SOME FACTORS DETERMINING THE FOOD INTAKE OF YOUNG CHICKS

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SUMMARY

This paper deals with two separate- factors which interact to determine the food intake of young chickens, the first being the characteristics of the food objects and the reward systems-which elicit pecking and ingestion, and the second the factors which influence competition between individuals for access to a food source.

Pecking preferences were determined by sub-dividing the pecks into three types; pecks made with the beak closed, pecks with picking up and mandibulation of the grain but not swallowing it, and pecks leading to ingestion of the grain. The pecking preferences of newly hatched chicks are determined by the visual cues of the seed types but, as shown here, by day 3 these preferences alter on the basis of tactile 'reward obtained by mandibulating the seeds in the beak. In control chicks, which have not been beak-trimmed, nutritive reward is without influence on these early feeding preferences. Beak-trimmed chicks show the same initial preferences for pecking at various seed types as do the controls, but the tactile feedback which they receive from mandibulation is reduced and they are consequently more dependent on feedback from nutritive reward. It is suggested that beak-trimming may increase the number of deaths through "starve-outs" in the first few days posthatching.

Competition for food is another factor which influences food intake, and even within the first twc weeks posthatching groups of chicks form a hierarchy for access to a food source. This competitive behaviour is affected by the incubation conditions just prior to hatching. Chickens reared from eggs kept in darkness during the last 3 days of incubation develop a more flexible group structure than those which have received light exposure during the same period. Position in the social hierarchy was scored in terms of competition for access to a food source from day 8 to 16 of posthatching life. Groups of chicks exposed to light during incubation formed a more rigid rank order with the lowest ranking birds rarely gaining access to the food. Groups of chicks hatched from eggs incubated in darkness showed more variability in the rank order from day to day and the lowest ranking birds competed for food more successfully. It is suggested that by maintaining eggs in darkness during the critical period it may be possible to reduce the proportion of young chicks which die from starvation.

INTRODUCTION

Death of young chicks by failure to ingest sufficient quantities of food, even when it is freely available, is a common problem in commercial

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hatcheries. Such deaths are referred to as "starve-outs", and 5 to 10 percent of chickens may be lost in this manner. It is therefore of interest to investigate the factors which initiate pecking to feed in young chicks, those which operate to keep them pecking to feed and the interaction of social factors which allow some individuals to gain better access to the feed source.

Young chicks have a predisposition to peck at yellow. to red, small, three-dimensional objects (Dawkins, 1968) . These perceptual preferences determine what seed type the chick will peck at first, and then a number of factors may determine whether the chick continues to peck at the same type of seed or switches to another type. This study investigated the relative importance of visual cues, tactile cues and nutritive reward in determining whether chickens will continue to peck at and/or ingest various types of seed. Preferences for seed type are usually measured in young chicks simply by giving the chicks a choice of seed types and scoring the number of pecks made to each type, irrespective of the nature of each peck delivered by the chick. Yet, pecks can be made with the beak closed, with beak open and followed by mandibulation of the seed but not ingestion of it, or with the beak open followed by both mandibulation and ingestion, and the consequences of each type of peck determine subsequent preferences.

One might at first consider that nutritive reward is the main factor determining whether a chick will continue pecking at its first preferred seed type, but for at least the first two days posthatching chicks are not dependent on nutritive intake as they still have sufficient nutritive supplies from the yolk sac (Hogan, 1973). Even in older chicks nutritive reward may play a less important role than expected, as it has been shown that pecking with the beak closed, or with mandibulation of grain not followed by ingestion of it, can act as a reward system in two-week old chicks learning to discriminate grain from small pebbles stuck down to the floor (Reymond and Rogers, 1981). Chicks which do not' ingest any of the grain learn the discrimination as fast as those which ingest grain.

The beak of the chicken is richly supplied with a neural system for proprioception, and the tactile cues of the grain may be at least as important as those of vision or taste. Indeed, the feedback they provide may be even more important than nutritive reward. Beak-trimming, which is a common practice in the commercial situation, removes the tip of the beak and it must reduce, or at least alter, proprioceptive feedback obtained from mandibulating grain. It may therefore influence pecking preferences and food intake. Thus, the feeding behaviour of beak-trimmed chicks was compared to controls.

Feeding in young chicks is not simply a matter of individual choices and learning of preferences on an individual basis. Commercial chickens are raised in groups and social behaviour may have a major effect on breeding behaviour. The area of social behaviour which has received most attention in the literature is that of the dominance hierarchy. Usually this order is based on pecking rights, and it is generally reported that such a social hierarchy remains unresolved for several weeks. A stable hierarchy as derived from peck order scores is most frequently said to form between weeks 6 to 8 for males and 8 to 10 weeks for females (Guhl, 1953; Kruijt, 1964). Recently it has been shown, however, that a relatively stable social hierarchy can be determined in chicks aged between one and three weeks using a number of tasks requiring competition for food (or a food related object), and that the rank orders determined on each of these tasks correlate reliably with each other (Astiningsih, 1987). Given the presence of stable hierarchies in very young chicks it seems reasonable to suggest that the individual chickens which are at the bottom of the hierarchy are most likely to "starve-out". Even if they do not starve-out, chicks at the bottom of the hierarchy are likely to gain less weight compared to the rest of the group. Moreover, in a flock with a rigidly maintained hierarchy, those individuals at the bottom of the hierarchy may be more likely to lose out than they would in a flock with more social flexibility.

The degree of social stability, or flexibility, may be influenced by light exposure prior to hatching, as previous studies have shown that light exposure at this time has a marked affect on brain organisation and long-lasting effects on behaviour (Rogers, 1986). Chickens have asymmetry of brain organisation such that each side of the brain controls a different set of behaviours (Rogers, 1986; Andrew, 1988). The left hemisphere, for example, is superior for visual discrimination learning, and the right has a controlling influence for attack and copulation. The direction of the asymmetry is determined by light exposure of the embryo during the final phases of development prior to hatching, at the time when connections between the eye and brain are forming (Rogers, 1983). The chick embryo is oriented in the egg such that it occludes the left eye with its body while the right eye, being next to the air sac, is exposed to light which penetrates the shell. All chicks hatched from eggs which have received as little as two hours of light exposure on day 19 of incubation have asymmetry in the same direction. Conversely, there is no population bias in asymmetry for chicks hatched from eggs incubated in the dark; half of those hatched from eggs incubated in darkness appear to have asymmetry in one direction and half in the other.

It seemed reasonable to suggest that a degree of flexibility may be introduced into the social order by randomizing, amongst individuals, the direction of brain asymmetry, and this can be achieved by incubating under dark conditions. Such variability may allow the individuals at the bottom of the hierarchy to feed more successfully. Hierarchies for such chicks were determined by measuring the success rate of gaining access to food under competitive conditions.

I. LEARNING TO FEED

METHODS

Two and three day-old, Australorp x White Leghorn chicks were given a choice of four seed types (white millet, japanese millet, canary seed and sorghum) and each of the three types of pecking (pecking with closed beak, mandibulating but not swallowing, pecks followed by ingestion of the seed) were scored for a total of 20 pecks on both these days.

The chicks were given no other experience with food. In the test 4 g. of one type of seed were placed in each of the four corners of the home cage. The chicks were tested individually. Control and beak-trimmed chicks were tested (n = 24 for each). After testing on day 2 half of each group of chicks received crop-feeding with a porridge of chicken mash to provide nutritive reward. The effect of this procedure was assessed on day 3.

RESULTS

On the first day of testing the white millet was the most preferred seed, followed by japanese millet, canary seed and sorghum, in that order (Fig. 1). These preferences were the same for all three types of pecking. Even though the chicks showed some closed beak pecking at and some mandibulation of sorghum they did not ingest it.

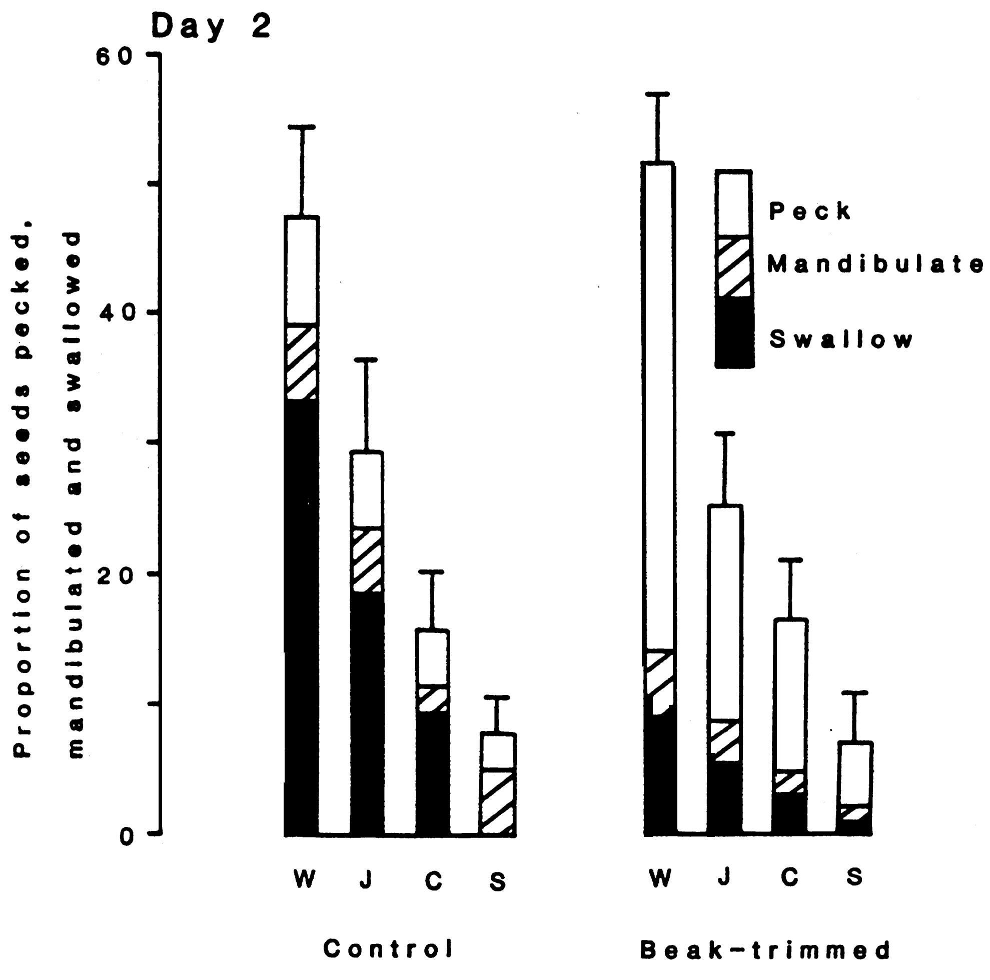

Figure 1. The proportion of each seed type pecked, mandibulated or swallowed on day 2. Each complete bar represents the mean percentage (and standard error)' of beak-to-seed-contacts made with each grain type for beak-trimmed and control groups. Each bar is subdivided into the proportions pecked with a closed beak (peck), taken up between the mandibles but not swallowed (mandibulate) and swallowed. W, white millet; j, japanese millet; c, canary seed, s, sorghum.

Beak-trimming had no effect on the order of seed preference displayed by chicks tested on day 2 and no significant effect on pecking rate, but it markedly reduced the number of grains ingested (Fig. 2).

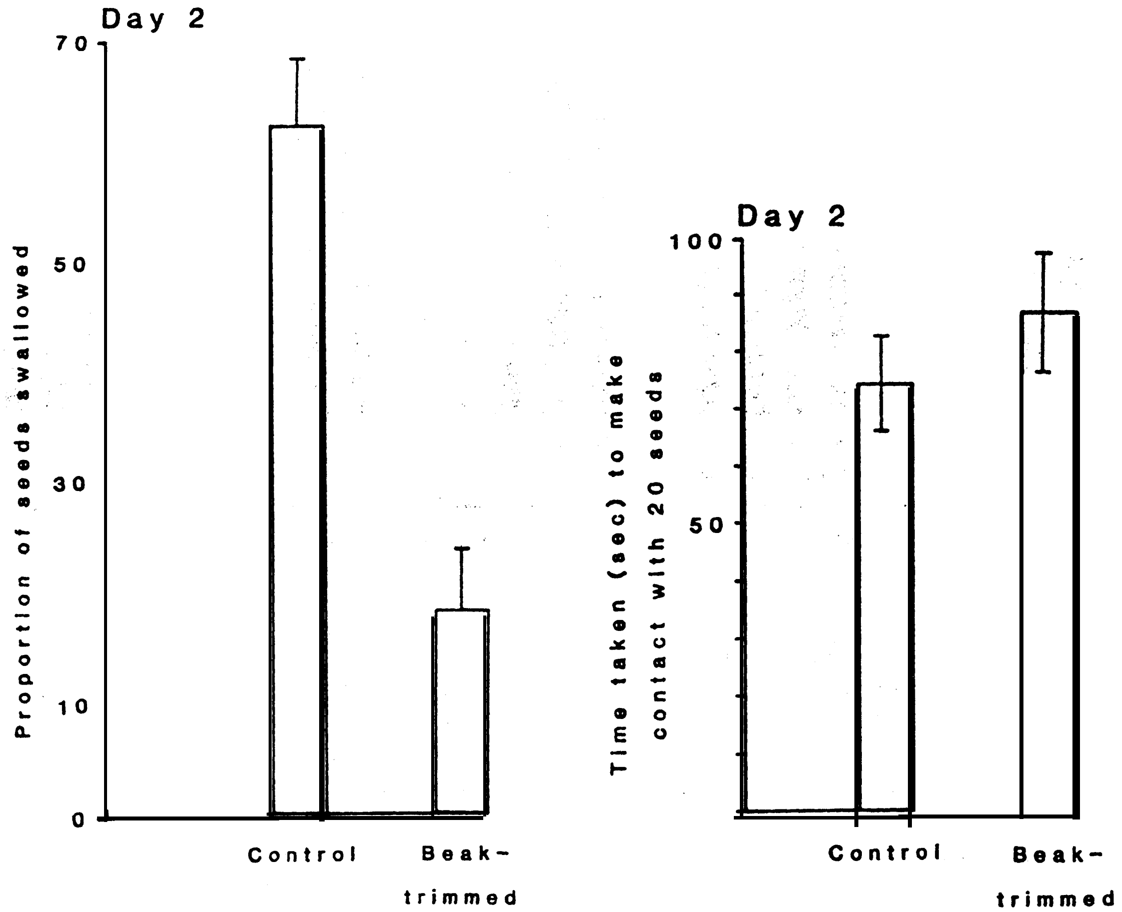

Figure 2. The bars represent the mean percentage (and standard error) of seeds with which beak-trimmed and control chicks make beak contact and that they swallow. Note that the beak-trimmed group swallows far less seed. The mean time (to make 20 beak to seed contacts) is represented for the beak-trimmed and control groups.

In the test on day 3 there were some changes in pecking preference: both types of millet were now equally preferred over canary seed and sorghum, and the amount of all three types of pecking at sorghum increased to be similar to the scores for canary seed. In controls this shift in preference from day 2 to 3 appears to be a result of tactile reward as crop-feeding had no effect on the preferences measured on day 3 (Fig. 3). Beak-trimmed chicks persisted in pecking more slowly and ingesting less seed on day 3 The crop-feeding on day 2 did, however, have an affect on the pecking preferences displayed by beak-trimmed chicks on day 3 (Fig. 3).

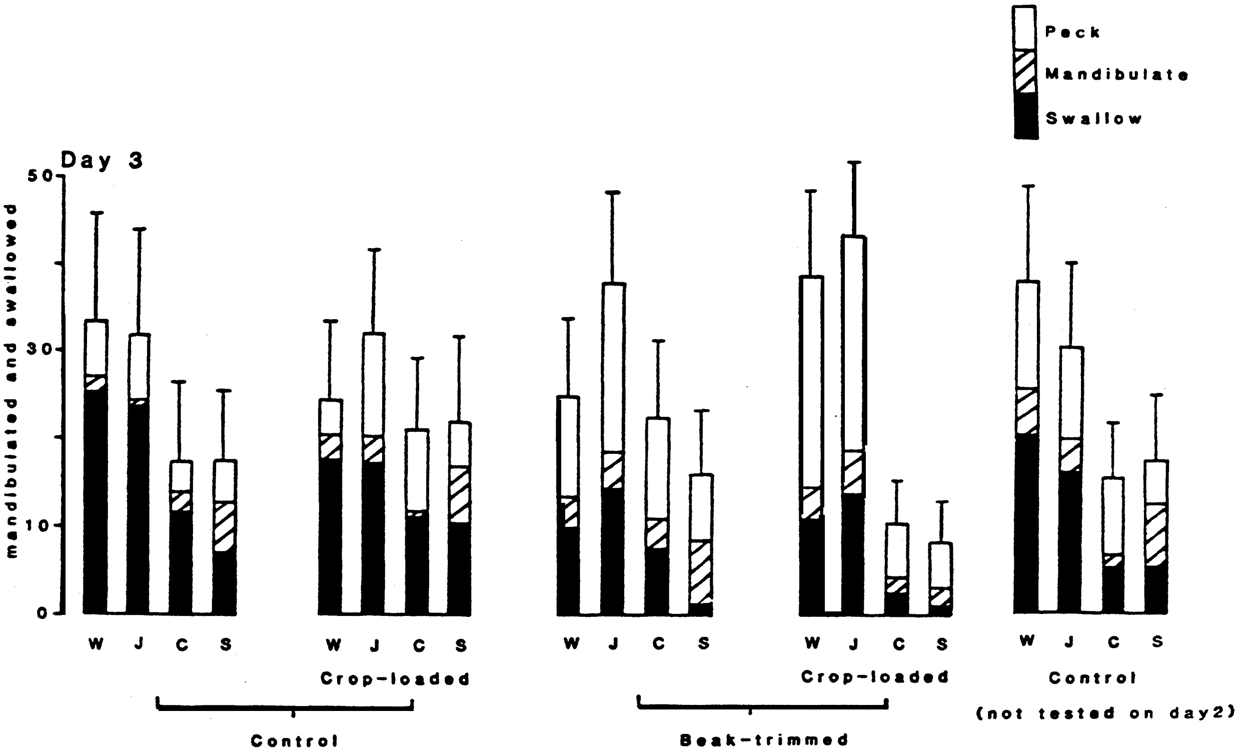

Figure 3. Proportion of each seed type pecked, mandibulated or swallowed on day 3. Each bar represents the mean percentage (and standard error) of beak to seed contacts made with each grain type for each of the five groups: beak-trimmed (both crop-filled and unfed) and control, non-beak-trimmed (both crop-filled and unfed), and a further control group lacking any prior experience with grains on day 2. Each bar is subdivided into the proportion pecked with a closed beak (peck), taken up between the mandibles but not swallowed (mandibulate) and swallowed. The first 20 seed contacts were recorded for each bird and there were 12 subjects in each group.

DISCUSSION

As the chicks tested on day 2 show a distinct preference order for the seed types presented (white millet over japanese millet, canary seed and sorghum least) and this preference was unaffected by beak-trimming, which removes the proprioceptors in the tip of the beak, it would seem that visual cues are the most important cues eliciting pecking at this stage.

But pecking in young chicks may not involve feeding; indeed, pecking with the beak closed, or with mandibulation not followed by ingestion, appears to be exploratory behaviour which may later lead to ingestion of seed. In controls the tactile cues received by mandibulation of the seed in the tip of the beak were important in determining the subsequent pecking preferences and ingestion of food, and nutritive reward played no role at this age. This is not to say that nutritive factors would not begin to play a very important role once yolk sac nutrition has been used up (say, by day 4), but clearly at the time at which chicks are learning to feed the nutritive value of the food is not important. Goodwin and Hess (1969) have shown that the long-lasting preferences for food are indeed determined in the first three days posthatching.

Beak-trimming may alter this situation by reducing the tactile feedback received from mandibulation and increasing the feedback received from nutritive reward. As beak-trimmed chicks ingest far fewer seeds than controls this presents a problem. They are more dependent on nutritive reward for feedback, but less likely to ingest food and so achieve it. Thus, beak-trimming may well increase the number of starve-outs, or at least, reduce weight gain. The latter has already been demonstrated in adult fowl (Bokhuis et al, 1987).

II. EFFECT OF INCUBATION CONDITIONS ON COMPETITION FOR FOOD

METHODS

Australorp x White Leghorn eggs were incubated until day 17 in a forced-draught, automatically turning incubator heated by a light source. On day 17 of incubation the eggs were divided into two groups. One group of eggs was exposed to 500 to 600 lux of light supplied by 40 W bulbs shining through the port-holes at the top of the incubator. The other group was incubated in darkness as the incubator was sealed from all external light. From here on these groups are referred to as 'light-exposed' and 'dark-incubated' respectively. After hatching groups, each containing 8 chicks, were comprised of chicks hatched either from eggs incubated in darkness from day 17 on or from eggs exposed to light over this period. There were eight 'light-exposed' and eight 'dark-incubated' groups.

The social rank order was measured from days 8 to 16 inclusive using a task of competition for food. The chicks were deprived of food for 3 h prior to testing. A dish of 6 cm diameter containing chicken crumbs was then placed in one corner of the cage, and competition for access to the dish was scored for 10 min. The dish was adhered to the floor with tape so that it could not be tipped over, and the level of grain was 1 cm below the top to prevent spillage. Each chick in the group was marked by a differently coloured ring-band. By observing through the side of the cage it was possible to note the band colour of each chick as it gained access to the dish (i.e. managed to peck at the grain in the dish), giving a total score of number of entries to the dish per testing period for each individual. The observer was not aware of the incubation conditions received by the groups of chickens.

RESULTS

The total number of entries scored per group over the entire testing period was significantly higher for the groups of chicks which had been incubated in the dark ($P = 0.02$, 2-tailed Students' t-test); That is, the groups comprised of dark incubated chicks showed a somewhat greater degree of competition at the dish.

Each individual's position in the hierarchy on each day was determined by calculating its entry score for that day as a percentage of the total entry scores for the group on that day. A mean percentage entry score was then calculated across days 8 to 16 for each individual. The bird with the highest mean entry score, expressed as a percentage, over the testing period was placed in rank 1, and so on to the bird with the lowest mean entry score which was placed in rank 8. These scores are presented in Fig. 4.

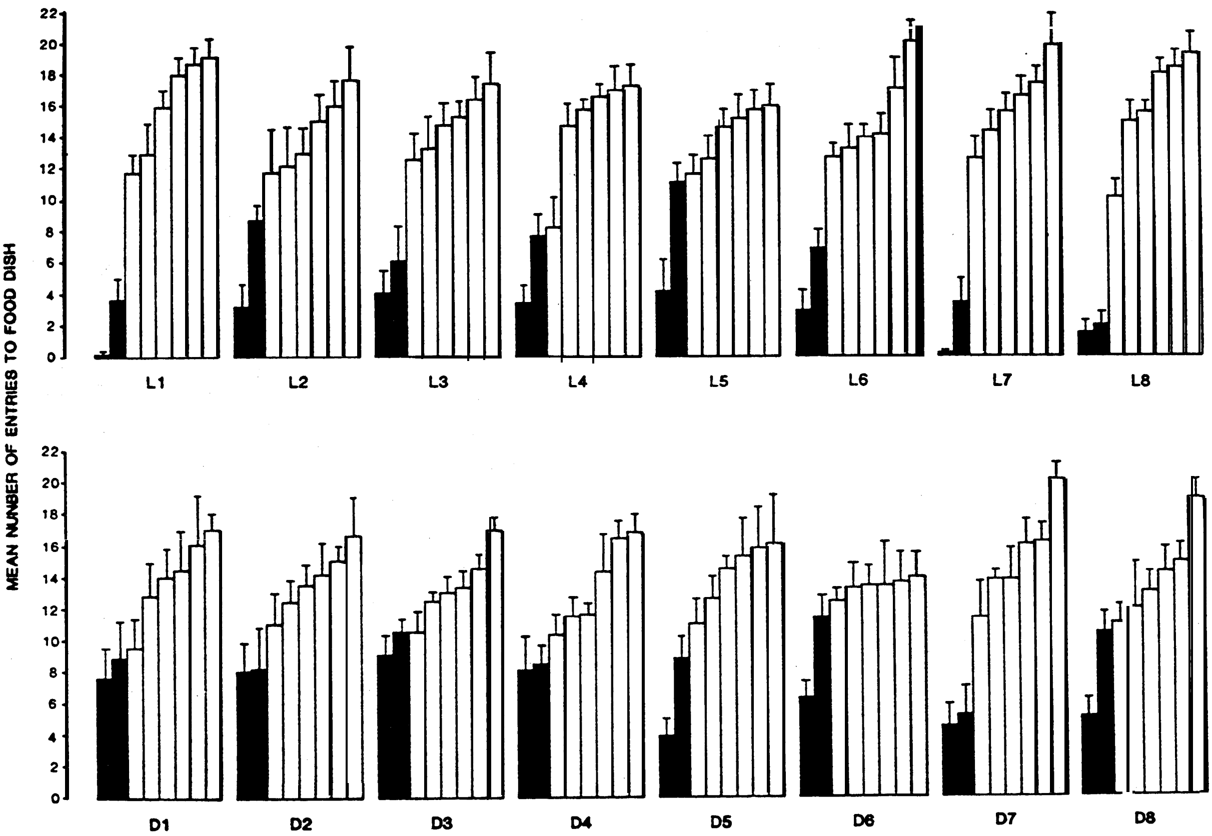

Figure 4. The mean number of entry scores to the food dish has been calculated for each individual in the eight L groups (groups of chicks exposed to light on the last three days of incubation) and the eight D groups (groups of chicks incubated in darkness over the last three days of incubation). For each individual this mean value has been calculated over the testing period from day 8 to 16. Note that the mean entry scores for the two chicks at the bottom of the hierarchy in each group (ranks 7 and 8) have lower scores in the L groups than in the D groups.

As can be seen in this figure, in each of the groups comprised of chicks exposed to light during incubation the mean entry scores for the two lowest ranking birds (ranks 7 and 8) were lower than their equivalents in the groups comprised of chicks incubated in the dark ($F_{1,31}$ = 13.944, P = 0.0008, one-way analysis of variance). The lowest ranking birds in the light-exposed group were less successful in gaining access to the food dish than were their equivalents in the dark-incubated groups. Indeed, in the light-exposed groups the lowest ranking bird frequently did not even try to compete to gain access to the dish (see groups L1, L7, L8). The lowest ranking chicks in the groups comprised of chicks hatched from eggs incubated in darkness showed more successful entries to the food dish over the testing period from day 8 to 16 and were less likely to hang back never attempting to compete.

DISCUSSION

The results bear out our suggestion that the social behaviour of groups of chicks raised from eggs incubated with light exposure from day 17 on would differ from that of groups raised from eggs incubated in darkness in such a way that the lowest ranking birds in the former group would compete less successfully for food (and possibly also for other sources). The two lowest ranking birds in each 'light-incubated' group gained significantly fewer successful entrances to the food dish than did their 'dark-incubated' counterparts. Indeed, it was not uncommon for the lowest ranking birds (ranks 7 and 8) in each light-incubated group to stand back and never attempt to gain access to the food dish.

It was predicted that chicks incubated in darkness, and therefore having the direction of brain asymmetry distributed randomly between individuals, would form groups with greater social flexibility or instability. In contrast, the social behaviour of groups in which all individuals have the asymmetry in the same direction (i.e. those exposed to light during the last days of incubation) may be more stable and predictable. With the development of a more stable order particular individuals would be consistently at the bottom of the hierarchy. One way to estimate stability versus flexibility in the social rank order is therefore to look at day-to-day variation in entry scores to the food dish. The cumulative variation in entry scores over the testing period from day 8 to 16 was significantly higher for the chicks at the bottom of the hierarchy in the groups comprised of chicks incubated in darkness. That is, the lowest ranking birds in these groups showed more variation in rank order from day to day, whereas the scores for the lowest ranking chicks in the groups exposed to light during incubation were more consistent from day to day, indicating a more stable hierarchy (for more details see Rogers and Workman, 1989).

In practical terms the short-term effects of incubation conditions on the social hierarchy is likely to be very important for food intake and survival in early posthatching life. The main advantage of dark incubation is to ensure that the lowest ranking chicks will compete for food during the critical first week of posthatching life. In this way incubating eggs in darkness over the last three days before hatching may reduce the number of chicks which die of starvation in their first week or two of life.

CONCLUSION

These data lead to the following suggestions for reducing starve-outs in the first two weeks of posthatching life; incubation in darkness over the last three days before hatching so that a less stable hierarchy is formed in the first two weeks of life; not performing beak-trimming (at least, at this age) as it reduces ingestion of seed and at the same time increases the dependence on nutritive reward which is less possible for the beak-trimmed chick to achieve.

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REFERENCES

ANDREW, R.J. (1988). Behav. Brain Res. 29:201-209.

ASTININGSIH, K. (1987). M. Rur. Sc. Thesis, University of New England.

BLOKHUIS, H.J., HARR, J.W. and KOOLE, P.G. (1987). Poultry Sci. 66:623-625.

GOODWIN, E.B. and HESS, E.H. (1969). Behaviour 25:255-266.

GUHL, A.M. (1953). Sci. Am. 194:42-46.

KRUIJT, P.J. (1964). Behav. Suppl. XII.

HOGAN, J.A. (1973). J. Comp. Physiol. Psychol. 83:355-366.

REYMOND, E. and ROGERS, L.J. (1981). Behav. Neural Biol. 31:425-434.

ROGERS, L.J. (1983). Nature 293:223-225.

ROGERS, L.J. (1986). Adv. Stud. Behav. 16:147-189.

ROGERS, E.J. and WORKMAN, L. (1989). Appl. Anim. Behav. Sci., in press.