ELSEVIER

Arthropod Structure & Development 34 (2005) 63–87

ARTHROPOD STRUCTURE & DEVELOPMENT

www.elsevier.com/locate/asd

The morphology and vasculature of the respiratory organs of terrestrial hermit crabs (*Coenobita* and *Birgus*): gills, branchiostegal lungs and abdominal lungs

C.A. Farrelly[a], P. Greenaway[b,*]

[a]*32 Tramway Pde. Beaumaris, Vic. 3193, Australia*

[b]*School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, N.S.W. 2052, Australia*

Received 23 August 2004; accepted 5 November 2004

Abstract

The morphology and vasculature of the respiratory organs of the terrestrial coenobitids were studied using light microscopy, TEM, SEM and corrosion casting. The gills of *Coenobita* and *Birgus* are modified for air-breathing but are reduced in number and size and have a comparatively small surface area. The branchiostegal lungs of *Coenobita* (which live in gastropod shells) are very small but are well vascularized and have a thin blood/gas barrier. *Coenobita* has developed a third respiratory organ, the abdominal lung, that is formed from highly vascularized patches of very thin and intensely-folded dorsal integument. Oxygenated blood from this respiratory surface is returned to the pericardial sinus via the gills (in parallel to the branchiostegal circulation). *Birgus*, which does not inhabit a gastropod shell, has developed a highly complex branchiostegal lung that is expanded laterally and evaginated to increase surface area. The blood/gas diffusion distance is short and oxygenated blood is returned directly to the pericardium via pulmonary veins. We conclude that the presence of a protective mollusc shell in the terrestrial hermit crabs has favoured the evolution of an abdominal lung and in its absence a branchiostegal lung has been developed.

Keywords: Coenobita; Anomura; Land crab; Lungs; Gill; Circulation

1. Introduction

The terrestrial hermit crabs (Family Coenobitidae) include 15 species of *Coenobita* and a single species of another genus, *Birgus latro*. The family is of marine origin and whilst its members have effectively colonised supra-littoral and terrestrial habitats, they continue to carry and live in mollusc shells. However, *B. latro*, which carries a shell in its early stages, discards it after several moults, which allows it to grow to a much larger size (Harms, 1938). These shell-less individuals have enlarged and heavily calcified abdominal terga to protect the abdomen and the abdominal integument becomes thick and rubbery.

Whilst extensive work has been conducted on the respiratory physiology of the highly terrestrial *Birgus latro*, relatively little information is available for *Coenobita* (see review by Greenaway, 2003). Furthermore, little seems to be known about the morphology of the respiratory structures involved or their relative contributions. In comparison to terrestrial brachyurans, the terrestrial anomurans (except *Birgus latro*) have fairly reduced branchiostegites, with development constrained by the need to accommodate the body within a gastropod shell. They also retain a large number of gills (14 pairs), and although these are reduced in size (Harms, 1932) it has been assumed that the gills remain the major respiratory organs. The occurrence of a third respiratory site was briefly reported by Bouvier (1890a) for *Coenobita clypeatus* (formerly *C. diogenes*) and comprises a vascular network in the thin dorsal integument of the abdomen. The existence of similar abdominal complexes has also been reported in *C. perlatus* and *C. rugosus* (Borradaile, 1903). Although these systems were discussed by Harms (1932), they have received no

* Corresponding author. Tel.: +61 2 9313 7730; fax: +61 2 9385 1558.
E-mail address: p.greenaway@unsw.edu.au (P. Greenaway).

1467-8039/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.asd.2004.11.002

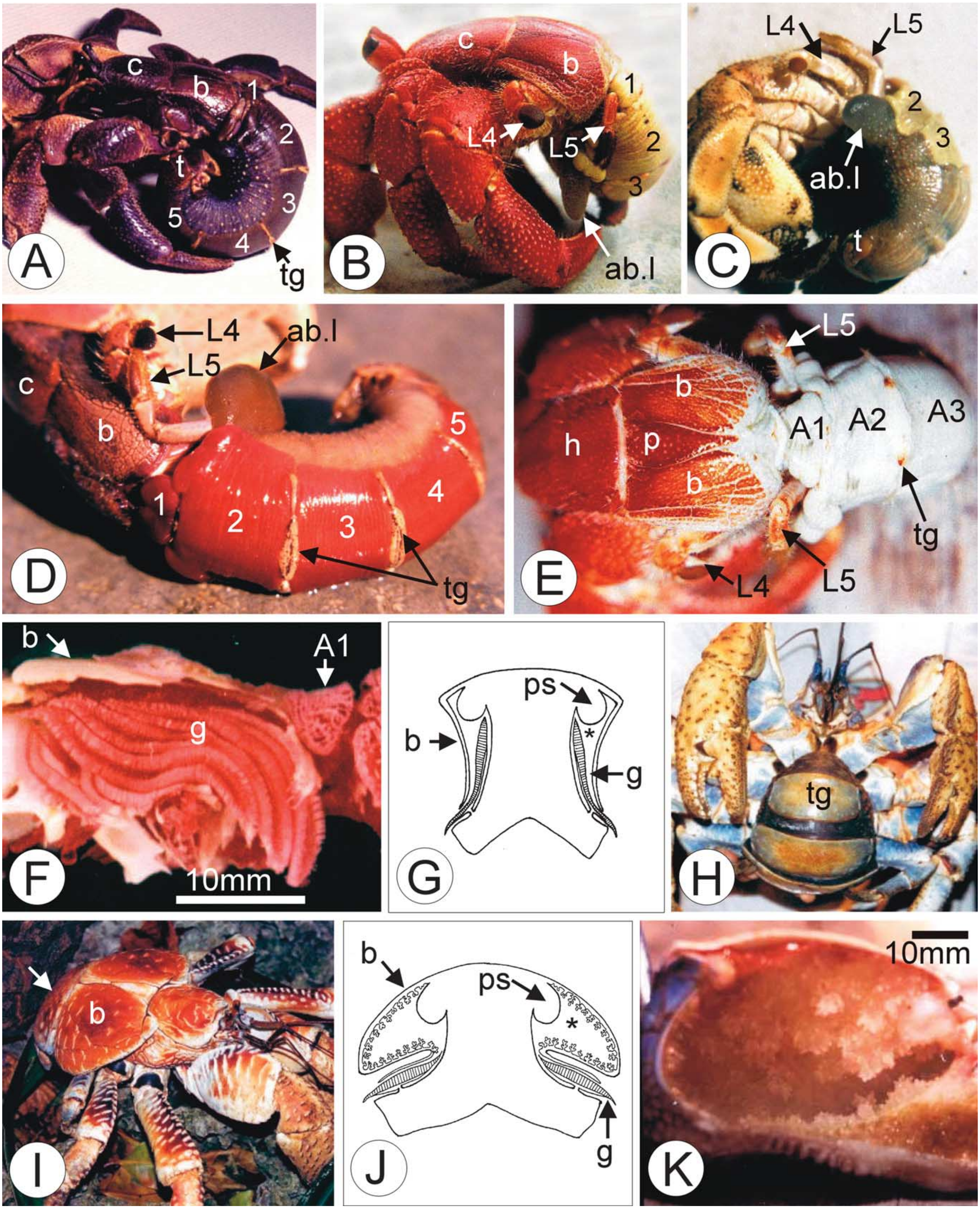

Fig. 1. (A) *Coenobita brevimanus*; (B) *Coenobita perlatus*; (C) *Coenobita rugosus*; (with gastropod shell removed). Note narrowly compressed cephalothorax (c). The 4th limb (L4) is held against the sides of the branchiostegites (b), while the 5th limb (L5) is normally inserted into the branchial chamber. The abdomen is covered with a thin, membranous cuticle and the abdominal tergites (tg) are reduced to narrow bars between the segments. The last segment and telson (t) are reduced and calcified. Distinctive vascular patches on the abdomen extend dorsally and mid-laterally where the surface forms tiny grooves that run laterally