TECHNIQUES IN WILDFOWL TAXONOMY

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(*The names of scientists who have collaborated with the Trust are shown in italics*)

A better understanding of the taxonomy of the *Anatidae*—the evolutionary relationships within the Family and its position with regards to other groups of birds—has from the start been one of the main aims of our research programme. The unique comparative Collection of wildfowl at Slimbridge, in which five-sixths of the living species have been represented at some time, offers outstanding opportunities for such work. Their study has gone forward both by work carried out at Slimbridge and by the provision of material for workers in other institutes. Many and diverse methods have been used and here an attempt is made to draw the threads together and indicate the scope of present researches, without reporting on the results in detail. It is intended that this should be done in a later paper.

External form and colouration have long been used in drawing up classificatory schemes. More and more it has been realised that attention should be directed to features not likely to be altered by adaptations to the immediate environment. Much of the assessment of similarities and differences is of an intuitive nature. *Mr. Peter Scott's* wide and intimate knowledge of the Family—he has seen all but seven of the 145 full species *alive*—both in captivity and in the wild has been particularly fruitful. His "*A Coloured Key to the Wildfowl of the World*" has recently appeared. Its 23 full-colour plates represent all the 247 known forms in the Family and, being a publishing venture of the Wildfowl Trust, has been produced at a price (8/6d.) which brings it within the reach of every student. Full detail and absolute faithfulness of colour reproduction cannot be expected at such a price. These are more nearly achieved in his illustrations for M. Jean Delacour's monograph " Waterfowl of the World." The sixty-four plates represent a definitive work of illustration. Of especial value are the plates depicting all forms of downy young. The patterns and colours of these are now recognised to be of great assistance in pointing relationships between birds which may appear very dissimilar in the adult form. The importance of the fact that 112 of the known forms have bred at Slimbridge is apparent. The case of the young of the Magpie Goose (*Anseranas semipalmata*) serves as an example. When the first volume of Delacour was being illustrated only a description was available and the downy young was depicted accordingly. Soon afterwards this species bred for the first time at Slimbridge and the young were found to be strikingly different from what is now recognised as the erroneous description.

Downy young are only available alive for short periods of the year and museum collections are generally very deficient in them. The Trust is therefore building up a reference collection of such skins as and when the birds die in good external condition. 97 skins of 68 forms of downy young are now preserved. Similarly the adult birds of the 173 forms which have been represented alive in the Collection are not all available at any one time and are in full plumage for only part of the year. 88 skins of 65 forms have been preserved. Two new cabinets of advanced design have recently been acquired from Copenhagen to house the growing collection.

The study of comparative internal anatomy, after many years of unfashionableness in the taxonomic field, has recently become a live subject again. The Trust has been able to assist in such work by the provision of post-mortem material. A number of trachea-and-syrinx preparations have been sent to *Dr. P. S. Humphrey,* now at Yale University, who is making a monographic study of these structures and the indications they provide of relationships. Dr. Humphrey also studies the musculature, requiring the provision of complete corpses when this can be done without conflicting with post-mortem requirements. *Dr. G. Kramer* of the Max Planck Institut, Wilhelmshaven is another bidder for complete bodies as he is studying the relation between bone size and structure and the bird's size, weight and method of flying. This is an investigation of functional anatomy and is not so likely to unravel evolutionary relationships. *Dr. J. G. Harrison's* work on the pneumaticity of the skull is likewise basically concerned with function but has in addition thrown light on taxonomic problems.

The development of behaviour studies reverses the usual trend whereby techniques from diverse and unrelated disciplines are pressed into the service of taxonomy. Heinroth (1910) realised that patterns of instinctive behaviour may be more stable than, say, plumage patterns. From the requirement for the precise description of such patterns of behaviour has stemmed a whole new discipline—*ethology*. This lays emphasis on the detailed observation of behaviour, and on the recording of all the facets of the pattern in an objective fashion, quantifying as far as possible. Important new advances in our concepts of behaviour have resulted. One of the pioneers of the method, *Dr. Konrad Lorenz,* has worked at Slimbridge for several periods and has continued Heinroth's original use of behaviour studies in the taxonomy of this Family, concentrating on courtship behaviour. *Dr. P. A. Johnsgard* of Cornell University, who will, it is hoped, be working at Slimbridge next summer, has been extending the work of Lorenz in this connection. *Dr. D. F. McKinney* worked for four years on comparative behaviour at Slimbridge, particularly on preening and other " comfort movements." He concluded that these were too uniform throughout the Family to be of taxonomic value. Dr. McKinney is at present continuing his investigations at the Delta Waterfowl Research Station, Manitoba, and is one of a group of workers in North America particularly concerned with the behaviours of Eiders and sea-ducks. The use of cine-film, both frame by frame and in slow motion has long been a vital tool in the analysis of movements that are too quick or occur in such rapid sequence that detailed recording by eye and brain are impossible. New types of high-speed camera and accurately-calibrated film projectors are being used by this group.

A fascinating field that has yet to be fully explored is the behaviour of hybrids. Already Lorenz has demonstrated certain ' basic ' behaviour patterns in duck hybrids that were not present in either parent. Such ' throwbacks ' in behaviour are paralleled by the emergence of ' ancestral ' types of plumage such as have been discussed by *Dr. J. M. Harrison,* in concurrence with Mr. Scott. Sometimes hybridisation produces a type closely resembling a third species. Thus the cross between Scaup and Tufted Duck is much like the Lesser Scaup, and Yamashina (1948) has suggested that the Marianas Mallard is a hybrid population derived from the Mallard and the Australian Black Duck. The extent to which hybridisation is an effective mechanism in the production of new species remains to be seen.

So far hybrids in the Collection have arisen by accident, but if opportunity for a full-scale investigation arose any number of known parentage could be produced. In some instances the intervention of artificial insemination would be needed to overcome gross anatomical discrepancies. In her book "*Bird Hybrids,*" *Dr. A. P. Gray* has listed more than four hundred types of hybrids as occurring in the Family *Anatidae,* part of her data being derived from the Trust's breeding records. The ease with which hybrids are produced seems to bear little relation to the similarity of the forms concerned. Intergeneric crosses are frequently reported, such as the bizarre result of a Goosander x Shelduck mating, whereas the closely related Carolina and Mandarin Ducks never produce hybrids.

As more refined physical and chemical techniques have become available, taxonomists have turned their attention to the structure and composition of the tissues themselves. Often such work has tended to take on the character of a search for the 'philosopher's stone,' for one character whose variations will enable all species to be fitted into a coherent evolutionary arrangement. It is more realistic to regard the results of such studies as additional information, to be used together with all existing data to draw up as natural a classification as possible. This point was emphasised by Delacour & Mayr (1945) in their classical appreciation of the Family which is taken as the starting point for subsequent investigations.

Yamashina (1952) has done a good deal of work on the numbers and shapes of chromosomes, the bearers of the hereditary particles, in the cell nuclei. This is a very delicate and laborious technique that has given interesting results, but also produced some odd conclusions. Probably it is too much to expect that the gross characteristics of the chromosomes reflect accurately the inheritance they bear. In time it may be possible to analyse the various types of DNA, the complex proteins of which the chromosomes are composed, and assess the similarities and dissimilarities between one type and another. There are a prodigious number of proteins, the building-bricks of the animal body, and it would be reasonable to expect related forms to have similar proteins in similar proportions. Work is being done now in making such assessments. A Collection such as that at Slimbridge can be used to full advantage if the source of protein can be obtained from the living birds without harming them. Feathers would be ideal from this point of view, but unfortunately their constituents are very closely bonded and extremely hard to analyse without destruction. Moreover the protein composition of feathers from different parts of the body appears to differ.

The egg is, of course, a source of proteins conveniently separated from the bird itself. Often infertile eggs are available so that it is not even necessary to sacrifice a potential young bird. Externally the eggs of the Family show a remarkable sameness. This is very apparent in the reference collection of infertile eggs from 82 of the forms that have bred in the Collection. Some differences in texture do appear to run through natural groups but when it is a question of identifying a nest, more reliance can be placed on the down lining the nest and the few breast feathers therein. Samples of such down from 78 forms are in the reference collection. A duplicate series has been passed to *Colonel R. Meinertzhagen* who is working on the structure and variation in down. His results are mainly of a functional rather than a taxonomic nature.

Professor C. Tyler of Reading University has been studying the egg shell in more precise detail, investigating the structure of the pores, the arrangement of the layers of the shell and the chemical nature of the proteins forming them. He has been using an ingenious series of methods, dissolving away the inorganic calcium carbonate, impregnating with plastic, selectively grinding away layers and staining them. His work with eggshells from the Collection is by no means finished but the indications are that their characteristics are remarkably uniform throughout the Family and will not be very useful in assessing where its subdivisions should lie.

Egg-white is another source of proteins. These are identified by separation, taking advantage of the fact that different proteins migrate over a strip of paper at different rates by simple capillary attraction (paper chromatography) or when an electrical potential difference is applied (paper electrophoresis). The various proteins are identified by the distance they have moved in a standard time and the relative proportions determined by their differential reaction to staining agents. Final representation is in graphic form so that each sample has its own " profile " that can be compared with those of other samples.

Professor C. G. Sibley of Cornell University is engaged in a far reaching survey of egg-white proteins by electrophoresis and has already examined some 400 species. The Trust has been able to supply him with many of the *Anatidae* specimens. His preliminary results also indicate a remarkable similarity in pattern which extends throughout the group, only the *Dendrocygnini* so far producing " profiles " differing markedly from others. Thus both these methods may be of more use in deciding extra-familial relationships, where the *Anatidae* stand in relation to the Flamingos and Herons, for instance.

Another source of protein from the living bird is provided by the blood, which can be drawn off in small quantities without harm. Work has in the past been done on the serum which remains when the blood corpuscles are filtered off. The serum is injected into the blood stream of rabbits resulting in the production of anti-bodies. If these anti-bodies are isolated from the rabbit and added to serum from the original bird species, a heavy precipitate is obtained. If added to the serum of an unrelated species a much lighter precipitate results. In this way the closeness of relationship can be determined. The technique is a complicated and laborious one requiring extensive laboratory facilities. Thus far the Trust has not collaborated in work of this kind, a recent example of which is that of Cotter (1957).

The properties of the protein comprising the corpuscles that contain the blood hæmoglobin were studied by Johnston and Hochman (1953) using an ingenious technique. If the corpuscles are placed in distilled water they absorb water, swell and eventually burst—a process known as hæmolysis. The time taken for this to occur will depend on the permeability of the corpuscle wall, a function of the proteins composing it. Different solutions will also penetrate at different rates, so by matching one sample of blood against a whole series of solutions an elaborate statement of its permeability properties is obtained. This can then be compared with that for other species. So far this promising and relatively simple technique has not been used in the *Anatidae*.

The hæmoglobins freed from the corpuscles can be analysed by the usual protein techniques. In human beings some nine different types of hæmoglobin have been isolated (Lehmann, 1957) and the occurrence of certain types shown to be different in various racial groups. It has even been possible to postulate the routes taken on prehistoric migrations of certain populations (Lehmann, 1954). This type of investigation therefore appeared to hold out distinct promise in our particular field. *Dr. H. Lehmann* of St. Bartholomew's Hospital undertook to make paper electrophoretic studies of material supplied by the Trust. Blood samples were taken from 118 individuals:—

25 *Anser brachyrhynchus*
13 *Branta c. canadensis*
1 *Branta sandvicensis*
1 *Tadorna tadorna*
78 *Anas p. platyrhynchos*

Using a cacodylate buffer to which a small amount of sodium chloride had been added, and working at a pH of 6.5, Dr. Lehmann was able to distinguish two types of hæmoglobins in all the samples. This confirms the contemporary results of Dunlap, Johnson and Farner (1956) and of Saha, Dutta and Ghosh (1958). But from the point of view of taxonomy the results are disappointing since no difference could be detected (in terms of the properties of the two hæmoglobins or their degree of separateness) between young and old, between broods, between sexes, between species or even between genera.

There remain two other methods of analysing hæmoglobin proteins. Transmission spectra obtained by passing light or X-rays through a solution of the protein do not appear to have much promise. Large quantities of blood are required and Winter and Honess (1952) concluded that differences in the spectra were in any case too slight to be of taxonomic use. These same workers suggested that a study of the crystallography of the hæmoglobins would be more fruitful. Such studies, involving the measurement and description of the crystal forms has been in abeyance since the massive work of Reichart & Brown (1909). These authors claimed that hæmoglobins could be distinguished by these means right down to specific level. Very small quantities of blood are required, indeed the technique has been used to examine bloodstains and so detect illegal killings in the enforcement of wildlife legislation in the United States. It is hoped that work of this nature may be started in the not too distant future.

We have seen that a whole variety of techniques are open to the modern taxonomist. Many of these techniques are incapable of assessing relationships below the Family level and are thus only of passing interest when we are concerned with relationships *within* a Family. Work with the most refined methods will be prosecuted as and when possible. But it is beginning to appear that the *Anatidae* is on the whole an unusually homogeneous and closely-knit Family.

SOME SELECTED REFERENCES

COTTER, W. B. (1957) A serological analysis of some anatid classification. *Wilson Bull.* 69/4:289-390.

DELACOUR, J. (1954-59) *The Waterfowl of the World* (illustrated by P. Scott), London. 3 volumes. Country Life.

DELACOUR, J. & MAYR, E. (1945) The Family Anatidae. *Wilson Bull.* 57/1:3-55.

DINNENDAHL, L. & KRAMER, G. (1957) Über grössenabhängige Änderungen von Körperproportionen bei Möwen. *J. F. Ornith.* 98/3:282-312.

DUNLAP, J. S., JOHNSON, V. L. & FARNER, D. S. (1956) Multiple hemoglobins in birds. *Experientia* 12/9:352.

GRAY, A. P. (1958) *Bird Hybrids.* Farnham Royal. *Commonwealth Agricultural Bureaux.*

HARRISON, J. G. (1958) Skull pneumaticity in wildfowl in relation to the mode of life. *Wildfowl Trust 9th Annual Report* 192-196.

HARRISON, J. M. (1959) Analagous variation in Mallard and its possible significance. *Bull. Brit. Ornith. Club* 79/2:22-24.

HEINROTH, O. (1910) Beiträge zur Biologie, namentlich Ethologie und Psychologie der Anatiden. *Verh. v. Internat. Kongr.* Berlin 589-702.

HUMPHREY, P. S. (1958) Classification and systematic position of the Eiders. *Condor* 60/2:129-135.

JOHNSTON, R. F. & HOCHMAN, B. (1953) Erythrocyte permeability and bird relationships. *Condor* 55:154-5.

LEHMANN, H. (1954) Distribution of the Sickle Cell gene. *Eugenics Rev.* 46/2:3-23.

LEHMANN, H. (1957) Hæmoglobin and its abnormalities. *The Practitioner* 178:198-214.

LORENZ, K. (1941) Vergleichende Bewegungsstudien an Anatimen. *J. f. Ornith.* 89:194-294.

MCKINNEY, D. F. (1953) Studies of the behaviour of the Anatidae. *Ph.D. Thesis, University of Bristol.*

REICHART, E. T. & BROWN. A. P. (1909) The crystallography of the hemoglobins. *Carnegie Inst. Wash.* 116.

SAHA, A., DUTTA, R. & GHOSH, J. (1958) Paper electrophoresis of avian and mammal hemoglobins. *Science* 125:447-8.

SCOTT, P. (1957) *A Coloured key of the Wildfowl of the World.* Slimbridge, The Wildfowl Trust.

SIBLEY, C. G. (1958) The egg-white proteins of birds as indicators of taxonomic relationships. *Proc. XII Int. Orn. Cong. Helsinki.*

TYLER, C. (1956) Studies on egg shells VII. Some aspects of structure as shown by plastic models. *J. Sci. Food Agric.* 7:483-493.

WINTER, K. B. & HONESS, R. G. (1952) The use of transmission spectra and crystallography of hemoglobin in law enforcement. *J. Wildl. Mgt.* 16/1:121-124.

YAMASHINA, Y. (1948) Notes on the Marianas Mallard. *Pacific Science* 2/2:121-124.

YAMASHINA, Y. (1952) Classification of the Anatidae based on the Cytogenetics. *Papers from the Co-ordinating Cttee. for Res. in Genetics,* 3:1-34.