## Lens Proteins and the Systematic Position of the Musophagiformes and Cuculiformes

In most taxonomic systems of birds, the *Musophagi* are linked either with the Cuculiformes or with the Galliformes[1–7]. Most modern investigators kept the *Musophagi* as a suborder of the Cuculiformes[8, 9], but some of them still believed that the turacos are related to the Galliformes only[10]. In fact the non-parasitic and important Centropodidae have frequently been overlooked[11]. Important biochemical similarities were found among the turacos and *Centropus* on the one hand, and some cuckoos and *Centropus* on the other; the Galliformes, however, were clearly different[12].

*Material and methods.* The present study deals with the taxonomic evidence provided by the agar-electrophoretic patterns of lens proteins. Preparation of the fresh lens extracts, electrophoresis and immunoelectrophoresis were carried out according to RABAEY[13]. Relative mobilities of the fractions ($m_r$) were calculated in function of the constant mobility of human serum albumin ($m_r = 100$), with dextran as a reference ($m_r = 0$). Individual variation and the influence upon the patterns of age, sex, breeding and other internal or external factors have been discussed in previous publications[14].

*Results and discussion.* The galliform lens pherogram (recorded with 18 species of the Phasianidae, the guineafowl and the turkey) shows a highly concentrated and well-limited component with an $m_r$ about 65, which was called first important soluble crystalline (FISC) (Figure 1). It also occurs in most other avian orders, but generally in a low concentration and with a changed mobility; sometimes it also appears in a multiple form[13]. It is not unlikely that the simple and highly concentrated FISC may thus be considered as an indication that the Galliformes are among the most primitive of recent birds, as was suggested already by several investigators in the anatomical and ethological field[4, 9, 15].

The Passeriform type (recorded with 86 species of the Oscines) is mainly characterized by the typical song bird component (TSBC). It is also a strongly concentrated, more narrow and strictly limited component which constantly migrates up to the $m_r$ 60. Besides in the Passeriformes it also occurs, though in a clearly lower concentration, in the Coraciiformes, Strigiformes, some Psittaciformes, Falconiformes, Gruiformes and some Ardeidae. It is however always sharply limited and the $m_r$ variation 59–61 is not greater than among song-bird families[16].

In the turaco pattern the TSBC occurs, although it may be observed in a very low concentration. Notwithstanding some slightly changed mobilities and different concentrations of most other fractions, the whole pattern has in fact a passeriform appearance. The cuckoo shows no TSBC and, further, very little apparent resemblance with the passeriform pattern. On the other hand, it is more like the pigeon, although there are not so many slightly concentrated fractions with middling mobility. It is quite unlike the parrot pattern, in which a very clear TSBC can be observed but in which almost no slower fractions are present (this lack is due to the fact that the parrot lens was obtained from an old bird[16]).

It is most unlikely that the presence in *Turacus* of such a complex pattern as in the Passeriformes, should be due to mere coincidence; it probably indicates a possible relationship to all orders in which this pattern occurs. A different pattern in the Cuculiformes and the Columbiformes, however, does not necessarily exclude these birds from any more or less close relationship with the orders of the passeriform group. The pattern is only one character and the other biochemical data should also be taken into

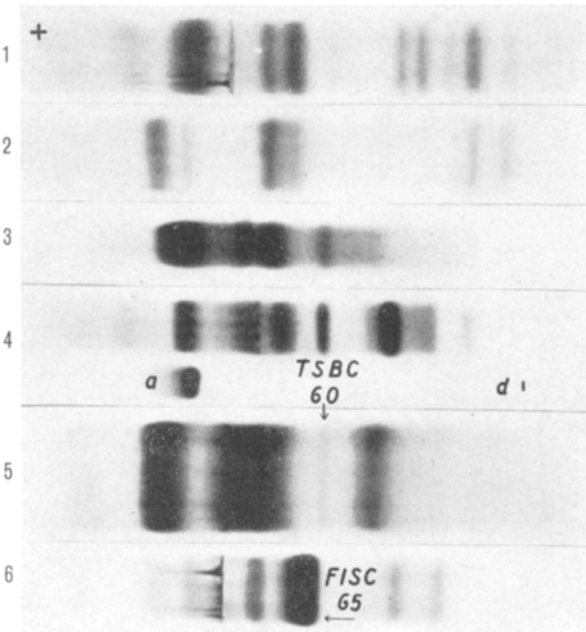


Fig. 1. Agar microelectrophoresis of lens extract of 6 different birds. (1) *Columba livia* (Columbiformes); (2) *Cuculus canorus* (Cuculiformes); (3) *Amazone ochrocephala* (Psittaciformes); (4) *Erithacus rubecula* (Passeriformes); (5) *Turacus erythrolophus* (Musophagiformes); (6) *Gallus gallus* (Galliformes).
(a–d) Mobility test substances human serum albumin ($m_r = 100$) and dextran ($m_r = 0$).
(TSBC) typical song bird component; (FISC) first important soluble crystalline.


Fig. 2. Immunodiffusion test revealing the similar reaction of the FISC-components of *Turacus* and *Corvus* against the specific anti-*Gallus*-FISC antiserum, with which the slot had been filled.


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account. In particular the immunological similarities shown against the anti-song bird antiserum are too important to be overlooked[14].

According to the lens protein evidence, the presumed relationship with the Galliformes, however, must be rejected completely. The galliform pattern is clearly set apart from the rest by the dominating FISC-fraction. Moreover, immunodiffusion studies have revealed the considerable difference in antigenic nature between the *Gallus*-FISC and the almost hidden corresponding fraction in *Turacus* that produces a reaction greatly similar to the *Corvus*-FISC one[17] (Figure 2). Finally the chicken lens is the only one (in this series) which contains no glycogen[18].

It may be summarized that according to lens protein data the Musophagiformes should be situated among the group with the passeriform lens pattern; the similarities with the Galliformes should be regarded as superficial. About the mutual relationship with the Cuculiformes, all possibilities remain open until indeed more species, and in particular *Centropus*, have been investigated, also on the biochemical plane.

*Résumé.* La micro-électrophorèse en agargel des protéines solubles de la lentille de *Turacus* a donné un phérogramme assez analogue à celui des Passeriformes. Aussi la présence de glycogène dans la lentille semble démontrer que les touracous doivent être classés parmi les ordres aviaires les plus évolués et non pas près des Galliformes.

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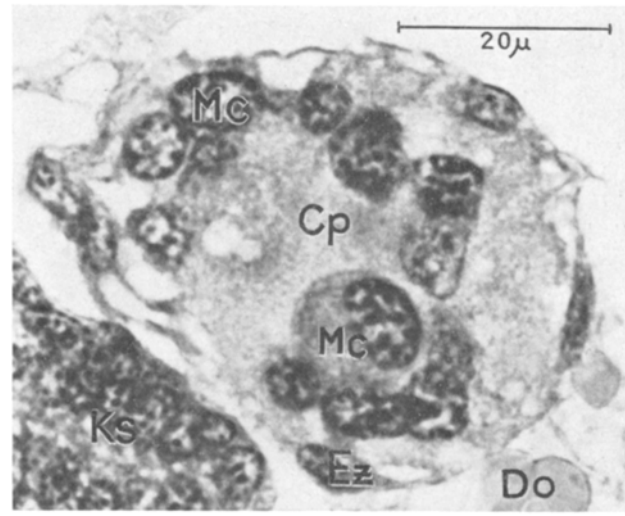
## Entwicklung der Symbiontenorgane einer Kleinzikade (*Euscelis plebejus* Fall.) nach Ausschaltung der Symbionten

Nahezu alle bisher untersuchten Zikadenarten besitzen zwischen 1–6 obligate Endosymbiontenarten. Einige werden als Pilze, die meisten als hochangepasste Bakterien identifiziert und mit lateinischen oder griechischen Buchstaben bezeichnet. Ihr physiologischer Nutzen für den Wirtsorganismus ist noch weitgehend ungeklärt. Die Symbionten werden in der Regel während der Embryonalentwicklung in Wirtszellen (Myzetozyten) aufgenommen, welche noch zu einem speziellen Organ (Myzetom) zusammentreten können. Ausführliche Beschreibung siehe BUCHNER[1,2].

Die einheimische Kleinzikade *Euscelis plebejus* Fall. besitzt 2 symbiontische Bakterien, Typ *a* und Typ *t*[3], die intraovarial auf die folgende Generation übertragen werden[1]. In einer früheren Arbeit[4] wurde die Aufnahme der *a*- und *t*-Symbionten in Myzetozyten und die Entstehung des Myzetoms während der Embryonalentwicklung von *Euscelis plebejus* beschrieben. Der Symbiontenball liegt anfangs am Eihinterpol und wird, am kaudalen Ende der Keimanlage befestigt, bei der Einrollung durch den zentralen Dotter bewegt. Dabei nehmen Furchungszellen die im Durchmesser ca. 5 µm grossen *a*-Bakterien auf. Die nur 2 µm grossen *t*-Bakterien werden erst während der Verkürzungsphase des Keimstreifs von Mesodermzellen aus dem 2. Abdomensegment aufgenommen. In dem so entstandenen transitorischen Myzetom degenerieren die primären oder $a_1$-Myzetozyten, während die *a*-Symbionten gleichzeitig in die sekundären oder $a_2$-Myzetozyten übersiedeln, zweikernige Zellen, die wahrscheinlich aus der mesodermalen Genitalleiste stammen. Das transitorische Myzetom teilt sich während und nach der Ausrollung des Embryos in die beiden definitiven, von einem Epithel umhüllten Lateralmyzetome, welche sich durch das 3. und 4. Abdominalsegment ausdehnen.

Die Entwicklung der symbiontischen Einrichtungen nach Ausschaltung der Symbionten untersuchte ich an Schnittserien von 70 Eiern verschiedener Entwicklungsstadien. In diesen Eiern wurden die Symbionten mit Sichtbarwerden der Vorkeimanlage durch Abschnüren eines hinteren Eiteils von etwa 20% Eilänge ausgeschaltet, nachdem zuvor im mittleren Furchungsstadium der




Pseudosymbiontenball mit symbiontenfreien $a_1$-Myzetozyten (Mc) am Hinterende eines Keimstreifs (Ks) während der Kaudalkrümmung. Cp, Zytoplasma; Do, Dotterschollen; Ez, Epithelzellen.

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