Value of the aphid Rhopalosiphum padi as food for grey partridge Perdix perdix chicks

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SHORT COMMUNICATION

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Value of the aphid *Rhopalosiphum padi* as food for grey partridge *Perdix perdix* chicks

Claus Borg & Søren Toft

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Controlled experiments were undertaken to examine the quality of the cereal aphid *Rhopalosiphum padi* as a food source for newly hatched grey partridge *Perdix perdix* chicks. Growth and flight feather development were measured on chicks fed on three different diets: aphid, grasshoppers, and a mix of the two. Growth and development of flight feathers differed according to diet in the following order: mix > grasshoppers > *R. padi*. A diet consisting solely of grasshoppers provided sufficient nourishment to partridge chicks but a diet consisting solely of aphids provided poor nourishment. Chicks benefitted from eating *R. padi* as a supplement to grasshoppers. Our results help to explain why some earlier studies reported a positive correlation between chick survival and cereal aphid density, while others did not.

Key words: aphids, cereal ecosystem, partridge chicks

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Grey partridge *Perdix perdix* chicks depend on arthropod food for the first 2-3 weeks of their lives and decreasing arthropod densities in cereal fields have been reported as the main reason for reduced chick survival since the 1950s (Potts 1986). Since the 1950s the density of dicotyledonous weeds has decreased in cereal ecosystems. The arthropod fauna therefore has become dominated by species associated with the cereal crops themselves. In particular the three cereal aphid species *Rhopalosiphum padi* (L.), *Sitobion avenea* (F.), and *Metopolophium dirhodum* (Walker) may at times form very large parts of the arthropod fauna. In a Danish cereal field, cereal aphids constituted 91.7% of arthropods caught by D-vac one year, calculated from Hald & Reddersen (1990). Partridge chicks normally hatch in mid to late June, just before the aphid peak; in some years aphids, therefore, form a large part of the potential prey of the chicks. Some studies report that cereal aphids are preferred as prey by partridge chicks (Itamies, Putaala, Pirinen & Hissa 1996) while others do not (Panek 1992, Potts 1986). Multiple regression analyses also give contradictory results. Green (1984) found a significant positive correlation of aphid density and partridge chick survival while a study carried out by Panek (1992) showed no such correlation. Having compared data from 1938, 1969, 1970, 1979 and 1984, Green (1984) suggested that partridge chicks had become more dependent on cereal aphids with time, and Potts (1970) suggested that the increased sensitivity of partridge chicks to cold springs could be due to increased dependence on aphids, which occur in low densities after cold springs.

Recent studies show that *R. padi* represents low-quality prey for the cereal spiders *Pardosa amentata* (Cl.) and *Erigone atra* (Bl.), and the carabid *Agonum dorsale* (Pont.). These predators tolerate only small amounts of the aphid and can maintain neither growth nor reproduction on a diet consisting solely of aphids (Toft 1995, Bilde & Toft 1994). As there is an assumed partial dependence of partridge chicks on cereal aphids and because cereal aphids are sometimes very numerous it is important to investigate the quality of aphids as food for grey partridge chicks. *R. padi* was selected as representative of the cereal aphids for this study as it is a common cereal aphid in Denmark.

Methods

Grey partridge chicks were obtained from a hatchery on the day of hatching. They were randomly divided into three groups each consisting of 15 individuals, and each chick was marked individually. Each group was kept in an enclosure with a diameter of 1.3 m surrounded by a 0.6-m high fence and heated by a lamp with a 250 w bulb that kept the temperature in the centre of the enclosure at approximately 41°C. The surrounding room temperature was kept above 25°C. The chicks had free access to water and access to food from 7:30 am till 11:30 pm every day. Food was weighed before being given to the chicks. The troughs were checked every hour and additional food was given when the troughs had been emptied. The following diet groups were established: 1) The aphid group, fed a pure diet of *R. padi*; 2) The grasshopper group, fed a pure diet of *Locusta migratoria* (R. & F.); 3) The mixed group, fed both *R. padi* and *L. migratoria*. In the mixed group, aphids and grasshoppers were given in different troughs so that the chicks could select between them. The grasshopper group served as a comparative control. Chicks were weighed individually every afternoon. After five days the maximum cord of the flight feathers was measured to the nearest mm from each wing as the length from the tip of the wing bone to the tip of the longest flight feather when the feathers were flattened.

The aphids used in the experiment were obtained from a laboratory culture raised on wheat seedlings. The grasshoppers were obtained commercially from a breeder. The insects were kept in a deep freezer until used. Grasshoppers were too big for the chicks to eat so they were chopped in a blender before being given to the chicks.

Results

There was a significant overall effect of diet on the daily weight measurements on days 0-5, (Repeated measures ANOVA, $P < 0.0001$, df = 2, Fig. 1). Pairwise post-hoc comparison (Fisher's LSD test) showed significant differences between all groups. The aphid group had an average growth rate of 2.67% per day during the first five days of the experiment, compared to 7.88% for the grasshopper group, and 9.21% for the mixed group.

On the fifth day of the experiment the chicks in the aphid group appeared apathetic and were much easier to catch than those of the other groups. The feeding behaviour also differed between groups. The chicks fed aphids only ate small amounts of food at a time and then moved around in a searching manner in the enclosure. The chicks in the mixed group and the grasshopper group ate for concentrated intervals and then rested.

As the chicks in the aphid group were clearly weak

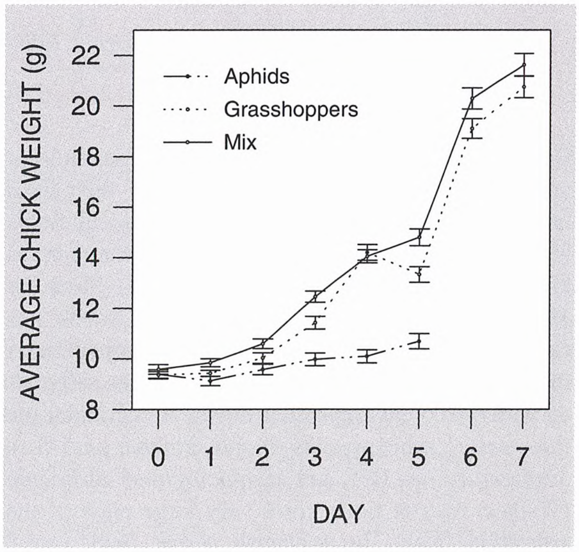

Figure 1. Average chick weight in the three groups on day 0-7.

Table 1. Total growth and amount of food supplied on day 0-5, for the three groups of chicks.

Group	Aphids supplied	Grasshoppers supplied	Total growth	g growth / g food supplied*
Aphids	245 g	0	19.5 g	0,080
Grasshoppers	0	451 g	59.6 g	0,132
Mix	111 g	362 g	78.3 g	0,166

* Not corrected for waste.

after five days this part of the experiment was stopped. The mixed group and the grasshopper group continued in the experiment for another two days (see Fig. 1).

At the age of five days, the length of the flight feathers showed a significant overall effect of diet (ANOVA, $P < 0.0001$, df = 2), and all groups were significantly different from each other (post-hoc; Fisher's LSD test, $P < 0.01$). The chicks belonging to the mixed group had the longest flight feathers with a mean of 13.6 mm, chicks belonging to the grasshopper group had a mean of 11.7 mm, and chicks belonging to the aphid group had the shortest flight feathers with a mean of 9.9 mm.

Food utilisation

During the experiment, the chicks wasted some of the food by scraping, making exact consumption difficult to measure. However, if we assume that the mixed group wasted the same proportion of aphids as the aphid group and the same proportion of grasshoppers as the grasshopper group, we can compare the growth efficiency (g growth / g food supplied) of the mixed diet with those of the two pure diets.

If the mixed group utilised aphids with the same efficiency as the aphid group, and grasshoppers with same efficiency as the grasshopper group (Table 1), they should have gained 56.7 g during the five days. The mixed group actually gained 78.3 g. Thus they utilised the food 38% better than expected from the results with single species diets.

Discussion

Our results show that partridge chicks fed exclusively on the aphid *R. padi* have poor growth and flight feather development. This can have serious consequences for their survival since low-weight chicks have low resistance against cold weather (Cross 1966, cited in Potts 1986, Marjoniemi, Hohtola, Putaala & Hissa 1995). With poor flight feather development the chicks may also be more vulnerable to predation.

Part of the experiment was stopped prematurely to prevent the chicks in the aphid group from dying, when they were clearly in poor condition. Aphids alone constituted a poor diet; but this had apparently nothing to do with the fact that the aphid diet was a monotonous single-species diet. If this had been the case the grasshoppers should also have constituted a poor diet, but the grasshopper group was able to sustain a high growth rate and chicks belonging to this group were healthy. Thus, a single-species diet of grasshoppers turned out to provide sufficient nourishment, at least on the time scale considered here. However, grasshoppers alone are not a completely optimal food source. The results clearly show that the chicks benefitted from eating some *R. padi* as a supplement to the diet of grasshoppers. Both growth, flight feather development and food utilisation improved when chicks fed on a mixed diet. It seems that *R. padi* contains some valuable components but that there is a limit to how large a proportion of the total food demand these aphids can constitute.

Why is *R. padi* a low-quality food for grey partridge chicks? If the low quality should be ascribed to aphids having the 'wrong composition' of amino acids or other vital food components, we would not have expected the low food intake by the aphid group. The results indicate that *R. padi* is toxic when eaten in large quantities but that the disadvantage of eating smaller amounts of *R. padi* as a supplement to another diet is compensated for by the nutritional benefits. This could be one reason why some earlier studies report a positive correlation between chick survival and cereal aphids (Green 1984) while others do not (Panek 1992). Apart from the fact that the species of cereal aphids may differ in different studies (the species were not named in the studies cited), the value of the aphids will depend on the relative density of the aphid itself, and not be fixed. In this way chick survival will be positively correlated with aphid density when aphids constitute a lower proportion of the total arthropod fauna than the optimal diet proportion for the chicks, and uncorrelated when the proportion of aphids in the fauna exceeds what the chicks can exploit.

Our results are comparable to those of Toft (1995) on cereal spiders. The spiders were unable to develop and maintain growth on a pure diet of *R. padi*. One species, however, was able to benefit from *R. padi* in a mixed diet of aphids and fruit flies by increased fecundity and egg hatching success. Two other common cereal aphids, *Sitobion avenae* and *Metopolophium dirhodum*, are also low-quality food for these spiders (S. Toft, unpubl. data).

In summary, *R. padi* (and perhaps other cereal aphids) can only constitute a minor part of the diet of the generalist predators of cereal fields without negatively affecting these (T. Bilde & S. Toft, unpubl. data). In the intensive, conventionally managed 'true monoculture' it might therefore be not only the low densities of insect prey species but also the composition of the prey that make this habitat unsuitable for several of the cereal insectivores including the grey partridge.

Our results indicate that partridge conservation strategies should also consider the nutritional value of the insect fauna available as food for the chicks. An abundance of cereal aphids cannot compensate for the lack of abundance and diversity of other arthropods.

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