AUTOGAMY IN THE HONEY BEE

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Abstract

Autogamy is an exceptional possibility how to get high homozygous bees in a few generations. The inbreeding coefficient (F) is in the first generation of autogamy F=0,5, in the second generation F=0,75 (3/4), in the third generation F=0,875 (7/8), and so on. Autogamic mating of a queen is not possible in the nature but only under breeder's management using the insemination technique. Autogamy leads to high genetic relationships among bee-workers in the colony. The coefficient of relationship is in the first generation of autogamy among bees from the same drone (supersisters) R=0,8333 (5/6), and among bees from two drones of the same queen (full-sisters) R=0,6667 (2/3). Thus, the average R-value inside the autogamic bee colony lies between 2/3 and 5/6 depending on the number of inseminated drones. For comparison, among common supersisters R=0,75, and among common full-sisters R=0,5. Formulas for calculating R-values are derived not only for the meant situations but, in general, for any case when in pedigrees of two relative individuals an autogamic ancestor appears.

Introduction

Autogamy or self-fertilisation is quite exceptional type of mating in animals. Hermaphroditic character of the honey bee makes possible the autogamic insemination of a queen. Autogamy in the honey bee does not happen in the nature but it is possible to realize it only under breeder's management using the insemination technique. Autogamy leads to quick increase of inbreeding and the rate of homozygosity. A quick accomplishment of high homozygotic bees may be useful in honey bee breeding in special cases.

Material and methods

Realization the autogamy in a few consecutive generations leads to these values of inbreeding coefficients (F): 1/2, 3/4, 7/8, 15/16, 31/32, etc. (for example LAIDLAW and PAGE, 1986) and these values are the same in diploid as well as in haplo-diploid organisms.

But deriving the values of coefficients of relationship (R) between autogamic sister bees is more complicated. The basic formulae by LAIDLAW and PAGE (1986) may be used but must be modified. It is specific for autogamic bees that mother and father is the same individual. LAIDLAW and PAGE (1986) also present rules for calculating F and R in haplo-diploid honey bees by analysing a pedigree.

A drone is not considered to be a male but, as a result of queen polyandry and drones' parthenogenesis, the drone-queen is genetic father. Therefore, the queen may be mother and father of the same bee. But two sister bees may be daughters of the same drone when two eggs are fertilised with two genetically identical spermatozoids. The bees are so called supersisters and their genetic relationships is R=0.75. In case the queen was inseminated with sperm of more than one drone of the same queen, some sister bees are daughters of two drones. These bees are normal sisters or full-sisters, and their genetic relationship is R=0.50.

By using the approach of BIENEFELD (1988), the average relationship coefficient R in a colony may be expressed by weighing the frequencies of supersisters and full-sisters in the queen's offspring.

Results and discussion

Relation between two autogamic bees B1 a B2 of the same mating is shown in fig. 1. Mother as well as father is the same individual (queen), consequently $F_{B1} = F_{B2} = 0.5$. Four genetic connections are valid for calculating the R-value: *mother of B1 – mother of B2, mother of B1 – father of B2, father of B1 – mother of B2, father of B1 – father of B2*. Number of paths in a genetic connection is labeled *r*.

Autogamic sisters from two drones

Each of four genetic connections (fig. 1) is composed of two paths (r=2), each path has the value 0.5, therefore each genetic connection has the value 0.5^2.

In case the queen Q is not inbred (F_Q=0), R is:

$$R_{B1,B2} = \frac{4 \times 0.5^2}{\sqrt{(1+F_{B1}) \times (1+F_{B2})}} = \frac{1}{1.5} = \frac{2}{3} = 0.6667 \qquad (1)$$

In case the queen Q is inbred (F_Q>0), $F_{B1}=F_{B2}=0.5 \times (1+F_Q)$, and R is:

$$R_{B1,B2} = \frac{4 \times 0.5^2 \times (1+F_Q)}{\sqrt{(1+F_{B1}) \times (1+F_{B2})}} = \frac{2 + 2 \times F_Q}{3 + F_Q} \qquad (2)$$

Autogamic sisters from the same drone (from two genetically identical spermatozoids)

Genetic connection *father of B1 – father of B2* is composed of two paths, each of the value √0.5, therefore 0.5 is set in the formula for this connection. The other three genetic connections have the value 0.5^2.

In case the queen Q is not inbred (F_Q=0), R is:

$$R_{B1,B2} = \frac{3 \times 0.5^2 + 0.5}{\sqrt{(1+F_{B1}) \times (1+F_{B2})}} = \frac{1.25}{1.5} = \frac{5}{6} = 0.8333 \qquad (3)$$

In case the queen Q is inbred (F_Q>0), $F_{B1}=F_{B2}=0.5 \times (1+F_Q)$. Because haploid drone represents the father, his F-value is not present in the formula as F_{drone}=0. Thus, R is:

$$R_{B1,B2} = \frac{3 \times 0.5^2 \times (1+F_Q) + 0.5}{\sqrt{(1+F_{B1}) \times (1+F_{B2})}} = \frac{5 + 3 \times F_Q}{6 + 2 \times F_Q} \qquad (4)$$

Average relationship inside the colony of autogamically inseminated queen

The average R-value is calculated by weighing the formulas (1) and (3) in case $F_Q=0$, or formulas (2) a (4) in case $F_Q>0$, with the frequencies of subfamilies by drones in the colony (d). The size of single subfamilies is supposed to be the same.

If $F_Q=0$:

$$R = \left(\frac{d-1}{d}\times\frac{2}{3}\right)+\left(\frac{1}{d}\times\frac{5}{6}\right) \tag{5}$$

If $F_Q>0$:

$$R = \left(\frac{d-1}{d}\times\frac{2+2\times F_Q}{3+F_Q}\right)+\left(\frac{1}{d}\times\frac{5+3\times F_Q}{6+2\times F_Q}\right) \tag{6}$$

The general formula:

$$R = \frac{4\times 0.5^r \times (1+F_Q)\times(d-1)/d + 0.5^r \times (5+3\times F_Q)/d}{\sqrt{(1+F_{B1})\times(1+F_{B2})}} \tag{7}$$

References

BIENEFELD K. (1988) Vererbung von Leistungseigenschaften bei der Honigbiene. Dissertation. Univ. München, 159 pp.
LAIDLAW H.H., PAGE R.E. (1986) Mating systems. In: Bee Genetics and Breeding, Academic Press Inc., ed. T. E. Rinderer, pp. 323-344

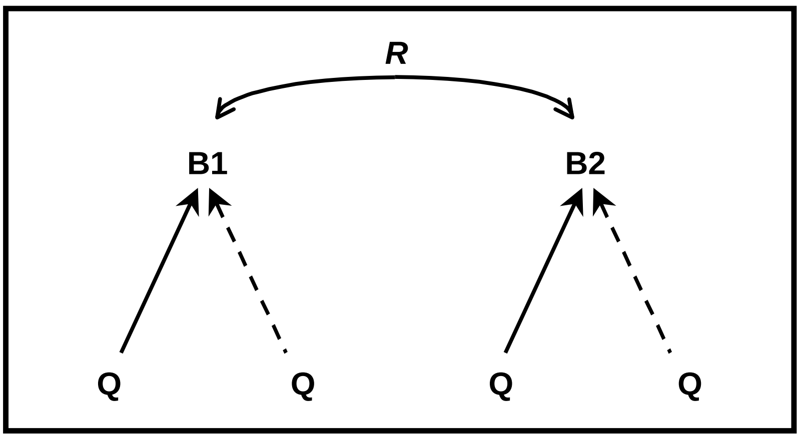

Fig. 1 ***Relationship coefficient R of two autogamic bees.*** *The full line represents the path between mother and daughter, the dashed line the path between father and daughter.*