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Effect of body weight, temperature and feeding on the metabolic rate in the spiny lobster *Panulirus argus* (Latreille, 1804)

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Abstract

Spiny lobsters are prevalent in tropical and temperate seas and support some of the largest commercial fisheries in the world. Studies on the metabolic rate of spiny lobsters contribute to the understanding of the relation of these widely distributed crustaceans with their environment, to the design of holding facilities and to the development of future aquaculture technologies. The current study attempts to describe the oxygen consumption of juvenile lobsters *Panulirus argus* in relation with body weight, temperature and feeding. Individual routine metabolism increased with body weight according to the regression line $Log_{10}MO_2$ (mg O_2/h)= $0.754Log_{10}W$ (g)−0.678 (r^2=0.71) whereas weight-specific respiration rate decreased according to the regression line $Log_{10}VO_2$ (mg O_2/kg/h)=−$0.774Log_{10}W$ (g)+3.395 (r^2=0.81). The metabolism of juvenile *P. argus* showed a linear increase with temperature and this relationship was best described by the regression line VO_2 (mg O_2/kg/h)=6.183*T* (°C)−110.21 (r^2=0.72). All regressions were found to be statistically significant. From the evaluated factors, feeding had the highest effect on oxygen consumption. The oxygen consumption increased after ingestion with the maximum within the first 5 h. Results are discussed in relation with their relevance for maintaining *P. argus* under captive conditions.

Keywords: Metabolism; Oxygen consumption; Allometry; Temperature; SDA; *Panulirus argus*; Spiny lobster

1. Introduction

Spiny lobsters are predators of several marine benthic species and important prey of larger predators. Their large size and abundance make them ecologically important as links in food webs of tropical and temperate seas (Lipcius and Eggleston, 2000). Additionally, spiny lobsters support some of the largest commercial fisheries in the world making *Panulirus argus* the most important fishery resource in the Great Caribbean.

The over-exploitation of most wild stocks and the high value of spiny lobsters in international markets continue to attract intensive interest in the aquaculture of spiny lobsters all over the world. Due to the difficulties with rearing lobsters through their complex larval period, the development of rock lobster aquaculture presently depends on the out-growing of juveniles captured from the wild (Crear et al., 2000). Sea-cage

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rearing of some spiny lobsters from wild seed (post-larvae and early juvenile) is developing rapidly in many Asian countries, including Viet Nam, Philippines, Indonesia, India, Thailand, Burma, China, Taiwan, Malaysia, Tahiti, Singapore (Jeffs and David, 2002), and New Zealand (Jeffs and Hooker, 1999) with native species. There are also encouraging prospects for profitable farming of *P. argus* (Jeffs and David, 2002) in the Caribbean. In addition, the grow-out of harvested lobsters to a bigger size either in sea cages or in land-based recirculation systems is a promising practice to increase the value of harvest.

Moreover, the number of markets for live lobsters is both large and growing (Stevens and Sykes, 2000). The success in this activity partially relies on keeping the spiny lobsters in holding tanks until shipping, where appropriate conditions must be provided to achieve high survival.

Knowledge of the effects of body weight, temperature and feeding on the metabolism of commercially valuable animals is important for the estimation of the energy requirement of these organisms. These data are very much needed for the establishment of optimal culture conditions and management strategies. Bioenergetics studies have been conducted on different economically important crustaceans (Logan and Epifanio, 1978; Zuñiga, 1983; Rosas et al., 1993, 1996, 2001; Crear and Forteath, 2002; Perera et al., 2005).

In spite of the interest in the grow-out of some spiny lobsters, little information is available regarding how the oxygen consumption of spiny lobsters is affected by intrinsic and extrinsic factors. Although there are many factors that have been shown to affect the rate of oxygen consumption in spiny lobsters such as body weight, dissolved oxygen level, salinity, temperature, activity, handling, diurnal rhythm and feeding, such studies have been conducted only for few species (Buesa, 1979; Crear and Forteath, 2002; Díaz-Iglesias et al., 2002, 2004; Perera et al., 2005).

The current study describes the metabolic performance of juvenile lobsters *P. argus* in terms of oxygen consumption in relation with body weight, temperature and feeding.

2. Materials and methods

2.1. Animals and experimental conditions

After a complex and prolonged larval period in the ocean involving several phyllosoma instars, spiny lobsters *P. argus* larvae metamorphosed into a colorless puerulus stage (4–6 mm of carapace length (CL)). The lobster-like pueruli migrate directionally into shallow waters such as mangrove areas, where it settles to the bottom. Shortly after settlement they moulted to become postpueruli or algal phase (6–16 mm CL) whereas lobsters bigger than 16 mm CL are considered as juveniles (Cruz et al., 2001). Juvenile lobsters have been frequently divided in two ecologically distinct phases: early juvenile or postagal phase (16–50 mm CL) and subadult (50–77 mm CL). However, there are few changes in morphology between these phases during the ontogenetic progression from early juvenile to adult. In addition, the size range for these different juvenile phases is controversial among species and therefore, all lobsters used in this work were considered just as juveniles.

Juveniles *P. argus* were they settle and transported to the Laboratory of Ecophysiology, Center for Marine Research, University of Havana, Cuba, from "Golfo de Batabanó" in the south-west of the Cuban archipelago. The collection area was: 21°39.0431′N–83°09.8436′W; 21°41.0015′N–83°09.2463′W; 21°40.1016′N–83°11.0297′W and collection was accomplished within the last 2 weeks of February 2004. In the laboratory, lobsters were placed individually in 90-L flow-through tanks connected to a recirculating aquatic system with biological–mechanical filtration and aerated seawater. Experimental conditions were (mean ± standard error): salinity of 36.1 ± 0.09‰, ammonia concentration of 0.07 ± 0.009 mg/L, oxygen concentration of 5.57 ± 0.010 mg/L, and pH of 7.9 ± 0.02. Temperature ranged between 20 °C and 28 °C and this variation was used to study its effect on metabolism. Equipment used for recording these factors were: refractometer Vital-Sine SR-6 for salinity, digital analyzer Orion 290A with respective electrodes for ammonia and pH, and a digital oxymeter YSI Y50B for oxygen concentration. Light was controlled by timers (Intermatic, HB111C) to provide a 12-h light–12-h dark photoperiod and light intensity was 261 lx (Minolta meter) during the light phase. Temperature was recorded twice a day by a digital temperature monitor (LifeGard) with a submersible probe.

Moulting cycle and daily rhythms have effects on the metabolism in crustaceans. Determination of molt state was achieved by examining a pleopod tip under a low-power microscope (Lyle and MacDonald, 1983). Lobsters in molt stage other than intermolt were not used in experiments as well as lobsters that did not ingest the experimental diets.

From collected animals, 104 lobsters complied with these requirements and provided the measurements of oxygen consumption for further analysis. Measurements were made between 09:00 h and 14:00 h, when