

Ecological Studies on Two *Amphiprion* Species in Maldivian Coral Reefs

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Abstract: *Amphiprion clarkii* and *A. nigripes* were found in coral reefs of three different atolls in the Maldives. *A. clarkii* was associated with five species of host anemones, but *A. nigripes* was only found in *Heteractis magnifica*. In few cases, both anemonefishes have utilized the same individual of *H. magnifica*. There was no significant correlation between the size of the anemones and the number of the inside living *Amphiprion*.

INTRODUCTION

All *Amphiprion* species are strongly depending on habitat structure and availability of certain host sea anemone species. Therefore, abundance and size of sea anemones are controlling the size of anemonefish populations (Richardson EBF 1999 and references herein) [1]. The Maldivian fauna has a relatively poor number of *Amphiprion* species. Just *A. clarkii* (Bennett, 1830), *A. nigripes* Regan, 1908 and *A. sebae*, Bleeker 1853 exist (Fautin WAM 1992) [2]. The latter is the only associated with *Stichodactyla haddoni* (Saville-Kent, 1893) which lives on sand and therefore was not observed in the present study. In Papua New Guinea the highest reported anemonefish diversity with 9 species is found (Elliott MB 2001) [3]. *A. clarkii* is the most widely distributed anemonefish ranging from the western Pacific to the Persian Gulf and from Japan to Australia whereas *A. nigripes* is endemic to the Maldives and Sri Lanka in the central Indian Ocean. *A. clarkii* is the highest host specific *Amphiprion* species which can be associated with ten host anemone species. Whereas *A. nigripes* usually is associated with only one anemone (Fautin WAM 1992) [2].

In August 1998, mass bleaching of corals occurred in many coral reefs around the world (Glynn BMS 2001) [4]. This bleaching caused not only the loss of many stone and soft corals, but also many anemones disappeared (Loch Das Aquarium 2003) [5], (Hattori IR 2005) [6]. Additionally, investigations on *Amphiprion* and their host anemones in the Maldives are rare. However, there exist some studies by Loch and Loch (Das Aquarium 1999, Das Aquarium 2003) [5] [7], precise data are still lacking. Therefore, the aim of this study was to get knowledge of the current situation of anemones and their hosts 10 years after the coral reefs had been destroyed by the bleaching process.

MATERIALS AND METHODOLOGY

Throughout the 'Expedition of Maldives 2007' in 24 different transects of North Male Atoll, Rasdhoo Atoll, Ari Atoll and South Male Atoll 173 host anemones were studied in March 2007 (Fig. 1). Observations were made on coral reefs using SCUBA, between a water depth of 1 and 15 m and in a

length of 70 m for each transect. The following parameters were considered: species of *Amphiprion*, species of anemone, size of the anemone, water depth (in strata of 1 – 4.9 m, 5 – 9.9 m, and 10 -15 m), number of adult *Amphiprion*, number of juvenile *Amphiprion* (3 size classes), and number of host anemone per 1,000 m² (with reference to Chadwick JMBA 2005) [8]. The size of an anemone was determined by measuring the lengths between the tentacle tips on both the long and short axes. The size, to the nearest 5 cm, was calculated by the formula of: long length x short length x $\pi/4$ (Hirose Galaxea 1985) [9].

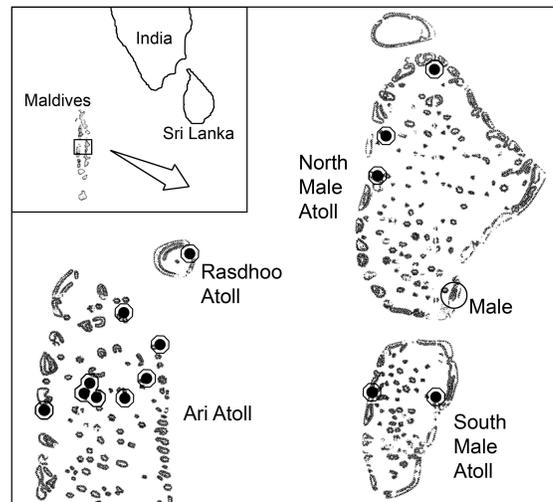


Fig. (1). Map showing the position of study sites at Maldives. Circle: start and end point of expedition; filled circles: investigated coral reefs with transects.

RESULTS

Host Anemones

In the studied area of the Maldivian coral reefs, five species of host anemones were found: *Cryptodendrum adhesivum* Klunzinger, 1877, *Entacmaea quadricolor* (Rüppel and Leuchart, 1828), *Heteractis aurora* (Quoy and Gaimard, 1833), *Heteractis magnifica* (Quoy and Gaimard, 1833), and *Stichodactyla mertensii* (Brandt, 1835). Each of them was at least harboured by one individual of *Amphiprion*. No 'vacant' anemones could be observed. The density of anemones within one transect varied between 0.5 and 11.4 per 1,000 m², with a mean of 3.1.

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A special case was observed at the island of Kandholud-hoo (Ari-Atoll, N4°00,221' E 72° 52,153'). A dense field of *Heteractis magnifica* was found all associated with *Amphiprion nigripes*. A number of 58 individuals of anemones were counted at a water depth of 3.5 to 11.5 m and in an area of 10.5 to 5.5 m. This represents a density of about one anemone per square meter.

There was no significant correlation between the size of the anemones and the water depth (Pearson's correlation analysis: *H. aurora* $r = 0.206$, *H. magnifica* $r = 0.058$, and *S. mertensii* $r = 0.182$). The number of *C. adhesivum* and *E. quadricolor* was too low for the statistical analysis.

Amphiprion clarkii (Bennett, 1830)

In 80 % of the observations, two adult animals were present in one anemone. In 17 %, one adult and in 3 %, no adult could be found. The number of juveniles in one anemone varied between zero and nine, with a mean of 2.2. *Amphiprion clarkii* could be observed in 5 different species of host anemones. Most of the fish were in an association with *Heteractis aurora* (39 %) and *Stichodactyla mertensii* (35 %). The other hosts were *Entacmaea quadricolor* (17 %), *Heteractis magnifica* (6 %) and *Cryptodendrum adhesivum* (3 %) (Fig. 2). There was a correlation between the size of the anemone and the number of *A. clarkii* living in, however, it was not highly significant (Pearson's correlation analysis: $r = 0.313$).

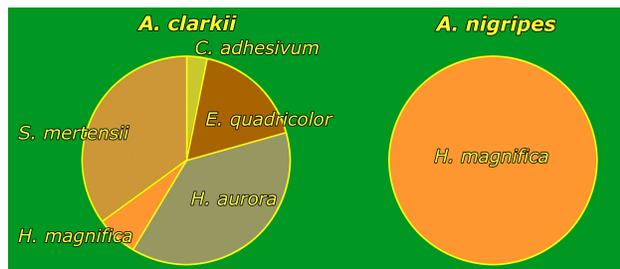


Fig. (2). Percentage of host anemones harbouring *Amphiprion clarkii* and *A. nigripes*, respectively.

Amphiprion nigripes Regan, 1908

In 99 % of the observations, two adult *A. nigripes* were seen in one anemone. In one small *H. magnifica* (80 cm²) only one juvenile was present. The number of juveniles in one anemone varied from zero to seven, with a mean of 1.3. *Amphiprion nigripes* was only found to be associated with the anemone *Heteractis magnifica* (110 observations) (Fig. 2). There was no significant correlation between the size of the anemone and the number of fish living in (Pearson's correlation analysis: $r = 0.176$).

The depth distribution of anemones, which utilized by *A. nigripes*, showed also no clear differences at the different depth strata. At 1 – 4.9 m, 5 – 9.9 m, and 10 -15 m; 36 %, 19 %, and 45 % of the anemones were observed, respectively.

Amphiprion clarkii and *A. nigripes*

In three cases (1.7 % of total observations), both species of *Amphiprion* were utilizing the same host sea anemone. The anemones were always *Heteractis magnifica* (Fig. 3). In case number one, 1 adult *A. clarkii* was observed with 2 adult, 1 juvenile size 3, and 2 juveniles size 2 of *A. nigripes*

in an anemone of 1,250 cm² at 15 m water depth. In case number two, 1 adult *A. clarkii* was observed with 2 adult, 1 juvenile size 3, and 1 juvenile size 2 of *A. nigripes* in an anemone of 940 cm² at a depth of 14.8 m. In case number three, 1 adult *A. clarkii* was found with 1 juvenile size 3 of *A. nigripes* in an anemone of 310 cm² at a depth of 14.5 m.



Fig. (3). *Amphiprion clarkii* and *A. nigripes* utilizing the same host anemone (*Heteractis magnifica*).

DISCUSSION

In the Maldives, a third species of *Amphiprion*, *A. sebae* with the host anemone *Stichodactyla haddoni*, is indicated (Fautin WAM 1992) [2]. However, as only coral reefs were investigated in the current study, this anemone was not detected because it lives only on sandy bottoms (Fautin WAM 1992) [2]. Also the elsewhere widely distributed anemone *Heteractis crispa* (Ehrenberg, 1834) was not found during the investigation. The latter species was severely affected by the coral bleaching of 1997/98 and has disappeared from many locations (Loch Das Aquarium 2003) [5]. No data are available for the density of host anemones in the Maldives before and after the coral bleaching. Loch and Loch (Das Aquarium 2003) [5] reported that most of *H. magnifica* and other anemone species had died because of the bleaching (without giving any concrete data). Worldwide the density of host anemones in coral reefs is widely different and varies between two anemones in Okinawa, Japan to 500 per 1,000 m² in Solidary Island, Australia (Hattori JJI 1991) [10], (Richardson EBF 1999) [1]. In anemone colonies a high density can be reached. Fricke (ZT 1979) [11] found at the Aldabra Atoll a field of 198 single host anemones, covering an area 6 by 3.5 m, which means 9,428 anemones per 1,000 m².

The distribution density of both species of *Amphiprion* in the present study showed that they do not have any depth preference, at least within the investigated depth range (1 to 15 m). Richardson (EBF 1999) [1] reported from Australia that the distribution of *Amphiprion latezonatus* showed a significant correlation with the depth, but *Amphiprion akin-dynos* in the same area did not show.

In *Heteractis crispa*, Hattori (JE 2006) [12] found that the sizes of anemones were positively correlated with their water depth in Japan. However, in the present investigation, the size of the three most common host anemones showed a very weak correlation with the water depth.

A utilization of one host anemone by two species of *Amphiprion* was previously reported by Hattori (EBF 1995, JAE

2002) [13] [14] from southern Japan and by Loch and Loch (Das Aquarium 1999, Das Aquarium 2003) [5] [7] from the Maldives. In Japan, *A. clarkii* and *A. perideraion* were found together in *Heteractis crispa*. This combination was quite common and found in 32.5 % of the observations. In the Maldives, *A. clarkii* and *A. nigripes* were found together in *Heteractis magnifica* and also in *Stichodactyla mertensii*. The latter combination is the first report, where *A. nigripes* is associated with an anemone other than *H. magnifica*. Loch and Loch (Das Aquarium 2003) [7] showed photographs and inform about *S. mertensii* which is harbouring an adult pair of *A. nigripes* and three juveniles of *A. clarkii*. This observation was made in 1997 when the coral bleaching had already started; that means that there was a scarcity of anemones.

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