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# Short Note

## Effects of Dissolved Oxygen on Oxygen Consumption and Ammonia Type Fixed Nitrogen Excretion of *Penaeus chinensis* Juveniles

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**Jiann-Chu Chen and Fan-Hua Nan (1994)** Effects of dissolved oxygen on oxygen consumption and ammonia-N excretion of *Penaeus chinensis* juveniles. *Zoological Studies* **33**(1): 90-93. When *Penaeus chinensis* juveniles (0.346 ± 0.065 g) were subjected to decreased dissolved oxygen (DO) levels in the range of 6.60-3.84 mg/l at 25°C and 30 ppt after 6, 12 and 18 h, the oxygen consumption rate was highest (0.671 mg/g/h) and ammonia-N excretion rate lowest (35 μg/g/h) at 3.84 mg/l DO. The decrease of the DO levels to both 4.68 and 5.55 mg/l significantly decreased the oxygen consumption rate of *P. chinensis* in 12 h ($p < 0.05$).

**Key words:** Penaeid, DO, Respiration, Nitrogen excretion.

Fleshy prawn, *Penaeus chinensis* (or *P. orientalis*), originally found in the Po Hai and Yellow Sea (Liu 1983), have been successfully introduced and reared in Taiwan (Tzeng et al. 1990).

Wang (1983) reported that the optimal temperature and salinity for *P. chinensis* postlarvae are 25-26°C and 16-39 ppt, respectively. Critical DO (dissolved oxygen) values for adult *P. chinensis* are 1.30 mg/l and 1.75 mg/l at 15°C and 25°C, respectively (Yang 1990).

In an intensive *P. monodon* and *P. penicillatus* culturing system, the DO levels declined over time to 4.66 and 3.47 mg/l after 103 and 115 days, respectively (Chen et al. 1988 1989). Therefore, primary concern is the physiological effect of low DO levels on penaeids. The purpose of this study was the determination of oxygen consumption and ammonia-N (unionized plus ionized ammonia as nitrogen) excretion of *P. chinensis* juveniles at different DO levels.

**Materials and Methods**—*P. chinensis* juveniles from the Taiwan Fisheries Research Institute, Tainan Branch were acclimated to 30 ppt seawater for two weeks. The juveniles used were third generation reared in Taiwan from three spawners originally introduced from Mainland China in February 1989 (Tzeng et al. 1990). The average wet weight of intermolt shrimp that were not fed for the two days prior to the test was 0.346 ± 0.065 g.

Seawater pumped from the Keelung coast adjacent to the University was diluted to 30 ppt with water dechlorinated with sodium thiosulfate and filtered through a gravel and sand filter bed. Seawater composition was the same as that reported previously (Chen and Nan 1991). Different DO level test solutions were prepared by dissolving 0, 0.1, 0.2, and 0.3 g of sodium sulfite in 10 l aerated seawater. Dissolved oxygen levels of 6.60, 5.55, 4.68, and 3.84 mg/l DO were selected for the study. These levels are based on a saturation of DO (6.95 mg/l) at 30 ppt and 25°C and the reduced levels of DO which commonly occur in intensive aquaculture. Sulfite was not detectable in every test solution.

Each shrimp was placed in a pyrex glass BOD bottle (308 ± 1.5 ml volume) which was then capped and placed in a water bath (25 ± 1°C). There were four treatments (6.60, 5.50, 4.68, and 3.84 mg/l DO); each treatment was conducted five times. Additionally, eight bottles containing each representative test solution (no shrimp) were used as a blank group. The experiment lasted 18 h with static renewal of test solution every 6 h. Dissolved oxygen was measured with a DO meter and electrode probe (Model 58, YSI Incorporated, Yellow Springs, Ohio, USA) attached to a battery powered stirrer following air calibration with salinity compensation (Weiss 1970). Prior to each DO reading, the stirrer was operated for 20 sec. Ammonia-N was determined by the phenolhypochlorite method (Solorzano 1969), when the test solution was renewed. Weight specific oxygen consumption ($O_2$ mg/g/h) and ammonia-N excretion rates (μg/g/h) were calculated by multiplying the water volume of each bottle, and dividing by body wet weight and time elapsed (h). Water temperature was maintained at 25 ± 0.5°C, and pH was kept at 8.03 ± 0.24.

All data were subjected to one-way variance analysis (Steel and Torrie 1980). If the differences were significant at the 0.05 level, then Duncan's Multiple Range test was used to identify significant differences between treatments (Duncan 1955).

**Results**—The dissolved oxygen of each test solution declined to 2.06-2.28 mg/l, 1.61-1.74 mg/l, 1.79-2.50 mg/l, and 0.62 to

**Table 1.** Mean (standard deviation) dissolved oxygen (mg/l) and ammonia-N (μg/l) at the beginning (B) and the end (E) of each test interval; *Penaeus chinensis* juveniles were exposed to 6 h intervals at different DO levels

| Measured DO (mg/l) | Range of DO (mg/l) | Time elapsed (h) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 6 | | 12 | | 18 | |
| | | B | E | B | E | B | E |
| | | Dissolved oxygen (mg/l) in the bottle | | | | | |
| 6.60 (0.19) | 6.75-2.06 | 6.72 (0.03) | 2.14 (0.74) | 6.34 (0.02) | 2.06 (0.94) | 6.75 (0) | 2.28 (0.95) |
| 5.55 (0.31) | 5.82-1.61 | 5.71 (0.02) | 1.61 (0.56) | 5.12 (0.03) | 1.70 (0.99) | 5.82 (0.03) | 1.74 (0.60) |
| 4.68 (0.13) | 4.83-1.79 | 4.70 (0) | 1.99 (0.89) | 4.83 (0.03) | 2.50 (0.72) | 4.52 (0.03) | 1.79 (0.56) |
| 3.84 (0.08) | 3.90-0.62 | 3.90 (0) | 1.02 (0.05) | 3.90 (0) | 1.12 (0.17) | 3.73 (0.02) | 0.62 (0.10) |
| | | Ammonia-N (μg/l) in the bottle | | | | | |
| 6.60 (0.19) | 6.75-2.06 | 23 | 347 (101) | 23 | 338 (99) | 23 | 305 (97) |
| 5.55 (0.31) | 5.82-1.61 | 23 | 337 (42) | 23 | 313 (65) | 23 | 298 (54) |
| 4.68 (0.13) | 4.83-1.79 | 23 | 293 (51) | 23 | 261 (35) | 23 | 187 (38) |
| 3.84 (0.08) | 3.90-0.62 | 23 | 234 (69) | 23 | 222 (23) | 23 | 156 (10) |

1.12 mg/l for the 6.60, 5.55, 4.68, and 3.84 mg/l DO groups, respectively (Table 1). No shrimp mortality occurred.

Oxygen consumption of *P. chinensis* juveniles at 5.55 and 4.68 mg/l DO were significantly lower ($p < 0.05$) than those at 3.84 mg/l DO after 12 and 18 h (Fig. 1). No significant difference of oxygen consumption was observed after 6 h.

Each test solution ammonia-N level increased to 305-347 μg/l, 298-337 μg/l, 187-293 μg/l, and 156-234 μg/l in the 6.60, 5.55, 4.68 and 3.84 mg/l DO groups, respectively (Table 1).

Ammonia-N excretion of *P. chinenesis* juveniles at 3.84 mg/l DO was significantly lower than those at 4.68 mg/l DO after 6 h. No significant difference of ammonia-N excretion was observed after either 12 or 18 h (Fig. 1).

**Discussion**—The rate of atomic oxygen consumption and ammonia-N excretion was considered an indicator of protein metabolism, and used to assess the physiological response of invertebrates to various stressful environments (Bayne 1973, Mayzaud 1973).

Effects of factors such as water temperature, salinity, dissolved oxygen, body weight, and molting on the oxygen consumption and ammonia-N excretion of penaeids were documented for *P. monodon* (Ting 1970, Liao and Huang 1975, Liao and Murai 1986, Lei et al. 1989), for *P. japonicus* (Dalla Via 1986), for *P. chinensis* (Liu 1983, Chen et al. 1991), and for *P. esculentus* (Dall 1986).

Liao and Huang (1975) reported that oxygen consumption of *P. monodon* juveniles (1.49 g) exposed to DO levels of 4.53, 3.95, 3.64, 3.13, 2.79, 2.26, and 1.18 ml/l at 29.7 ppt and 29°C were 0.21, 0.17, 0.21, 0.34, 0.20, 0.12, and 0.08 ml/g/h respectively (equivalent to 0.30, 0.24, 0.30, 0.49, 0.29, 0.17,

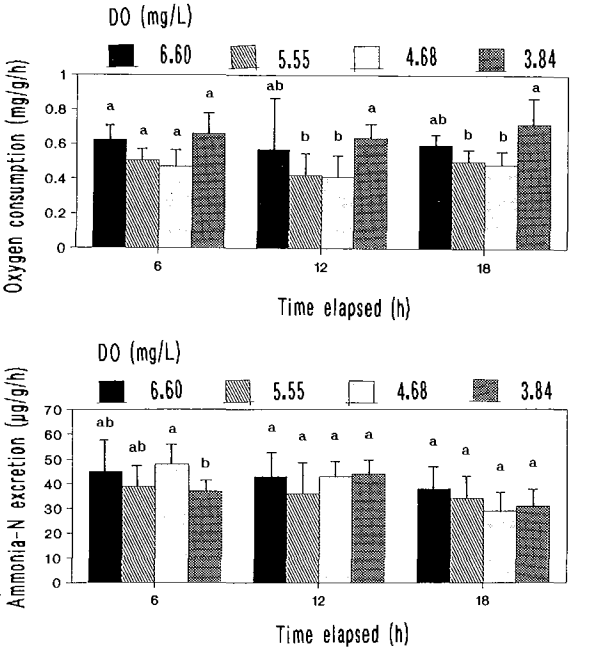


**Fig. 1.** Oxygen consumption (mg/g/h) and ammonia-N excretion (μg/g/h) of *Penaeus chinensis* juveniles exposed individually at different DO (dissolved oxygen) levels (mg/l) after 6, 12, and 18 h in 30 ppt and 25°C. Data in the same time period having different letters are significantly different ($p < 0.05$).

and 0.11 mg/g/h, respectively). They suggested that a critical dissolved oxygen level was 3.0-3.5 ml/l (4.29-5.00 mg/l). Oxygen consumption of *P. monodon* reported by Liao and Huang (1975) reached a peak at the DO level of 3.13 ml/l (4.48 mg/l), and it declined regardless of DO level increases or decreases from that level. On the contrary, Liao and Murai (1986) reported that oxygen consumption of *P. monodon* (0.4 – 8.0 g) remianed constant at DO levels above 3.0-4.0 mg/l, and gradually decreased until the shrimp became moribund at 0.4-0.7 mg/l DO in 25 ppt at 20°C. The discrepancies between these two studies is attributed to animal size and environmental condition differences.

The present study indicates that oxygen consumption of *P. chinensis* at 3.84 mg/l DO is significantly higher ($p < 0.05$) than those at 5.55 and 4.68 mg/l DO after 12 and 18 h, and ammonia-N excretion of the shrimp at 3.84 mg/l DO is significantly lower ($p < 0.05$) than that at 4.68 mg/l DO after 6 h.

Frequently used as a parameter in crustacean physiology, oxygen consumption is affected not only by locomotor activity but also by other physiological activity. Increased ventilation of *Carcinus maenas* that occurred with the decrease of environmental salinity (Taylor 1977) and with the increase of water temperature (Taylor et al. 1973) resulted in increased oxygen consumption. Regulation of cardiac output to adjust crustacean oxygen consumption in response to environmental changes has previously been reviewed by Mangum and Towle (1979). In the present study, the oxygen consumption of *P. chinensis* decreased with decreased DO levels from 6.60 to 4.68 mg/l, but increased with decreased DO levels from 4.68 to 3.84 mg/l; moreover, ammonia-N excretion decreased along with the decrease of DO levels from 6.60 to 3.84 mg/l. The fact that oxygen consumption of *P. chinensis* at 3.84 mg/l DO was significantly higher than that at 4.68 mg/l suggests an increase of ventilation and an increase of cardiac output under hypoxic condition; this was also found in *Cancer magister* (McMahon et al. 1979).

The present study indicated that ammonia-N excretion was the lowest in *P. chinensis* juveniles exposed to 3.84 mg/l DO after 6 h. Haberfield et al. (1975) observed in *Carcinus maenas* an increase in nitrogen excretion, mainly ammonia as salinity decreased. Lei et al. (1989) stated that ammonia-N excretion of *P. monodon* decreased, as salinity increased in the range of 15-35 ppt. However, we do not know whether low DO levels causes a shift from ammonotelic to ureotilic excretory patterns in penaeids.

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# 不同溶氧對中國對蝦耗氧與排氨態氮之影響

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於鹽度30ppt，水溫25°C，將中國對蝦幼蝦(0.346±0.065克)暴露於6.60到3.84毫克／升不同溶氧下經過6、12及18小時，以在溶氧3.84毫克／升之耗氧率最高，爲0.671毫克／克／小時，排氨－氮率最小，爲35微克／克／小時。水中之溶氧降至5.55毫克／升及3.84毫克／升，經過12小時及6小時後使中國對蝦之耗氧率與排氨－氮率顯著減少($p<0.05$)。

**關鍵詞**：中國對蝦、溶氧、呼吸、氨排泄。