Social and sexual promiscuity in the pygmy seahorse, *Hippocampus denise*

Richard Smith[1], Alexandra Grutter[1] and Ian Tibbetts[1]

[1] School of Biological Sciences, The University of Queensland, Brisbane, QLD. Australia.

Introduction

Denise's pygmy seahorse, *Hippocampus denise* (Lourie and Randall, 2003), is a diminutive hippocampid fish reaching a maximum standard length of 24 mm. They live in an obligate association with at least eight genera of tropical gorgonian corals. Individuals appear not to move between gorgonians as adults and remain resident in small mixed sex groups (Smith et al., 2012).

Like other seahorses, pygmies are paternal brooders and males brood the developing young in a specially adapted abdominal pouch (Smith and Tibbetts, 2008). Male seahorses are only able to receive a clutch of eggs from one female at a time as the opening to the pouch is sealed following egg transfer (Foster and Vincent, 2004). Females, however, continuously mature ovarian follicles, which suggests that they might have the potential to mate more frequently, despite this never having been observed (Masonjones and Lewis, 2000). Strict monogamy, has thus far been recorded among all hippocampids.

This study explores the influence of social and ecological factors on the mating system of *H. denise*. Constantly changing social and environmental conditions may drive plasticity of their mating systems, as flexible behavioural responses should be favoured in variable environments. As one of the smallest hippocampids, which differs considerably from larger congeners, *H. denise* offers the chance to test theories of syngnathid mating systems.

Materials and methods

The study was conducted off the small island of Onemobaa, in the Tukangbesi region of southeast Sulawesi, Indonesia. The density of *Hippocampus denise* in this area is low (0.0059 m^{-2}) (Smith et al., 2012), but groups were located at sites with easy access from shore.

Upon finding a group:

- number of *H. denise* present on the gorgonian recorded.
- sex established from a magnified digital image of the urogenital pore, which is slit-like in males and a raised circular pore in females (Smith et al. 2012).

Seahorses are unusual in that both sexes can easily be identified as having mated (Fig. 1). This allows mated pairs to be easily identified, even if mating was not directly observed.

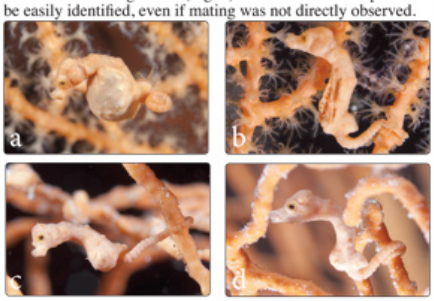

Fig. 1. Change in trunk size of *Hippocampus denise* individuals before and after birth and mating, used to identify mated pairs. Male prior to (a) and after (b) birth and female immediately prior to (c) and following egg transfer (d).

Prior to data collection:

- a series of familiarisation dives totalling 3 h were conducted by the observers to familiarise themselves with each group.
- the small size of these fish precluded physical tagging of individuals, individuals were instead identified by colour, tubercle prominence and relative size.

Fig. 2. Observations conducted on SCUBA.

Focal behavioural observations:

- lasted 30 min each.
- carried out on SCUBA (Fig. 2).
- conducted from dawn until dusk and with one night dive per seahorse group, to establish if any nocturnal activity occurs.
- seahorses did not respond noticably to our presence.

Data recorded during observation periods:

- reproductive state.
- various social, competitive and reproductive behaviours.

Results

Reproductive behaviours were recorded for four seahorse groups, involving a total of 18 adult seahorses (9 male : 9 female). Observations were carried out for a total of 217 thirty minute observation periods, over 99 study days.

Male gestation lasted 11-12 days. Birth was directly observed on three occasions, just before sunrise. The number of offspring estimated (by the first author and an additional observer) was between 6-16 for the three births. Juveniles were dark in colour and born in a curled position. They quickly assumed an adult-like posture whilst floating in the current, resembling miniature adult pygmy seahorses, measuring approximately 3 mm SL.

Following the birth, males returned to their partner and began courtship, remating within 30 min of the birth. The loss of mass from the female's trunk was clearly visible following a copulatory rise (Fig. 3).

Fig. 3. Mating *Hippocampus denise*. Female (left) swollen with eggs and male (right) showing stretch marks having given birth 15 mintes before.

Mating system plasticity within groups of *H. denise* was observed (Fig. 4).

- Group A (3 male : 1 female) - a stable sequential polyandrous pairing of the female (A4) was observed with two males (A1 & A2).
- All other reproductively active seahorses mated monogamously for the duration of their cohabitation on the gorgonian, totalling six full pregnancy cycles and five partial ones.
- There was one incidence of mate switching following the disappearance of the male's original mate.

At dusk each day, seahorses were observed to meet at the same location on their gorgonian host. Here, social behaviours were conducted and this area was termed the core area. After sunset, the group became inactive until first light, when they separated.

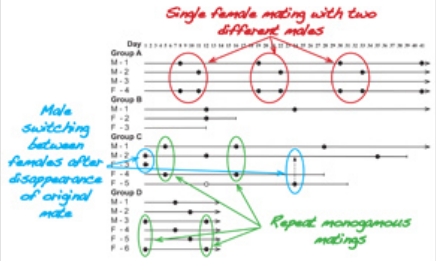

Fig. 4. Residency periods of adult seahorses in focal groups, showing birth and egg transfer events. — indicate presence of seahorses; →indicate seahorses to be present beyond the duration of the study period, —|indicate that the seahorse was no longer found on the gorgonian after this day. ● located along the lines indicate, in the case of males, birth, and females, egg transfer.○ indicates eggs voided after hydration, which did not result in male pregnancy.¦ indicates egg transfer following the voided clutch. F, female, M, male.

Conclusions

For the first time in a seahorse species, sequential polyandry has been identified. This was observed under conditions of high male to female ratio, and occurred without an increase in interbrood interval. Despite significant research focus on congeners, a polygamous mating system has yet to be identified in other hippocampids (Kvarnemo et al., 2000).

Sequential monogamy was the most frequently observed mating system in the present study and while both partners were present, mate switching was not observed. Monogamy is likely to be favoured when a female is able to maximise reproductive output (fecundity) through a single mating, suggesting that perhaps fewer or lower quality eggs are produced when mating polyandrously.

The reproductive ecology of H. denise *appears to favour the maximisation of reproductive output*, which is evident from early maturation, reduced inter-brood interval and mating system plasticity.

Mating system plasticity in *H. denise* may be interpreted as a bet hedging strategy aimed at maximising the reproductive output of a short-lived species in an unstable environment where the sex ratio of individuals is unpredictable.

Core areas are seemingly vital arenas for the social interactions of *H. denise*, providing a location where pairs conduct daily greetings and reproductive behaviours. Shared core area use provides sufficient opportunity for the female to gauge the commitment of both males to reproduction in polyandry and for synchronisation of the female's reproductive cycle with both males.

Extremes in nature can provide an exception to the rule. *H. denise* ecology appears to have favoured the evolution of plastic mating systems and maximisation of reproductive output. The small size, skewing of sex ratios and density of individuals on hosts are likely to have been the drivers of change in this case.

Fig. 5. Male *Hippocampus denise* in the process of giving birth to a brood of young.

References

Foster, S. J. & Vincent, A. C. J. (2004). Life history and ecology of seahorses: implications for conservation and management. *Journal of Fish Biology* **65**, 1-61.

Lourie, S. A. & Randall, J. E. (2003). A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific. *Zoological Studies* **42**, 284-291.

Kvarnemo, C., Moore, G. I., Jones, A. G., Nelson, W. S. & Avise, J. C. (2000). Monogamous pair bonds and mate switching in the Western Australian seahorse *Hippocampus subelongatus*. *Journal of Evolutionary Biology* **13**, 882-888.

Masonjones, H. D. & Lewis, S. M. (2000). Differences in potential reproductive rates of male and female seahorses related to courtship roles. *Animal Behaviour* **59**, 11-20.

Smith, R. E. & Tibbetts, I. R. (2008). Mating and birth of Denise's pygmy seahorses (*Hippocampus denise*) observed in the wild. *Coral Reefs* **27**, 617-617.

Smith, R. E, Grutter, A.S. & Tibbetts, I. R. (2012). Extreme habitat specialisation and population structure of two gorgonian-associated pygmy seahorses. *Marine Ecology Progress Series* **444**, 195-206.

Acknowledgments

We are extremely grateful to the management and staff of Wakatobi Dive Resort for their generosity and support of this project, particularly L. Mader, W. Brown, Y. Alfian, G. Tione and I. Rante. Without their financial support, enthusiasm and invaluable field assistance this study would not have been possible.