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NOTES AND COMMENTS

Seasonal inconsistencies in the relationship between honey bee longevity in field colonies and laboratory cages

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Sufficient winter longevity of honey bees (*Apis mellifera* L.) is critical for colony performance. For example, the pollination of almonds in California, USA requires populous colonies in February. Furthermore, the dwindling of colony populations in winter and spring could be due to insufficient longevity of winter bees. The size of colonies in winter and spring might be improved if bees had increased longevity as a result of artificial selection.

Honey bee longevity measured in cage studies varied substantially in a free-mating population of honey bees (Rinderer and Sylvester, 1977), had a heritability of 0.32 and was favourably correlated (r = 0.76) to survival after challenge with *Nosema apis* (Rinderer *et al.*, 1983). Although these results are encouraging for a potential selection programme, the relationship between worker bee longevity measured in cages and worker bee longevity (including in winter) in field colonies has not been determined.

We measured this relationship in Baton Rouge, LA, USA, using 28 colonies of honey bees of various strains that had emerging brood in November 2008. Brood combs from each colony were held separately in an incubator (*ca.* 34ºC; 50% RH). After 24 h, emerged bees were marked with enamel paint (Testor Corp.; Rockford, IL, USA) so that they were identifiable to colony. Each of two hoarding cages (Rinderer and Sylvester, 1977) received 50 bees, and 50 bees were returned to their original colony.

Caged bees were fed *ad lib.* from a vial with sucrose solution (1 water: 2 sucrose, w:w) and a vial with water. Cages were housed in an incubator and inspected every second or third day. Dead bees were removed from cages and recorded until all bees died. The median LT_{50} (in days) was calculated for each cage and the average median LT_{50} for the two cages representing each colony was used for correlation analyses (SAS, 2010).

Field colonies, located in eight apiaries, were inspected comb by comb each week when there was little or no flight to determine the number of marked bees remaining. We used the initial count (three days after introducing bees) as the baseline for estimating longevity; the starting number of bees per colony was 39 ± 6 (sd). The median LT_{50} was interpolated to the nearest 0.1 week for the marked bees in each colony and used for correlation analyses.

Emerging brood was harvested from each of the 18 colonies that retained original queens in March 2009. Again, bees were emerged in an incubator, paint marked and placed in groups of 50 into cages. Four cages were stocked from each colony. Bees in all cages were fed *ad lib.* sucrose solution and water. Bees in two cages were also given 4 g of fresh bee collected pollen moistened with sugar syrup. As before, the median LT_{50} was calculated for each cage. The average median LT_{50}s were determined for all cages, the pollen-fed cages (SCF) and the cages not fed pollen (SCNF) that represented each colony.

The correlation between the longevity of worker bees in hives in winter (WH) and in cages in winter (WC) was reasonably strong (r = 0.592, n = 28, P < 0.001). This suggests that WC model the biology of WH. Although queen propagation for breeding is not practical until spring, selecting for winter bee longevity is easier in cages than in field colonies.

Unfortunately, the longevity in springtime cages (SC) was poorly correlated with WH (r = -0.131, n = 17, P = 0.616). Longevity in WH was correlated neither with the springtime longevity of pollen-fed (r = -0.162, n = 17, P = 0.534) nor pollen-deprived bees (r = -0.059, n = 18, P = 0.817) in cages. The correlation of longevity of WC and SC, although somewhat stronger, was also not significant (r = 0.373, n = 17, P = 0.141). The longevity of free-flying bees is known to vary according to season (Free and Spencer-Booth, 1959; Fukuda and Sekiguchi, 1966). Perhaps the underlying physiological differences between bees produced in the autumn and those produced in the spring (Maurizio, 1950; Fluri *et al.*, 1977) vary between colonies and so cause this lack of correlation.

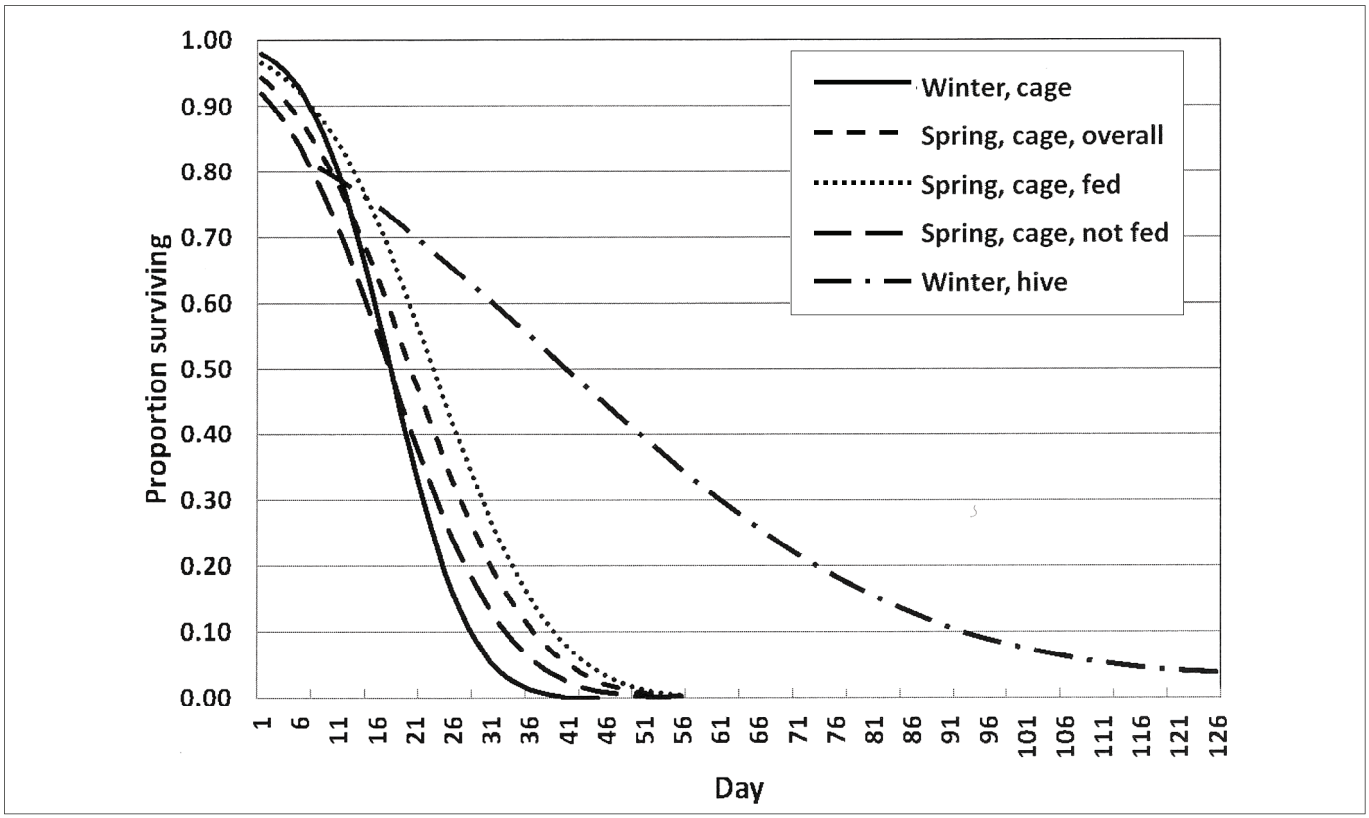

Fig. 1. Predicted survival as a function of time for honey bees observed in five combinations involving season (winter or spring), housing (hive or cage) and protein feeding (fed or not). Probabilities are based on probit analysis using a survival response (Probit; SAS, 2010).

SCF had greater longevity than SCNF (SCF median longevity = 24 ± 9 days, SCNF median longevity = 19 ± 7 days (Figure); $t = 4.62$, $P = 0.039$) and these longevities were well correlated ($r = 0.741$, $P < 0.001$). Neither SC was, however, correlated with WC (SCF: ($r = 0.296$, n = 17, $P = 0.249$; SCNF: $r = 0.414$, n = 18, $P = 0.087$). We therefore recommend that seasonal inconsistencies between field longevity and the longevity of caged bees be considered when using caged bees to measure longevity for breeding programmes.

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