Physiology and Biochemistry of the Domestic Fowl

Volume 4

Edited by B. M. Freeman

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Houghton Poultry Research Station, Houghton, Huntingdon, England

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Contributors

R. L. Allen Department of Chemistry and Biochemistry, Liverpool Polytechnic, Liverpool L3 3AF, England.

E. F. Annison Department of Animal Husbandry, University of Sydney, Camden, New South Wales 2570, Australia.

E. J. Butler Houghton Poultry Research Station, Houghton, Huntingdon, Cambridgeshire PE17 2DA, England.

M. E. Coates National Institute for Research in Dairying, University of Reading, Shinfield, Reading, Berkshire RG2 9AT, England.

V. Eisen Rheumatology Research Department, Middlesex Hospital Medical School, 40–50 Tottenham Street, London W1P 9PG, England.

B. M. Freeman Houghton Poultry Research Station, Houghton, Huntingdon, Cambridgeshire PE17 2DA, England.

R. Fuller National Institute for Research in Dairying, University of Reading, Shinfield, Reading, Berkshire RG2 9AT, England.

J. R. Harris North East Thames Regional Transfusion Centre, Crescent Drive, Brentwood, Essex CM15 8DP, England.

A. L. Harvey Department of Physiology and Pharmacology, University of Strathclyde, Glasgow G1 1XW, Scotland.

K. J. Hill Unilever Research Laboratory, Colworth House, Sharnbrook, Bedford MK44 1LQ, England.

A. L. Holden Department of Visual Science, Institute of Ophthalmology, Judd Street, London WC1H 9QS, England.

J. McLelland Department of Anatomy, Royal (Dick) School of Veterinary Studies, University of Edinburgh, Edinburgh EH9 1QH, Scotland.

I. G. Marshall Department of Physiology and Pharmacology, University of Strathclyde, Glasgow G1 1XW, Scotland.

V. Molony Department of Physiology, Royal (Dick) School of Veterinary Studies, University of Edinburgh, Edinburgh EH9 1QH, Scotland.

J. Pearce Agricultural and Food Chemistry Department, The Queen's University of Belfast, Newforge Lane, Belfast BT9 5PX, Northern Ireland.

W. G. Siller Agricultural Research Council's Poultry Research Centre, Roslin, Midlothian EH25 9PS, Scotland.

E. Skadhauge Department of Veterinary Physiology and Biochemistry, Royal Veterinary and Agricultural University, Copenhagen N, Denmark.

S. E. Solomon Department of Veterinary Anatomy, University of Glasgow Veterinary School, Glasgow G12 8QQ, Scotland.

R. I. C. Spearman Dermatology Department, School of Medicine, University College London, University Street, London WC1E 6JJ, England.

A. H. Sykes Wye College (University of London), Ashford, Kent TN25 5AH, England.

Preface

It is now rather more than a decade since the first three volumes of the series were published. Overall they have had a generous reception which led to the publishers asking for them to be brought "up to date". It is said, however (with some truth one may add), that all scientific texts are out of date by the time that they are published. Nevertheless I was pleased to find that many of the original contributors were willing to summarise the more interesting advances that had been made during the intervening years. Unfortunately, some were unable to meet the time table and it has therefore proved necessary to allot these to a fifth volume which we hope will be ready for the press later this year. Some readers will no doubt find this arrangement a little irksome and I have sympathy for their view. Nevertheless I feel that this approach is justified.

David Bell died suddenly only a few months after the publication of the first three volumes. I therefore had to undertake the present task without the prospect of his good sense and innate cheerfulness to encourage me during the more daunting moments. He is sadly missed. This volume is dedicated to his memory.

Houghton.

B. M. Freeman
January, 1983

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1 Food Intake and Its Control

A. H. SYKES

Wye College (University of London), Ashford, Kent, England

I. Introduction

Until comparatively recently the nature of hunger had been considered mainly in relation to gastric movements and it was not until the discovery of the ventromedial hypothalamic satiety centre in 1939 and the lateral hypothalamic feeding centre in 1951 that the concept of food intake being a homeostatic function, comparable with, for example, the regulation of plasma glucose, arose. Since that time there has been an upsurge of research activity and many reviews are available which detail the importance of gastro-intestinal, metabolic, neural and behavioural factors which determine how much food is eaten at any given time. But despite this activity there is, so far, no general theory which brings together the considerable body of facts which have now accumulated. This is in marked contrast with the control of water intake which has acquired a well-defined foundation based upon the fluid compartments of the

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body and recognized hormones. Since for much of its life an animal maintains a fairly constant body weight it follows that there is some regulation of intake (or of expenditure?) but there is much plasticity in the system which allows for fluctuations in the natural food supply.

When animals are fed discrete meals dietary intake can be controlled but when feeding *ad libitum* is allowed, as with poultry, then a knowledge of the factors that regulate voluntary intake becomes more important. But animals differ considerably in their diet and feeding habits and although there may be much in common in their basic biochemistry and physiology there is no justification for assuming that the mechanisms which control food intake in, say, a nocturnal, omnivorous rat apply equally to a diurnal, granivorous bird. Moreover, in an animal used in agriculture the absolute quantity of food consumed, rather than relative differences between control and experimental situations, assumes greater importance. Therefore, wherever possible, weight of food is given rather than indirect indications of intake such as the number of feeding movements. The nature of the food is not always specified by authors. Generally compounded diets with a conventional formulation are fed in mash or pellet form and amounts refer to wet weight which can mean that the diet contains anything from 8 to 16% moisture.

This chapter is in two parts: firstly, an account of how much food is eaten by the fowl under different circumstances and, second, a consideration of the possible physiological mechanisms which start and stop feeding activity in such a way that these amounts of food, neither more nor less, are consumed.

A complete bibliography of food intake in the fowl has not been attempted since there are a number of reviews already available (Lepkovsky *et al.*, 1967; Wright, 1975; Boorman and Freeman, 1979). The latter is a very valuable source which is not superseded by the present account.

II. Factors Affecting Food Intake

A. The Pattern of Food Intake

The amount of food consumed by the fowl of any age and of any type is reasonably well known. Typical values, for a hybrid White Leghorn hen up to point of lay are shown in Fig. 1; daily food intake increases regularly with age from 10 g/d at 1 week up to nearly 70 g/d at 12 weeks. The subsequent growing period is characterized by a fairly constant intake and is followed by a further increase, up to 120 g/d, when laying starts.

The daily intake of food is not consumed in one single bout of eating, commencing at daylight or at any other fixed time. It is consumed intermittently over the whole of the lighted period at rates which are variable but not at

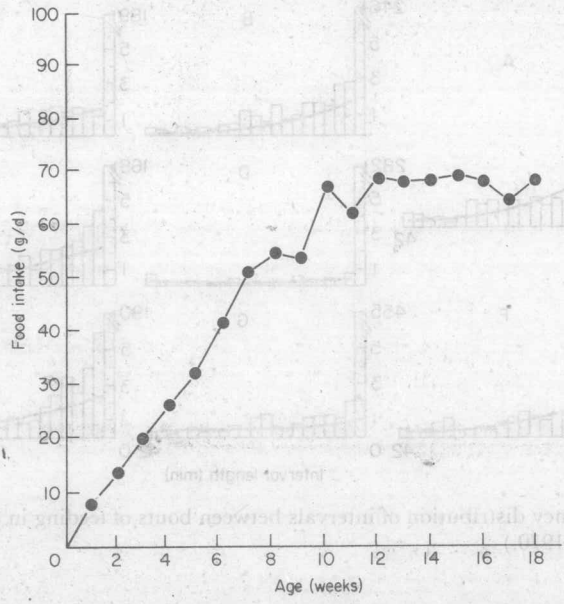

Fig. 1. Mean daily food intake of a White Leghorn female from 1 to 18 weeks old.

random. There is evidence that eating occurs in discrete bursts of feeding activity or meals and that the distribution of these meals shows diurnal periodicity.

Observation and analysis of feeding activity (Duncan *et al.*, 1970) led to the view that bouts of two minutes or less constitute individual meals. Within this period the birds are actively interested in food and not in any other activities such as preening or courtship although the whole of the two minutes is not spent in continuous eating. Obviously any period of time allocated exclusively to meals is somewhat arbitrary but the distinction is a useful one. Most (90%) of the feeding activity (not necessarily food intake) takes place within these two minute periods; the frequency of longer intervals between successive bouts falls on a negative exponential graph (Fig. 2).

The fowl must be considered to be a "nibbler" rather than a "meal eater" in the sense that food is consumed throughout the day but the feeding pattern nevertheless can adapt to the availability of food and the total daily intake can be consumed in a few hours (Leveille and Hanson, 1965; Griminger *et al.*, 1969), which would bring it into the meal-eating category. Such behaviour is to be found only in experimental situations and this applies also to feeding in the dark which can occur, but normally does not. Within the diurnal light cycle

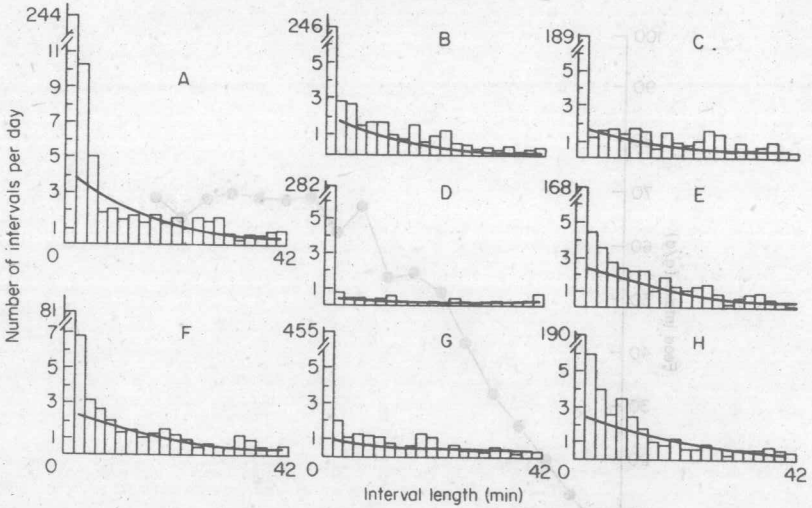

Fig. 2. Frequency distribution of intervals between bouts of feeding in 8 hens. (After Duncan *et al.*, 1970.)

feeding is usually cyclical with a peak of activity occurring either in the early morning, or in the evening shortly before dark (Savory, 1980). Sometimes peaks are seen both in the morning and evening and, occasionally, although far less often, a peak is found in the middle of the day. There is no diurnal feeding pattern which is characteristic of any particular age or condition and the expected patterns are not always observed but a generalization that may be made is that an early morning peak follows the overnight fast and is typical of growers and non-layers. An evening peak is a consequence of egg laying and provides calcium for calcification of the shell overnight. It must, however, be emphasized that these are not causal relationships and their absence does not indicate anything unusual. Moreover, many of the diurnal patterns that have been reported refer only to feeding activity or responses in a Skinner box and not to intake. It is difficult to determine whether a pattern bears any relation to intake or whether the same total quantity of food is distributed in different ways throughout the day according to the influence of various factors. In continuous light feeding takes place throughout the 24 h but there is still a circadian rhythm as shown by a peak of activity during normal daylight. On reducing the day length to 12 h the feeding period contracts accordingly and if instead of abrupt changes in lighting there is an artificial dawn and dusk then a well-defined evening peak is seen (Fig. 3). These findings apply both to growing males (Savory, 1976) and to laying hens (Duncan and Hughes, 1975).