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in

Baselga M. (ed.), Marai I.F.M. (ed.).
Rabbit production in hot climates

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 8

1994
pages 279-283

HERITABILITY OF SOME MALE REPRODUCTIVE TRAITS IN RABBIT (*)

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Summary

The quanti-qualitative characteristics and the heritability of rabbit semen were evaluated. During the period 1991-93, 3,670 semen samples were collected from 158 N.Z.W. bucks coming from a semen center and reared in four different rabbitries. The examined traits were the followings: *libido*, ejaculate volume, spermatozoa/ml, motility, live sperms, fertility rate and litter size. The variability factors studied were: year, rabbitry, kindling order and buck. A different variability was observed for the semen traits: libido (mean = 2.8) and ejaculate volume (mean = 0.65 ml) showed the lowest variability, live sperms (mean = 72.03%) and progressive motility (mean = 57.4%) showed an intermediate variability while the spermatozoa/ml (mean = 583.1 millions), the fertility rate (mean = 72.06%) and the litter size (mean = 8.14) were very variable. The phenotypic correlation coefficients were negative between volume, spermatozoa/ml, motility, fertility rate (r=-0.13; -0.10; -0.14), while sperms concentration was positively correlated with live sperms, motility, fertility (r= 0.21; 0.32 and 0.30). Almost all the genetic correlations were negligible; exceptions were concentration and live sperms (0.33); concentration and motility (0.40); fertility and litter size (0.40), motility and live sperms (0.30). The heritability ranged from 0.17 (fertility rate) to 0.60 (spermatozoa/ml).

Key words: rabbit, semen characteristics, heritability.

Introduction

Artificial insemination (a.i.) is widely used in all the countries (Italy, France, Spain) where the rabbit farming is intensive. Also in the developing countries a.i. could play an important role for selection purposes not only to improve the diffusion of the selection results but also to ameliorate the selection accuracy. The success of this reproduction technique mainly depends from the physiology of the doe (receptivity, lactation stage, etc.) but an important factor is also the semen quality.

Therefore quanti-qualitative traits of semen must be known in order to select bucks which produce large quantities of semen with good fertilizing characteristics. To date few studies have been done on this subject but the results cannot be easily compared and generalized. Some works (CARVAJAL et al., 1983) provided general information while others give more specific details on the main factors affecting semen characteristics, such as breed (DUBJEL et al. 1984), collection order and frequency (BENCHEIKH, 1993). Some researchers (BATTAGLINI et al., 1992; BENCHEIKH, 1993) also evaluated the correlation coefficients, and the repeatabilities of these traits.

The present research was conducted to evaluate the variability of the main semen traits and their heritability.

(*) Research founded by MURST 40%.

Materials and Methods

The trial was carried out during the years 1991-1993 on 158 New Zealand White bucks coming from an insemination center of Northern Italy related each other by different relationships and reared in four different rabbitries. All these bucks were form a strain specially selected to improve semen quality and quantity.
The chosen rabbitries had similar management, environmental conditions and feeding systems and were very close each other. The photo-period was 16 hours/day and the animals fed the same commercial feed (17% crude protein, 16% crude fiber, 2,550 DE kcal/kg) ad libitum.
The semen was collected once a week (3,670 observations) with the artificial vagine of IMV; immediately after collection each individual sample was examined.
The examined traits of the ejaculates were: sperm concentration, live sperms and progressive motility. The sperm concentration was determined on semen diluted 1:100 with phosphate buffer by a photometer (wavelength 520 nm).
The proportion of live sperms was estimated by staining them with tryphan blue, according to the method of CHEN et al.(1989). After centrifugation, resuspension and incubation, the sperm suspension was smeared on a glass slide. Two-hundred sperms from each ejaculate were examined to determine the percentage of live sperm. The percentage of motile sperm was estimated subjectively placing a drop of semen on a microscope slide at 37° C and determining the progressive motile sperms with a video camera and a monitor connected to the microscope.
The samples showing sufficient characteristics (motility > 50%, spermatozoa number > 450 x 10^6) were successively diluted (1:6 with an extender consisting of tris buffer with 20% egg yolk) for the a.i..
The semen was refrigerated at 18° C and used within 12 hours after collection in the four different rabbitries.
In all the rabbitries the does were treated with 20 IU of PMSG two days before the insemination and with 10 µg of GnRH at the insemination. The does were divided in two categories (nulliparous or multiparous) and if lactating were inseminated 8-15 d after kindling.
The traits studied were the following:

- Libido (arbitrary scores: 1 = no mating; 2 = collection after 5 min; 3 = immediate collection);
- Ejaculate volume (ml)
- Spermatozoa/ml (No.)
- Progressive motility (%)
- Live sperm/total sperm (%)
- Fertility rate (kindling/inseminations x 100)
- Litter size at birth (No.)

A previous statistical analysis was carried out to estimate the effect of the main environmental factors according to the following linear model:
- For seminal traits:

$$Y_{ijk} = \mu + R_i + B_j + e_{ijk}$$

Y_{ijk} = experimental items;
μ = overall mean
R_i = fixed effect of i^{th} rabbitry (i=1,..,4);
Y_j = fixed effect of j^{th} year (j=1,..,3);

e_{ijk} = residual random effect

For the reproductive traits the effect of parity (l=1,2) was added to the statistical model.
These statistical analysis were carried out using SAS software (SAS-STAT, 1989).
The estimation of variance and covariance components was carried out according to this mixed animal model:

$y = X\beta + Zu + e$

X = incidence matrix for fixed effects;
β = vector of fixed effects (rabbitry, year, parity);
Z = incidence matrix for random effects (animal);
u = vector of random effect (animal);
e = vector of residual random effects.
The solutions were obtained by DFREML (MEYER, 1991, BOLDMANN and VAN VLECK, 1991)

Results and Discussion

The observed performance are shown in Table 1. The average value of the libido was 2.8 with a small variability between rabbitries and years; in the ejaculate volume (mean = 0.65 ml) the differences between farms ranged from 0.58 to 0.67 ml and those ones between years from 0.56 to 0.72 ml. The percentage of live sperms was 72.03 and the differences between rabbitries and years reached 4.4 and 3.6 respectively.
The average number of spermatozoa per ml in the studied sample was 583.1 millions with a rather high variability between rabbitries (I vs II: about 67 millions) and years (92.4 millions). Regarding sperm motility the 57.4% showed a good kinetic and the variability between rabbitries and between farms ranged around 10%. The fertility rate was 72.06% with a rather strong difference between rabbitries (62.5 - 78.0), years (62.6 - 77.5) and parities (67.3 - 73.0). The litter size was 8.14 with high differences mainly in the rabbitry factor (7.55 - 9.34). The fertility rate and the litter size were similar to those usually observed, indicating good management conditions during the trial.
The results obtained in this investigation are in agreement with those found by other researchers regarding the average values of different traits and their high variability. The only exception is on the sperm concentration that is higher than those previously reported (PANELLA and CASTELLINI, 1990) probably because of the different estimation method (photometer vs Thoma chamber) and collection frequency that in the present study was once a week only. If the comparison is done with works executed by similar methods (BATTAGLINI et al., 1992) and rhythms (BENCHEIKH, 1993) the results are very close (583 vs 561 vs 548 millions).
The phenotypic correlation coefficients (Table 2) showed that when volume increased the spermatozoa/ml, motility and fertility rate decreased (r=-0.14; -0.13; -0.10 respectively). Finally the more concentrated semen was characterized by a higher value of live sperms, progressive motility and fertility (r= 0.21; 0.32 and 0.30).
The correlation values were similar to those previously reported by others (JARPA MENDEZ, 1984; BENCHEIKH, 1993; BATTAGLINI et al., 1992).
For selection purposes it is important to know the genetic correlations but most of these correlations were negligible. The only exceptions were between libido and volume (0.99); concentration and live sperms (0.33); concentration and motility (0.40); fertility and litter size (0.40).

Other coefficients of consistent magnitude are those relating fertility vs motility and live sperms (0.24; 0.73). This trend seems to have an easy biological meaning, in fact more are the live sperms more is the ejaculate motility estimation and more its fertility power.
The estimated heritability (table 2) ranged from 0.17 (fertility rate) to 0.60 (spermatozoa/ml). The observed h^2 seems to be rather high for the reproductive traits; it is difficult to make some comparisons on the sperm traits with other estimations because there is an absolute lack of information on this topic. The only exception is the work of BENCHEIKH (1993) who, for some of these traits, found repeatability values equal or smaller than heritability estimations here reported. That could mean that the data set utilized in this research get an overestimation of the genetic parameters. Also the heritability coefficients estimated in the fertility (0.17) and litter size (0.21) are higher than those reported by FERRAZ et al. (1992), PANELLA et al. (1992) and BASELGA et al. (1992).
Tryng to explain the large magnitude of the estimated coefficients must be taken into consideration that the hormonal treatments of the does with PMSG and GnRH could reduce the variability of the ovarian response.
In conclusion it is possible to affirm that the obtained results showed a rather large h^2 in the studied traits. If it is taken into account that usually the reproductive characters have a very low genetic determination has to be checked if these ones are an exception or if the sample gives these results because of the hormonal treatments or because of the selection carried out on it.

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Table 1 - Semen characteristics (LSMeans -SE, No.).

	Libido	Volume ml	Live sperms %	Spermatozoa /ml No. x 10^6	Motility %	Fertility %	Litter size No.
Overall mean	2.80	0.65	72.03	583.1	57.37	72.06	8.14
Rabbitry							
I	2.85	0.58	70.3	537.4	56.5	66.2	7.55
II	2.90	0.61	74.7	604.6	62.1	78.0	9.34
III	2.88	0.63	71.6	555.1	57.4	62.5	8.18
IV	2.90	0.67	71.2	552.2	57.0	73.8	8.20
Year							
I	2.9	0.60	74.4	507.7	60.4	62.6	8.07
II	2.8	0.56	70.8	593.1	59.7	77.5	8.19
III	2.8	0.71	70.6	586.5	55.5	77.5	8.15
Kindling order							
Primiparous						73.0	7.86
Pluriparous						67.3	8.76
SE	0.17	0.27	7.31	98.1	13.5	7.1	0.65
No.	4,150	3,670	2,520	3,670	3,670	2,010	2,010

Table 2 - Heritability, genetic and phenotypic correlations (over and under the diagonal).

	Libido	Volume	Live sperms	Spermatozoa /ml	Motility	Fertility	Litter size
Libido	**0.30**	0.99	0.13	0.02	-0.02	0.04	0.06
Volume	*0.08*	**0.44**	0.12	0.01	0.12	0.19	0.05
Live sperms	*0.02*	*-0.14*	**0.37**	0.33	0.30	0.73	0.07
Spermatozoa/ml	*-0.02*	*-0.13*	*0.21*	**0.60**	0.40	-0.31	-0.01
Motility	*-0.01*	*-0.10*	*0.41*	*0.32*	**0.56**	0.24	0.35
Fertility	*-0.09*	*-0.14*	*0.10*	*0.30*	*0.02*	**0.17**	0.40
Litter size	*0.05*	*0.02*	*-0.02*	*-0.03*	*0.02*	*-0.11*	**0.21**