

Effect of water temperature on the survival and growth of endobenthic *Holothuria scabra* (Echinodermata: Holothuroidea) juveniles reared in outdoor ponds

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Abstract

The present work analyzes data from Madagascar Holothurie Société Anonyme to determine the effect of water temperature on the survival and growth of *Holothuria scabra* juveniles in ponds, and tests a system for heating pond water during the cold season (April–August). Our study shows that while water temperature does not affect the survival of endobenthic juveniles of *H. scabra* it greatly affects their growth. We strongly recommend using a system to shade farming ponds during the hot season (September–March), and a water heating system such as greenhouses during the cold season.

Introduction

At the Madagascar Holothurie Société Anonyme (MHSA) farm in Belaza (Eeckhaut et al. 2008), juvenile *Holothuria scabra* 0.8 cm long (0.03 g) were transferred from the hatchery to outdoor ponds filled with a thin layer of sediment collected from the natural environment (i.e. sea grass bed). Juveniles were reared in ponds for about two months until they reached an average size of 7 cm (15 g), and were then transferred into fenced in areas containing sea grass for mariculture.

In the ponds, several factors influenced the growth of *H. scabra* juveniles:

- food quality, which can be “artificially added” (Rasolofonirina 2004; James 1994,1999);
- photoperiod (Pitt and Duy 2004);
- season (Lavitra 2008);
- sediment quality (James 1994; Lavitra 2008); and
- rearing densities (Battaglione 1999; Pitt and Duy 2004; Lavitra 2008).

Water temperature also plays a fundamental role in the biological activities of sea cucumbers (Wolkenhauer 2008; Battaglione et al. 1999; Mercier et al. 1999; Purcell and Kirby, 2005).

This paper analyzes the data recorded at MHSA (from December 2008 to October 2009) in order to determine the effect of water temperature on the survival and growth of *H. scabra* juveniles, and presents an adequate water heating system for the farming ponds during the cold season.

Material and methods

Pre-growth of H. scabra at MHSA

Juveniles were transferred from the hatchery to the outdoor ponds in Belaza (23 km south of Toliara) when they were two to three months old (larval stage included), 0.8 cm in length, and 0.03 g in weight. The ponds were concrete and measured 8 m long by 4 m wide (32 m²). Each pond was filled with a thin layer of sediment collected from the sea grass bed. The water was changed weekly while the sediments were retained throughout the two-month farming period (i.e. they were not discarded). Parameters potentially affecting the survival and growth of *H. scabra* juveniles were monitored from December 2008 to October 2009 in the farming ponds. These parameters were surveyed daily (at 3:00 pm) and the monthly average calculated.

Effect of water temperature on the survival and growth of H. scabra juveniles

In order to survey the effect of water temperature on the survival and growth of *H. scabra* juveniles, only trials with the same farming conditions were considered for the analysis:

- water salinity: $33 \pm 0.6\text{‰}$
- initial rearing density: 700 individuals pond⁻¹ (22 individuals m⁻²)
- sediment volume : 0.6 m² (covering 2 cm depth)

In total, 16 trials (from 5 December 2008 to 5 October 2009) were analyzed and were regrouped within

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three temperature levels: T1 ($28 \pm 0.6^\circ\text{C}$: 5 trials), T2 ($30 \pm 0.2^\circ\text{C}$: 3 trials) and T3 ($31 \pm 0.3^\circ\text{C}$: 8 trials). Towards the end of the first farming cycle (one month), the number of juveniles in each pond was counted, their average weight calculated, and the yields obtained for each temperature level were compared.

Heating water systems during the cold season

During the cold season, a greenhouse system made from a plastic sheath made and stretched with a frame (Fig. 1) was installed in each pond. In order to determine the effects on the production yield, two ponds were used (with and without greenhouse). Water temperature was surveyed daily and the yield obtained after the farming period compared. This experiment lasted 39 days (from 15 June 2009 to 23 May 2009).

Results

Temperature and salinity in the farming ponds

The water temperature in the farming ponds was generally high (more than 26°C) during the whole year (Fig. 2A). From September to March (hot season), the water temperature was above 30°C and remained below 30°C from April to August (the cold season). Salinity remained stable and averaged 34‰ (Fig. 2B), except in March 2009 (32‰) when it was lower due to a cyclone and associated rains.

Effect of water temperature on the survival and growth of *H. scabra* juveniles

The results show that water temperature did not effect the survival of *H. scabra* endobenthic juveniles ($p = 0.156$). After one month of farming, survival rates were 94, 97 and 92, respectively, for the water temperatures 28°C , 30°C and 31°C . However, juvenile growth rates were highly influenced by water temperature. A significant difference was observed between 28°C and 31°C ($p = 0.005$). Growth rates were $0.09 \pm 0.05 \text{ g d}^{-1}$, $0.193 \pm 0.053 \text{ g d}^{-1}$ et $0.379 \pm 0.168 \text{ g d}^{-1}$, respectively, for 28°C , 30°C and 31°C (Fig. 3). The growth of *H. scabra* juveniles is exponentially related to water temperature and is statistically significant ($p < 0.001$). The higher the temperature, the greater the growth (Fig. 4).



Figure 1. Outdoor ponds with greenhouse.

Effect of the greenhouse

Water temperature in the pond with a greenhouse reached $30.8 \pm 1^\circ\text{C}$ (3.1°C of increase; $p = 0.0001$), and was $27.7 \pm 0.7^\circ\text{C}$ in the pond without a greenhouse. At the beginning, *H. scabra* juveniles weighed 0.03 g. After 39 days of farming, the average weight of juveniles was $9.9 \pm 6.5 \text{ g}$ in ponds with a greenhouse, and $3.7 \pm 1.6 \text{ g}$ in ponds without a greenhouse (Table 1).

Discussion

Our study shows that water temperature does not affect the survival of endobenthic juveniles of *H. scabra*. However, it has a predominant effect on their growth. In general, high temperatures (above 30°C) favor greater growth. Nevertheless, the growth and the biological activities of holothurians might decrease under excessive temperatures (Renbo and Yuan 2004; Xiyin et al. 2004). An experiment conducted at MHSA in December 2008 showed that juvenile *H. scabra* survived at 39°C water temperature, above which they became weak, and die at 41°C (unpublished data). Thus, during the hot season, it is strongly recommended to shade farming ponds (Renbo and Yuan 2004; Xiyin et al. 2004; Lavitra 2008) and to use a heating system in the cold season (present work). This knowledge of the effect of water temperature on the survival and growth of *H. scabra* juveniles is very important in order to

Table 1. Water temperature, growth and survival rates of farmed juvenile *Holothuria scabra*.

Ponds	Average temperature ($^\circ\text{C}$)	Initial weight (g)	Final weight (g)	Growth rate (g d^{-1})	Initial number	Final number	Survival rate (%)
With greenhouse	30.82 ± 1.04	0.03	9.94 ± 6.51	0.254	700	629	89.43
Without greenhouse	27.67 ± 0.75	0.03	3.74 ± 1.64	0.095	700	654	93.43

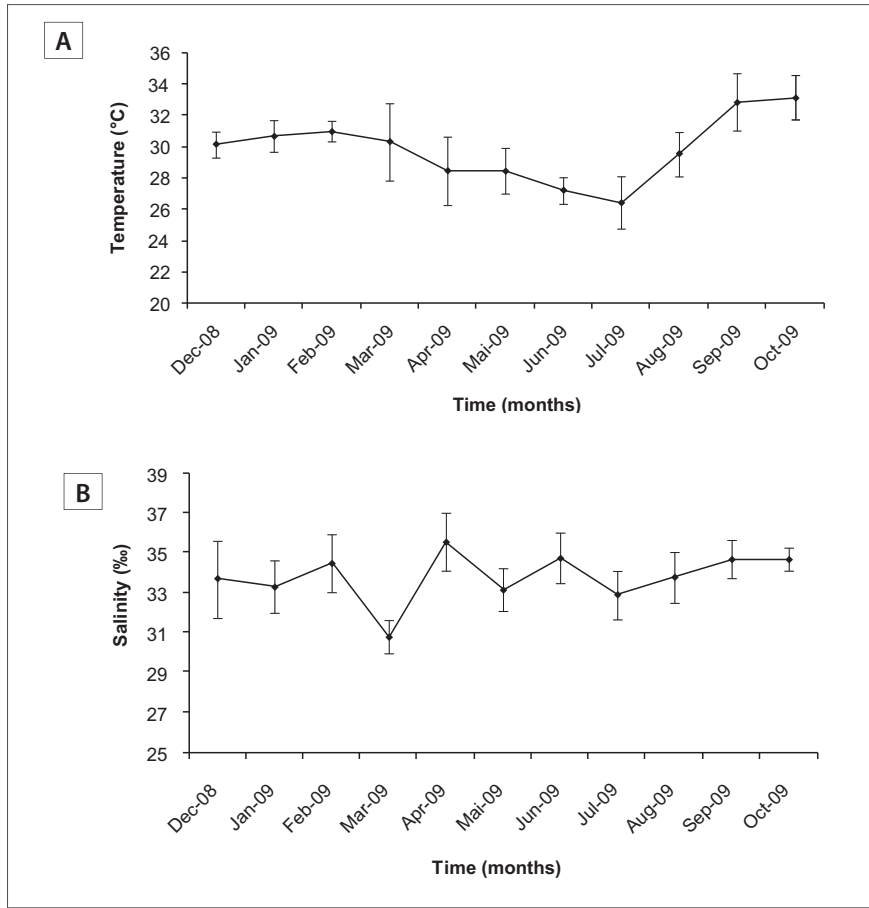


Figure 2. Monthly variations of water temperature (A) and salinity (B) in the outdoor ponds at Belaza. Vertical lines represent standard deviations.

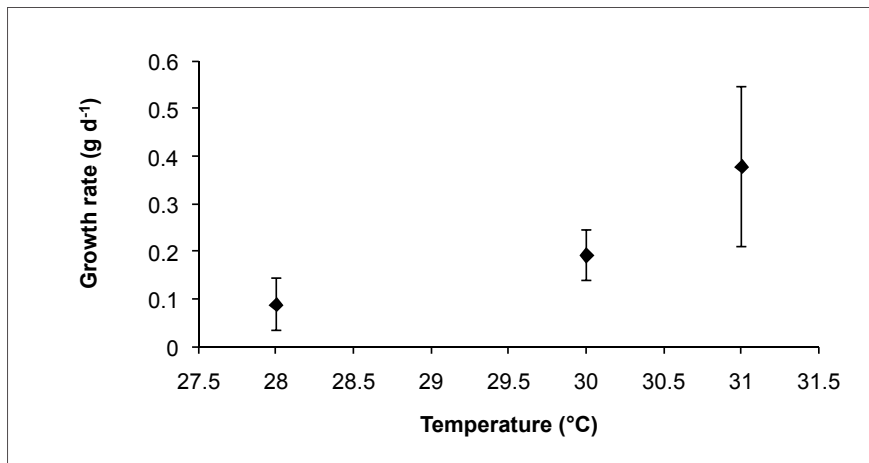


Figure 3. Growth rate of *H. scabra* endobenthic juveniles according to water temperature. Vertical lines represent standard deviations.

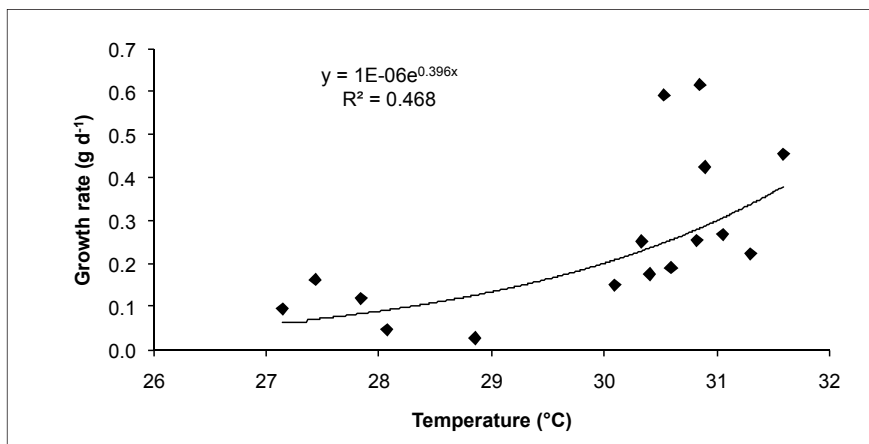


Figure 4. Relationship between temperature and growth rate of endobenthic juveniles of *H. scabra*.

develop mariculture in other regions or countries in the future.

The effect of water temperature on the growth of *H. scabra* juveniles may be related to the animal's feeding behavior. When the water temperature was increased to more than 30°C, *H. scabra* changed their usual burying cycle and remained on the surface (Mercier et al. 2000). When water temperature was reduced, sea cucumbers buried into the sediment for long periods (Purcell and Kirby 2005), which reduced the animal's time spent feeding (Wolkenhauer 2008). The effect of water temperature on feeding behavior has been observed in sea cucumbers in general (Li 1990), and in some echinoderm species (Thompson and Riddle 2005). Besides feeding behavior, the rapid growth of *H. scabra* juveniles at high temperatures might also be explained by the abundance of phytobenthos in the farming ponds during this period, as they constitute their main food (Uthicke 1999; Uthicke 2001; Pitt and Duy 2004; Taddei 2006).

Aknowledgements

The authors thank Madagascar Holothurie Société Anonyme and Blue Ventures for their technical, logistical and financial assistance.

References

- Battaglione S.C. 1999. Culture of tropical sea cucumber for stock restoration and enhancement. Naga, the ICLARM Quarterly 22(4):4–11.
- Battaglione S.C., Seymour J.E. and Ramofafia C. 1999. Survival and growth of cultured juvenile sea cucumbers, *Holothuria scabra*. Aquaculture 178 (3/4):293–322.
- Eeckhaut I., Lavitra T., Rasolofonirina R., Rabenevanana M.W., Gildas P. and Jangoux M. 2008. Madagascar Holothurie SA: The first trade company based on sea cucumber aquaculture in Madagascar. SPC Beche-de-mer Information Bulletin 28:22–23.
- James D.B. 1994. A review of the hatchery and culture practices in Japan and China with special reference to possibilities of culturing holothurians in India. Central Marine Fisheries Research Institute Bulletin 46:63–65.
- James D.B. 1999. Hatchery and culture technology for the sea cucumber, *Holothuria scabra* Jaeger, in India. Naga, The ICLARM Quarterly 22 (4):12–18.
- Lavitra T. 2008. Caractérisation, contrôle et optimisation des processus impliqués dans le développement post-métamorphique de l'holothurie comestible *Holothuria scabra* (Jaeger, 1833) (Holothuroidea : Echinodermata) [Thèse], Université de Mons-Hainaut, Belgique. 166 p.
- Li X. 1990. Sea cucumber fishery in South China Sea. Ocean Fishery 6:7–9.
- Mercier A., Battaglione S.C. and Hamel J.F. 1999. Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors. Journal of Experimental Marine Biology and Ecology 239(1):125–156.
- Pitt R. and Duy N.D.Q. 2004. Breeding and rearing of the sea cucumber *Holothuria scabra* in Viet Nam. p. 333–346. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J. F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. Fisheries Technical Paper No. 463. FAO, Rome.
- Purcell S.W. and Kirby D.S. 2005. Restocking the sea cucumber *Holothuria scabra*: Sizing no-take zones through individual-based movement modelling. Fisheries Research 80:53–61.
- Rasolofonirina R. 2004. Reproduction et développement de l'holothurie comestible *Holothuria scabra* (Jaeger 1833), Holothuroidea: Echinodermata [Thèse], Université Libre de Bruxelles. 175 p.
- Renbo W. and Yuan C. 2004. Breeding and culture of the sea cucumber *Apostichopus japonicus*, Liao. p. 277–286. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. Fisheries Technical Paper No. 463. Rome, FAO.
- Taddei D. 2006. Transfert de matière et d'énergie dans les sédiments d'un complexe récifal anthropisé (Ile de la Réunion, Océan Indien). [Thèse] Université de la Réunion, U.F.R. Sciences et Technologies. 229 p.
- Thompson B.A.W. and Riddle M.J. 2005. Bioturbation behaviour of the spatangoid urchin *Abatus ingens* in Antarctic marine sediments. Marine Ecology Progress Series 290:135–143.
- Uthicke S. 1999. Sediment bioturbation and impact of feeding activity of *Holothuria* (*Halodeima*) *atra* and *Stichopus chloronotus*, two sediment feeding holothurians, at Lizard Island, Great Barrier Reef. Bulletin of Marine Science 64:129–141.
- Uthicke S. 2001. Interactions between sediment-feeders and microalgae on coral reefs: grazing losses versus production enhancement. Marine Ecology Progress Series 210:125–138.
- Wolkenhauer S.M. 2008. Burying and feeding activity of adult *Holothuria scabra* (Echinodermata: Holothuroidea) in a controlled environment. SPC Beche-de-mer Information Bulletin 27:25–28.
- Xiyin L., Guanghui Z., Qiang Z., Liang W. and Benxue G. 2004. Studies on hatchery techniques of the sea cucumber, *Apostichopus japonicus*. p. 287–295. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. Fisheries Technical Paper No. 463. Rome, FAO.