Kansas Ornithological Society
BULLETIN
PUBLISHED QUARTERLY
Vol. 38 June, 1987 No. 2

BILIVERDIN AND BILIRUBIN IN THE SERUM OF ROCK DOVES

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The bile pigments, biliverdin and bilirubin, result from the degradation of the heme portion of hemoglobin following necrosis of erythrocytes in vertebrates. Among birds, domestic chickens (*Gallus domesticus*) and turkeys (*Meleagris gallopavo*) have been shown to possess biliverdin as the major bile pigment, since the liver of those birds lacks the enzyme, biliverdin reductase, which is responsible for the conversion of biliverdin to bilirubin (Lind et al. 1967; Tenhunen 1971; Lin et al. 1974; Himes and Cornelius 1975). While biliverdin is produced in relatively large quantities in the bile, Lind and coworkers (1967) found that neither biliverdin nor bilirubin were present in detectable levels in the serum of normal cockerels. Dramatic increases in serum biliverdin and bilirubin were observed only following ligation of the biliary ducts. More recent investigations confirm that bilirubin is quite low in the serum of domestic chickens (Paulson and Struble 1981; singh and Bhattacharyya 1984). Similarly, low levels of bilirubin also have been found in Northern Bobwhites (*Colinus virginianus*) and numerous other more primitive species of birds (Gee et al. 1981).

In marked contrast, however, serum bilirubin levels near those of human levels (> mg/100 ml) have been reported in female House Sparrows (*Passer domesticus*) (Parrish and Mote 1984) and Rock Doves (*Columba livia*) (Parrish and Workman 1984). The present investigations were performed to determine whether biliverdin levels were as elevated as bilirubin in the serum of Rock Doves.

Methods

Five male Rock Doves were captured in the vicinity of Herington, Kansas, and transported to the Biology Division at Emporia State University for use in the biliverdin studies. The birds were housed in wire cages and maintained on Purina Chick Starter for one week before use in the experiment. Blood levels of biliverdin were measured by the methods described by Larson et al. (1947), with a limit of detectability of about 0.1 mg/100 ml serum. Biliverdin IX (Porphyrin Products, Logan, Utah) was used for the standards. Five additional male pigeons were used from a colony maintained in Emporia, Kansas, for the bilirubin investigations. Those birds were fed Purina Pigeon Chow while in the colony. Blood levels of bilirubin were measured using an Abbott VP Bichromatic Analyzer according to methods previously described (Parrish and Mote 1984; Parrish and Workman 1984). Blood was obtained by cardiac puncture, and serum samples were assayed following clotting for biliverdin, and within 12 hours after collection for bilirubin. Blood samples for the biliverdin assays were obtained from birds just prior to noon, while those for bilirubin were obtained shortly after noon.

Results and Discussion

Serum samples of bilirubin (BR) in domestic pigeons (Table 1) were 10-150 times those found in more recent investigations of hens (Paulson and Struble 1981; Singh and Bhattacharyya 1984) and nine times those reported in the Northern Bobwhite (Gee et al. 1981). They also were 2- to 9-fold greater than those of several other non-passerine species (Gee et al. 1981). However, the BR levels were similar to those previously reported in both male and female Rock Doves (Parrish and Workman 1984) and the more recently evolved House Sparrows (Parrish and Mote 1984). On the contrary, biliverdin (BV) was below the level of detectability in the serum of Rock Doves (Table

1), just as Lind and coworkers have reported in cockerels (1967). Preliminary evidence indicates that House Sparrows also appear to have below detectable levels of serum BV (Parrish unpublished). The finding that BR is exceptionally high in pigeons (Table 1; Parrish and Workman 1984) and sparrows (Parrish and Mote 1984) is quite surprising in view of the fact that chickens secrete more than 15 times the amount of BV, than BR, into the bile (Lin et al. 1974; Sturkie 1976). In addition, BV concentrations in the bile of chickens also are about 10 times greater than BR concentrations (Lin et al. 1974). Turkeys, likewise, have about 10 times greater bile concentrations of BV than BR, and similarly, secrete about 10 times more BV than BR (Himes and Cornelius 1975). Whether pigeons and sparrows secrete similar ratios of the bile pigments as chickens and turkeys has yet to be determined. It is apparent that unlike chickens and turkeys, pigeons and sparrows must have sufficient biliverdin reductase to adequately accomplish the conversion of BV to BR. Further investigation is required to determine if the enzyme is located in the liver or other tissues. Since BR is essentially unexcretable because of its lipophilic and protein-binding affinities, pigeons and sparrows also must likely possess glucuronyl transferases that would permit BR conjugation with glucuronic acid, as has been demonstrated in humans (Lightner and McDonagh 1984). This would be necessary because prolonged exposure to high levels of BR can be fatal. The reason for the exceedingly high BR levels in pigeons and sparrows is not known. They may result from the exceptionally high erythrocyte (RBC) levels characteristic of these species of birds (Nice et al. 1935; Powell 1983). Thus, a high number of RBC's would result in substantially greater levels of hemoglobin, which subsequently would produce more bile pigments following erythrocyte destruction. One way to determine whether this might be the case would be to monitor respiratory carbon monoxide levels (CO), since CO production has been used to measure the rate of erythrocyte destruction in humans (Lightner and McDonagh 1984). Thus, it is possible that pigeons and sparrows produce greater amounts of CO than birds such as chickens, cranes, and quail which have lower BR levels, as well as lower blood levels of RBC's (Gee et al. 1981).

Table 1. The levels of biliverdin and bilirubin in the serum of five male Rock Doves (mg/100 ml)

Bile Pigment	Range	Mean ± SEM
Biliverdin	—	n.d.[1]
Bilirubin	1.0-1.7	1.32 ± 0.125[2]

[1]n.d. = not detectable (limit of sensitivity about 0.1 mg/100 ml)
[2]mean ± standard error of the mean (SEM)

Whether other more recently evolved birds have similar levels of BR and BV as the pigeon and House Sparrow remains to be determined. There is the possibility that the high BR levels in the pigeon may be related to the fact that pigeons are among the several species of columbiforms, cuculids, trochilids and other birds that lack a gall bladder (Gorham and Ivy 1938; Ziswiler and Farner 1972). It would be especially interesting to examine other species of birds without gall bladders to determine if serum bile pigments might be similarly elevated. At the same time, the absence of a gall bladder is not a prerequisite for high serum BR levels, since high serum BR levels are present in the House Sparrow (Parrish and Mote 1984), which does possess a gall bladder (Gier and Grounds 1944). It also might be extremely interesting to look at bile pigment levels in birds that produce blue or blue-green eggs, since BV and metal chelates of BV are deposited as bluish and greenish pigments in the shells of many such birds (Kennedy and Vevers 1973, 1976). Whether higher BV blood levels would be found in thrushes, starlings, catbirds, some thrashers, some ravens and crows, and other birds with blue or greenish eggs is not known.

Acknowledgements

The authors are grateful to Mrs. D. Schrader, Director of the Newman Memorial Hospital Laboratory, for use of the Abbott analyzer to determine bilirubin levels. We also thank D. Workman for supplying pigeons and for his assistance with this research.

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First Nesting Record for the Bewick's Wren in Finney County, Kansas. — A pair of Bewick's Wrens, *Thryomanes bewickii*, nested successfully in a bluebird box in Finney County, southwestern Kansas, in the spring of 1986. It is the first record for this species in the county (Marvin Schwiling, pers. comm.). Previous investigations in southwestern Kansas (Menke. 1894. Kansas Univ. Quarterly, 3, no. 2; Linsdale. 1927. Auk 44:47-58; Rising. 1974. Univ. Kans. Sci. Bull. 50, no. 8; Herbert. 1985. unpublished checklist) failed to record this species in Finney county. Rising, however, did note their occurrence in small numbers in Clark, Ford, Meade, Seward, and Stevens counties. Graber and Graber (1951. Trans. Acad. Sci. 54:145-174) may have not censused Finney county, but nevertheless *bewickii* was recorded but four times during their study in southwestern Kansas.

The nest was located along a dry portion of the Arkansas River at the Weldon Soil Conservation District land. 6.4 km WNW of Pierceville, KS. The completed nest was discovered on 5 April, when an adult wren flushed from the box. A second adult was

scolding nearby. A clutch of six eggs was found on 12 April. Three nestlings, less than 24 hrs old, occupied the box on 29 April. The other three eggs failed to hatch. The nestlings were banded on 8 May, and they fledged on 15 May, about 17 days after hatching. The wrens were not found again after 15 May.

An interesting aspect of this observation was the length of nesting time. Bent (1948. U.S. Natl. Mus. Bull. 195:176-183) records the incubation period as 10 to 14 days and the brooding period as 14 days. Very chilly weather throughout April 1986 may have prolonged incubation to near 16 days for this clutch. Furthermore, a nestling period of about 17 days for this brood may have been the result of continued cold weather and a moderate to heavy mite infestation. When the three nestlings were banded, their appearance and behavior was anything but plump and vigorous. Their feathers and the nest were dusted with 0.5% pyrethin powder, and they did appear a little friskier a couple of days later.

While Bewick's Wrens are commonly double brooded, a second nesting attempt was not made at this location. One possible cause was the presence of House Wrens (*Troglodytes aedon*), which were first heard singing on 7 May and had become abundant by mid-May. House Wrens do not normally tolerate Bewick's Wrens in their territories, which may have made renesting by the Bewick's Wren difficult.

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Addendum

The participants list was omitted from the Cimarron National Grasslands winter bird count report (1987. Kans. Ornithol. Soc. Bull. 38:4). The following persons should have been listed: W. Champeny, M. E. and S. Corder, S. Crawford. S. Patti (compiler - 552 W. Belden Ave., Chicago, IL 60614), M. Radell, M. Rader, S. and D. Seltman, L., R. and L. Smith, M. Thompson, and D. and F. Vannoy.

Book Review

Pheasants of the World. Johnsgard, Paul A. Oxford University Press, Oxford and New York. 300 pages, illustrated (53 color plates and 69 line drawings and maps). $75.00. 1986.

The *Pheasants of the World* is the latest book by Professor Johnsgard of the University of Nebraska. Like his other recent books (i.e. *The Grouse of the World* published in 1983), it is a popular monograph of a group of game birds. Most of the three hundred pages of the book is comprised of species accounts of the taxa included (tragopans to peacocks). For each species the author has the common names, distribution, measurements, brief descriptions, field identification characteristics, ecology, and social behavior.

The introductory chapters of the book are well written and informative. These chapters introduce the reader to the classification, biogeography, biology and phylogeny of the Phasianidae and are very interesting reading. Even if your only contact with the family is eating chicken or harassing Ring Necked Pheasants in the fall, this section is worth the effort. The phylogeny section consists of a dendrogram based on the intuition of the author, but this is s book for a popular audience, not bird systematists and evolutionary biologists.

The color plates in the work deserve special mention. All but two of these are reproductions of early 20th century watercolors by Major Henry Jones, a British officer. When he died Major Jones gave his collection of paintings (about 1,200 of them) to the Zoological Society of London. Little is known about the artist, but it does not take much imagination to bring into the mind's eye a white clad man at some outpost in the tropics, standing at his easel, painting away amid caged birds and study skins. If pheasants are of interest to you, put it on your list of things to buy for yourself. The book is worth the purchase price for the illustrations alone.

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ISSN 0022-8729