Reprinted from “Copeia” Volume 1964, number 3, 1964, pp. 586-587, Engel and Davis: Relationship between activity and blood composition in certain marine teleosts. With permission from the American Society of Ichthyologists and Herpetologists.

ERRATUM

Engel, D. W., and Edna M. Davis.

Relationship between activity and blood composition in certain marine teleosts.

Copeia, 1964, No. 3, September 10, pp. 586-587.

Page 586, Table headings, correct to read.

Erythrocytes X 10^6 Cells/mm^3	Thrombocytes X 10^4 Cells/mm^3

Page 587, paragraph 5, second line from the bottom, correct to read.

----1,250 to 62,500 cells per cubic millimeter.

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ICHTHYOLOGICAL NOTES

RELATIONSHIP BETWEEN ACTIVITY AND BLOOD COMPOSITION IN CERTAIN MARINE TELEOSTS.—The blood composition of fishes has been related to their ecological niche by various investigators. In general, both the size and numbers of erythrocytes and the level of hemoglobin are highly correlated with the activity of both freshwater and marine fishes (Hall and Gray 1929, *J. Biol. Chem.* 81: 589; Saito 1954, *Bull. Jap. Soc. Sci. Fish.* 19: 1134; Smith, Lewis, and Kaplan 1952, *Prog. Fish-Cult.* 14:169; Haws and Goodnight 1962, *Physiol. Zool.* 35:8). Gray (1953, *Biol. Bull.* 107:219) demonstrated a positive correlation between the gill surface area and activity of fish. Pelagic species had more gill lamellae per millimeter of gill filament and a larger gill area per gram of body weight than did the benthic forms. Vernberg and Gray (1953, *Biol. Bull.* 104:445) found also that the brain homogenates of active fishes had a higher respiratory rate than the more sluggish fishes. Since physiological activity has been related to fishes from benthic and pelagic habitats, we have compared the blood characteristics of indigenous benthic and pelagic fishes to determine if there is a relationship between fishes from these habitats and the cellular components of the blood.

Determinations made on the blood samples included erythrocyte counts, hematocrit ratios, and hemoglobin values. Leucocyte and thrombocyte counts also were made for some species. The following 7 species of adult fishes were used in these determinations: toadfish, *Opsanus tau*; flounder, *Paralichthys* sp.; Atlantic croaker, *Micropogon undulatus*; striped bass, *Roccus saxatilis*; bluefish, *Pomatomus saltatrix*; king mackerel, *Scomberomorus cavalla*; and Spanish mackerel, *Scomberomorus maculatus*.

Blood samples were collected from the fish in the laboratory and in the field. In the laboratory, blood samples were obtained from fish narcotized with tricane methansulfonate, M.S.-222 (Tech. Bull., M.S.-222-Sandoz, The Anesthetic of Choice in Work with Cold Blooded Animals, Sandoz Pharmaceuticals, Hanover, N. J.), which facilitated handling of the fish. Since the mackerels could not be brought back to the laboratory alive, the blood samples were obtained at sea, without the benefit of M.S.-222. Preliminary results indicate that blood samples taken from the active fishes in the laboratory were not different from blood samples taken at sea.

The kidney-puncture technique of Boroughs and Reid (1957, *Anat. Rec.* 128: 524) was used for the collection of all blood samples. Hypodermic syringes used were flushed with aqueous heparin to prolong the coagulation time of the blood. The blood sample was then placed in a 10-ml beaker coated with a mixture of dried ammonium and potassium oxalate. The oxalate mixture prevented blood clotting for several days. Analyses were completed within 24 hr of blood collection.

Three solutions were tested for the dilu-

TABLE 1. COMPARISON OF BLOOD CHARACTERISTICS FOR 7 SPECIES OF TELEOSTS.

Species	Hematocrit Percent of Volume		Hemoglobin Grams Percent		Erythrocytes $\times 10^6$ Cells/ml		Thrombocytes $\times 10^4$ Cells/ml		
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	n
Benthic									
Opsanus tau	23.0–33.7	27.50	5.3– 7.1	6.21	0.61–0.84	0.68	10.0–40.0	23.50	10
Paralichthys sp.	25.5–37.0	29.25	5.6– 7.9	6.64	2.22–3.86	2.91	—	—	10
Micropogon undulatus	18.0–39.8	29.00	4.7– 9.8	7.30	1.69–4.90	3.33	12.0–32.0	20.30	30
Pelagic									
Roccus saxatilis	36.0–41.3	38.70	8.6–10.4	9.50	3.42–4.53	3.95	—	—	5
Pomatomus saltatrix	29.0–57.0	43.35	7.0–15.4	10.40	3.12–5.63	4.21	0.0–21.0	10.27	34
Scomberomorus cavalla	32.0–43.0	36.30	7.3–10.3	9.30	2.66–4.59	3.54	—	—	6
Scomberomorus maculatus	26.5–48.0	38.80	7.6–12.2	10.40	3.15–6.13	4.54	—	—	58

tion of fish blood for cell enumeration: isotonic saline; Rees and Eckert's formula suggested by Slicher (1961, *Bull. Bingham Oceanogr. Coll.* 17:3); and Shaw's dilution fluids (1931, *J. Path. Bact.* 33:833). The Rees and Eckert's formula was chosen since the diluted sample could be used to count erythrocytes, leucocytes, and thrombocytes. All dilutions were made with red blood cell ratio pipettes; cell numbers were counted in a standard hemocytometer.

The hematocrit values were determined by the clinical microhematocrit method of Guest and Siler (1934, *J. Lab. Clin. Med.* 19:757) and recorded as percentage of volume. Capillary tubes 1–1¼ mm in diameter coated with heparin were used in all determinations.

Hemoglobin content was measured according to the standard cyanmethemoglobin method. Using a Sahli pipette, 0.02 ml of anticoagulated blood was added to 5 ml of cyanmethemoglobin reagent with the hemoglobin content being determined colorimetrically at a wave length of 540 mμ. The hemoglobin value was expressed in grams per 100 ml of whole blood.

The erythrocyte counts, hemoglobin levels, and hematocrit values were higher for the pelagic species than for the benthic species (Table 1). The pelagic species, as typified by the bluefish, are highly active predaceous fishes requiring more oxygen than the less active benthic fishes, such as the toadfish. When pelagic and benthic fishes were compared as separate groups, it was demonstrated that the pelagic fishes had statistically significant larger numbers of erythrocytes and higher hemoglobin levels than the benthic fishes. However, there were significant interspecies differences in erythrocyte numbers within the groups. Even though there was an obvious difference between the mean hematocrit values for the pelagic and benthic fishes, no statistical comparisons were made since these values were in part influenced by the volumes of the blood cells.

Thrombocyte and leucocyte numbers did not show a correlation with the activity of the fish. Thrombocyte counts varied over a wide range. In some cases, such as the mackerels, thrombocytes were not detected. The range in leucocyte numbers was from 1,250 to 62,500 cells per milliliter. Such great ranges in leucocyte numbers may be the result of the routine handling of the fish. It has also been determined that fright can cause increases in the numbers of leucocytes.

Our results suggest a relationship between certain blood characteristics of fish and their respective ecological niche. — DAVID W. ENGEL AND EDNA M. DAVIS, *U. S. Bureau of Commercial Fisheries, Radiobiological Laboratory, Beaufort, North Carolina.*