genetic resources can be understood as an investment in known and unknown genetic potential to serve future needs of man.

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However, to our knowledege, no investment appraisal for different conservation strategies, which include the costs of reactivation of a breeding population, is available. Here we report on a simulation study to compare different conservation strategies with regard to discounted costs and expected inbreeding.

Methods and assumptions

It is assumed, that cattle breeds are to be conserved for 50 years. In year 50 for all conservation strategies a breeding population with an effective population size of Ne = 50 should be available for immediate use. Ne = 50 is equivalent to maximum increase of inbreeding in the order of 1 percent per generation in reproducing populations. Correspondingly live animal conservation should start with Ne = 50, the structure of cryoconservation should allow reactivation of a breed of the same size. Effective population size is computed by the formula $Ne = 4N_mN_f/(N_m+N_f)$ (Falconer, 1989), with N_m, N_f = number of male and female breeding animals, respectively. Four main conservation strategies with three levels of milk production of cows are compared.

1. Cryoconservation of semen (CS); reactivation by upgrading with AI

Table 1. - REACTIVATION FROM CRYOCONSERVED SEMEN, SINGLE CALVINGS PER FEMALE. REACTIVATION TIME 13,5 YEARS

Generation	original genes,%	Number of matings or females for backcrossing year:37 38 39 40 41 42 43 44 45 46 47 48 49 50
0	0	8437→↓
1	50	2785 ⇒ ↓
2	75	919 ⇒ ↓
3	87,5	303 ⇒ ↓
4	94	100 ⇒ ↓
5	97	33 ⇒ ↓ 25 females with life offspring

Symbols in table 1: (horizontal arrows: duration of keeping females (→) 1 year, (⇒) 2,5 years)

→ serviceperiod: 2,5 months; gravity: 9,5 months, calvin interval = 1 year

↓ birth of useable descendents with 50 % increased genes of the original breed

⇒ rearing: 18 month; serviceperiod: 2,5 months; gravity: 9,5 months
(age of first calving: 2,5 years)
success rate fertile heifer per cow: 0,9•0,85•0,48•0,9 = 0,33
(rate of gravity, calfes alife, female, rearing)

The number of semen doses which have to be stored depends on the assumed number of storage locations (3), the number of females which have to be inseminated during 5 generations of upgrading (table 1), number of inseminations per service period (3), and on fitness factors. The following assumption were made (in percent): Gravity (90), calving plus survival of calfs up to 2 weeks (85), female sex (48), fertile heifer (90). As a result 113.250 semen doses have to be stored (3*3 (8437+2875+616+100+33)=113.250) 25 males should be represented in the semen-storage. Reactivation of a breed: 5 generations of upgrading of a female population with conserved semen starting in year 37 results in 25 females with 97 % of original genes and with live offspring in yaear 50.25 females + 25 males (semen) = Ne = 50. Success of matings: 0.9.0.85.0.48.0.9=0.33, or 3.03 matings/mates are needed to abtain one fertile heifer.

In order to accelarate the process of upgrading and to avoid overlapping generations famales will be used only for one calving season. 8473 females are required in year 37 as mates in order to reactivate the population with 25 females with offspring in year 50.

2. Cryoconservation of embryos and semen (CE+CS)

Strorage of 300 embryos and 2500 doses of semen from 25 males per breed. Fitness factors in percent: Rediscovery after thawing (89), live embryos after thawing (75), gravity after transfer (45), calving plus survival of calf (85), female sec (48), fertile heifer (90), gravity (90), calving plus survival of calf (85). Success of reactivation from frozen embryos: 0.89*0.75*0.85*0.48*0.9*0.9*0.85=0.084 or 11.85*25=300 cryoconserved embryos are needed, to reactivate the original population with 25 females with offspring. Number of donors for 300 cryoconserved embryos: According to Schutz (1988) the following assumptions are made: Suitability for flushing (0.73), 2 repeated stimulations per donor, reaction to stimulation (0.82), 8 embryos per flushing, freezable embryos (0.35). Rate of success: 0.73*2.*0.82*8*0.35=3.35 embryos per donor, or 90 donors are required to produce 300 embryos in cryoconservation. Reactivation of population: Thawing of embryos in year 47 and transfer of 300 embryos to 300 recipients to produce 25 femeles with offspring in year 50. For the reproduction of this population 100 doses of semen from each of 25 males, i. e a total of 2500 doses, should be cryoconserved. 25 females + 25 males (males (semen) = Ne = 50.

3. Live animal conservation in reproducing herds (LA)

64 cows and 16 bulls, i.e. a total of 80 breeding animals are kept in 16 herds, each with 4 cows and 1 bull. 64 females + 16 males = Ne = 51,2. Animal use for breeding: bulls for 2 years, cows for 4 years. Planned matings of bulls from different herds in order to minimize the genetic relationship among mates. No reactivation necessary, the population is permenently available.

4. Combination of live animals and cryoconservation of semen (LA+CS)

Population size: 26 cows, 4 bulls for natural service + 42000 doses of semen of 20 males for AI to get the bulls = Ne = 50. Stayability of cows until fourth calving = 90 %, other fitness factor assumed as in live animal conservation (LA). Natural service bulls are abtained by AI of some females per generation to minimize inbreeding as described by Simon (1993) Reactivation is not necessary.

Economic assumptions:

All costs and returns are expressed in German Marks, DM. Heifers are rented for one gravity for 500,- DM for reactivation from embryos (CE+CS) and for first generation of reactivation from semen (CS). Costs for the live animals of a preserved breed are calculated as subsidies necessary to compensate for additional costs compared to keeping high producing cattle according to official data for agriculture in Northern Germany 1991 - 1993 (Lömker, 1993):

Dairy cow with 3000 kg milk yield/year	DM = 1.068,-
dairy cow with 5000 kg milk yield/year	DM = 121,-
suckler cow	DM = 149,-
heifer	DM = 446,-
bull	DM = 243,-

Table 2. - DISCOUNTED COSTS OVER A TIME PERIOD OF 50 YEARS FOR AN EMBRYO BANK WITH REACTIVATION IN YEAR 47 WITH ET, COSTS AND RETURNS IN DM

Year	nitrogen per year	discounted	rent of recipients costs of ET heifers grow up and Ai	discounted	returns from selling bullcalves	discounted
1	157	150				
2	157	142				
3	157	136				
4	157	129				
5	157	123				
-	-	-				
45	157	17				
46	157	17				
47	157	16	110.000	11.104		
48	157	15	39.680	3.815	-9.520	-915
49	157	14				
50	157	14	1.089	95		
	7850	2.866	150.769	15.014	-9.520	-915
	maintai-nance:	2.866	reactivation:	15.014	-915	=14.099

Net discounted costs of reactivation = 15014-915=14099 DM.

Fixed and variable costs of running the farm are not included. Due to health regulations in the EU it is assumed that the equipment of commercial AI stations can not be used for collection and cryoconservation of semen and embryos. These investiments are completely attributed to the conservation costs of one single breed. The decrease of costs is relatively low, if the equipment is used for two, three, five, ten or twenty breeds. Costs and returns arising during 50 years of conservation are discounted to year 0. The capital value of investment CV ist calculated according to (Hill, 1971):

$$CV = \sum_{t=1}^{50} \frac{C_t - R_t}{(1+i)^t}$$

with C = costs, R = returns, T = year, i = interest rate. An interest rate of 5 % was assumed. Detailes on assumed costs and on computing are described by Lömker (1993).

For example in table 2 the discounted costs are computed for an embryo bank, which is reactivated by embryo transfer in year 47 to have the population available in year 50, returns from not used calves are considered as income.

Results

1. Cryoconservation of semen and reactivation (CS)

Costs of semen bank (Lömker 1993)
Setting up a semen bank for one breed (25 bulls, each 4530 doses of semen):

Fixed costs (equipment, instruments)	80.100 DM
Variable costs (collection of semen, processing)	34.000 DM
Costs of a semen bank for one breed	114.000 DM

Costs of reactivation

Costs of renting one heifer for one gravity	500,- DM
Insemination and control of gravity for a rented heifer	33,- DM
Return from male calf:	280,- DM

Discounted costs of reactivation of one breed by grading up with single calving in each generation. 1.251.902 DM, also shown in table 5.

2. Cryoconservation of embryos and reactivation (CE+CS)

Costs of embryo and semen bank (Lömker 1993).
Setting up of an embryo bank for only one breed

Fixed costs (equipmennt and instruments)	36.730 DM
Variable costs (material, costs of processing, personnel costas, driving costs, premium to owners of useable animals)	285.420 DM
Variable costs for semen collection and processing until freezing	4.250 DM
Costs of an embryo bank for one breed	326.400 DM

3. Live animals in reproducing herds

Costs of live animals of a breed over a time period of 50 years are shown in table 3a and 3b

Table 3a.- PURCHASING COSTS FOR LIVE ANIMALS OF ONE BREED

Ne	bull	cows	animals/breed	purchasing costs of a bull: 1956,-DM and of a cow: 1593,-DM (price of heifer+old cow)/2)
51	16	64	80	133.248

It is assumed that animals can be purchased at breeding age.

Table 3b. - COSTS OF MAINTAINANCE OF LIVE ANIMALS OF A BREED, PER YEAR AND ACCUMULATED AND DISCOUNTED OVER A TIME PERIOD OF 50 YEARS

Ne	bulls	cows	animals/ breed	MO costs in DM/a	costs MO discounted	M3 costs in DM/a	costs M3 discounted	M5 costs in DM/a	costs M5 discounted
51	16	64	80	13.424	245.068	72.240	1.318.808	11.632	212.353

Production level of cows:
MO : suckler cows, no milking
M3 : 3000 kg milk yield per cow/year, respectively
M5 : 5000 kg milk yield per cow/year, respectively

4. Combination of live animals with a semen bank

In table 4 the costs of maintainance of a bred are shown

Table 4. - COSTS OF MAINTAINANCE OF LIVE ANIMALS COMBINATED WITH A SEMEN BANK WITH SPERM OF 20 BULLS WITH DIFFERENT HERD-AND POPULATION SIZES, PER YAEAR AND ACCUMULATED AND DISCOUNTED OVER A TIME PERIOD OF 50 YEARS.

Ne	bulls	cows	animals/ breed	costs/a DM MO	costc MO dis-counted	costs/a DM M3	costc M3 dis-counted	costs/a DM M5	costs M5 dis-counted
50	4	26	50	5.628	102.747	29.522	538.951	4.900	89.454

Production level of cows:
MO : suckler cows, no milking
M3 : 3000 kg milk yield per cow/year, respectively
M5 : 5000 kg milk yield per cow/year, respectively

Costs of setting up of a semen bank with semen of 20 bulls, 2100 doses each:

Nitrogen container	12.500,- DM
Collection of semen and processing until freezing	20.400,- DM
	32.900,- DM

In Table 5. all costs of the strategies of conservation for a population of Ne = 50 seperated for setting up, maintainance and reactivation are shown.

Table 5. - DISCOUNTED COSTS OF CONSERVATION STRATEGIES RESULTING IN A POPULATION WITH EFFECTIVE POPULATION SIZE NE = 50 AFTER 50 YEARS OF CONSERVATION, IN DM PER BREED

Cost pasition	CS Cryoconservation of semen 113250 doses from 25 bulls reactivation by upgrading	CE+CS Cryoconservation of embryos and semen 300 embryos from 90 donors 2500 semen doses from 25 bulls 300 recipients	LA Live animals 64 cows+16 bulls in 16 reproducing herds	LA+CS Combination of live animals and cryoconserved semen 26 cows 4 bulls and 42000 semen doses from 20 bulls
Setting up	114.100	326.400	133.248	82.140
Maintainance	53.919	2.866	MO 245.068	MO 102.747
			M3 1.295.440	M3 538.951
			M5 212.313	M5 89.454
Reactivation	1.251.902	14.099	-	-
Total costs	1.419.921	343.365	MO 378.316	MO 184.887
			M3 1.428.688	M3 621.091
			M5 345.601	M5 171.594

Production level of cows:
MO : suckler cows, no milking
M3 : 3000 kg mulk yield per cow/year, respectively
M5 : 5000 kg mulk yield per cow/year, respectively

The conservation strategies show extrem differences in the relative magnitude of costs for setting up the conservation programme, for maintainance and for reactivation. Initial costs are highest for cryoconserved embryos and lowest for live animal conservation LA, which on the other hand requires the highest costs for maintainance. Costs for reactivation are not necessary in live animal conservation programmes LA and La+CS but are extremly high in cryoconservation of semen. This situation shows that discounting costs are essential for meaningful comparison of costs of conservation strategies.

Table 6. - INCREASE OF INBREEDING (ΔF), GENERATION INTERVALL (L), NUMBER OF GENERATIONS (G), AND ACCUMULATED INBREEDING (F50) IN 50 YEARS OF CONSERVATION FOR FOUR CONSERVATION STRATEGIES

strategies	CS	CE+CS	LA	LA+CS
(sperm) bulls	(25)	(25)	16	(20)+4
cows	2785/919/303/100	89	64	26
ΔF=(%)	Ø 0,54	0,64	0,98	1,0* / ≈ 0,0**
L = (years)	10	50	3,625	3,625* / Ø 21,4**
t =	4(5)	1	≈ 15	≈12* / 2,39**
Ft = (%)	2,17	0,64	13,74	11,8* / 0,00005**

*random mating
**planed matings with artificial Insemination (descendent meets his ancestor after 20 years)

Discussion

Cryoconservation of semen CS is economically attractive only if the costs of reactivation of a breeding population are neglected; if these are included CS - together with live animal conservation with low milk production (3000 kg) - turns out to be the most expensive strategy (approx. 1.4 Million DM per breed). Live animal conservation LA with no milking of cows or with reasonable milk production (5000 kg) and cryoconservation of embryos CE+CS cause far lower costs (approx. 0,34 Million DM), where LA leads to the highest value of inbreeding. Cryoconservation of embryos plus semen CE+CS is attractive in costs and low inbreeding, but it may be difficult to find 90 donors of the endangered breed. The combination of live animals and cryoconserved semen LA+CS is characterized by lower costs and inbreeding than live animal conservation, in respect to costs and inbreeding the combination of live animals and cryoconservation of semen turns out to be the most attractive conservation strategy. Other advantages are permanent availability of population for further evalutions, for adaptation and for the atraction of people. The number of assumed breeding animals in LA and LA+CS are relatively small, they have been decided to minimize costs, given an effective population size of Ne = 50. Higher numbers of live animals which may be desirable for various reasons, will increase the costs of conservation.

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