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Research Article

First evidence of color change from normal color to xanthism pattern in leopard grouper *Mycteroperca rosacea*, in captivity

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ABSTRACT. This study reports the first occurrence of xanthism in captive juveniles of the leopard grouper *Mycteroperca rosacea*, a species of high ecological and commercial value in the Gulf of California. One hundred fifty individuals (mean ± standard deviation: 106.1 ± 36.7 g; 19.5 ± 2.3 cm) were reared from eggs obtained at the Centro de Investigaciones Biológicas del Noroeste (CIBNOR, La Paz, Mexico) between March and October 2009. Changes in body coloration from the normal brown pattern to a yellow (xanthic) phenotype were observed on five separate occasions during this period. The transition began in the dorsal and ventral regions and extended to the flanks and caudal fin, eventually covering the entire body surface. These findings provide the first documentation of xanthic pigmentation in *M. rosacea* under controlled aquaculture conditions and highlight the potential influence of genetic, environmental, and dietary factors on colour expression in this species.

Keywords: *Mycteroperca rosacea*; pigmentation; xanthochromism; aquaculture; Gulf of California

INTRODUCTION

Coloration patterns in fish play a significant role in survival and reproductive success in the wild (Wakida-Kusunoki et al. 2024). In aquaculture, pigmentation anomalies can reveal important information about a species' health, stress levels, and adaptability, and may serve as indicators of environmental conditions, nutritional factors, or genetic factors (Colihueque 2010, Liu et al. 2024a). Such abnormalities both often reduce the market value and ecological fitness of affected species (Bañón et al. 2023, Liu. et al. 2024a). Xanthism is an uncommon pigmentation abnormality characterized by yellow or orange hues resulting from the dominance of carotenoids (red/orange) and pteridines (yellow) over melanin. The dysfunction or absence of melanophores, which produce melanin, allows lighter pigments to predominate, resulting in the xanthic phenotype (Fujii 2000, Liu et al. 2024b). The absence of melanophores in the skin may result from mutations affecting melanin biosynthesis or melanophore differentiation pathways. Reduced melanin expression can also be triggered by endocrine or environmental stressors that alter pigment cell regulation (Bañón et al. 2023, Liu et al. 2024b). Xanthism has been reported in many wild fish species, such as *Centropomus undecimalis* (Wakida-Kusunoki et al. 2024), *Diplodus puntazzo* (Bañon et al. 2023), *Scomberomorus commerson*, *Lobotes surinamensis*, *Sphyraena putnamae*, *Seriola rivoliana* (Jawad et al. 2021), *Kyphosus*

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sandwicensis (Franklin et al. 2024), *Epinephelus drummondhayi* (Ross 1988), and *Cephalopholis fulva* (Simon et al. 2009). Although still rare in natural populations (<0.2% of species), such recessive mutations may reduce camouflage or alter social signalling (Carson 2011, Jawad et al. 2021, Liu et al. 2024a). Members of the family Epinephelidae exhibit highly variable colour patterns across species, habitats, and behaviours. Reef-dwelling species often display brown, green, or grey backgrounds with pale, bright, or reddish spots. Juveniles typically exhibit lighter coloration compared to adults (Heemstra & Randall 1993). Members of the family Epinephelidae can change colour in response to stress, social hierarchy, or reproductive activities through both reversible and genetically determined mechanisms (Fontes et al. 2023). The typical coloration of leopard grouper *Mycteroperca rosacea* is greenish to greyish brown with small reddish-brown spots, irregular pale spots, and lines on the body, as well as white margins on the fins (Heemstra & Randal 1993). However, partial or total xanthism has been observed in wild individuals from the Gulf of California (Irigoyen-Arredondo et al. 2017). Over the past few decades, interest in the biology and aquaculture of *M. rosacea* has grown to support production goals (Sala et al. 2003, Gracia-López et al. 2004, 2005, 2023, Erisman et al. 2007, Kiewek-Martínez et al. 2010a,b, Maldonado-García et al. 2018) and conservation since the species has been classified as "Least Concern" on the IUCN Red List, primarily due to fishing pressure (Erisman & Craig 2018). The present note provides the first description of xanthic coloration in captive-reared individuals and contributes to the understanding of pigmentation variability in this species.

MATERIALS AND METHODS

Fifteen wild leopard groupers, *M. rosacea*, were captured at San Jose Island, Baja California Sur, Mexico, between March and June 2008 and cultured at the Centro de Investigaciones Biológicas del Noroeste (CIBNOR, La Paz, Mexico). After four months, eggs were obtained from controlled spawning of broodstock maintained in captivity, as described by Gracia-López et al. (2004). Newly hatched larvae were stocked at an initial density of approximately 50 larvae L^{-1} for four months in a 3,000 L fiberglass circular tank containing green water with *Isochrysis galbana* and *Tetraselmis suecica*, following the protocol of Martínez-Lagos & Gracia-López (2009) with slight adjustments to the feeding schedule. Larvae were fed *Pseudodiaptomus eurihalinus* copepods, *Brachionus plicatilis* rotifers (<75 µm) from day 3 to 8, enriched *B. plicatilis* (Ratio HUFA Enrich; Salt Creek Inc., USA) from day 7 to 25, and *Artemia* nauplii (INVE Aquaculture Inc., USA). From 30 days after hatching, fish were weaned to 200 µm commercial feed (Caviar; BernAqua NV, Belgium). After the fourth month, 150 juveniles (initial weight of 106.1 ± 36.7 g and length of 19.5 ± 2.3 cm) were transferred to 65 L floating cages (30 fish per cage), which were maintained inside a 7,000 L fiberglass tank supplied with a continuous flow of filtered and UV-sterilized seawater and supplemental aeration. Illumination was maintained at 600 lux at the water surface, using overhead fluorescent lights. Fish were hand-fed to apparent satiation four times daily with 1.5 mm pellets (Mem; BernAqua NV, Belgium). Temperature, dissolved oxygen, and salinity were recorded three times per day using a YSI 55 oxygen meter and RF20 refractometer. pH was measured weekly (HI 98127; Hanna Instruments, USA). Means values were: temperature 24.4 ± 0.8°C, dissolved oxygen 6.1 ± 0.4 mg L^{-1}, salinity 38 ± 0.1 and pH 7.4 ± 0.3.

RESULTS

Colour change in leopard grouper *M. rosacea* was observed in 5 ind. Colour transitions were documented on 5 ind during 2009. The first occurred on March 13 (Fig. 1), when 1 ind (95 g, 18.4 cm) began shifting from the normal brown pattern to a xanthic one. Initially, marginal brownish areas extending from the head to the tail, fading gradually into a whitish background with numerous large yellow spots. Overall, the transition followed a consistent sequence: it began on the ventral and dorsal surfaces, including fins and head, and progressed laterally, with the mid-flank and caudal regions being the last to change. Eventually, the entire body became uniformly xanthic. A second case was recorded on August 6 (Fig. 2), when 1 ind (118 g, 19.5 cm) showed lightening on the head, dorsal area, and fin bases. Eleven days later (August 17), the same fish had completely transitioned to xanthic coloration, while the remaining specimens retained normal pigmentation. The third observation occurred between October 16 and October 25 (Fig. 3). Of 30 fish kept together, one initially (170 g, 22.9 cm) exhibited light patches on the fin bases, head, dorsal, and abdominal regions. Within 24 h, two additional individuals (143 g, 21.5 cm and 194 g, 24.2 cm, respectively) showed similar early changes. By October 25, one fish was almost entirely pale-yellow, with only small brown remnants on the

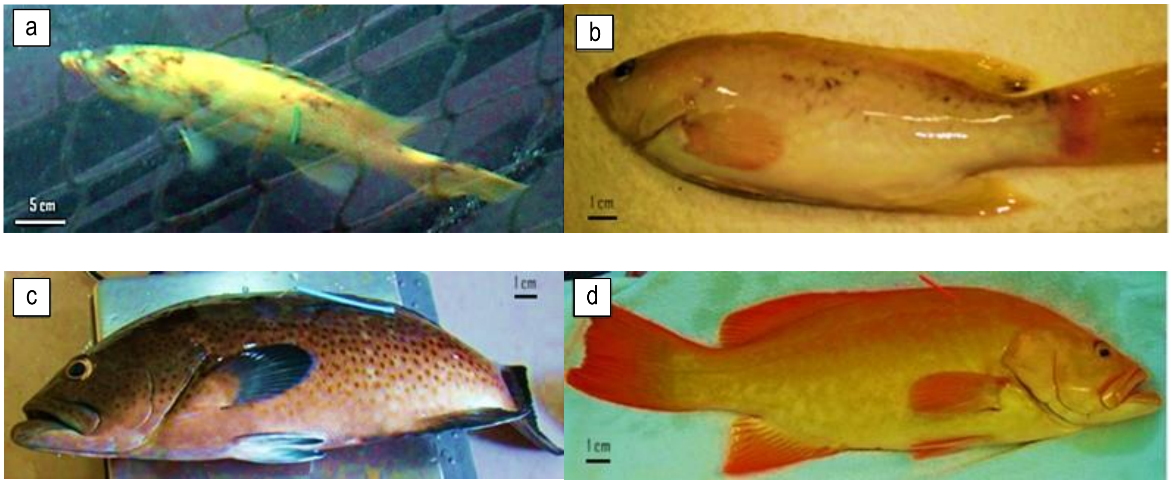

Figure 1. a) Observation occurred on March 13, 2009, of 1 ind with almost all of its coloration with a xanthic pattern; b) anesthetized individual where the whitish coloration on the body and yellow on the head and fins can be seen; c) normal color pattern; d) xanthic coloration with yellow and orange colors present in the body and fins.

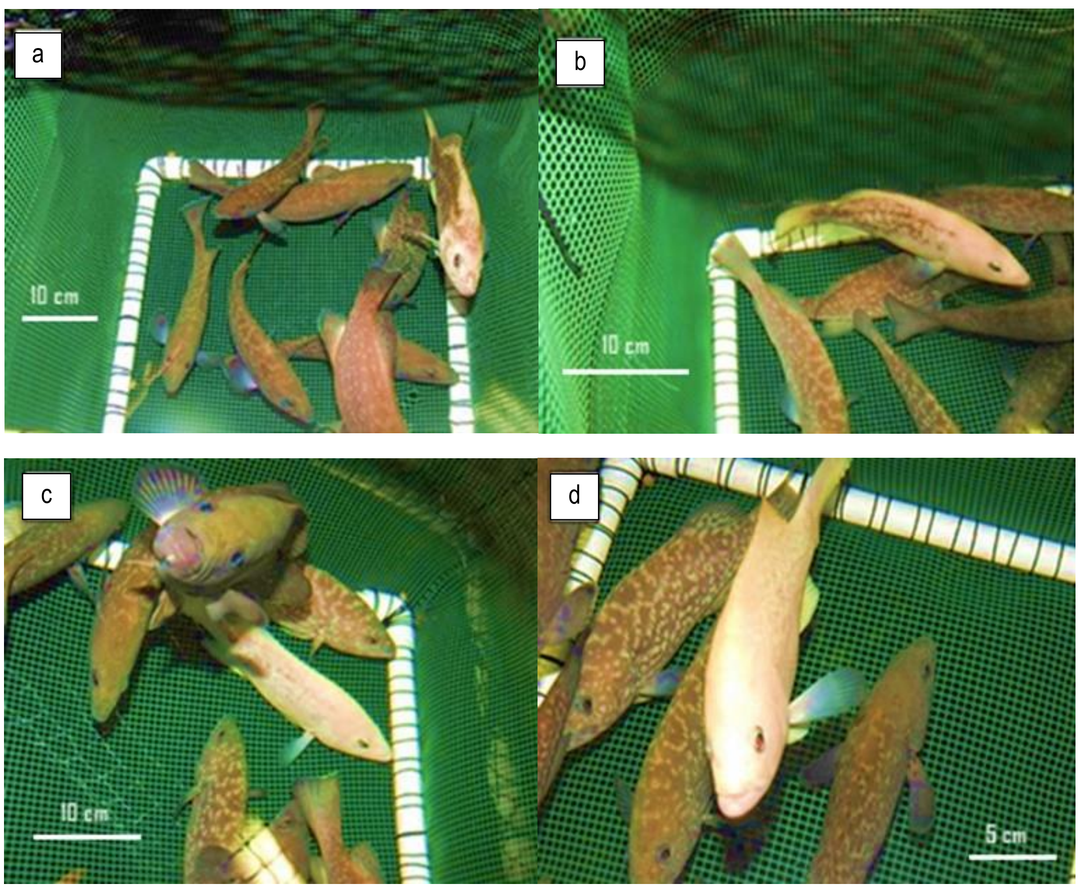

Figure 2. a) On August 6, 2009, 1 ind was observed at the early stages of color change. At this point, fish displayed lighter coloration on the head, dorsal region, and fin bases; b) xanthic color was more apparent in the cephalic region on August 13; c) on August 17, the individual shows almost the entire body and fins with the xanthic pattern; d) on August 19, 2009, the individual had fully transitioned to a complete xanthic coloration.

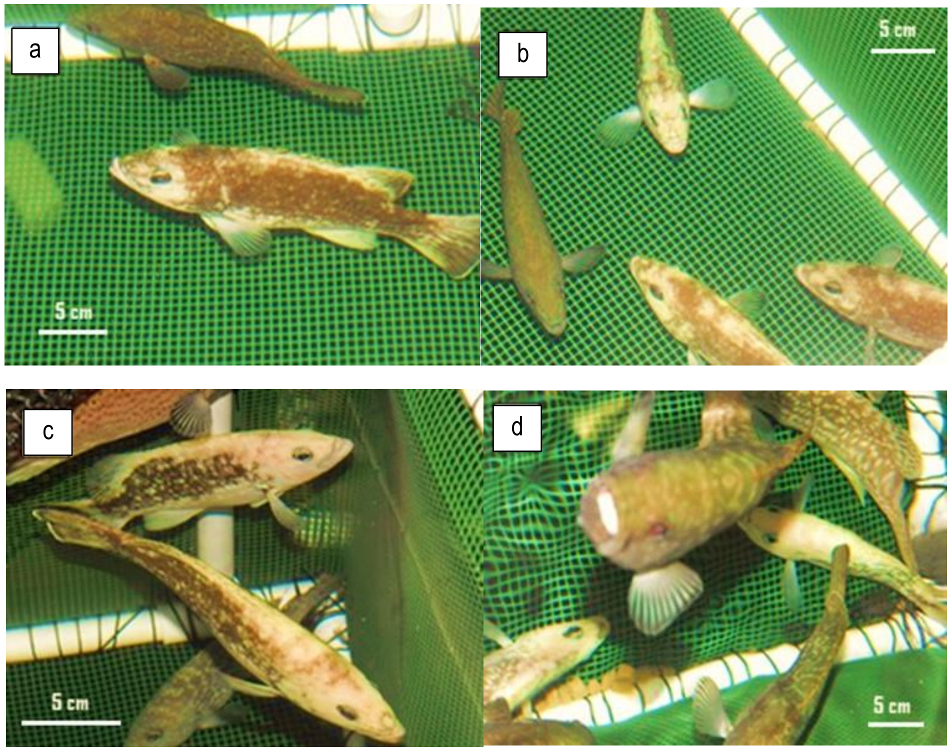

Figure 3. a) On October 16, of the 15 ind kept in a cage, one of them exhibited light coloration on the head, dorsal region, abdominal area, and fin bases; b) on October 19, two additional individuals began to show early signs of color change, with the normal coloration fading in the same body regions described above; c) three days later, the color change became more pronounced; d) by October 25, 1 ind had almost entirely transitioned to a pale yellow coloration, with only small areas of brown remaining on the mid-flanks. The other two individuals displayed a similar pattern, though the brown areas were slightly more extensive.

flanks, and the other two showed comparable but slightly darker patterns.

DISCUSSION

The xanthism observed in captive juveniles of *M. rosacea* represents a rare and noteworthy case of pigmentation change, one that is scarcely documented in this species. This yellow or orange coloration likely results from a combination of genetic, environmental, and physiological factors. A similar phenomenon has been reported in both wild and cultured marine species, indicating that xanthic expression can arise under diverse conditions (Wakida-Kusunoki et al. 2024).

Xanthism in *M. rosacea* appears to be associated with genetic mechanisms that alter pigment cell function or distribution. Such mutations, often recessive, disrupt melanophore activity and reduce melanin synthesis, allowing carotenoids and pteridines to dominate (Colihueque 2010, Liu et al. 2024 b). The fact that xanthic individuals appeared only in the 2009 cohort, despite thousands of juveniles produced in other years under identical rearing conditions, suggests a spontaneous or cohort-specific genetic event affecting chromatophore regulation. This interpretation aligns with patterns reported in other epinephelids, where xanthic pigmentation is transient or developmentally regulated (Bañón et al. 2023). Moreover, the absence of xanthic offspring from xanthic parents indicates that this condition may not follow simple Mendelian inheritance but instead involves polygenic or epigenetic control modulated by environmental cues. Future genomic comparisons between xanthic and normally pigmented individuals of *M. rosacea* could clarify whether the observed phenotype originated from a single mutation or complex regulatory changes in pigment-related genes.

In *M. rosacea*, colour change occurred in subadult individuals, suggesting that xanthism may also be influenced by environment or dietary factors. In captivity, controlled conditions such as temperature, lighting, water quality, and diet can affect pigment expression. Carotenoids, responsible for yellow to red hues, are obtained exclusively from the diet and play a key role in fish pigmentation (Liao et al. 2025). In this study, juveniles were fed a commercial diet that may have contained elevated carotenoid levels, potentially enhancing yellow coloration. Similar effects have been reported in salmonids and other marine fishes supplemented with dietary astaxanthin or β-carotene (Colihueque 2010, Shastak & Pelletier 2023, Liu et al. 2024a). Although no specific diet analyses were performed here, future controlled feeding trials could test whether varying carotenoid levels influence the incidence of xanthism in *M. rosacea*.

Additionally, Copper treatments, occasionally used in aquaculture to control parasites, can also affect pigmentation by altering melanophore activity and oxidative stress responses (Kumar et al. 2024). This element may act as an environmental trigger of xanthism in sensitive individuals, though further verification is required. Stress and hormonal regulation may also contribute to pigment alteration. Elevated cortisol levels under confinement or handling stress can modify melanophore distribution and reduce melanin synthesis (Dara et al. 2023). While fish in this study were maintained under optimal conditions, mild chronic stress cannot be ruled out. The gradual and systemic colour change observed suggests possible hormonal modulation of melanophore function, as documented in other reef species showing environmentally induced pigment shifts (Liu et al. 2024b).

The occurrence of xanthism in *M. rosacea* raises important questions about the ecological and evolutionary relevance of this trait. In the wild, anomalously pigmented fishes may face disadvantages such as increased visibility to predators or reduced camouflage (Jawad et al. 2021). However, in reef environments dominated by yellow or orange sponges and corals, xanthic individuals might gain cryptic advantages that enhance concealment from predators or ambush success during hunting. Such colour variants could also influence intraspecific interactions, including dominance and mate selection, as pigmentation often functions as a social signal in serranids (Liu et al. 2024a). From an ecological standpoint, the persistence of xanthic individuals in the wild suggests that this phenotype, although rare, is not strongly selected against and may represent a neutral or context-dependent adaptation. These findings highlight the potential role of xanthism in shaping visual communication and habitat use in reef ecosystems, warranting further behavioural and ecological studies. In aquaculture, the presence of xanthic individuals may influence the commercial appeal of the species. Brightly coloured variants can be valued in ornamental or niche markets, though their growth performance and reproductive success under culture conditions remain to be evaluated (Bañón et al. 2023). Reports of xanthic *M. rosacea* in the Gulf of California (Irigoyen-Arredondo et al. 2017) suggest that this phenotype, although rare, does not preclude survival in natural environments. Similarly, captive xanthic individuals in this study showed no health or behavioural abnormalities, indicating that the condition is not deleterious. Overall, these findings provide the first documented evidence of xanthism in cultured *M. rosacea*. Further studies combining genomic, dietary, and environmental approaches are needed to clarify the mechanisms regulating pigmentation and to determine whether xanthic expression follows comparable patterns to those reported in other epinephelids.

CONCLUSIONS

This study documents, for the first time, the occurrence of xanthism in captive-reared juveniles of *M. rosacea*. The colour change from the normal brown pattern to a yellow phenotype was observed in a limited number of individuals from the 2009 cohort, while all other cohorts reared under identical conditions showed normal pigmentation. These findings indicate that xanthism in this species is a rare and spontaneous event, possibly influenced by genetic or environmental factors. Although no physiological or behavioural alterations were detected in the affected individuals, further controlled studies are needed to determine the underlying mechanisms and potential implications for aquaculture and natural populations.

Credit author contribution

A. Omont: conceptualization, methodology, formal analysis, writing and original draft; M. Spanopoulos-Zarco: methodology, data curation, formal analysis, review and editing; V. Gracia-López: conceptualization, validation, funding acquisition, project administration, supervision, review and editing. All authors have read and accepted the published version of the manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest.

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REFERENCES

Bañón, R., Quigley, D., Cerdeira, D., et al. 2023. A review of xanthochromic malpigmentation in wild marine fishes with the first case in *Diplodus puntazzo* (Walbaum, 1792) (Spariformes: *Sparidae*). Cybium: International Journal of Ichthyology, 47: 197-205. doi: 10.26028/cybium/2023-017

Carson, E.W. 2011. Xanthochromism in fishes: A review and new cases from the Gulf of Mexico. Journal of Fish Biology, 78: 1425-1434. doi: 10.1111/j.1095-8649.2011.02954.x

Colihueque, N. 2010. Genetics of salmonid skin pigmentation: Clues and prospects for improving the external appearance of farmed salmonids. Reviews in Fish Biology and Fisheries, 20: 71-86. doi: 10.1007/s 11160-009-9121-6

Dara, M., Carbonara, P., La Corte, C., et al. 2023. Fish welfare in aquaculture: Physiological and immuno-logical activities for diets, social and spatial stress on Mediterranean aquacultured species. Fishes, 8: 414. doi: 10.3390/fishes8080414

Erisman, B.E., Buckhorn, M.L. & Hastings, P.A. 2007. Spawning patterns in the leopard grouper, *Mycteroperca rosacea*, in comparison with other aggregating groupers. Marine Biology, 151: 1849-1861. doi: 10.1007/s00227-007-0623-2

Erisman, B.E. & Craig, M.T. 2018. *Mycteroperca rosacea*. The IUCN Red List of Threatened Species 2018: e.T14053A100466656. doi: 10.2305/IUCN.UK. 2018-2.RLTS.T14053A100466656.en

Fontes, J., Afonso, P. & Santos, R.S. 2023. New additions to black and white fish mutants. Biological Conservation, 284: 2304375. doi: 10.1016/j.biocon. 2023.2304375

Franklin, E.C., Platt, M.T. & Andrade, P. 2024. Increased occurrence of the rare golden color morph of Pacific chub, *Kyphosus sandwicensis*, in a no-take marine reserve. Journal of Fish Biology, 104: 1237-1240. doi: 10.1111/jfb.15644

Fujii, R. 2000. The regulation of motile activity in fish chromatophores. Pigment Cell Research, 13: 300-319. doi: 10.1034/j.1600-0749.2000.130502.x

Gracia-López, V., Rodríguez-Romero, J. & Pérez-Ramírez, J.M. 2004. Hormone-induced spawning (HCG) and embryonic and larval development of the leopard grouper *Mycteroperca rosacea* (Streets, 1877). Ciencias Marinas, 30: 279-284.

Gracia-López, V., Kiewek-Martínez, M., Maldonado-García, M., et al. 2005. Larvae and juvenile production of the leopard grouper, *Mycteroperca rosacea* (Streets, 1877). Aquaculture Research, 36: 01186.x. doi: 10.1111/j.1365-2109.2004.01186.x

Gracia-López, V., Maldonado-García, M.C., Quiñones-Arreola, M.F., et al. 2023. Natural spawning of the leopard grouper (*Mycteroperca rosacea*) in captivity in La Paz, Mexico. Ciencias Marinas, 49: 3332. doi: 10.7773/cm.y2023.3332

Heemstra, P.C. & Randall, J.E. 1993. Groupers of the world (Family Serranidae, subfamily Epinephelinae). FAO Fisheries Synopsis, 16: 125.

Irigoyen-Arredondo, M., Escobar-Sánchez, O., Abitia-Cardenas, A., et al. 2017. Incidence of xanthism in the leopard grouper *Mycteroperca rosacea* (Perciformes: Serranidae) in the Gulf of California. Marine Biodiversity, 48: 2255-2258. doi: 10.1007/s12526-017-0753-9

Jawad, L.A., Moazzam, M., Osmany, H.B., et al. 2021. First records of xanthochromism in four marine fish species collected from the Arabian Sea coasts of Pakistan. Thalassas: An International Journal of Marine Sciences, 37: 897-903. doi: 10.1007/s41208-021-00318-z

Kiewek-Martínez, M., Gracia-Lopez, V. & Carrillo-Estévez, M. 2010a. Comparison of the effects of HCG and LHRHa on the induction of ovulation of wild and captive leopard grouper, *Mycteroperca rosacea*. Journal of the World Aquaculture Society, 41: 733-745. doi: 10.1111/j.1749-7345.2010.00415.x

Kiewek-Martínez, M., Gracia-Lopez, V. & Rodríguez-Jaramillo, C. 2010b. Evidence of sexual transition in leopard grouper (*Mycteroperca rosacea*) held in captivity. Hidrobiologica, 20: 233-239.

Kumar, N., Thorat, S.T. & Chavhan, S.R. 2024. Multifunctional role of dietary copper to regulate stress-responsive gene for mitigation of multiple stresses in *Pangasianodon hypophthalmus*. Scientific Reports, 14: 2252. doi: 10.1038/s41598-024-51170-z

Liao, Y., Zhang, B., Wang, D., et al. 2025. Metabolism, function, molecular mechanism, and application of carotenoids in coloration of aquatic animals. Reviews in Aquaculture, 17: e70016. doi: 10.1111/raq.70016

Liu, J., Yin, M., Ye, Z., et al. 2024a. Harnessing hue: Advances and applications of fish skin pigmentation genetics in aquaculture. Fishes, 9: 220. doi: 10.3390/fishes9060220

Liu, X., Wang, S., Feng, Q., et al. 2024b. Thyroid hormone regulates both melanin and non-melanin pigmentation in *Sinibrama taeniatus* via three types of chromophores. Frontiers in Marine Science, 11: 1482306. doi: 10.3389/fmars.2024.1482306

Maldonado-García, M., Gracia-López, V., Kiewek-Martínez, M., et al. 2018. Reproductive cycle of leopard grouper *Mycteroperca rosacea* (Streets, 1877) held in captivity: relationship between gonad development and sex steroid concentration. Latin American Journal of Aquatic Research, 46: 83-90. doi: 10.3856/vol46-issue1-fulltext-10

Martínez-Lagos, R. & Gracia-López, V. 2009. Morphological development and growth patterns of the leopard grouper *Mycteroperca rosacea* during larval development. Aquaculture Research, 41: 120-128. doi: 10.1111/j.1365-2109.2009.02308.x

Ross, S.W. 1988. Xanthic coloration as the normal color pattern of juvenile speckled hind, *Epinephelus drummondhayi* (Pisces: *Serranidae*). Copeia, 1988: 780-784. doi: 10.2307/1445398

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Sala, E., Aburto-Oropeza, O., Paredes, G., et al. 2003. Spawning aggregations and reproductive behavior of reef fishes in the Gulf of California. Bulletin of Marine Science, 72: 103-121.

Shastak, Y. & Pelletier, W. 2023. Captivating colors, crucial roles: Astaxanthin's antioxidant impact on fish oxidative stress and reproductive performance. Animals, 13: 3357. doi: 10.3390/ani13213357

Simon, T., Joyeux, J.C. & Macieira, R.M. 2009. First record of partial xanthism in the coney *Cephalopholis fulva* (Perciformes: *Serranidae*). Marine Biodiversity Records, 2: e84. doi: 10.1017/S1755267209000941

Wakida-Kusunoki, A.T., Rojas-Galaviz, J.L. & González-Solís, D. 2024. First records of xanthochromism in common snook *Centropomus undecimalis (Actinopterygii:* Carangiformes: Centropomidae), collected in the Gulf of Mexico. Acta Ichthyologica et Piscatoria, 54: 25-30. doi: 10.3897/aiep.54.138051