



The sex change of the caridean shrimp *Hippolyte inermis* Leach: temporal development of the gonopore morphology

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Abstract

Sex reversal is a process observed in several marine organisms, including some lineages of caridean shrimps. We investigated the gonopore shape and size, to study the sex reversal using *Hippolyte inermis* as a model. A method was developed which can be applied to identify the sex in juveniles of *H. inermis*, especially, useful when the standard method of sex assessment is not applicable. The position and the shape of gonopores was recorded under a light microscope. The sex of mature individuals was then determined by observing the presence/absence of the *appendix masculina*. In addition, analysis of ontogenetic changes of gonopores were performed to compare their morphology with other species of shrimps whose gonopore morphology was previously known. Female gonopores are located at the far proximo-medial end of the third pair of pereopod coxae and distally they bear cup-shaped structures, whilst male gonopores are located at the far proximo-medial end of the fifth pair of pereopod coxae and they have a simpler structure. The shape and structure of gonopores in *H. inermis* resembled that of other caridean decapods. Intersex individuals were never observed, although this species was demonstrated to be protandric. This observation confirmed previous assumptions indicating that the process of sex reversal is very fast in *H. inermis* and that it takes place within a single moult. The identification of sex based on the position and shape of gonopores is feasible in this species, and it provides helpful insights for studying sex reversal in small decapods.

Keywords Sex reversal · *Appendix interna* · *Appendix masculina* · Gonopore · Protandric hermaphroditism

Introduction

Caridean shrimps exhibit a range of sexual systems and several investigations clarified details of their maturation and reproduction (Gherardi and Calloni 1993; Bauer 2000; Bergström 2000; Lin and Zhang 2001; Chockley and St. Mary 2003; Zhang and Lin 2005; Baeza 2006; Zupo et al. 2008). In particular, according to the tissue persistence of the androgenic gland, various sexual strategies were observed in a gradient of cases, from total stability of androgenic gland (persistence of testes in gonochoristic species) to fast sex reversal as observed in *H. inermis* (Table 1; Zupo and Maibam 2010).

Hippolyte inermis is a protandric consecutive hermaphroditic shrimp (Reverberi 1950; Veillet et al. 1963; Yaldwyn

1966), distributed from Ireland and Western Channel to Morocco (O’Céidigh 1962; Murray 1980), Sea of Marmara (d’Udekem d’Acoz 1996) and Mediterranean sea-grass meadows (Zariquiey Alvarez 1968; Guillén 1990; d’Udekem d’Acoz 1998), in particular, *Posidonia oceanica* (Gambi et al. 1992). Two periods of recruitment have been observed in the field (Zupo 1994). The first reproductive period occurs in spring and yields offspring consisting of both males and females. The second occurs in fall, and offspring are characterised by males that undergo sex reversal after the next spring recruitment period (Veillet et al. 1963). In fact, *H. inermis* is characterised by sex reversal that proceeds through complete regression of the male gonad and development of an ovary from undifferentiated germinal cells (Reverberi 1950), without passing through a transitional stage of “ovotestis” (Cobos et al. 2005) as commonly observed in decapod crustaceans (Bauer and Holt 1998). Another feature making the reproductive biology of this species unique is that, besides the well-known sex reversal process observed in individuals aged approximately 1 year, as first described by Reverberi (1950), an additional

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