OCCURRENCE OF *PANULIRUS ARGUS* (LATREILLE, 1804) (DECAPODA, PALINURIDAE) IN THE NORTHWEST ISLANDS OF THE CAPE VERDE ARCHIPELAGO (CENTRAL-EAST ATLANTIC)

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ABSTRACT

Panulirus argus is herein reported from the Cape Verde Islands for the first time. In May 2002 and February 2005, local lobster fishermen captured two specimens at depths of 20-40 m. Other occurrences of this species during the last 15-20 years suggest that a permanent population of *P. argus* is established in the Cape Verde Archipelago. Two invasion theories (ship ballast mediation and dispersal during the larval phase) and two possible source populations (Brazil and the Caribbean) are proposed, and discussed in view of oceanic currents.

RESUMO

A presença de *Panulirus argus* nas ilhas de Cabo Verde é referida pela primeira vez. Em Maio de 2002 e Fevereiro de 2005, dois exemplares foram capturados por pescadores locais, a profundidades de 20-40 metros. A ocorrência desta espécie nos últimos 15 a 20 anos sugere a existência de uma população permanente de *P. argus* no Arquipélago de Cabo Verde. São propostas duas teorias para explicar a ocorrência desta população (transporte de larvas na água de lastro dos navios e por correntes oceânicas), e sugeridas duas possíveis populações de origem (Brasil e Caraíbas).

INTRODUCTION

Panulirus argus (Latreille, 1804) occurs in the western Atlantic between 35°N and 23°S, from Bermuda and the east coast of the U.S.A. at North Carolina, down to the coast of Rio de Janeiro, Brazil, including the Gulf of Mexico and the Caribbean Sea (fig. 1) (Holthuis, 1991). Sarver et al. (1998), using electrophoretic analysis, have recognized two genetic forms of *P. argus* and have recommended

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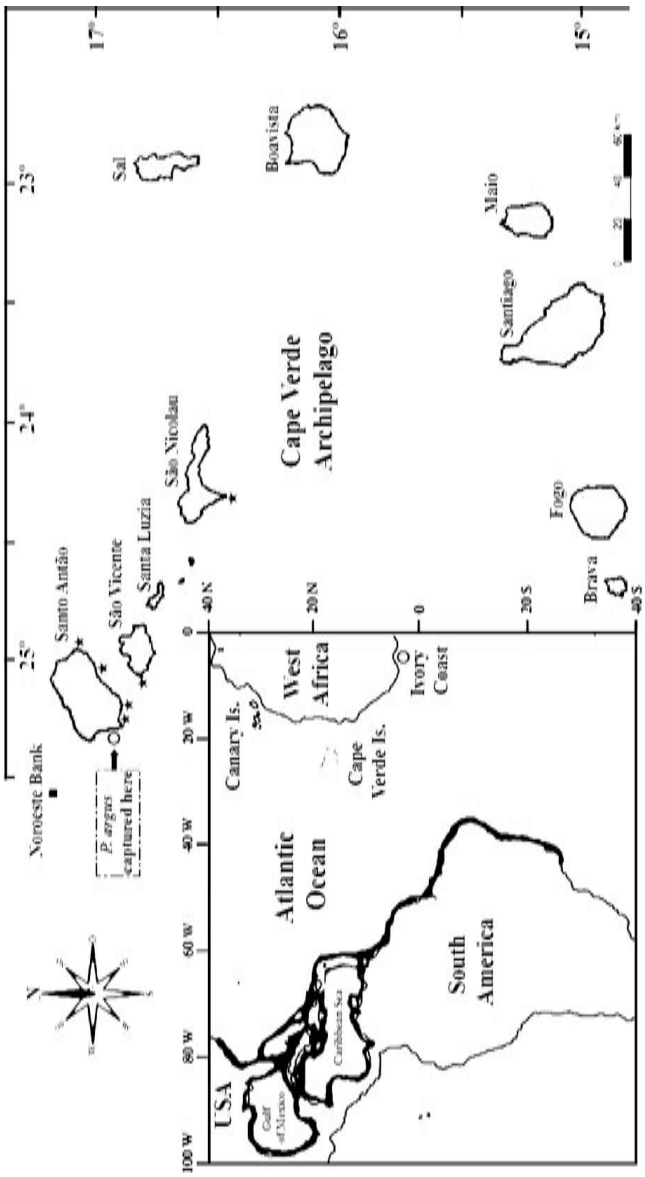

Fig. 1. Maps showing the *Panulirus argus* (Latreille, 1804) distributions in the western Atlantic (smaller map) and eastern Atlantic (larger map), adapted from Holthuis (1991). Symbols: ■, Northwest Bank; ○, position of *P. argus* captures in Cape Verde and Ivory Coast; ★, other additional areas were *P. argus* has been reported by Cape Verdean SCUBA fishermen.

provisional subspecific status: *P. argus argus* (Caribbean) and *P. argus westonii* (Brazil), until a formal taxonomic revision can be made.

There are other notes of occurrence for *P. argus* on the African coast: two different locations off the Ivory Coast (open circle in fig. 1) in September and December 1964 (Marchal, 1968; Fischer et al., 1981), suggesting that palinurid larvae from Florida, Bermuda, or Brazil may have crossed the Atlantic Ocean (Silberman et al., 1994). Fischer et al. (1981) assumed that this presence of *P. argus* on the Ivory Coast could be intentional, unintentional, or accidental, but that there were no signs of the establishment of a West African population.

The Cape Verde Archipelago, covering 4033 km^2(land area) and composed of 10 islands and 5 islets, is located in the eastern Atlantic (14°50′-17°20′N 22°40′-25°30′W), 750 km to the west of Senegal (Menezes et al., 2004). There is a coastline of 965 km (DGMP, 1998) but the sea-surface area over depths less than 200 metres is only 5934 km^2(Bravo de Laguna, 1985). There are four species of lobsters with commercial value belonging to the families Palinuridae and Scyllaridae that occur among these islands.

Three are shallow-water species: *Scyllarides latus* (Latreille, 1802), *Panulirus regius* De Brito Capello, 1864, and *Panulirus echinatus* Smith, 1869; *Palinurus charlestoni* Forest & Postel, 1964, is endemic and is a deep-water species (Holthuis, 1991; Dias, 1992).

Occasionally, specimens of the Caribbean spiny lobster, *Panulirus argus* were found: in May 2002, a female of 79 mm carapace length (CL), was captured by SCUBA diving; in February 2005, a second individual was caught, a male with 98 mm CL. Both were found at depths between 20 and 40 m, off Santo Antão Island (open circle in fig. 1; Tarrafal de Monte Trigo Bay). The first specimen collected (fig. 2) was preserved in 96% alcohol and has been deposited in the NOAA/NMFS Systematics Laboratory, Smithsonian Institution, Washington, D.C. The second was kept frozen at the University of Algarve, Portugal for future integration in a reference collection. Both specimens were measured alive and match the original description of the species. A morphological comparison between *P. argus*, *P. regius* and *P. echinatus* does not leave any doubts about the identity of the specimens. *P. argus* shows some of its distinctive characteristics, like: tail with four conspicuous and large yellowish-white spots, one on each side of the second and the last abdominal somites; tailfan banded with a dark red or brown posterior margin (fig. 2, left); very strong frontal horns, sharp and strongly curved (fig. 2, right); *P. regius* has a uniform tailfan and short frontal horns; *P. echinatus* has only two spines on the antennal plate, while *P. argus* has four (Fischer et al., 1981; Holthuis, 1991).

An inquiry to experienced fishermen working in the area where the two specimens were found, revealed that the presence of *P. argus* has been persistent

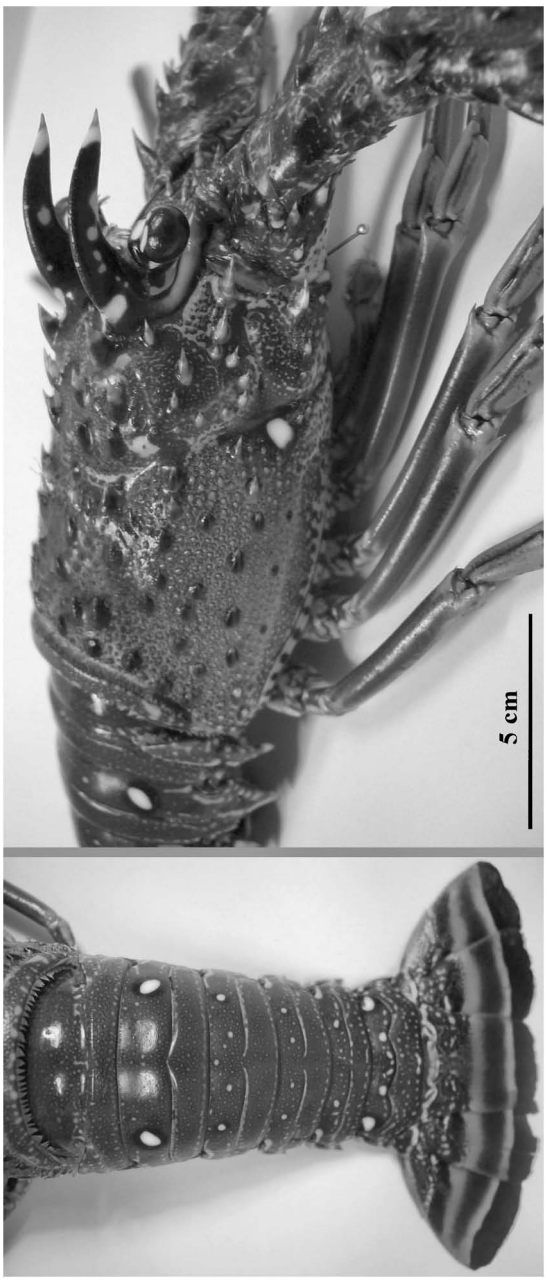

Fig. 2. Female of *Panulirus argus* (Latreille, 1804) caught off Tarrafal de Monte Trigo Bay, Santo Antão, 7 May 2002. Measurements: total length, 212.4 mm, carapace length, 79.4 mm, carapace width, 55 mm, width of fifth abdominal somite, 40 mm.

during the last 15-20 years, with a couple of individuals caught per year (fig. 1, filled star). These have been caught in three regions of Santo Antão Is. (Passo de Pau Bay, Capelinha near Porto Novo, and Lombo de Boi islet), in São Vicente Island (São Pedro lighthouse), and in São Nicolau Island (Vermelharia point).

The fact that only recently specimens of *P. argus* have been found in Cape Verde, may be the result of more scientific work developed in this region, and not an indicator of recent colonization by this species. Several decapod crustaceans had been reported for the first time from the Cape Verde Islands in these last years: *Enoplometopus antillensis* Lütken, 1865 (Nephropidae) and *Rhynchocinetes rigens* Gordon, 1936 (Caridea) (ct. Wirtz et al., 1988); caridean shrimps (Wirtz & d'Udekem-d'Acoz, 2001), and *Enoplometopus callistus* Intés & Le Loeuff, 1970 (cf. Merino & Lindley, 2003).

Two theories were formulated to explain the presence of *P. argus* in Cape Verde, based on two different invasion processes: ship ballast-mediated invasion and larval-dispersal invasions.

INVASION PROCESSES

Ballast-mediated invasion

Over 80% of the world's commodities are moved through shipping (IMO, 2005). Ships also carry water as a ballast (Tavares & Amouroux, 2003) resulting in 3 to 5 billion tonnes of ballast water transported internationally each year; it is estimated that at least 7000 different species are carried in ships' ballast tanks around the world (IMO, 2005). Ballast water is widely known to be an effective vector for the introduction of aquatic organisms (Ruiz et al., 2000), as was demonstrated by Tavares & Amouroux (2003) for an Indo-West Pacific native crab, *Charybdis hellerii* (A. Milne-Edwards, 1861) (Decapoda, Portunidae), which colonized the western Atlantic via the Mediterranean Sea.

P. argus could have expanded eastward through ballast-mediated invasion, from the Central-West Atlantic (United States, Cuba, or Brazil) directly to the Cape Verde Is. (Porto Grande port in São Vicente Is.). Northeastern Cape Verde ports are the principal and historical entrance (São Vicente-Santo Antão canal) for international ships since the 18th century.

Larval dispersal

Recent work confirms earlier results that, in many lobster species, larvae hatch on or near the outer edge of the continental shelf, but are transported over large distances offshore (Booth & Phillips, 1994). The complex life cycle of spiny

lobsters is characterized by a protracted larval phase (the phyllosoma), which can last from several months to two years and can result in prolonged transport by ocean currents (Sims & Ingle, 1967). Pollock (1992) has suggested that palinurid larvae are capable of remaining planktonic for up to 4 years, delaying the change into puerulus, with settlement and metamorphosis triggered by environmental (rather than ontogenetic) cues. Offshore dispersal can be rapid (5.25 km/day for some lobsters) in the wind driven surface layer of the water (Herrnkind et al., 1994). Phyllosoma abundance offshore can vary widely, depending on levels of local larval production, larval behaviour, larval survival, and oceanographic conditions (Booth & Phillips, 1994). For *Panulirus argus*, the phyllosoma phase lasts over 6 months and the puerulus phase from 4 to 8 months; the larvae may or may not return to shore (Lewis, 1951; Butler & Herrnkind, 1991). Distances of 2000 km between adult populations and settlement areas have been reported, but the proportion of larvae travelling very long distances is unknown (Booth & Phillips, 1994) because natural mortality of pelagic larval stages is substantial (Phillips & Sastry, 1980). Movement of phyllosoma larvae is restricted to vertical migration (Phillips & Sastry, 1980), so ocean currents are responsible for transporting larvae: so-called Ekman transport and surface currents can explain the drift of lobster larvae (Silberman et al., 1994).

The strong current regime of the tropical western North Atlantic (20-80 cm s^{-1} in the Caribbean basin and average velocities of 150 cm s^{-1} in the Gulf Stream) (Silberman et al., 1994), can transport the larvae of *P. argus* over a long distance and allow settlement far from the original spawning populations. Another hypothesis could be that they travel a shorter distance, from the lower Caribbean to Cape Verde, through the eddies, gyres, and counter-currents of the Caribbean Sea (Silberman et al., 1994). Thus, the North Atlantic gyre may serve to connect populations in the subtropical northwestern Atlantic (Florida and Bermuda) with populations in the south (South America and the Caribbean), either by intermediate populations in West Africa or by complete circumnavigation of larvae in the gyre (Silberman et al., 1994). In this case, the larvae would arrive with the surface current that flows north-south along the west coast of Cape Verde; this is a weak, cold current, 15 cm s^{-1}, part of the Canary Current System (east of the Azores anticyclone). When it reaches the north western African coast, it joins the northern current affected by trade winds, and the speed increases to 25 cm s^{-1}. This water mass circles the islands of Santo Antão counter-clockwise, increasing its speed to 30-35 cm s^{-1}(Almada, 1993).

The stable conditions (salinity and temperature, 22-27°C annual oscillation, low levels of suspended sediments, few pollutants and turbidity) (Almada, 1993) could allow continuous recruitment of *P. argus* phyllosoma larvae in Cape Verde, as suggested by Kanciruk & Herrnkind (1976) for the Bahamas. The presence of

red algae (*Laurencia* spp.) in Cape Verde (Prud'homme van Reine & Van den Hoek, 1990), essential for larval settlement and metamorphosis, also favours the establishment of *P. argus* pueruli.

Given the previous information, *P. argus* larvae could have been transported by ocean currents and gyre systems from the western Atlantic. The island of Santo Antão, where *P. argus* occurs, is the Cape Verdean Island closest to Bermuda (about 4300 km), the lower Caribbean (about 3700 km from Barbados Is.), and Brazil (about 2700 km from Fortaleza).

ADDITIONAL INFORMATION ON THE SPECIMENS OF *PANULIRUS ARGUS* CAUGHT IN CAPE VERDE

In Cape Verde, lobsters are caught with traps or SCUBA diving, using a gaff to extract lobsters from their dens; fishing grounds are on reefs or on the narrow island shelf, in depths of 10-50 m (Dias, 1992).

According to experienced SCUBA fishermen, the two *Panulirus argus* specimens caught about three years apart, were captured in the same den in Tarrafal de Monte Trigo Bay, Santo Antão Island. In fact, the second specimen (February 2005) was captured by request of the first author. Local fishermen confirmed they had caught 4-5 specimens per year during the last 15-20 years. *P. argus* is caught in Cape Verde from January to April, and sold together with other *Panulirus* species.

These facts led us to consider that *P. argus* is a target species in Cape Verde; even with small abundances, it is caught regularly by the fishermen, so we assume this species has settled in the northwestern islands of the Cape Verde archipelago around the Santo Antão Is. shelf, at least two decades ago.

Den occupancy by multiple species is common, and seems to be a typical and perhaps necessary condition for some species (Kanciruk, 1980). Cape Verde fishermen have observed multiple den occupancy in the den where the two specimens referred to in this work were caught, stating that they observed 5-6 *P. argus* for every 20 *P. regius*, together with a few *P. echinatus* specimens; in another den, at 40 m depth, more than 10 *P. argus* juveniles weighing about 100 g, were together with adult males and berried females. Like reported by Kanciruk (1980), local fishermen described an aggressive posture of adult *P. argus*, defending the den from diver intrusion, a behaviour not observed for *P. regius* or *P. echinatus* occurring in the same den.

FINAL REMARKS ON A CAPE VERDEAN *PANULIRUS ARGUS* POPULATION

Year-round spawning occurs in tropical waters (e.g., Venezuela), extended spawning (spring through fall) in the Bahamas, and restricted spawning (March

through June) in the Florida Keys. These variations may be caused by a physiological adjustment to differing photoperiods and temperatures (Quackenbush & Herrnkind, 1981). In north-eastern Brazil, mating begins in January and the main spawning season takes place from January to May (Soares et al., 1998). Studies on reproductive biology have shown that size distributions, breeding seasons, and size at first maturity of *Panulirus argus* also vary widely over the geographic range of the species (Chubb, 2000). Soares & Peret (1998) estimated mean size at first maturity for the *P. argus* population of Ceará (Brazil) to be 79-80 mm CL. Early maturity (or maturity at smaller sizes) for *P. argus* is associated with warmer waters (Sutcliffe, 1953) or intense fishing effort (Leocádio, 2004).

For Cape Verde *Panulirus* spp., the peak spawning is June to August (Dias, 1992) and small *P. regius* females (61.9 mm CL) or *P. echinatus* females (67.5 mm CL) are already ovigerous (Freitas et al., 2005). The female of *P. argus* caught in May 2002, with 79.4 mm CL, did not show any pleopodal setae, indicating it was an immature female. We suggest the establishment of a northwestern Cape Verdean (West Africa) deep population of *P. argus*, which makes reproductive migrations to 20-40 m on the shelf between January and April, during the same reproductive season that holds for western Atlantic *P. argus*.

According to Holthuis (1991) *P. argus* inhabits shallow waters but can occasionally be found down to 90 m depth, perhaps even deeper. Outside the season January-April, when *P. argus* is found in shallow waters, we assume it migrates to deeper water. In the same area, there is a deep-water fishery for *P. charlestoni*, operated with traps at 160-350 m (Dias, 1992) and there is no report of *P. argus* caught in this fishery. Therefore, the lower depth limit of *P. argus* in Cape Verde must be above 160 m.

We suggest further studies to determine the origin of this population of *P. argus* in the eastern Atlantic, in particular genetic studies to understand its relationship to other *P. argus*. Given the probably small size of the Cape Verde *P. argus* population, conservation measures are required for the areas where the species is already established and inquiries should be undertaken in Northeast Bank (near Santo Antão Is.), Fogo, and Brava Islands in order to find out if other populations exist in Cape Verde. Also, several of the FAO crustacean catalogues for area 34 must be updated.

The fishermen operating in the area where the two specimens referred to in this work were found, are already aware of the need to report *P. argus* occurrences, even if the specimens are not captured.

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