Protein to carbohydrate ratio in the diet affects cognitive abilities in honey bees

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Malnutrition in vertebrates, including humans, is known to impair cognitive abilities. Protein deprivation dramatically affects brain development and maturity. In social insects, dietary protein deficiency influences several physiological and behavioral traits, yet the consequences on cognitive abilities remains unknown. We used the geometric framework approach to examine the effects of the protein to carbohydrate (P:C) ratio on learning, memory, and survival of honey bees. We fed newly emerged bees with different P:C ratio diets and tested one week later their learning abilities and memories by conditioning of the proboscis extension response (PER). We found that bees fed a protein-free diet did not learn well and were not able to form a robust short-term memory. Bees fed with an excess of protein (i.e. high P:C ratio), on the other hand, exhibited intermediary levels of learning and short-term memory compared to the other diets. Best performance was achieved with intermediate P:C ratios. We did not find any effect of the diets on long-term memory. We hypothesized that this absence of effect on long-term memory was due to the bees in all treatments having been fed sucrose solution until satiety after the conditioning so that they would survive the 24h until the long-term memory test. In a follow-up experiment, instead of feeding sucrose solution after conditioning, we fed the bees with the same or different P:C ratio diet eaten during the week. We found that only bees that received a diet with protein in the last 24h were able to form a long-term memory, regardless of the diet eaten during one week. Our results show that nutrition affects honey bee cognitive abilities, but that these effects can be quickly reversed with an appropriate diet. Our survival experiments show that the range of dietary P:C ratios allowing the longest lifespans differ from those allowing the best cognitive abilities, suggesting a possible tradeoff in life history traits.