The role of insects in the diet of Mallard ducklings—an experimental approach

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Introduction

Ducklings of dabbling ducks, including those of the Mallard *Anas platyrhynchos* show a preference for invertebrate animals, particularly insects, as food in the first weeks of life (Chura 1961, Perret 1962, Collias & Collias 1963, Bartonek 1972, Bengtson 1975). It has been suggested in a previous paper (Street 1977) that the very high (77%) mortality among ducklings hatched in the Amey Roadstone Corporation—Game Conservancy Wildfowl Reserve, near Newport Pagnell, Buckinghamshire, is due to the lack of animal food items in the diet. There is a relative scarcity of such foodstuffs in the study area due to the oligotrophic nature of the newly flooded gravel pit habitat.

This paper describes the results of two feeding trials which test the hypothesis that invertebrates are essential foods for newly hatched Mallard ducklings.

Methods

The first trial, in June 1976, was to determine whether ducklings could survive and grow satisfactorily either on a diet of insect larvae alone, or on a vegetable diet containing no animal proteins. Two groups of ducklings were fed on turkey and chick starter crumbs as controls. The second trial, in June 1977, was to measure growth on a more natural vegetable diet, approximately that eaten by wild ducklings in the study area (Street 1977), and to estimate the minimum proportion of invertebrate foods in the diet which would allow satisfactory growth.

Four groups, each of ten game farm hatched Mallard, collected on the day of hatching, were used for each experiment. They were housed in adjoining outdoor pens on a gravel floor over concrete, each pen being 3 × 1·5 metres and containing a paraffin heated brooder maintained at an average temperature of 27°C. The ducklings were enclosed in the brooder overnight for approximately 12 hours, after which they were given access to the runs.

Each day a known weight of each of the foods was provided in shallow polythene food boxes placed on plywood trays, each 1 metre square, with a lip of 15 mm beading to retain spilled food. The trays were covered by a similar piece of plywood raised on 250 mm legs to prevent rain entering the food. Water was provided ad lib in 1·8 litre drinking fountains placed on the food trays. Each pen was entirely covered by fine mesh plastic netting to keep other species away from the food.

The ducklings were weighed at the same time each day, using a Gallenkamp rotating weight balance. Surplus food in the boxes was removed from each pen for 30 minutes before each weighing, and this allowed the ducklings to clear up much of the spilled food from the trays.

In the first trial the surplus food, including the spillage and food lost in the drinking fountains was collected daily, dried, weighed and subtracted from the amount of food given on the previous day to arrive at the amount of food eaten daily by each group. In the second trial the weight of additional food provided each day was recorded and the residue was collected, dried and weighed when the experiment ceased on the fifth day. This allowed the calculation of the amount of food eaten by each group.

It was impracticable to collect a sufficient quantity of fresh insects to feed the ducklings, so the larvae of the blowfly *Calliphora vulgaris* were therefore used in both experiments. In the first trial, barley meal was the standardised seed diet. There were two control groups, one fed turkey starter crumbs and one fed chick starter crumbs containing 26% and 21% by dry weight protein respectively.

A more natural diet, a mixture of seeds as shown in Table 1, was used in the second trial. This seed mixture was added to blowfly larvae in different proportions (Table 2), calculated according to their dry matter content. The percentage composition by wet weight is shown in Table 3. To prevent the ducklings selecting larvae preferentially the larvae were killed by freezing, minced and mixed with the seeds, which had been moistened so that they adhered loosely.

The first trial was continued for 14 days, after which the diets of experimental groups 1 and 2 were exchanged. Group 1 was gradually changed to a diet of barley meal over a 3-day period and blowfly larvae were introduced to the diet of group 2 over the same period so that they were eating nothing else after 3 days. The second trial was

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Table 1. The composition of the seed mixture used in the 1977 experimental diets.

Seed	Parts by weight	% composition	% Protein	% Fibre	% Moisture
Ryegrass *Lolium perenne*	100·0	77·8	12·42	15·1	—
Dock *Rumex crispus*	15·0	11·7	8·49	19·7	—
Couch grass *Agropyron repens*	5·0	3·9	7·0	—	—
Redshanks *Polygonum persicaria*	5·0	3·9	7·61	—	—
Fat Hen *Chenopodium album*	2·5	1·9	14·34	—	—
Creeping buttercup *Ranunculus repens*	1·0	0·8	8·92	—	—
Mixture	—	100·0	11·42	16·4	12·5

Table 2. The composition of the experimental diets.

Year	Group		%Moisture	%By dry weight Protein	%Fibre
1976	1	Blowfly larvae	70·1	51·8	—
	2	Barley meal	8·7	13·4	—
	3	Turkey starter crumbs	7·0	26·0	3·0
	4	Chick starter crumbs	7·5	21·0	4·0
1977	5	100% Seed mixture	12·5	11·4	16·4
	6*	95% Seed mixture +5% Blowfly larvae	15·4	13·4	15·7
	7*	88% Seed mixture +20% Blowfly larvae	24·0	19·5	13·2
	8*	50% Seed mixture +50% Blowfly larvae	41·3	31·6	8·3

* This is the % composition by dry weight.

A sample of mixed aquatic and terrestrial invertebrates, mainly insecta and Mollusca was 44·8% protein.

stopped after five days only, as groups 5 and 6 had lost weight, became weak and were in danger of dying. They recovered rapidly when fed on blowfly larvae alone.

Results

The growth of the ducklings is shown in Figures 1 and 2. In the first trial the growth of group 1 fed on blowfly larvae was almost as good as that of group 3 fed on turkey starter crumbs and a little better than that of group 4 fed on chick starter crumbs. The mean body weight and coefficient of variation of body weight for each group at the start and after 14 days is shown in Table 4. There was no significant difference between the initial weights of each group or between the weights of groups 1, 3 and 4 at day 14, but the day 14 weight of group 2 ducklings was markedly different. The amount of food eaten by each group was recorded and the conversion ratio for each diet, also shown in Table 4, was calculated assuming the dry matter content of a Mallard duckling to be 26·5% (Marcström 1966).

Immediately following the introduction of larvae into their diet on day 14, the barley fed ducklings (group 2) began to gain weight rapidly. The amount of food eaten also began to increase although it declined a little in proportion to their body weight. On day 14 the amount of barley meal eaten was 10·2 g dry weight, 16·4% of body weight, while on day 18 the amount of larvae eaten was 19·8 g, dry weight, 13·8% body weight, and on day 20 30·9 g, or 15·0% body

Table 3. The percentage composition by wet weight of the diets used in the June 1977 trial.

	Percentage by wet weight	
Group	Seed mixture	Larvae
5	100·0	—
6	86·3	13·7
7	57·1	42·9
8	25·0	75·0

weight. From day 16–20, when they were eating larvae alone the conversion ratio of larvae to body tissue was 3·15:1, almost exactly the same as that for group 1 fed on larvae from the start of the experiment. In contrast, the growth rate of group 1 slowed down when their diet began to be changed to barley meal at day 14, and by the 17th day they had begun to lose weight despite an initial slight increase in food intake (Table 5).

In the second trial the seed-fed group 5 and those fed seeds plus 5% larvae (group 6) gradually lost weight. The group fed on seeds

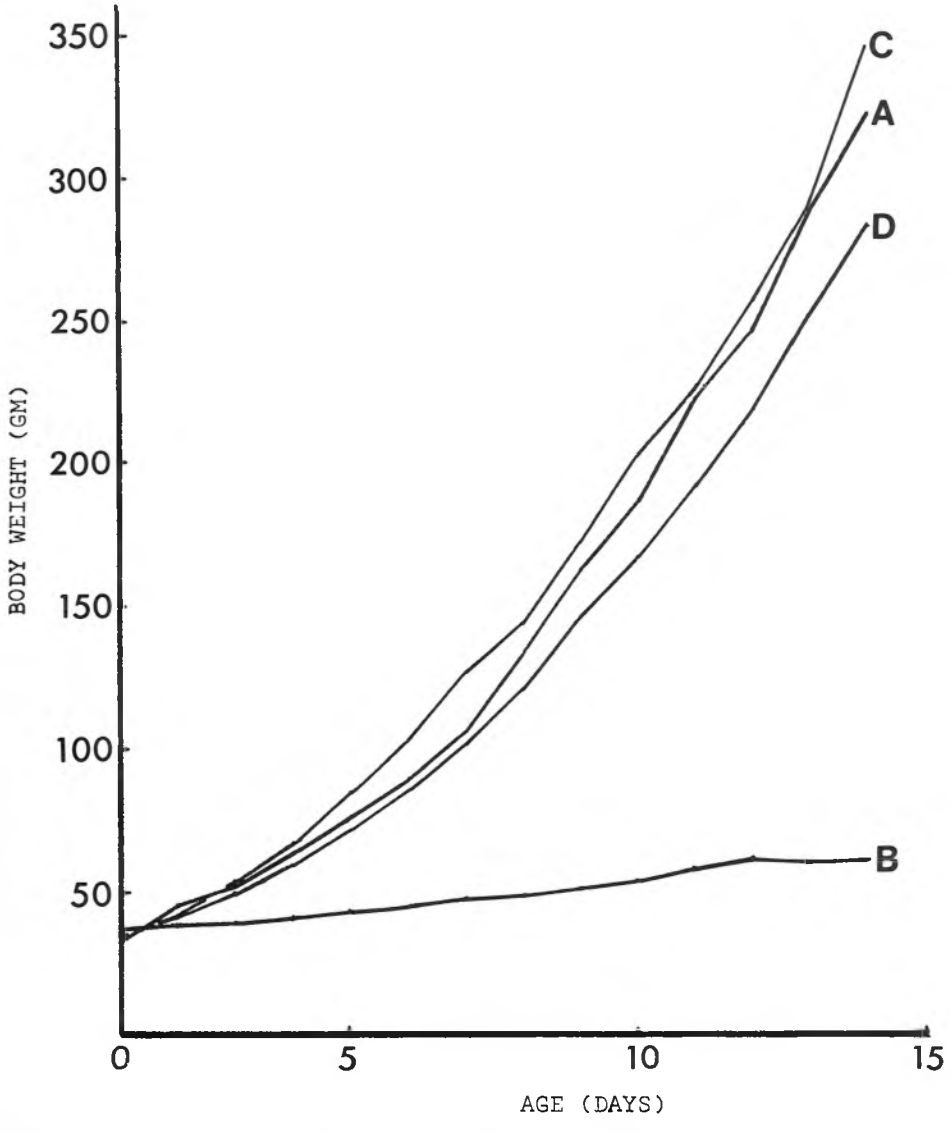

Figure 1. The growth rate of the ducklings in the first trial (June 1976).

plus 20% larvae (group 7), grew only slowly and those fed seeds and 50% larvae (group 8) showed a reasonable growth rate, better than the barley meal fed group 2 in the previous experiment, but not as high as those which received 100% blowfly larvae (group 4). At the start there was no significant difference in weight between the groups but

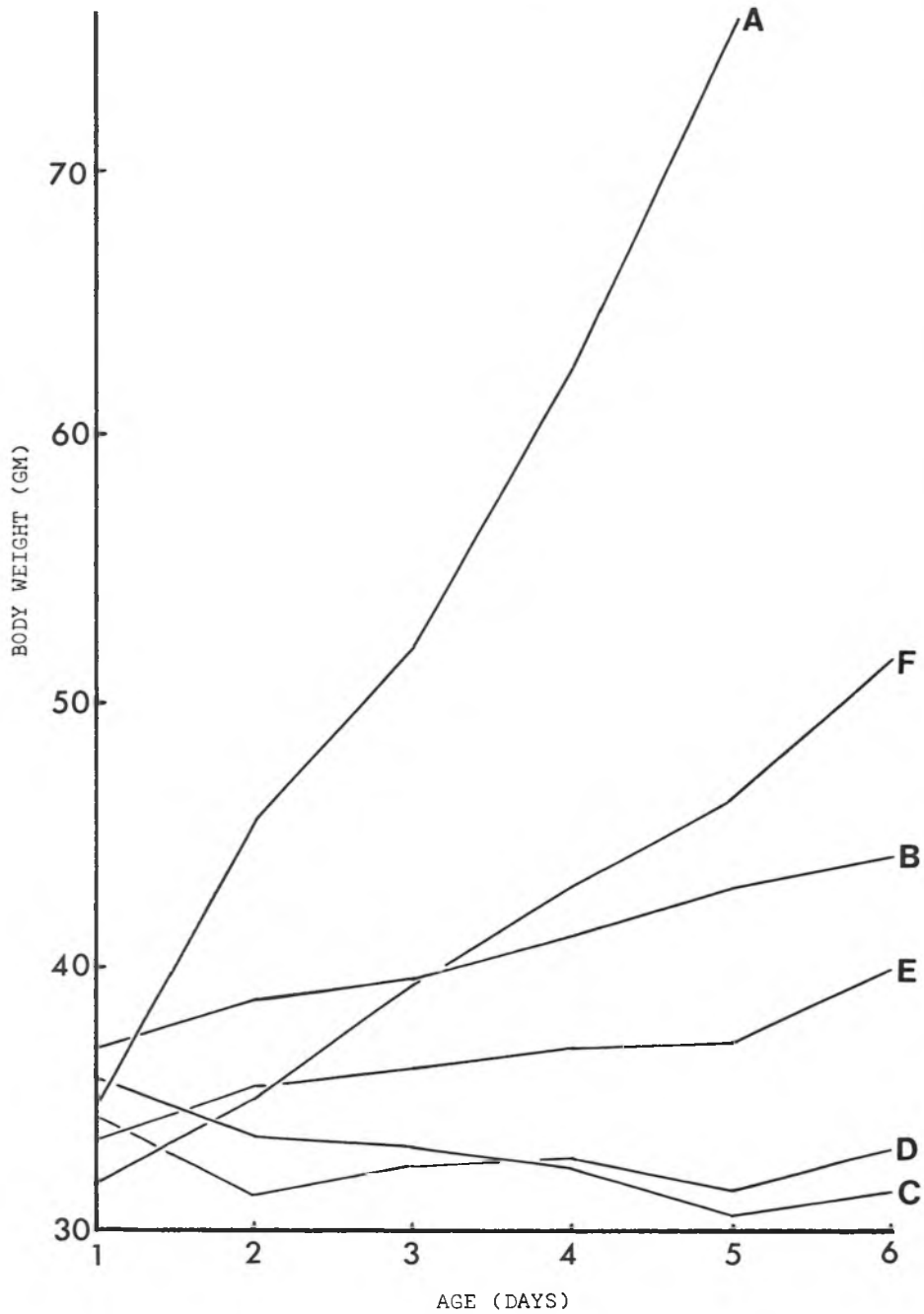

Figure 2. The growth rate of the ducklings in the second trial (June 1977) compared with that of group 1 and 2 in the first trial.

there was between groups 5 and 6, and groups 7 and 8, by the fifth day. The body weights at day 1 and day 5, and food conversion ratio for these ducklings at day 5 are shown in Table 6.

The growth rate of those ducklings which received invertebrates was proportional to the level of invertebrates present in the diet (Figure 3), and when both years' results were pooled there was a high degree of correlation between the weight of protein eaten and the percentage increase in body weight of the ducklings over the first four days (Figure 4).

Discussion

The artificial environment and diets makes it difficult to extrapolate to the wild. However, by comparing growth rates on each of the diets it is possible to draw reasonable conclusions about the importance of insect foods to wild Mallard ducklings. Insect larvae alone, of only one species, was a satisfactory food for the ducklings. When the food conversion efficiencies are considered it is apparent that the blowfly larvae were a better food than either turkey or chick starter

Table 4. The mean weight of ducklings on days 1 and 14, and the food conversion ratio at day 14.

		Body weight (g)		Coefficient of variation		Food conversion ratio
Group	Diet	Day 1	Day 14	Day 1	Day 14	
1	Blowfly larvae	34·4 ± 2·8	332·3 ± 44·6	8·1%	13·4%	3·1:1·0
2	Barley meal	36·9 ± 2·4	71·0 ± 9·1	6·5%	12·8%	17·2:1·0
3	Turkey starter crumbs	35·3 ± 1·6	352·8 ± 24·4	4·5%	6·9%	5·3:1·0
4	Chick starter crumbs	35·9 ± 1·9	308·1 ± 29·3	5·2%	9·7%	5·8:1·0

Table 5. The weight change and food intake of groups 1 and 2 ducklings following the exchange of their diets.

	Body weight (g)		Dry weight of food eaten (g)		Dry weight of food eaten as a % of body weight	
Group	1	2	1	2	1	2
Day: 13	277·5	60·3	32·0	11·9	11·5	19·7
14	321·0	60·9	34·0	10·2	10·5	16·7
15	335·3	71·8	38·7	9·5	11·5	13·2
16	353·1	96·1	51·8	15·4	14·6	16·0
17	342·1	116·5	43·0	16·0	12·6	13·7
18	343·0	142·5	40·0	19·8	11·7	13·9
19	340·5	173·0	44·3	24·3	13·0	14·0
20	332·5	205·1	34·1	30·9	10·2	15·0

Table 6. The mean weight of ducklings on days 1 and 5 and food conversion ratio at day 5.

		Body weight (g)		Coefficient of variation		Food conversion ratio
Group	Diet	Day 1	Day 5	Day 1	Day 5	
5	100% seeds	35·9 ± 2·8	30·6 ± 3·4	7·7%	11·1%	—
6	95% seeds +5% larvae	34·3 ± 2·3	31·5 ± 2·7	6·7%	8·6%	—
7	80% seeds +20% larvae	33·3 ± 1·7	37·1 ± 2·1	5·0%	5·6%	17·4:1·0
8	50% seeds +50% larvae	31·8 ± 3·0	46·2 ± 3·0	9·5%	6·5%	5·2:1·0

crumbs; much better food than a habitat without insects could provide.

A diet wholly of plant seeds, either barley meal or a mixture of the naturally occurring seeds eaten by wild ducklings in the study area, was not sufficient to allow satisfactory growth, even when provided ad lib so that little energy was used in the search for food. Wild ducklings on such a diet would have undoubtedly died.

The addition of 50% by dry weight of larvae to the seed mixture gave reasonably satisfactory growth, but even then, not as rapid as it was in the ducklings fed entirely on insect larvae. The fact that the ducklings fed entirely or mainly on the seed mixture did not grow as well as the barley fed group was due probably to the high fibre nature and lower calorific value of the seed mixture as well as the lower protein content. The seeds also appeared to be less palatable—the ducklings did not attempt to compensate for the low nutrient content by increasing their intake when the food was freely available.

The change in growth rates of group 1 and 2 ducklings following the gradual exchange of their diets showed that, to those which had just managed to maintain themselves on barley meal, blowfly larvae were palatable and immediately usable for rapid growth. The other group may have lost weight after their diet change was complete because they found the barley less palatable, although they did initially increase their food intake slightly (Table 5).

The digestible protein content of the food appears to be a major factor which influences the growth rate of the ducklings, shown by the high positive correlation between the growth rate and the amount of total crude protein eaten in the first four days (Figure 6). Such dietary components as carbohydrates, fats, minerals and vitamins are also of importance but were not investigated in this study.

It is evident that the rate of growth and plumage development of a wild hatched Mallard duckling would be at its maximum when it could obtain large quantities of animal food, particularly insect larvae. Chironomid larvae are approximately 56% protein (Sugden 1973) and aquatic insects average 55% by dry weight protein (Moyle 1961). The growth rate would be much slower where the duckling was forced to eat only seeds, with a lower protein content.

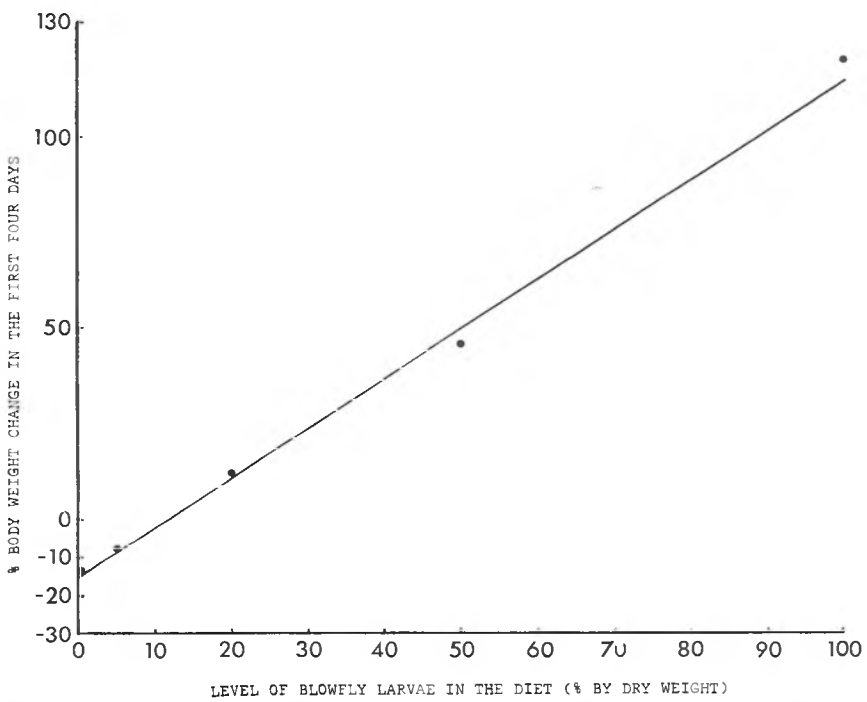

Figure 3. The growth of the ducklings in the first four days in relation to the level of blowfly larvae in the diet. ($r = 0{\cdot}99$; $P < 0{\cdot}001$).

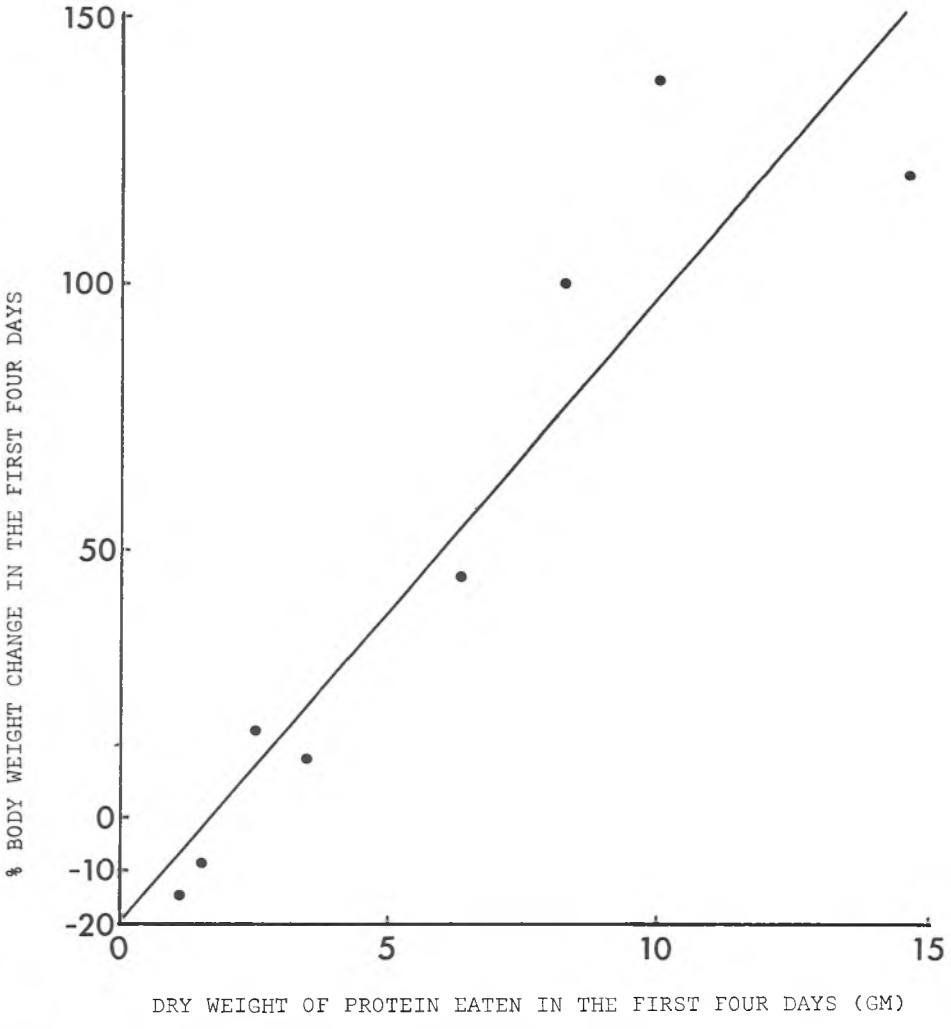

Figure 4. The growth of the ducklings in the first four days in relation to the weight of protein eaten. ($r = 0{\cdot}94$; $P < 0{\cdot}001$).

Throughout this discussion there is the assumption that growth is roughly equivalent to survival. Cross (1966) showed that in Partridge *Perdix perdix* chicks resistance to chilling increased in proportion to their weight, and Sturkie (1954) showed that temperature control in birds becomes effective only when the juvenile plumage develops. So fast growth in a duckling is ecologically beneficial.

If the minimum rate of growth to ensure survival in the wild under normal conditions were known, it would be possible to state the minimum level of invertebrate material necessary. Unfortunately this is not possible but it seems reasonable to speculate that a growth rate at least as good as that of group 8 would be necessary, i.e. 50% seeds and 50% blowfly larvae, and the food available ad lib. Where ducklings had to search for and capture live food under adverse weather conditions, the insect proportion needed would obviously need to be greater.

Bad weather, especially air temperatures below 2°C, high rainfall and strong winds are probably the main environmental stresses upon young ducklings (Bengtson 1972) and are the most likely proximate cause of deaths. Inclement weather acts directly, by chilling and indirectly by restricting feeding activity and by reducing the availability of animal food organisms, causing the

ducklings to use up their lipid reserves from the yolk sac, liver and eventually the body fat deposits. All ducklings hatch with relatively large lipid stores (Kear 1965) and those which are not fed use almost all of their yolk sac and 30% of their body fat within four days, thus reducing their resistance to further stress. The weight losses of group 5 and 6 was undoubtedly due to the utilisation of their lipid reserves. On the other hand, ducklings which are fed adequately increase their body fat deposits quite markedly in the first four or five days, providing good insulation and temperature control and a useful food reserve. (Marcström 1966). Although newly hatched ducklings can live for four or five days without food or on poor food, other things being equal, survival will be markedly improved where insect food is abundantly available and can be obtained soon after hatching. Growth will be more rapid, insulating body fat will be laid down and chances of survival will be higher.

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Summary

Two trials were carried out to assess the relative importance of insects and seeds as food for newly hatched Mallard ducklings *Anas platyrhynchos*.

The growth rate of ducklings which were fed a diet of blowfly larvae was much faster than that of those fed either barley meal or a mixed seed diet. An addition of 50% (dry weight) blowfly larvae to the seed mixture was needed before the ducklings showed any significant increase in weight. The efficiency of utilisation of larvae was much better than seeds and larvae were a better food than proprietory turkey or chick starter crumbs.

The growth of the ducklings over the first four days showed a high positive correlation with both the proportion of invertebrates in the diet and with the total amount of protein eaten.

The importance of an adequate supply of insect foods to ensure good survival of wild Mallard ducklings is indicated.

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