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Worker's Genetic Diversity Has No Relation to Pollen Diversity in a Honey Bee Colony (*Apis mellifera* L.)

Michał WOYCIECHOWSKI[1] and Zofia WARAKOMSKA[2]
[1]Bee Research Department, Agricultural University Al. 29 Listopada 52,
31-425 Kraków, Poland
[2]Department of Botany, Agricultural University Akademicka 15,
20-050 Lublin, Poland

Abstract — No differences were observed between the species diversity of pollen gathered by colonies with artificially reduced worker genetic diversity and those derived from naturally mated queens. Such a result does not support the hypothesis that polyandry increases colony fitness in which a genetic basis is created for using a wider range of food sources.

In the honey bee, a strongly polyandrous species (queens usually mate with 6–17 drones; Woyke 1964; Adams et al. 1977), there is much evidence for the functional significance of a genetic basis for the division of labor (cf. Oldroyd et al. 1992a). Within a colony, patrilines may differ in their foraging behaviour (Calderone et al. 1989; Robinson & Page 1989; Oldroyd et al. 1992a), guarding of the hive entrance or remove all of dead bees (Robinson & Page 1988). These factors and others determine colony performance (Calderone & Page 1991; Oldroyd et al. 1992b), and suggest that genetic diversity of workers may significantly influence colony fitness. However, a genetical basis for the division of labor has been reported mostly in colonies with artificially small genetic diversity and visible mutations of the workers, which could influence the results obtained (Frumhoff 1991; Moritz & Heisler 1992). So far, there has been no convincing evidence that polyandry increases colony fitness in natural conditions.

The influence of workers' genetic diversity on species diversity of pollen gathered was checked, by comparing the efficiency of workers derived from a naturally mated queen with those with an artificially small number of patrilines. It has been suggested that the use of a wider range of food sources is a result of "colony genetic structure in the division of labor" (Robinson & Page 1989), and/or a tendency for preferential communication in the patrilines, i.e. by "dances with super-sisters" (Oldroyd et al. 1991).

Methods

Three groups of honey bee colonies (5 in each group) were used: group A, with the lowest worker genetic diversity (each queen artificially inseminated by only 1 unrelated drone); group B, with medium worker genetic diversity (each queen inseminated by 6 brother drones unrelated to the queen); and group X, with the highest worker genetic diversity expected, since the queens were naturally inseminated.

Pollen loads were collected by forcing the foragers to return to the hive through 5.1 mm (dia.) slots. This was done in June and in the beginning of July 1988 (7 days), between 0900 and 1400, in an apiary 17 km NWW of Kraków (southern Poland). The duration of pollen collection (3.5 h on average) depended on how quickly a minimum of 200 pollen loads could be collected from a particular colony. Pollen from each of the colonies was powdered, and 249 to

491 pollen grains were identified by microscope. The proportions of the various pollens were used to calculate the pollen diversity (H) from the Shannon-Weaver function:

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

where P_i is proportion of the i-th species and S is number of species in a total sample.

Results

We identified a total of 55 types of pollen (single species, e.g. *Polygonum bistorta, Trifolium repens*; or groups of unidentifiable species, e.g. *Helianthus* typ., *Majorana* typ., *Begonia, Campanula*). From 2 to 15 (mean 8.18) types of pollen were found in individual colonies each day. Then, various H-values of pollen diversity were obtained and are shown in Fig. 1 (cf. Table 1).

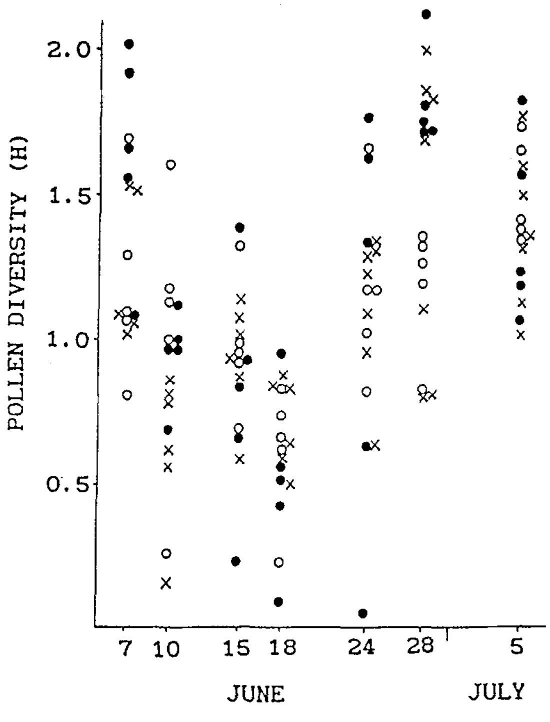

Fig. 1. Shannon-Weaver measure of diversity (H) of pollen collected by colonies with low A (○), medium B (●) and high X (×) worker genetic diversity.

No differences in H-values, however, were detected between groups of colonies with different worker genetic diversities. Instead, differences between particular days of the experiment were highly significant (Table 1). Differences in the diversity of pollen gathered by workers during the experiment (which lasted over a month) were probably a result of the variation of sources of pollen during the season and at the times of pollen collection on particular days.

Discussion

The number of inseminations of the queen has a significant effect on the genetic diversity of the workers in a colony. At the same time, each successive mating prolongs the duration of the nuptial flight or gives the queen extra reason to leave the nest (Woyke 1964). In spite of the dangers associated with multiple mating, this strategy is widespread in eusocial Hymenoptera (Page & Metcalf 1982). Consequently it is believed that polyandry must have a compensatory adaptive value (Laidlaw & Page 1984; Oldroyd et al. 1992b), an argument that may be somewhat circular.

In eusocial Hymenoptera, the benefits derived from multiple mating are usually thought to be an increase in overall colony efficiency (see Moritz & Southwick 1992). It is argued that genetically diverse colonies have a higher number of individuals (Cole 1983), more resistance to parasites and pathogens (Hamilton 1987; Sherman et al. 1988), and a genetic predisposition to the division of labor (Robinson & Page 1989). In the honey bee, polyandry also increases reproductive success by reducing the variance of diploid male production (Page 1980). Another group of hypotheses, based on kin-selection theory, explains multiple mating in terms of benefits to the queen herself. It is thought that the queen's fitness is increased, either by limiting queen-worker conflict over her offspring's sex ratio (Moritz 1985), or by inducing the workers to cease production of male-determined eggs (Woyciechowski & Lomnicki 1987).

However, we assumed that genetic diversity

Table 1. Shannon-Weaver measure of pollen diversity (H) and number of types of pollen collected (P) by colonies with low (A), medium (B) and high (X) worker genetic diversity, on seven different occasions.

Data	Hive	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	X1	X2	X3	X4	X5	Mean H SD
5 June	H	1.69	1.08	1.30	0.82	1.10	1.09	1.56	2.01	1.69	1.92	1.53	1.08	1.03	1.51	1.10	1.37
	P	13	12	15	9	12	10	12	14	14	14	10	12	8	9	9	0.36
10	H	1.60	1.19	1.00	0.26	1.13	1.12	1.00	0.99	0.70	0.99	0.64	0.57	0.16	0.81	0.78	0.86
	P	8	7	8	3	8	10	7	7	6	7	7	9	6	6	6	0.37
15	H	1.33	0.98	0.94	0.69	0.95	0.84	1.38	0.93	0.23	0.68	1.02	0.93	0.60	0.87	1.07	0.90
	P	6	5	7	2	6	5	7	6	4	7	7	6	6	6	8	0.28
18	H	0.23	0.75	0.67	0.83	0.62	1.05	0.56	0.53	0.10	0.43	0.82	0.83	0.51	0.87	0.6	0.63
	P	5	3	2	7	4	5	4	4	4	6	5	7	2	4	7	0.25
24	H	1.66	0.82	1.17	1.17	1.02	0.64	0.05	1.76	1.64	1.34	1.09	1.29	1.30	1.22	0.65	1.12
	P	10	6	8	7	6	8	2	10	10	6	6	7	8	5	7	0.45
28	H	1.26	1.35	1.19	1.33	0.84	1.71	1.74	2.11	1.72	1.80	1.86	1.69	1.83	0.80	0.82	1.47
	P	11	11	8	10	10	11	9	15	11	14	13	11	10	10	8	0.42
5 July	H	1.73	1.37	1.35	1.41	1.64	1.24	1.07	1.82	1.19	1.56	1.50	1.60	1.35	1.01	1.31	1.41
	P	14	7	10	6	11	12	8	13	8	14	9	13	11	10	9	0.23
Mean H		1.36	1.08	1.09	0.93	1.05	1.10	1.05	1.45	1.04	1.25	1.21	1.14	0.97	1.02	0.91	
SD		0.53	0.25	0.24	0.40	0.32	0.34	0.59	0.62	0.70	0.57	0.43	0.41	0.58	0.26	0.25	P<0.0001, F=14.02, df=6
Mean H±SE (each genetic group)				1.10±0.06					1.18±0.10					1.05±0.07		ns, F=1.32, df=2	

Results of 2-way ANOVA are indicated in marginal columns.

in such colonies, a result of the natural tendency of the queen towards polyandry, was significantly higher than in those where queens were artificially inseminated by 1 drone or by 6 brothers. We realize, however, that our data can be interpreted in several different ways, as we did not assess the relatedness of workers derived from naturally mated queens. Our results give us no reason to suppose that the diversity of the collected pollen (a part of the colony's behavioural phenotype) has some relationship to the genotypic diversity of workers in the colony, and do not support hypotheses that attempt to explain polyandry by a genetical basis for intra-colonial foraging specialism.

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