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Journal of Aquaculture & Marine Biology

Metabolic rates in hatchery-reared European lobster juveniles *(Homarus gammarus L.)*

Abstract

The existing information on the metabolism in European lobster (Homarus gammarus) is sparse. However, dimensioning of intensive systems for commercial production of lobster in recirculating aquaculture systems (RAS) requires adequate information in order to optimise financial calculations and profit margins. Thus, a lack of available data, especially regarding oxygen consumption and ammonia excretion, hampers development and commercialisation of lobster aquaculture. During 2010 and 2013, respiration and excretion rates in juvenile lobsters ranging from 0.06 to 208 g were recorded in a respirometer. These tests aimed to obtain data of standard metabolism in lobster at normal activity and optimum temperature (20 ±1°C). The metabolic rate in fed juveniles < 2 g varied from 1.2 to 14.3 mg O2/kg min. In the larger juveniles and adults, the metabolic rate was less variable ranging from 1.1 to 3.1 mg O2/kg min. The respiration rate in unfed lobsters was relatively stable, varying from 0.8 to 2.4 mg O2/kg min. The excretion rate was likewise larger in the smaller juveniles with a mean of 0.51 mg TAN/kg/min compared with the largest individuals of 0.07. This article briefly describes the two respirometer tests performed in order to improve the financial stipulations and reduce the economic risk in a critical stage of development.

Research Article

Volume 5 Issue 5 - 2017

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Received: April 29, 2017 | **Published:** May 18, 2017

Introduction

European lobster (*Homarus gammarus*) is a high value species where landings are low and commercial farming has yet to be established. On the other hand, European lobster is identified as one of the most promising aquaculture species, due to very high prospected profit margins (e.g. Anon. 2003; Anon. 2005; Anon. 2003) [1,2]. Moreover there is a huge gap between supply and demand, resulting in stable and high consumer demand and market price in all market segments around the globe. During the last decade, several break-troughs were made in the progress of developing lobster aquaculture. These include recirculation of seawater and development of low-cost industrial automation technology making it possible to meet the particular demands of lobster farming [3-5]. Based on the promising potential for farming lobsters, the European industry joined forces and established the network association the European Lobster Center of Excellence (ELCE – www.elce-net.org). ELCE has members from Norway, Denmark, Sweden, Italy, Spain, Iceland and UK. The main aim with the association is to develop business cases enabling multiple establishments in the EU implementing state-of-the-art land-based culture systems for European lobster. The network also facilitates R&D facilities where new aquapreneurs can do preliminary testing of new technologies for on-shore lobster farming. In order to succeed with land-based farming, major prerequisites such as feed utilisation/feed conversion ratio (FCR), oxygen consumption, excretory values on carbon dioxide (CO_2) and total ammonia (TAN) must be acquired. Currently, knowledge is lacking on among others respiration and excretion rates in European lobster. This is urgently needed for dimensioning criteria for water treatment units in Recirculating Aquaculture Systems (RAS). During the last years, Norwegian Lobster Farm AS (NLF) has jointly with International Research Institute of Stavanger (IRIS) and Institute of Marine Research (IMR) conducted preliminary studies aiming to determine respiration and excretion rates in European lobster. These studies were made in order to determine the range of optimal and critical/threshold levels of key water quality parameters for European lobsters.

Material and Methods

All juveniles were hatchery-reared based on genetically tagged brood-stock. In 2010, juvenile European lobster from NLF's commercial RAS factory on Kvitsøy were tested, whereas in the 2013 the juveniles were from Institute of Marine Research, research station in Parisvatnet. The sizes ranged from recently settled stage III larvae at 0.02 gram (corresponding to 5 mm carapace length, CL) to juveniles/subadults at 208 gram (corresponding to CL of 70 mm). CL was recorded with a vernier caliper from the base of the eye socket to the posterior-medial edge of the cephalothorax. Wet body weight was recorded to nearest 0.1 g. In both years, the IRIS laboratory performed the tests according to standardised procedures which can be replicated (Figure 1). The lobsters were kept separately throughout the process. In order to reduce the stress level caused by handling and transport, the animals were acclimatised for 7 days upon experimental start. The animals were fed commercially prepared feed (tailor made for lobster by NLF), one pellet every three days according to the production protocols developed by NLF. No feeding took place throughout the respirometer stay. A group of lobster were also analysed in non-fed condition. For these individuals, feeding ended 7 days prior to experimental start.

For the larger lobsters, two identical respirometers of 3.9 L were used with online dissolved oxygen/temperature sensors

(Oxygen Optode/Temperature Sensor 3830/3835 from Aanderaa Data Instruments). A program allows for table and/or graphical forms of the results. The respirometer chambers differed a bit in size depending on the lobster size. At the start of each test, DO concentration was 240-265 µM or 90-100 % of saturation level at 19.5-21.0°C and > 32 % salinity. All calculations of specific oxygen consumption were based on the DO concentration reduction rate from start level to 200 µM equal to 70-75 % of saturation level. This procedure was introduced to avoid any extra stress due to hypoxia. Sampling for total ammonia analysis (TAN) was performed at the end of each test. The samples were added acid for conservation and sent to the Norwegian Institute for Water Research (NIVA) for further analysis. On several occasions this sampling took place at lower DO concentrations than 200 µM and therefore more and less affected by stressful conditions pH was measured at the same time and levels below 7.9 are not considered representing routine conditions.

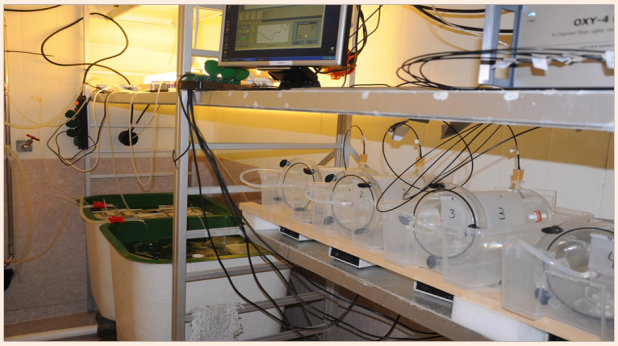

Figure 1: Test facilities with running respirometers and logging of data.

Results

Total oxygen consumption in the individuals from 2010 and 2013 showed very similar results (Figure 2), with higher variation in the smaller individuals compares with the larger ones. In the experiment where the juveniles were fed, the oxygen consumption in lobster < 2 g varied from 1.2 to 14.3 mg O_2/kg x min. In the larger juveniles and subadults the consumption rate was less variable, from 1.1 to 3.1 mg O_2/kg x min. In un-fed lobster, the metabolic rate was relatively stable, varying from 0.8 to 2.4 mg O_2/kg x min. Carbon dioxide can be a limiting parameter, especially when pure oxygen is added in order to sustain intensive production (> 40 kg/m^3). The measured CO_2-production was on average 1.5 – 2 times the corresponding O_2-consumption.

Excretion rates were measured, and the ammonia analyses indicate, as expected, a higher specific excretion rate in terms of mg TAN/kg x min in juveniles compared to the larger-by size individuals (Table 1). However, replicate sampling of the same size groups demonstrated considerable fluctuation from one test situation to another. Increased excretion rate in the largest animals (120 - 210 g) was positively correlated with increased oxygen consumption in the same individuals (Figure 3).

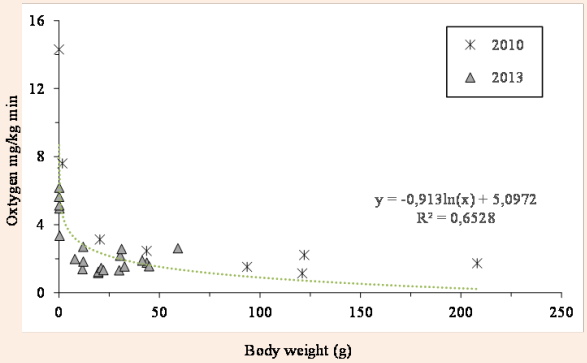

Figure 2: Mean oxygen consumption in hatchery-reared European lobster (*Homarus gammarus*), ranging in size from larvae to adults. The experiments were run in 2010 and 2013.

Table 1: Excretion rates measured as mg total ammonia (TAN) per kg per minute in European lobster (Homarus gammarus) in three size ranges.

Size Category	N	Weight (g) Range	TAN
Small	6	0.5 – 2.0:	0.51 ± 0.21
Medium sized	18	8.0 – 60.0:	0.14 ± 0.08
Large	4	94.0 – 208.0	0.07 ± 0.02

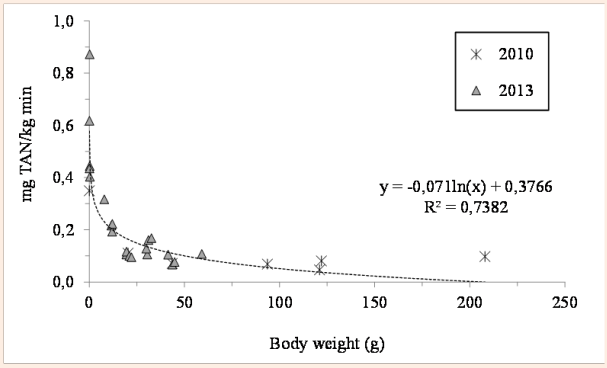

Figure 3: Excretion measured in mg total ammonia (TAN) per kg per minute in hatchery-reared European lobster (*Homarus gammarus*) ranging in size from larvae to adults. The experiments were run in 2010 and 2013.

Discussion

The large individual variability in oxygen consumption at various sizes demonstrates rapid adaptability to new conditions. Typical stress influenced respiration rate seems to be approximately twice the standard rate. The standard rate of European lobster within the size interval 230-600 g was found to be 0.73 mg O_2/kg x min at 20°C [6] i.e. about half of the lowest rate found in this study for lobster of 208 g. The oxygen consumption ranges were large, 1:8 to 1:3 within the same size groups, and the

Citation: Drengstig A, Bergheim A, Westerlund S, Agnalt A-L (2017) Metabolic rates in hatchery-reared European lobster juveniles *(Homarus gammarus L.)*. J Aquac Mar Biol 5(5): 00134. DOI: 10.15406/jamb.2017.05.00134

fluctuations may be due to diurnal rhythm and peak at feeding. The measured CO_2-production was on average 1.5-2 times the corresponding O_2-consumption. As in other aquatic animals with similar activity levels, the oxygen uptake is closely linked with the oxygen demand and will vary according to physiological state, behavioural status, activity level and changes in environmental factors as e.g. temperature [7]. One obvious physiological state in lobster is moulting. Two individuals moulted just before or during the respiration experiment in 2013 (nr.2; 31.2 gr and nr. 19; 59.2 gr), and in fact the oxygen consumption was slightly in the upper range.

Some of the lobsters during the 2010 experiment were probably temporarily stressed, despite the acclimatisation period of 7 days, as peak rates higher than 14.3 mg/kg x min were recorded. However, such peak rates were always recorded during the first phase of experiment, and could therefore be due to the introduction to the respiration chamber. In addition, several of the adults, i.e. lobsters > 94 gram also seemed to suffer from stress in the respirometer, probably due to the small size of the chamber.

The studies indicated strongly fluctuating oxygen consumption in lobster of different size at 20 ±1°C. The large variability in oxygen consumption at various sizes also demonstrated rapid adaptability to new conditions. Stress influenced respiration rates to increase to approximately twice the standard rates. Ammonia analyses indicated, as expected, a higher specific excretion rate in terms of mg TAN/kg x min in juveniles compared with sub adults. However, replicate sampling of the same size groups demonstrated considerable fluctuation from one test situation to another. Increased excretion rate in the larger animals was positively correlated with increased oxygen consumption [8-28].

Conclusion

Based on the economic importance of metabolism data, priority is given to detect critical water quality values for dimensioning of technical equipment in order to sustain a healthy environment for lobsters farmed in RAS. Moreover, such data is important to improve growth performance, survival and feed conversion ratio (FCR) in RAS in order to increase the turn-over and successful commercialization for the industry.

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