

Acoustic tag retention of the Mediterranean slipper lobster *Scyllarides latus* (Latreille, 1802) in the Azores

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Moulting, growth and retention of externally attached acoustic tags were studied in ten Mediterranean slipper lobsters, *Scyllarides latus* (Latreille, 1802). Animals were kept in a cage at 20 m depth in Faial Island, Azores, over a period of nine months. No negative effects of tag attachment on moult or behaviour were detected, but a negative effect on growth cannot be excluded. Moulting was correlated with ambient water temperature and resulted in an increase of approximately 7% in mean size and 17% in mean weight. The results demonstrate that the use of externally attached acoustic transmitters in this species is adequate for medium-term movement studies but not for longer-term annual studies, due to the rate of molting.

Key words: acoustic telemetry, behaviour, cage, moult, weight

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INTRODUCTION

The Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1802), is present in the Mediterranean Sea and the eastern Atlantic from the coast of Portugal to Senegal, including the archipelagos of the Azores, Madeira, Canaries and Cape Verde. Mediterranean populations are highly overexploited (Spanier & Lavalli 1998, 2006; Lavalli & Spanier 2007 and references therein). In the Azores, local populations also showed signs of decline: a progressive reduction in abundances and percentage of larger, mature individuals over 1 kg in weight (Martins 1985), led to the establishment of catch restrictions (closed season from May 1 to August 31, minimum landing size of 77 mm carapace length, and bag limits (i.e. two crustaceans per spearfisher/day) in the Azores in the late 1980's. Nevertheless, these measures have not been successfully implemented, and the decline in local populations has apparently continued ever

since. Alternative measures could include the establishment of marine protected areas that could protect the spawning biomass. The effectiveness of such measure seems highly facilitated by the supposed spatial behaviour of the Mediterranean slipper lobster, given that the species is known to aggregate, including throughout the spawning season (Spanier 1994; Spanier et al. 1988, 1990; Spanier & Lavalli 1998), and there is also evidence for site-fidelity from mark-and-recapture studies (e.g. Spanier et al. 1988; Bianchini et al. 2001).

In the Azores, the Mediterranean slipper lobster is known to aggregate in highly exposed coastal and offshore reefs over shallow depths during the summer spawning season. The lobsters start to migrate to deeper waters in October, returning to shallower waters during May (Martins 1985). Spanier et al. (1980) and Spanier & Lavalli (1998) suggest that inter-annual site fidelity and aggregation in shallow waters (~20 m) in the Mediterranean is probably due to a

shortage of natural rocky habitats that supply shelter. However, those habitats are not limited in Azores, which supports the alternative hypothesis of inter-annual site fidelity to shallow spawning areas. The Mediterranean slipper lobster has been studied in the laboratory (e.g. Martins 1985; Spanier et al. 1991; Spanier & Almog-Shtayer 1992; Barshaw & Spanier 1994) and via visual marking in the wild (e.g. Spanier et al. 1988; Bianchini et al. 2001), but testing such alternative hypothesis requires an adequate methodology.

Acoustic telemetry is increasingly used to study movement patterns, migrations, activity and habitat use of marine fauna, including some lobsters and further crustaceans (e.g. Hines et al. 1995; Kelly 1999; Mills et al. 2000; Brousseau et al. 2004; Cowan et al. 2007; Hovel & Lowe 2007; Bertelsen & Hornbeck 2009), and its potential for wider applications in this group has been pointed out (Freire & González-Gurriarán 1998, Cowan et al. 2007). However, the frequent moulting of crustaceans has hampered the capacity to use this technique for long-term studies, given that transmitters are typically attached externally on the carapace.

The aim of this study was to explore the potential of passive acoustic telemetry to test the inter-annual site fidelity of slipper lobsters.

MATERIAL AND METHODS

Ten Mediterranean slipper lobsters were caught on 25 September 2008 by SCUBA at 3 to 10 m depth in the Marine Reserve of Monte da Guia, Faial Island, Azores. It was difficult to get more and further large sized lobsters because we sampled at the beginning of the migrating season and overfishing causes a gradual decline of the population, especially of larger, mature individuals.

Lobsters were measured, weighed, sexed and photographed in the laboratory (Table 1). The following measurements were taken: body weight (BW, to the nearest 0.1 g), carapace width (CW, maximum width perpendicular to median axis), carapace length from the tip of the rostrum to the posterior end of the carapace (CL) and carapace length from the posterior margin of the right eye

socket to the posterior end of the carapace (CL2). Length measurements were taken with a calliper to the nearest 1 mm. The four largest individuals were selected for acoustic tag retention studies because of anticipated lower frequency of moulting (e.g. Aiken 1980; Phillips et al. 1980).

Table 1. Characteristics of ten *Scyllarides latus*. Four animals were equipped with an acoustic transmitter dummy ("Tag"). F= female, M= male, BW= body weight (g), CL= carapace length (mm), CW= carapace width (mm), Days= Number of days from capture until moulting; dates of moult are from 2009, * from 2008.

Ind.	Tag	BW	CL	CW	Moult	
					Date	Days
1 _F	Yes	771,5	121	102	09-11*	46
2 _F	Yes	506,1	108	86	13-03	169
3 _M	Yes	560,4	112	89	01-04	189
4 _M	Yes	530,7	109	85	no moulting	
5 _F	No	382,4	94	72	13-03	169
6 _M	No	319,6	91	74	21-02	150
7 _M	No	348,3	92	76	07-01	104
8 _M	No	331,5	95	74	01-04	189
9 _M	No	282	87	71	08-02	136
10 _F	No	237,4	84	66	07-01	104
mean _M	-	395	98	78	-	153
mean _F	-	474,4	102	82	-	122

The top of the carapace was cleaned with a metal brush and wiped with ethanol. An acoustic transmitter dummy (30 x 9 mm, ~5 g, Vemco V9) was then glued to the surface with 3-minute epoxy (Fig. 1). We did not mark the lobsters visually (i.e. by punching holes in the telson), given its probable influence on their growth and health (Kulmiye & Mavuti 2005), in which case this would confound the effects of the transmitter attachment, which was the main thrust of this study. Gills of the lobsters were moisturised by covering the body with wet towels during the laboratory procedure. All individuals were released right after the treatment into a cylindrical cage (18 m³) moored on the bottom at 20 m depth in the Monte da Guia Reserve. Crevices and hollows between twelve small boulders and four old car tires (one with a small boulder inside)

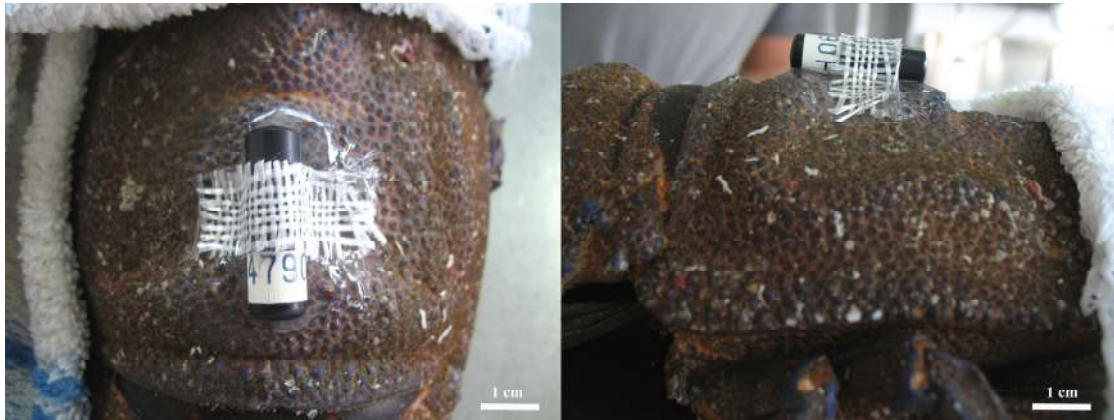


Fig. 1. Top and side view of an acoustic pinger dummy glued with epoxy on top of the carapace of the Mediterranean slipper lobster *Scyllarides latus*.



Fig. 2. *Scyllarides latus* inside its shelter (a used car tire, with one boulder inside) during feeding with limpets.

served as potential shelters inside the cage (Fig. 2). Lobsters were monitored and fed with fish and limpets about once a week, depending on weather conditions, over a period of nine months.

Individual moults were identified by size, sex, biofouling, and photographs. The date of moult was calculated as the mean between the two consecutive dives before and after the moulting event. Water temperature was monitored in the vicinity at 30 m depth at a permanent station with a data logger at the Monte da Guia Reserve and taken at the cage during each dive with a dive computer. The individuals were recovered from the cage on the 24 June 2009, measured, weighed, tagged with T-bar anchor tags (Hallprint Pty Ltd.) and released by SCUBA close to the original site of capture for future monitoring. We shaped the plastic part of the tag to have conical tips as per Spanier & Barshaw (1993) and implanted it between the 3rd and 4th abdominal segment, halfway between the midline and the right edge.

RESULTS

Four female and six male slipper lobsters ranging from 84 to 121 mm in size (CL) were studied (Table 1). The size-to-weight linear relationship was $BW = 11.3876 \times CL - 716.7763$ ($n = 6$) for males and $BW = 18.26 \times CL - 1418.6$ ($n = 4$) for females. Carapace width was correlated to BW and CL (Spearman's rho (ρ) = 0.9118583, $p < 0.01$, $n = 10$).

Lobsters were nearly always inside the shelter during winter, and we did not see an obvious

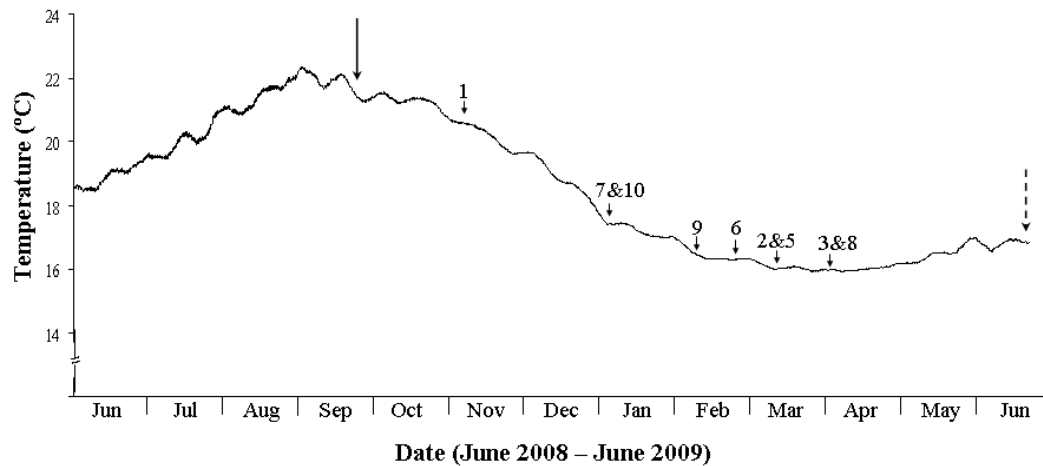


Fig. 3. Sub-surface (30 m) water temperature (weekly average) at the Monte da Guia Marine Reserve over the study period. Solid arrow indicates initial capture of slipper lobsters. Dashed arrow marks date of release to the wild. Numbered arrows indicate the moulting events of nine individuals.

difference between behaviour during dives in the morning, afternoon, and at dusk during this period. They sheltered under boulders and within the tires and typically aggregated with two to five individuals in one den. The tire with a boulder inside (Fig. 2) was permanently occupied by a minimum of three individuals whereas other tires were typically empty. From April onwards, the lobsters increased their activity, and we observed them feeding frequently outside the shelter or barely hidden under boulders and clinging on the top of the cage during daytime.

All acoustic tags dummies were retained on the carapace until moulting. Nine of ten lobsters

moulted after a minimum period of 46 days and a maximum of 189 days between November 2008 and April 2009 (Table 1). No individual moulted twice. There was a strong negative correlation ($\rho = -0.847$, $p < 0.01$, $n = 9$) between the days-to-moult and water temperature. Temperature was highest in autumn 2008 when placing the slipper lobsters into the cage (21-22 °C) and dropped to about 16 °C from February until the end of May 2009, before rising again (Fig. 3). Two thirds of the individuals moulted during the coldest months, and only one specimen (# 1) moulted above 20 °C.

Table 2. Pre- and postmoult measurements, increments (Δ) and mean (*italic*, \pm SE) for four female *Scyllarides latus* kept in a bottom cage at 20 m over 9 month. BW= body weight (g), CL= carapace length (mm).

Premoult		Postmoult		Increment	
BW (g)	CL (mm)	BW (g)	CL (mm)	Δ BW (g)	Δ CL (mm)
771,5	121	841,2	122	9	0,8
506,1	108	606,4	113	19,8	4,6
382,4	94	461,2	104	20,6	10,6
237,4	84	341,8	95	44	13,1
<i>474.4 \pm 113.2</i>	<i>102 \pm 8.1</i>	<i>562.7 \pm 107.5</i>	<i>109 \pm 6.5</i>	<i>23.4 \pm 7.4</i>	<i>7.3 \pm 2.8</i>

Mean postmoult lobsters body weight (\pm SE) was 456.1 ± 30.2 g for males and 562.7 ± 107.5 g for females. Mean CL (\pm SE), was 106 ± 2.3 mm for males and 109 ± 6.5 mm for females. We were able to individually track the four females based on clear differences in size and weight. They showed positive increments in weight (10-44%) and size (0.8-13.1%) after moult (Table 2), which were negatively correlated to the initial measurements of each individual: larger/heavier females gained less size/weight with moult (Kendall's tau (τ) for BW and CL: $\rho = -1.0$, $p < 0.05$, $n = 4$).

The two largest females carried bright orange eggs when recovered from the cage in June 2009.

DISCUSSION

Our results indicate that acoustic telemetry can be used to study the movements and habitat use of Mediterranean slipper lobster, but is limited in temporal scale to the typical period between consecutive moulting events, which appears to be annual for medium sized animals.

All acoustic dummy tags were retained until moulting, and there was no evidence for influences on the feeding behaviour, activity, moulting, or shelter preference between tagged and untagged individuals. Analyses of the exuviae did not reveal any penetration of epoxy through the carapace. One specimen (# 4) did not moult and still carried the acoustic tag after nine months. Thus, long-term data about migration and return in subsequent years can be collected if no moult occurs. However, we observed slight abrasions of the epoxy, which might result in tag loss in extreme cases, and increased fouling on the epoxy, mainly by serpulid polychaetes, which might have a negative effect on the animal in extreme cases (Thorstad et al. 2001). Nevertheless, acoustic tags and data loggers have been successfully used in other lobster species (e.g. Cowen et al. 2007) and similar approaches are applicable for short- to medium-term studies of the slipper lobster in the Azores. Ninety percent of the lobsters in our study moulted within less than a year, and thus testing interannual site fidelity via passive acoustic telemetry is likely to fail for slipper lobsters of the size classes studied here.

The use of internal tags appears to be an alternative to overcome the acoustic transmitters shedding limitation, but transmitters available to date are too large for internal implantation in the slipper lobster. An option would be the use of internal PIT (Passive Integrated Transponder) tags to identify individuals after moulting and to monitor long-term residence at the aggregation sites. PIT tags are successfully used for this purpose in shallow aquatic habitats (e.g. Bubb et al. 2008) and aquaria but automated or diver-controlled monitoring is limited and challenging in water depths greater than 10 m.

Gregarious sheltering is a common behaviour for the Mediterranean slipper lobster (e.g. Barshaw & Spanier 1994; Spanier & Lavalli 1998) and was observed in our study as well. The tire with an additional stone inside was permanently inhabited by three to seven lobsters. Shelter was not limited, as demonstrated by frequently unoccupied tires and empty dens between stones. Noticeable, the permanently inhabited tire was also occupied by a young moray eel (*Muraena helena*, ca. 50 cm) which entered the cage and resided nearly the entire study period.

Moulting spanned over five months, but eight out of nine lobsters moulted at water temperatures of 18°C or below, and over half of these (six out of nine) occurred at the seasonal temperature minima (ca. 16°C) (Fig. 3). These results generally agree with those of Martins (1985) for captive Azorean lobsters (moulting from end of November until the end of February) and those of Spanier et al. (1988) for wild Mediterranean lobsters (moulting at the lowest water temperature, ca. $17-19^\circ\text{C}$), and support the well established notion that temperature is a triggering factor for moulting (Bianchini & Ragonese 2007 and references therein). It could also explain the migration to deeper waters in September-October, when the thermal stratification is high in the first 50 m in the Azores (Locarnini et al. 2006).

Return to shallower habitats in spring is probably also triggered by temperature to meet optimal criteria for egg and larvae development. Cowen et al. (2007) suggested that lobsters need a sufficient amount of degree-days for successful embryonic development and that migration might reduce the variation in the thermal regime that

embryos experience. In agreement, we observed egg extrusion in June, analogous to earlier studies in the Azores (Saldanha 1979; Martins 1985).

Information about the growth of the Mediterranean slipper lobster is scarce, and the most comprehensive work was done by Bianchini et al. (2001) and Bianchini & Ragonese (2007). In concordance with their studies, we found that the lighter and smaller the individual, the larger was the increase in weight and size. Our sampling design did not account for testing the influence of acoustic transmitters on growth increment, but we believe the observed pattern is an effect of the initial size rather than of tag attachment on the two largest females. Body weight and CL2 of lobsters in our study fit well the weight/length relationship previously estimated for captivity female slipper lobsters in the Azores ($BW = 0.0065 \times CL2^{2.58}$, Martins 1985). According to Bianchini et al. (2001), it is possible to estimate the age of the Mediterranean slipper lobster as a function of CL. Based on his results, our lobsters were approximately seven to nine years old at the beginning of the study. Mediterranean specimens seem to be lighter/smaller than Atlantic ones (e.g. Spanier & Lavalli 1998) and thus this estimation is probably overestimated.

In summary, our results indicate that the use of acoustic telemetry to study the movements and habitat use of Mediterranean slipper lobster is limited to short-to medium-term studies between consecutive moulting events. This conclusion applies to small to medium sized animals. Given that large size spawners such as those captured in the seminal work of Saldanha (1979) are increasingly rare in the region, alternative methods should be applied to devise well informed spatial management schemes of the present-time population.

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