As we have briefly indicated, compounds of the second class can serve both these functions and it may be in this direction that future research should be concentrated if useful progress is to be made in the chemotherapy of malignant disease.

We wish to express our gratitude to Prof. A. Haddow for interest and encouragement, and to Dr. W. C. J. Ross for much helpful discussion and advice, especially in connexion with the chemistry of the haloalkylamines and for valuable criticisms of the manuscript. Thanks are also due to Dr. D. A. Peak and the Boots Pure Drug Co. for the specimen of protoanemonin and their valuable co-operation in carrying out assays. The work upon which this paper is based has been supported by grants to the Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the Research Grants Division of the U.S. Public Health Service.

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BIRD BEHAVIOUR

ON September 6, Section D (Zoology) of the British Association held at Newcastle upon Tyne a symposium on the subject of bird behaviour.

Mr. P. H. T. Hartley, speaking on "Routines in Bird Life", gave an account of some activities concerned in the maintenance of the individual bird. The value of such studies is three-fold: they are part of the basic ethology of birds; they provide the setting in which more complex actions must be studied and compared; and they throw light on certain ecological problems which are difficult of direct attack. In illustration of daily routines in feeding activity, herring gulls *Larus argentatus* in west Cornwall have three feeding periods in the day in the second half of September, separated by two resting periods; in the second half of October there are two feeds separated by a single rest. Blackbirds *Turdus merula* in Berkshire in winter feed all through the day, but are especially active in the hours after sunrise. The study of the feeding routines of two congeneric species, chiff-chaff *Phylloscopus collybita* and willow warbler *Ph. trochilus*, living in one wood showed that the chiff-chaffs forage consistently higher than willow warblers; this implies that the two species are not in close competition, although living on the same ground. The discovery of the same foods in two species does not necessarily imply competition between them. The different titmice of the genus *Parus* show ecological isolation, each species having its own feeding levels. The fact that any breakdown of species segregation is explicable by the occurrence of a temporarily superabundant food (such as caterpillars in early summer, and nuts or wild fruits in autumn) suggests that the possession of a separate feeding niche by each species at other times points to a genuine need to avoid interspecific competitions.

Mr. Hartley also gave examples of variations in routines of song utterance. In discussing the work of D. R. Barber on the song of the chaffinch *Fringilla cœlebs* (see *Nature*, **161**, 277; 1948), he pointed out that any study of local variations in phrase length would be stultified if allowance were not made for the stage in the annual song cycle.

In his survey "Some Aspects of the Relationship between the Pair Bond and Breeding Economy of Birds", the Rev. E. A. Armstrong urged the need for an integrative approach to the study, in which psychological, ethological, morphological and physiological factors should be equally considered. He pointed out that at the time of the formation of the pair bond, there takes place a revolutionary change in the approach of each bird to another individual. Hostility or indifference must be replaced first by tolerance and later by co-operation, often with a fixed allotment of the roles in the breeding cycle.

When both sexes of a species are conspicuous, both share in the rearing of the young; and when there is colonial nesting the bright colours of the adults may function as a warning. In such colonial species as are conspicuous in coloration, it is almost inevitable that monogamy should be the rule of life, as there must be one parent always on duty at the nest. An unattended nest in a conspicuous colony offers an invitation to the raids of predators. In species wherein the male is conspicuous and the female cryptically coloured, the nest is hidden, and the hen usually bears the major part of the care of eggs or young. In such cases the species may be promiscuous or polygynous. In promiscuous species a 'lek' is used

for courtship assembly. In polygynous species the cock makes himself conspicuous by voice or appearance, and his territory is the rendezvous where he can be found by the hens. Mr. Armstrong said that he regards the provision of a rendezvous as a most important function of the territory in polygynous species. With bright colours which are aposematic in function, it is clearly necessary that both sexes should be so coloured; if only one sex were aposematically coloured, there would be selection as between the sexes.

Mr. Armstrong then developed the theory of social signals, or synepisematic coloration. He pointed out that in a number of species which often feed communally—avocets *Recurvirostra avosetta*, gannets *Sula bassana* and goldfinches *Carduelis carduelis*—the wings are conspicuously coloured, black and white, or black and gold. These brilliant colours may serve to signal to other members of the same species the existence of some temporarily or locally abundant food. Mr. Armstrong advanced the view that there is social selection as well as individual selection.

Environment may play a dominating part in the formation of the pair bond. In the snow bunting *Plectrophenax nivalis* the cock is conspicuous and the female cryptic; but the conditions of life are rigorous, the young are fed by both parents and the care of the newly fledged juveniles is rigidly divided between male and female. Should one parent die or desert, the young which are in its charge are allowed to starve by the other adult—so stringent has selection of behaviour been in the short northern summer. In the corn bunting *Emberiza calandra*, though the sexes are similar, there is frequent polygyny. Mr. Armstrong regards this as an adaptation to areas of especially abundant food. In support of this view he pointed out that the wren *Troglodytes t. troglodytes* is polygynous in England, but the St. Kilda wren *Troglodytes t. hirtensis* is monogamous. The Icelandic subspecies *Troglodytes t. islandicus* has polygynous tendencies. The appearance of the habit of polygyny in an area so far to the north of the range of a monogamous subspecies could possibly be attributed to the abundance of food in the Iceland birch scrub.

Dr. Robert Carrick began his talk, "The Feeding Reactions of Starlings", by a survey of Dr. David Lack's thesis that family size in birds is fixed by the fact that there is an increase in mortality as broods increase in size above a certain level, with the result that broods above the optimum in size produce fewer young per pair than broods of the optimum size. Lack and Arn have shown that in the alpine swift *Apus melba* the average number of young reared from clutches of four eggs is the same as the number reared from clutches of three. In the starling *Sturnus vulgaris* there is evidence of a greater growth-rate in broods of less than maximal size; but in the robin *Erithacus rubecula* the evidence is less satisfactory. In the study of Dr. Lack's theory, information is needed on four points: (1) that clutch size is inherited; (2) that there is under-nourishment in broods of more than optimal size; (3) that this under-nourishment is the principal cause of nestling mortality; (4) that the under-nourishment is the result of the inability of the parents to do better.

Dr. Carrick then gave an account of work on starlings bearing on the last three of these problems. Both sexes feed the young, the cock at one nest responding to auditory stimulation by bringing food while the chicks are yet cheeping within the egg. Several young are fed at each visit of the parent; up to the age of six days there is equality of distribution among the nestlings. An exception to this rule was found at a nest where six young were being reared by the female alone. Competition among the young increases when their eyes open. A hungry nestling has a great capacity to foree its claim before the better fed members of the brood, and can make weight rapidly. The feeding-rate increases with the demand. By altering the numbers of birds in two broods, Dr. Carrick was able to show that there exists an immediate adjustment to brood size. This adjustment is made by an increase in effort on the part of the male. The larger the brood, the greater the contribution of the cock to the total feeding effort. A cock with a small brood reverts to pre-breeding behaviour and spends much time in song.

When the young are large, the stimuli to the parents are both visual and auditory. The parent will put food into the open gape of a dead nestling, despite the silence, and will take food to a covered cage in which a concealed nestling is calling hungrily. Each of the two releasers is therefore sufficient to guide feeding activity. There is a greater range of weight in broods of six than in broods of two or three: in the brood of six fed by a hen alone, the heaviest chick at the time of fledging was equal in weight to an average chick of other broods; the rest of the brood fledged under weight.

The discussion which followed centred largely on the feeding activities of parent birds. Prof. H. R. Hewer gave an account of the feeding activities of green woodpeckers *Picus viridis*; in this species both parents feed by regurgitation. The parents have a considerable storage capacity. Up to nine morsels may be produced in succession at one visit. The number of visits per hour is small—from one to something less than three. When the young grow large, two or three of the brood are fed at the nest entry, and the adult bird then pushes into the nest to feed the others. There is an integration of the feeding rhythms of male and female. At one nest a widowed female failed to rear the young, apparently as a result of loss of time wasted in indecision between the feeding and brooding drives.

Dr. C. Ellenby suggested that with so low a feeding frequency, there is time for all the nestlings to become hungry between the visits of the parents, including those most recently fed; there might, therefore, be an increased competition for any surplus food packets at each distribution. Mr. Armstrong pointed out that the capacity to store and to regurgitate food gives a greatly increased feeding-range. In green woodpeckers the scrabbling of the feet of the adult bird signals its coming with food. In wrens the parent sings a very soft song, and great tits *Parus major* have a short, soft note to attract the attention of sleeping or well-fed nestlings.

In reply to a question, Dr. Carrick said that he had attempted the experiment of establishing three broods of nine starlings; for various causes all these three experiments had been interrupted. Prof. G. C. Varley inquired if any data are available on changes in routine indicating times when availability of food is becoming a limiting factor. Mr. Hartley replied that in blackbirds there seems to be more feeding activity after noon on days of hard frost; but the winter routine of titmice suggests a slackening of feeding activity in the afternoon long before the onset of darkness prohibits the search for food. Mr. Armstrong said that, in contrast to this, wrens continue to hunt until late dusk.