GILL MORPHOLOGY AND TERRESTRIAL ADAPTATION IN THE
ESTUARINE CRAB *UCA URUGUAYENSIS* NOBILI, 1901 (DECAPODA,
BRACHYURA)

BY

CARLOS M. LUQUET

Laboratorio de Fisiología Animal Comparada, Ineuci-Conicet, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pab. II, Ciudad Universitaria, 1428 Buenos Aires, Argentina

GLADYS PELLERANO and JORGE DE CARLO

Laboratorio de Histología Animal, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pab. II Ciudad Universitaria, 1428 Buenos Aires, Argentina

ABSTRACT

Gill area (GA), proportion of ion-regulation and respiratory tissue surface, mean thickness of diffusion barrier (epithelium plus cuticle) and metabolic rate/gill area ratio (VO₂/GA) were measured in the intertidal fiddler crab *Uca uruguayensis*.

Mean GA was 351.56 mm² ± 19.55, n = 18, 60% corresponding to ion-regulation tissue surface and 40% to respiratory area. Mean diffusion distance was 8.02 µm, ranging from 1.63 µm at the fourth gill pair (fully respiratory) to 12.0 µm for the seventh, ion- regulatory, gill pair. Cuticle thickness was 0.81 µm in the lamellae of all the gills; a thicker cuticle was noted in the marginal channels (up to 10 µm), that provide structural support to the gills.

VO₂/GA was calculated for *U. uruguayensis* and compared with the same ratio for several species living in different habitats. This ratio increased with terrestrial tendencies, being sevenfold higher in terrestrial crabs than in aquatic and low tide ones. Air-active intertidal species, like *U. uruguayensis* showed intermediate values between those groups.

RESUMEN

Se midieron en el cangrejo intermareal *Uca uruguayensis*, el área branquial (AB), la proporción de tejidos ionorregulador y respiratorio, la distancia media de difusión (epitelio mas cutícula) y el cociente entre tasa metabólica y área branquial (VO₂/AB).

El área branquial media fue de 351.56 mm² ± 19.55, n = 18 de la cual 60% y 40% correspondieron a tejido ionorregulador y respiratorio, respectivamente. La distancia media de difusión fue de 8.02 µm, con un valor mínimo de 1.63 µm medido en la branquia 4 (netamente respiratoria) y un máximo de 12.0 µm para la branquia 7 (ionorreguladora). El grosor de la cutícula en las lamíllas de todas las branquias fue de 0.81 µm, con excepción de los refuerzos cuticulares ubicados sobre el canal marginal (hasta 10 µm) que proveen soporte estructural para la respiración aérea.

Se calculó el cociente VO₂/AB para *U. uruguayensis* y se lo comparó con el correspondiente a otras especies de distintos hábitats. Dicho cociente se incrementó con la terrestrialidad de las especies, obteniéndose valores siete veces mayores para las especies terrestres con respecto a las acuáticas y de marea baja. Las especies intermareales activas en aire, como *U. uruguayensis*, mostraron valores intermedios entre los grupos mencionados.

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Brachyuran crabs have colonized a wide range of environments, from their marine ancestral habitat, to semiterrestrial and terrestrial habitats (Pearse, 1929; Gray, 1957; Gross, 1964; Bliss, 1968; Powers & Bliss, 1983). Intertidal crabs represent transitional forms in the evolution of crustaceans from water to land. Due to tide action, these animals must face alternating periods of exposure to air and water (Burnett, 1988). Several species, like fiddler crabs of the genus *Uca* and some grapsids are capable to move actively between air and water, maintaining similar rates of oxygen uptake in both media (Teal, 1959; Burnett & McMahon, 1987; Santos et al., 1987; De Fur, 1988). Such active intertidal species depend on the versatility of their respiratory systems to efficiently perform gas exchange in two different respiratory conditions.

Morphological adaptations to air breathing such as development of branchiostegal lungs (Diaz & Rodriguez, 1977) or modifications of gill lamellae to prevent their adherence, were often reported for terrestrial crabs (Cameron, 1981; Maetzold & De Fur, 1984), but not for intertidal species. However, several works indicate a trend to the reduction of respiratory surface area with terrestrial tendencies (Gray, 1957; Hawkins & Jones, 1982; Rabalais & Cameron, 1985) and enhancement of the diffusion barrier across the gills (Copeland, 1968; Maetzold & De Fur, 1984; see Taylor & Taylor, 1992 for a review). Capacity for active ion exchange has been considered as related with terrestrial adaptation (Gross, 1964). It was specifically involved in the improvement of carbon dioxide excretion and acid-base balance during emersion (Burnett & McMahon, 1987). Thus the reported increase in the thickness of diffusion barrier, mentioned above for semiterrestrial and terrestrial crabs, probably reflects the increased proportion of thick cells with ion regulation function.

*Uca uruguayensis* Nobili, 1901 is an intertidal fiddler crab widely distributed from Rio de Janeiro, Brazil to Mar Chiquita, Argentina, and is considered as one of the more conspicuous species in the crab community that live in Samborombón Bay, Argentina (35°26'S 57°07'W to 36°18'S 56°48'W) (Boschi, 1964). In previous studies, this species has been reported as spending most of the time exposed to air, even at high tide, when the animals plug their burrows and maintain an air column inside (De la Iglesia et al., 1994). As other members of the genus *Uca* (cf. Green et al., 1959; Rabalais & Cameron, 1985), *U. uruguayensis* was reported an effective sodium hyper- and hyporegulator (Luquet et al., 1992).

The aim of the present study is to characterize structural and ultrastructural features of the gills of *U. uruguayensis*, as anatomical adaptations to the semiterrestrial habitat of this species.