

Developing in warm water: irregular colouration and patterns of a neonate elasmobranch

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Temperature can impact embryonic development in nearly all vertebrates. This may be particularly evident in ectotherms—especially embryos developing in eggs outside of the female. Until hatching, the eggs can be restricted to their local thermal environment. Temperature can affect development rates, and skeletal abnormalities and abnormal colouration and patterns (e.g., snakes; Vinegar 1974) can result from elevated temperatures. While perhaps not directly life-threatening, temperature-mediated changes in colouration and pattern development may impact biological fitness because patterns are often required for camouflage, to attract mates, and/or for deterring predators.

Epauvette sharks (*Hemiscyllium ocellatum*) are small (70–90 cm), oviparous long-tailed carpet sharks commonly found on reef flats from Papua New Guinea to Australia. Sharks reared at annual summer average temperatures (~28 °C; 24.114° S, 152.717° E) develop distinct colouration and patterning in ovo ($n=16$). Upon

hatching ($n=11$), their namesake epaulettes are clearly defined (Fig. 1a). An additional 8 eggs (mixed clutches, >6 mothers) were reared at predicted end-of-century temperatures (32 °C). Upon hatching ($n=3$), all sharks displayed irregular colouration and patterning (Fig. 1b). All except for one 32 °C hatchling died after 3 days, and none had developed the distinct epauvette observed in control sharks. The surviving hatchling was maintained at 32 °C for 30 days post-hatch and then slowly transitioned to control temperatures (28 °C). Even after 120 days post-hatch, the neonate's patterns were still not properly developed (Fig. 1d).

Although it is known that some adult elasmobranchs change skin tone in response to environmental conditions (Visconti et al. 1999), the impact of prolonged exposure to elevated temperatures on elasmobranch development has not been investigated. Our observations prompt questions about the role of temperature in colouration and pattern development. Hormonal pathways may be directly affected by temperature during development and indirectly affected if other crucial physiological processes require more energy as a result of elevated temperatures. Ultimately, if colours and patterns develop incorrectly under elevated temperatures, ocean warming could pose problems for species that depend on colouration and patterns to survive.

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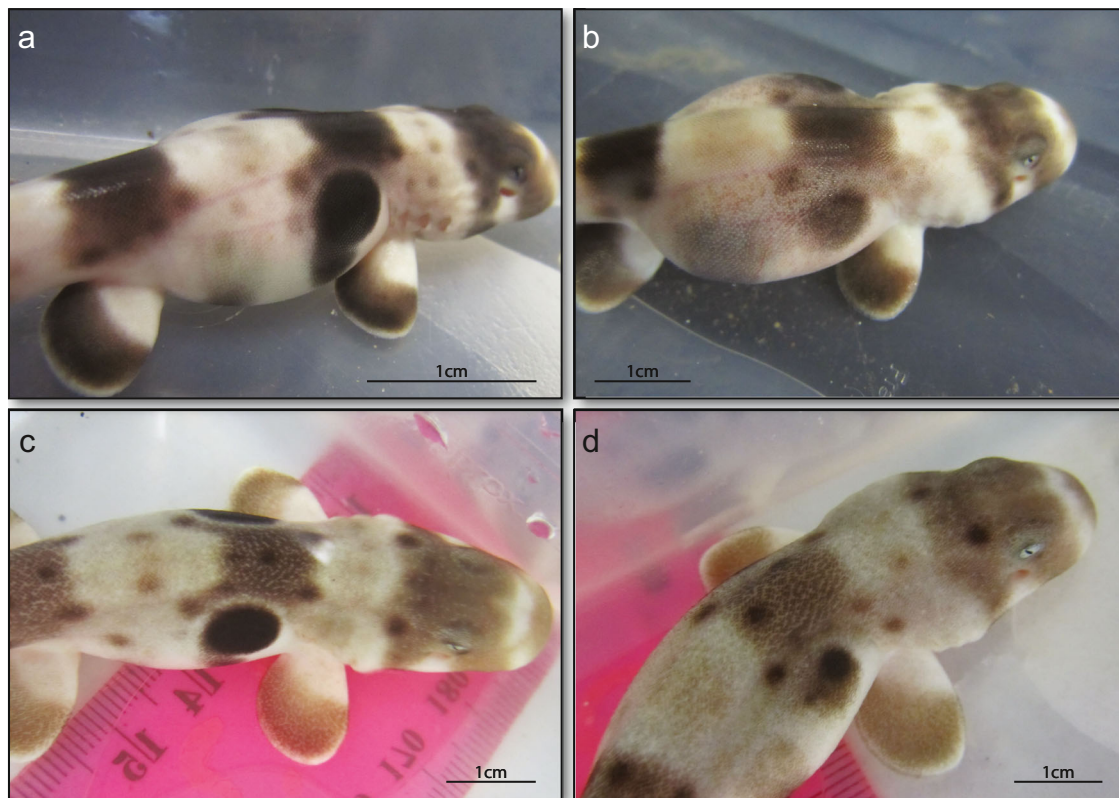


Fig. 1 Normal pattern development of a neonate epaulette shark (i.e., defined epaulette spot) reared in ovo (28 °C) at 14 days post-hatch (**a**) and 120 days post-hatch (**c**) in contrast to patterns of a neonate reared in ovo at

32 °C at 14 days post-hatch (**b**) and then transitioned to 28 °C (at 30 days post-hatch) until 120 days post-hatch (**d**)

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