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A Bilateral Color Anomaly in the Crayfish, *Orconectes immunis* (Hagen)

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Abstract. A live female crayfish, *Orconectes immunis* (Hagen) exhibiting unusual body coloration was given to the biology laboratories at the University of Northern Iowa for study. Its right half, including antennae and other appendages, was colored an azure blue; the left half was colored normally. This bilateral coloration mosaicism persisted following molting. Gynandromorphism as a corollary factor is eliminated on the basis that no apparent external sexual intergradation of sexual dimorphism was noticeable. Somatic mutation in early embryonic development is the most likely explanation. A mutation in a gene affecting some aspect of the biochemical synthesis pathway in pigmentation seems to be operative.

A female crayfish, *Orconectes immunis* Hagen, with an unusual color pattern was maintained in our laboratory from July 16, 1968, to March 16, 1969. Its left half was colored normally (predominantly green) but all parts on the right half, including antennae and all other appendages, were a pronounced azure blue. The color change was abrupt and distinct with a sharp demarcation along the median axis the full length of the body. The rostrum-telson length was 75 mm when collected. It has been deposited at the Smithsonian Institution, Washington, D. C.

The crayfish was collected by Roy Hauser of Allison, Iowa, July 10, 1968, from an unnamed small creek located in T-92N, R-16W, Sec. 17 in Butler County, Iowa. It was found among others of normal coloration while seining crayfish for fish bait and was delivered to us on July 16. The water level of the creek is subject to considerable seasonal fluctuation and was limited to a few isolated potholes at the time of collection. Most of the land in the drainage area is under cultivation with corn the principal crop. The stream's bottom is predominantly sand-silt.

The literature pertaining to the general phenomena of color in crustaceans is quite extensive. The biochemistry of their pigments is discussed in depth by Fox (1953) and Goodwin (1960), and each provides an extensive bibliography. Color change and related conditions have received much attention and are discussed by Kent (1901), Carlisle and Knowles (1959), Kleinholtz (1961), Schmitt (1965) and others. Abnormal color patterns in crustaceans of one type or another have been reported on numerous occasions and seem to be particularly well documented for the American lobster, *Homarus americanus* (M. Edw.). A thorough treatment of unusual

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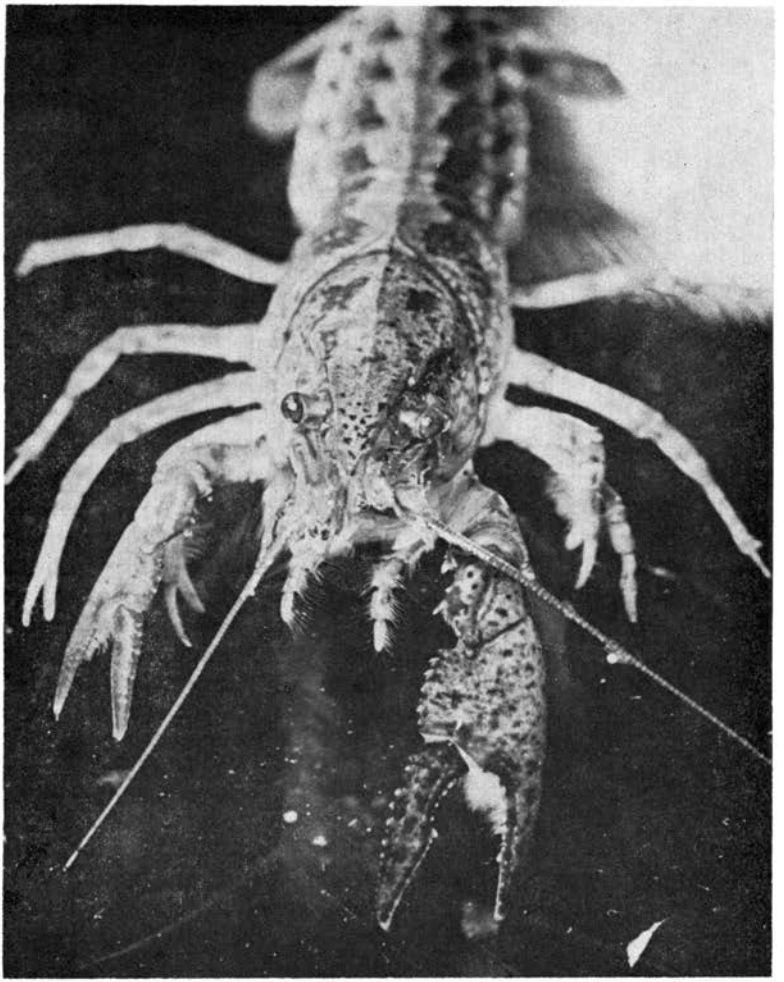

Figure 1. A crayfish exhibiting a bilateral color anomaly. The left half was pigmented normally and the right half an azure blue.

color patterns in this species is given in Chapter VIII by Herrick (1895). He refers to specimens which were blue, red, cream-colored, spotted (calico) and parti-colored. Referring to the parti-colored specimen he states, "One half of the body was light yellow, clearly defined up the middle line of the back from the color of the other half, which was bright red." He refers to additional literature on similar bilaterally colored specimens involving normal olivaceous green on one side and light sky-blue on the other in one case, and another where one side was blue and the other side white or "albino."

Atz (1939) published a picture of an "American northern lobster" and reported "The right half of the animal is more or less ordinarily colored; that is, it is predominantly very dark green, with black and a little red interspersed. The left side is a bright orange-red throughout." The specimen did not appear to be a perfectly demarcated bilaterally-colored individual since there was a sizable area on the right side of the head which corresponded in color to the left half of the body. He states that color variations are not rare in the American northern lobster and that such specimens are taken by commercial lobstermen of the Atlantic coast every year. Of special interest is a report by Chace and Moore (1959) on a rare occurrence of a bicolored gynandromorph of the American lobster.

Abnormal color patterns of crayfish have also been reported on several occasions, but seem more uncommon than in lobsters. Blue phased color anomalies have been reported by Newcombe (1929) from West Virginia for *Cambarus carolinus dubius* Faxon, Penn (1951) from Louisana for *Procambarus clarkii* (Girard) and Hand (1954) from California for the genus *Pacifastacus*. According to Dr. Horton H. Hobbs of the Smithsonian Institution *Cambarus monongalensis* Ortmann, *Procambarus hagenianus* (Faxon) and two undescribed species of the genus *Cambarus* presently being described are typically blue species. He also indicated that there may be blue phases in local populations of *Cambarus carolinus* Erichson and occasional blue specimens of *Procambarus clarkii* (Girard), *P. a. acutus* (Girard) and *P. advena* (LeConte).

Bilaterally-colored crayfish such as is reported in this paper are rare. It would appear that this specimen is only the second reported with this condition. Dr. Hobbs indicated that he had only recently received a photograph of what appeared to be a similar specimen from a graduate student, Mr. Rollin Reimer, of Tulane University. On the basis of this photograph it was tentatively identified as *Cambarus tenebrosus* Hay and appeared green on the right side and brown on the left. However, all of the appendages except the right antenna, including the uropods were brown.

Laboratory Care and Observations

No special problems were encountered in maintaining the crayfish in a laboratory environment. The animal was housed in an aerated fifteen-gallon aquarium at room temperature. A number of small stones were added to the aquarium to provide hiding places. Small pieces of fresh chicken liver were used as food twice weekly. The specimen appeared to remain vigorous until death.

It was important to learn whether the animal would retain its bilateral color pattern following molting. It did exuviate on Decem-

ber 17, 1968, five months after it was brought into the laboratory. The unusual bilateral color pattern persisted, the color hues appearing even more intense and dramatic than during the pre-molt period.

These results eliminated doubt in the minds of those who speculated that someone had, with meticulous care, painted the right side of the animal an azure blue as a bit of tom-foolery. Retention of the bicolor character following molting was significant as it suggested some causative genetic mechanism. Environmental factors as causative agents seemed less likely.

A normally pigmented male crayfish of another species, *Orconectes virilis* (Hagen), was added to the aquarium on January 22, 1969. The following morning the two crayfish were observed in a copulating position, the male grasping the inverted female and holding her walking legs with his two chelae. Although a mating act occurred, the bilaterally-colored female did not produce eggs before dying. This was not entirely unexpected for two species were involved, but it is unfortunate she did not live a few weeks longer for it may have been too early in the season for her to lay eggs. Most bodies of water at this latitude were still ice-covered on the date of her death and, though she had been maintained at room temperature, it seems unlikely that she would have layed eggs appreciably earlier than usual.

Successful mating and production of offspring may have provided valuable clues from which to determine the genetic basis for this type of crayfish pigmentation. Production of offspring could have proven useful in determining whether or not the pattern of pigmentation was related to germ cells only or manifested an event confined to somatic cells.

Discussion

A number of speculations, largely of a genetic nature, can be applied in accounting for this unusual pigmentation pattern. These are tenuous in character simply because the direct cause of a variation of this kind can be established with certainty only in those situations where the behavior characteristics of known genes can be followed during segregation. Chromosomal deletion and fragmentation, somatic crossing over, position effect, gene mutation and abnormal fertilization must be included as possible genetic events responsible for this rare phenotype in a crayfish. Environmental agents, viral infections and cytoplasmic factors must not be discounted even though they are unlikely to play a role in this case.

Gynandromorphism as a factor in the bilateral color pattern is eliminated on the basis that no apparent external sexual intergradation was noticeable. The animal was completely female.

Denton W. Crocker, Chairman, Department of Biology, Skidmore College, suggests that an autosome could have been lost in the first cleavage division, and if it were one containing a body color gene, then such a color anomaly as seen in this crayfish could result. This possibility was also suggested by Dr. George W. Beadle, Professor of Biology at the University of Chicago, who had occasion to see the specimen alive.

According to Dr. Ernst Florey, Biology Department, University of Washington, apparently there was an accidental differentiation (early somatic mutation?) during one of the first cell divisions that was responsible for the difference in pigmentation of the two halves of the animal. This was our assumption, and others with whom we corresponded seem to concur.

It is known that the pigment responsible for coloration in crustaceans is a carotenoid, astaxanthin, (Fox, 1953 and Goodwin, 1960). Astaxanthin appears red if unconjugated with a protein, and green, purple, blue and other colors if conjugated with a protein. The blue pigment is a carotenoid-protein complex which favors the conversion of virtually all the carotenoid to the conjugated state. Anything that denatures the protein releases the carotenoid which then reverts to a red color.

Dr. Denis L. Fox, Chairman of the Marine Biology Research Division and Professor of Marine Biochemistry, Scripps Institution of Oceanography, wrote, "I do not know yet how the deposition of carotenoid pigment is controlled biochemically, nor how there may be control of the kind and extent of chelation with protein to give rise to these different color effects. The appearance of such animals may indeed reflect even more significant biochemical changes, of which what is seen is but an outward, visible sign. If there be a biochemical mutation this would not appear to involve the state of oxidation of the carotenoid, astaxanthin, which is a dihydroxy-diketo-β-carotene. Rather, what is governed is the kind, amount or binding character of the protein molecules with which the astaxanthin becomes chemically conjugated". Dr. Fox believes such bilaterally-colored specimens as we discuss herein are genetic recessives.

We can only conclude that the specimen represents a case of mosaicism brought on by somatic segregation of which one of a number of chromosomal or genic anomalies may be the responsible factor. The most plausible explanation is a somatic mutation in very early cleavage.

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Literature Cited

Atz, J. W. 1939. Half-boiled lobster. Bull. N. Y. Zool. Soc., 42:128.

Carlisle, David B., & Frances Knowles. 1959. Endocrine control in crustaceans. Cambridge University Press, London and New York, 120 pp.

Chace, Fenner A., & George M. Moore. 1959. A bicolored gynandromorph of the Lobster, *Homarus americanus*. Biol. Bull., 116(2):226-231.

Fox, Denis L. 1953. Animal biochromes and structural colours. Cambridge University Press, London and New York, 379 pp.

Goodwin, T. W. 1960. Biochemistry of pigments. pp. 101-140. In: The physiology of crustacea. (Talbot H. Waterman, Ed.). Academic Press, New York and London. Vol. 1, 670 pp.

Hand, Cadet. 1954. A blue crayfish from California. California Fish and Game, 40(4):437-438.

Herrick, Francis Hobart. 1895. The American lobster. A study of its habits and development. Bull. U. S. Fish Comm., 15:1-252.

Kent, W. J. 1901. The colors of the crayfish. Amer. Nat., 35(419):933-936.

Kleinholtz, Lewis H. 1961. Pigmentary effectors. pp. 133-169. In: The physiology of crustacea. (Talbot H. Waterman, Ed.). Academic Press, New York and London. Vol. 2, 681 pp.

Newcombe, Curtis L. 1929. A new blue crayfish. Science, 70:217.

Penn, George Henry. 1951. A color anomaly of the Louisiana red crawfish, *Procambarus clarkii* (Girard). Proc. La. Acad. Sci., 14:66-67.

Schmitt, Waldo L. 1965. Crustaceans. Univ. Mich. Press, Ann Arbor, Mich., 204 pp.