

Blue Color Anomaly in Turkish Crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823) (Crustacea, Decapoda, Astacidae) From Atikhisar Reservoir in Çanakkale, Turkey

Semih Kale¹ • Selçuk Berber² • Deniz Acarlı³ • Tekin Demirkıran⁴ • Pervin Vural⁵ • Sefa Acarlı⁶ • Bayram Kızılkaya⁶

¹ Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Department of Fishing and Fish Processing Technology, Çanakkale, Turkey, semihkale@comu.edu.tr

² Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Department of Basic Sciences, Çanakkale, Turkey, selcukberber@comu.edu.tr

³ Çanakkale Onsekiz Mart University, Gökçeada School of Applied Sciences, Department of Fisheries Technology, Çanakkale, Turkey, denizacarli@comu.edu.tr

⁴ Çanakkale Onsekiz Mart University, Graduate School of Natural and Applied Sciences, Department of Fishing and Fish Processing Technology, Çanakkale, Turkey, tekindemirkiran@hotmail.com

⁵ Çanakkale Onsekiz Mart University, Bayramiç Vocational School, Department of Fisheries, Çanakkale, Turkey, pervinvural@comu.edu.tr

⁶ Çanakkale Onsekiz Mart University, Faculty of Marine Sciences and Technology, Department of Aquaculture, Çanakkale, Turkey, sefaacarli@comu.edu.tr; bayram342001@yahoo.com

✉ Corresponding Author: semihkale@comu.edu.tr

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Two individuals of *Pontastacus leptodactylus* (Eschscholtz, 1823) were collected from Atikhisar Reservoir in Çanakkale, Turkey. The individuals were caught by using a fyke-net. The fyke-nets were collected after 3-days soaking time from the reservoir on 18 July 2020. The sampling was carried out during the daytime. The sediment of the sampling location had a muddy substrate. Both blue colored individuals of crayfish (*Pontastacus leptodactylus*) were female. Blue color anomaly was observed in all parts of the bodies of both individuals. Morphometric characteristics were measured and the total lengths were 104.83 mm and 76.92 mm, and weights were 36.09 g and 11.76 g, respectively. The genetics of the mutant species should be examined in future studies to better understanding of the main factors causing color anomalies.

INTRODUCTION

Color anomalies in crayfish might be the consequence of several factors such as genetics, environmental conditions, food and diet, stage of development and molting, or a combination of any factors (Schuster, 2020). Colors in crayfishes and other crustaceans are known as the

consequence of carotenoid pigments (such as astaxanthin and canthaxanthin) responsible for an extensive coloration range from colorless to dark red (Fox, 1953; Goodwing, 1960; Buchwald & Jencks, 1968; Latscha, 1989; Ando & Tanaka, 1996; Walker et al., 2000; Patoka et al., 2013; Schuster, 2020). Astaxanthin is the most common carotenoid in crustaceans (Latscha, 1989).

Some color anomalies have been reported in natural populations for some crustaceans including crayfish species by various scientists. Dowel & Winier (1969) documented a bilateral color anomaly in the crayfish (*Orconectes immunis*) captured from a stream in Iowa, USA. Kale et al. (2020) reported an albinism in crayfish (*P. leptodactylus*) collected from Atikhisar Reservoir in Çanakkale, Turkey. Although several color anomalies have been reported in the literature, the most common observed color anomaly for the crayfish is blue color anomaly (Black, 1975; Black & Huner, 1980; Walker et al., 2000). Hayes and Reimer (1975) noted a blue color anomaly in crayfish (*Orconedes deanae*) from Oklahoma, USA. Aksu et al. (2012) reported blue color anomaly in crayfish (*Astacus leptodactylus*) captured from Çıldır Lake in Ardahan, Turkey.

The aim of the present paper is to contribute to the literature by providing a new knowledge on the observation of blue color anomaly in crayfish species in Atikhisar Reservoir, Çanakkale, Turkey. This paper is the first report on the observation of blue color anomaly in Atikhisar Reservoir.

MATERIAL AND METHODS

Two individuals of *Pontastacus leptodactylus* (Eschscholtz, 1823) were collected from Atikhisar Reservoir in Çanakkale, Turkey. The individuals were caught by using a fyke-net. The fyke-nets have 17 mm mesh size and they were positioned in the bottom of the reservoir at the depth of 5 m. The fyke-nets were collected after 3 days soaking time from the reservoir on 18 July 2020. The sampling was carried out during the daytime. The sediment of the sampling location had a muddy substrate.

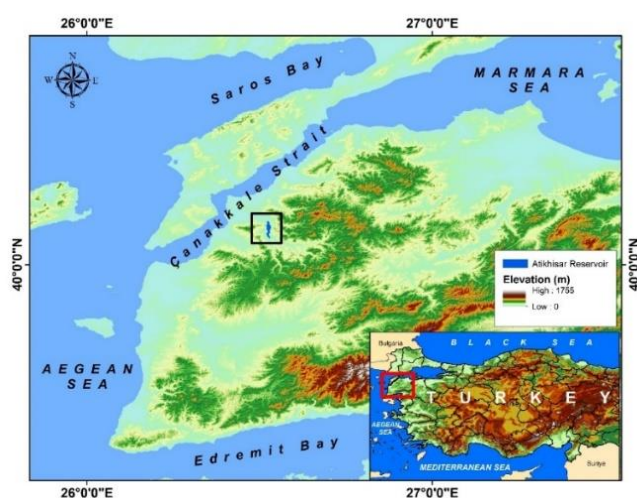


Figure 1. Sampling location of blue colored crayfish, Atikhisar Reservoir, Çanakkale, Turkey

Atikhisar Reservoir was built on Sarıçay Stream to supply water for drinking purposes (Kale, 2019) and the reservoir

also functions as a water supplier for irrigation and drinking purposes to anthropogenic and non-anthropogenic activities in the basin (Kale & Acarlı, 2019a,b). It has a crucial importance since it is the sole source of drinking water for people living in Çanakkale (Kale & Acarlı, 2019a).

RESULTS

Both blue colored individuals of crayfish (*Pontastacus leptodactylus*) were female. Blue color anomaly was observed in all parts of the bodies of both individuals.



Figure 2. The blue colored mutant crayfish individuals (both female) caught from Atikhisar Reservoir, Çanakkale, Turkey

Morphometric characteristics were measured and the total lengths were 104.83 mm and 76.92 mm, and weights were 36.09 g and 11.76 g, respectively.

The blue colored crayfish individuals were caught from 5 m water depth in the muddy sediment. The physicochemical characteristics of lake surface water were measured with a YSI probe. The salinity was 0.20 ppt, the percentage of dissolved oxygen was 148.20%, dissolved oxygen was 11.92 mg/l, pH was 8.27, the electrical conductivity was 435.00 $\mu\text{s}/\text{cm}$, and the temperature of the lake surface water was 27.2°C.

The blue colored mutant crayfish and normal crayfish were compared to well understanding the coloration between the two phenotypes (Figure 3). It can be noticeably seen that the color of the mutant crayfish is obviously different from normal crayfish.

DISCUSSION

Scientists have ascribed that differences in the color of crayfish could be influenced by several factors such as environmental conditions (Kent, 1901; Thacker et al., 1993), food and diet (Wolfe & Cornwell, 1964; Momot & Gall, 1971; Kaldre et al., 2015), molting stage and age (Timmermans et

al., 1995), and genetics (Volpe & Penn, 1957; Wolfe and Cornwell, 1964; Dowell and Winier, 1969; Black, 1975; Black & Huner, 1980; Latscha, 1989; Thacker et al., 1993; Walker et al., 2000; Aksu et al., 2012; Kale et al., 2020). One of the first investigations on the coloration of crayfish was published by Kent (1901). The author claimed that key factors are environment and the sun in the coloration of crayfish. Dowell & Winier (1969) documented a bilateral color anomaly in the crayfish (*Orconectes immunis*) captured from a stream in Iowa, USA. The authors concluded that the specimen represented a case of mosaicism conveyed on by somatic separation of which one of a number of chromosomal or genie anomalies may be the responsible factor. The most acceptable reason was noted by the authors as a somatic mutation in very early cleavage. Thacker et al. (1993) put forward that genetic variation among crayfish populations, environmental conditions, and interaction between both environment and genetics are common reasons in the coloration of crayfish. Truong et al. (2002) compared a blue strain of *Cherax destructor albidus* with two normal-colored strains of *Cherax destructor destructor* and *Cherax destructor albidus* in terms of brood size and juvenile weight. The authors found that the reproductive performance and juvenile weight of the blue strain were significantly lesser than the two normal-colored strains. In addition, the authors indicated that the differences in phenotypes between the blue strain and normal-colored strains are most likely genetic. Aksu et al. (2012) claimed that the genetic structure of the species, food composition, and chemical characteristics of water resources have an impact on the color of crayfish.



Figure 3. Comparison of normal crayfish and the blue colored crayfish from Atikhisar Reservoir, Çanakkale, Turkey (both individuals are female)

Kale et al. (2020) reported the presence of albinism in crayfish (*P. leptodactylus*) collected from Atikhisar Reservoir in Çanakkale, Turkey, the same location with the present paper, and the authors noted that albinism is a syndrome that occurs in the lack of melanin. In addition, the authors clearly indicated that there were no further reason as causative agents in the sampling location. As previously noted by Kale et al. (2020), there was no fishing pressure or overexploitation probability of fisheries resources in the reservoir. Then again, any pollution was not observed in the lake surface water of the reservoir during the sampling period. Thus, blue color anomaly is probably occurred due to the genetic mechanism of the specimen and environmental factors are less likely factors that affecting the anomaly for the reported specimens in the present paper. Environmental factors were observed in normal conditions and any extreme weather condition was not recorded during the sampling period.

Schuster (2020) noted that color visualization could be a key factor in interspecific and intraspecific competition, sexual choice, communication, territoriality and camouflage. Hence, this may lead to pressure over the populations in the reservoir. Therefore, a further investigation should be carried out to better understand the main reason causing color anomaly in crayfish in the reservoir.

Colors in crayfishes and other crustaceans are known as the consequence of carotenoid pigments (such as astaxanthin and canthaxanthin) (Fox, 1953; Goodwing, 1960; Buchwald & Jencks, 1968; Latscha, 1989; Ando & Tanaka, 1996; Walker et al., 2000; Patoka et al., 2013; Schuster, 2020). The most common carotenoid is astaxanthin in crustaceans (Latscha, 1989). These pigments can also be found in the integument in addition to the exoskeleton (Schuster, 2020). Patoka et al. (2013) indicated that these pigments forms the color of carapaces and the color changes according to the concentration of each pigment. On the other hand, Buchwald and Jencks (1968) reported that the blue color anomaly in carapace of lobsters was caused by crustacyanin. Momot & Gall (1971) claimed that observed color anomalies in crayfishes could be attributed to genetics and/or diet. Black (1975) noted that the blue color anomaly of *Procambarus acutus acutus* was caused by carotenoid pigments (probably crustacyanin) deposited in the exoskeleton. The author also indicated that the blue color anomaly was still observed in the exoskeleton after molting. Latscha (1989) suggested that pigmentation in crustaceans could also be due to the complex of carotenoid-protein known as carotenoproteins. The author attributed the color anomaly in *Penaeus* shrimp to a dietary carotenoid deficiency such as astaxanthin. Latscha (1989) documented that blue colored shrimp species mutated back to their normal color when they were fed diets with astaxanthin. As noted by Schuster (2020), all these papers

highlighted that a single autosomal recessive gene was the main reason of the observed color anomalies in animals. Therefore, further investigations are required to determine the underlying reason of the color anomaly in the crayfish.

CONCLUSION

The present paper significantly contributes to the scientific literature by providing the first information on the occurrence of blue color anomaly in crayfish (*P. leptodactylus*) in the Atikhisar Reservoir, Çanakkale, Turkey.

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Compliance with Ethical Standards

Authors' Contributions

SB and SK designed the study. SK, SB, DA, TD conducted sampling in the field. SK wrote the first draft of the manuscript. SA, PV, BK helped in the laboratory. All authors have read and revised the manuscript. All authors approved the final version of the paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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