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MELANISM IN ENDANGERED MOHAVE TUI CHUB *SIPHATELES BICOLOR MOHAVENSIS* SNYDER 1918 (CYPRINIFORMES: CYPRINIDAE)

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ABSTRACT.—Although melanism has been reported in a wide variety of taxa, the presence of melanic individuals is relatively rare in fishes. Melanism in Mohave tui chub (*Siphateles bicolor mohavensis*), an endangered endemic of the Mojave Desert in California, is reported from 2 of 4 surveyed populations. The typical body color varies from dark brown to olive brown dorsally and is whitish ventrally; sides are silvery or golden, and fins are pale yellow to dusky red. While conducting population censuses in 2007–2008, we found 4 melanic Mohave tui chubs from 2 of 4 surveyed habitats. Two of 1049 fish (0.19%) handled from Lake Tuendae (Mojave National Preserve) and 2 of 1516 fish (0.13%) handled from Bud's Pond (Camp Cady Wildlife Area) were melanic. Melanic individuals were dorsally black, gradually fading into blackish brown on the sides; the sides had a golden or silvery sheen, and fins were blackish brown. Though the occurrence of melanism is very rare, it may reflect underlying genetic variation, which is of particular interest to the conservation of rare and endangered species.

RESUMEN.—Aunque se han reportado casos de melanismo en varios taxa, son relativamente poco frecuentes los individuos melánicos entre los peces. Se reporta la presencia de melanismo en 2 de las 4 poblaciones estudiadas de la carpa tui del Mohave (Siphateles bicolor mohavensis), una especie endémica en peligro de extinción del Desierto de Mojave en California. El color típico de su cuerpo varía entre café oscuro y café olivo en el dorso, con el abdomen blancuzco, los costados dorados o plateados y las aletas entre amarillo claro y rojo violáceo. Encontramos 4 carpas tui del Mohave melánicas en 2 de los 4 hábitats estudiados al hacer censos poblacionales entre 2007 y 2008. Fueron melánicos 2 de los 1049 peces (0.19%) y 2 de los 1516 peces (0.13%) examinados en el lago Tuendae (Mojave National Preserve) y en el estanque de Bud (Camp Cady Wildlife Area), respectivamente. Los individuos melánicos tenían el dorso de color negro que gradualmente se convertía en café negruzco hacia los costados, los cuales tenían un brillo dorado o plateado. Las aletas eran color café negruzco. Aunque el melanismo es relativamente poco común, podría reflejar la variación genética subyacente, la cual es de especial interés para la conservación de especies raras y en peligro de extinción.

The occurrence of phenotypic novelty in body color is of particular interest to evolutionary biologists (Kettlewell 1973, Nelson and Planes 1993, Baer et al. 1995, True 2003). Melanism is one extreme of color variation in animals and is defined as the occurrence of dark or black forms in a species due to an increase of melanin in the epidermis (Kettlewell 1973, Majerus 1998). Although melanism has been reported in a wide variety of taxa, the presence of melanic individuals is relatively rare in fish (Regan 1961, Majerus 1998). Field- and laboratory-based research has shown that melanic individuals in fish populations are subjected to differential pressures of sexual (Nelson and Planes 1993, Baer et al. 1995) and natural selection (e.g., predation; Horth 2004). Although rare, melanism has been reported in several freshwater fish families including Poeciliidae (Halter 1924, Myers 1925, Regan 1961, Colin 1982, Snelson et al. 1986), Lepisosteidae (Goff 1935, Woolcott and Kirk 1976, Pigg 1998), Polyodontidae (Marcoux 1966), Gasterosteidae (Bell 1982), Cyprinidae (Dawson 1964), and Percidae (Dawson 1969, Simon et al. 2009), and in some marine fish families such as Paralichthyidae (Dawson 1969), Liparidae (Orlov 2001), and Pomacanthidae (Colin 1982).

Here we report 4 melanistic individuals of the endangered Mohave tui chub (*Siphateles bicolor mohavensis*). Historically, the Mohave tui chub was the only native fish in the Mojave River drainage (Hubbs and Miller 1943). However, the fish was extirpated from the Mojave River in the late 1960s (Miller 1969), presumably due to the impacts of introduced brown bullhead (*Ameiurus nebulosus*) (Thompson 1929), hybridization with introduced arroyo chub (*Gila orcutti*), and a severe flash flood in 1938 (Hubbs and Miller 1943). A relictual population was rediscovered in 1936 near Soda Dry Lake (Miller 1938), and subsequently, additional refuge populations were established (Miller 1968, St. Amant and Sasaki 1971), resulting in a total of 5 extant

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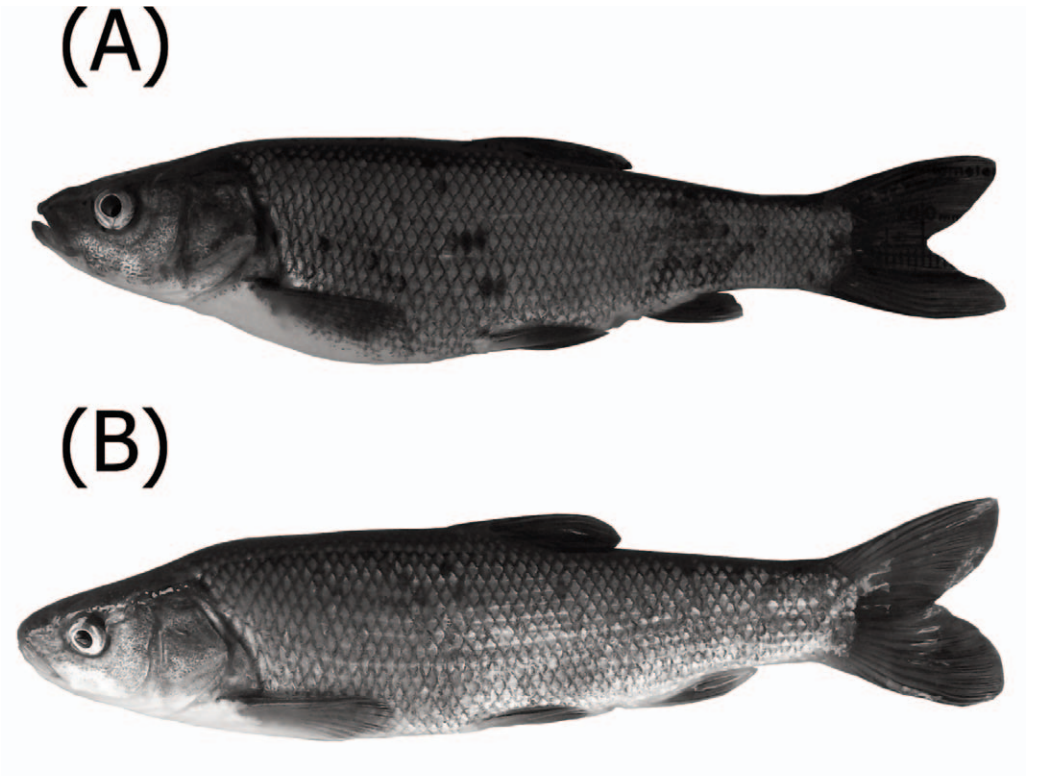

Fig. 1. Mohave tui chub (*Siphateles bicolor mohavensis*) from Lake Tuendae (photo by Sujan M. Henkanaththegedara): A, melanic individual (TL = 129 mm); and B, typical individual (TL = 131 mm).

populations in southern California: (1) Lake Tuendae and (2) MC Spring at Mojave National Preserve, (3) Bud's Pond at Camp Cady Wildlife Area, (4) seep system at Naval Air Weapons Station China Lake (NAWS China Lake), Ridgecrest, and (5) Deppe Pond at the Lewis Center for Academic Excellence, Victorville (established in 2008). Currently, Mohave tui chub is a federally and California State–listed endangered species due to its restricted range and the potential impacts of introduced species (Taylor and Williams 1984).

Mohave tui chub may grow to about 30 cm, but an average body size is about 10–15 cm. The typical body color varies from dark brown to olive brown dorsally and is whitish ventrally and silvery or golden on the sides; a greenish tinge is present in some dorsal scale rows of breeding individuals. Some large individuals are bluish gray or orangish brown. Fins vary from pale yellow to dusky red in breeding individuals (Fig. 1B). Sexes are similar in color pattern.

We conducted population census work at 4 of the 5 remaining sites known to contain Mohave tui chub. The fifth population at Deppe Pond near Victorville had not yet been established. Depletion sampling was used at MC Spring, while mark-recapture estimates were conducted at the other 3 sites. Surveys were conducted in May 2007, except for the China Lake survey, which occurred in April 2008. Lake Tuendae is a spring-fed pool expanded to a small lake (Turner and Liu 1976) approximately 140 × 40 m and up to about 2 m deep. MC Spring is a very small, spring-like habitat (4 × 5 m and approximately 1 m deep) located about 300 m south of Lake Tuendae. Both Lake Tuendae and MC Spring are jointly managed by the Desert Studies Center and the National Park Service. Bud's Pond is a turbid, man-made pond (approximately 55 × 30 m and up to 2 m deep) managed by the California Department of Fish and Game (CDFG) and located about 52 km southwest of Lake Tuendae. An extensive seep system at NAWS China Lake near Ridgecrest harbors the other population of Mohave tui chub, which is jointly managed by the CDFG and NAWS China Lake.

In total, 1049 fish from Lake Tuendae were handled and 2 individuals were melanic (0.19%). Of the 1516 fish handled from Bud's Pond, 2 were melanic (0.13%). No melanic individuals were observed among the 369 fish handled from MC Spring or the 725 fish handled from China Lake. All melanic individuals were comparatively larger fish, displaying normal health conditions compared to other tui chubs. Lake Tuendae melanic individuals were 129 mm and 128 mm in total length and 21.3 g and 24.8 g in total wet mass, respectively. Two melanic individuals from Bud's Pond were 170 mm and 125 mm in total length and 46.6 g and 20.8 g in wet mass, respectively. The average sizes of Lake Tuendae and Bud's Pond tui chub were 132 mm (range 47–272 mm, $n = 172$) and 104 mm (range 57–208 mm, $n = 114$), respectively.

The melanic individuals were readily distinguishable due to dark-colored pigmentation. Melanic tui chubs were dorsally black, gradually fading into blackish brown on the sides; their sides had a golden or silvery sheen and a few scattered black scales. Ventrally, the melanic chubs were dark grayish in color, compared to whitish bellies of a typical chub. The dorsal and lateral aspects of the head were blackish. The rays of all fins were either black or blackish brown with a dark membrane between the rays (Fig. 1A).

According to the published literature, this is the first record of melanism in Mohave tui chub and the first recorded occurrence of melanism in a southwestern desert fish species. The melanic tui chubs did not change color during the 2–3-hour handling period. (We kept all processed fish in an aerated live car until we had processed all captured tui chubs from the 16 traps.) Furthermore, melanic tui chubs did not show any signs of diseases or parasitic infections which, according to Collyer and Stockwell (2004), could contribute to melanism in some fish. Additionally, body color of melanic tui chubs did not fade when they were placed in a white holding bucket. By contrast, the color of normal-colored tui chubs faded when they were placed in the white bucket.

These findings of melanism in an endangered species might be relevant to conservation genetics. The inheritance of melanic pigmentation in fish has been studied in a few species of livebearing fish (Poeciliidae), and it has been shown that melanism is controlled by a single sex-linked allele, which is also temperature sensitive (Nayudu 1979, Angus 1989, Horth 2006). Although the occurrence of melanism is very rare (Majerus 1998, Horth 2004), it may reflect underlying genetic variation, which is of particular interest for the conservation of rare and endangered species. The retention of this allele at Bud's Pond is particularly striking, as this population was established by transplantation of 10 fish in 1986 and 55 fish in 1987 from Lake Tuendae (Steve Parmenter personal communication). In general, some rare alleles were lost in the Bud's Pond population (Chen 2006); nevertheless, this rare melanic allele was apparently retained. Thus, given the limited number of variable molecular markers, genetically based phenotypic traits may provide additional information on the retention or loss of genetic variation for protected species.

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