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A Typical Mediterranean Fishery and an Iconic Species: focus on the common Spiny Lobster (*Palinurus elephas*, Fabricius, 1787) in Corsica

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Abstract

The common spiny lobster (*Palinurus elephas*, Fabricius, 1787) is an iconic species of the Mediterranean Sea. Despite the existence of data on the artisanal fishery of *P. elephas* in the Mediterranean Sea and particularly in Corsica, knowledge on the biology and life history traits of this iconic species is still lacking. This paper identifies the main gaps in current knowledge and suggests future directions of research to answer these fundamental questions, which are currently unanswered.

Kewords: Small-scale fisheries; Mediterranean Sea; common spiny lobster; Genetic; Age; Growth; Movement; Connectivity

Introduction

The common spiny lobster (*Palinurus elephas*, Fabricius, 1787) is an iconic species of the Mediterranean Sea. This species has a wide geographic distribution spreading along the Northeast Atlantic coasts (from the south of Norway to Mauritania including the Canary Islands and the Azores) and along the Mediterranean coasts except in the extreme eastern and south-eastern basins [1]. The common spiny lobster mainly colonizes rocky bottoms associated with various coralligenous assemblages between 0 and 200m deep [2]. The movements of *P. elephas* have been reported rarely in the literature, but it is considered to be a sedentary species with a low level of mobility. The only tagging experiments, in the Atlantic and the Mediterranean (recapture rate between 5-10%), show limited movements, generally less than 5 km, even if some recaptures have been recorded more than fifty kilometers away [3,4]. However, larval stage seems to be the main way of dispersal. The maximum size reported for this species is 50 cm (total length). The lifespan of this crustacean is important, its longevity can reach a maximum age of 30 years (maximum estimated age) [5]. The age of reproduction is late for lobsters as it needs 5-6 years to become adult and sexually mature, which corresponds to an average size (Cephalothoracic Length, CL) of 86 mm for females and 76 mm for males in the Mediterranean Sea [5]. As the growth of crustaceans depends on its environment (quantity of food, pollution), estimating its age is a major challenge [6]. In fish, direct anatomical aging methods have been developed on

specific structures, e.g. otoliths or scales, that can record annual growth rings [7]. However, in crustaceans, it has been assumed that growth bands do not exist due to the loss of hard structures with the moult [8]. This moult with the loss of the hard structure has known to "trash" molecular damage. This complicates the estimation of the age of crustaceans by this method. Thus, new approaches are being developed using age pigment markers (e.g, lipofuscin) to more precisely determine the age of crustaceans [9].

P. elephas has a particularly long larval stage in the Western Mediterranean basin with eggs hatching in December and last larval stage recruitment (Puerulus) on coastal hard bottoms occuring in May-June. While larvae distribution during this long pelagic phase remains unknown, larval morphology (Phyllosoma) tends to show that larvae are adapted to move offshore in the whole Western Mediterranean basin. Nonetheless, periodic events (several years periodicity) of massive recruitment have been reported [10] and it could take place simultaneously throughout the basin (Corsica, Baleares, Spain Coast). This suggests that the recruitment success of Mediterranean *P. elephas* is tightly linked to large-scale oceanographic processes and therefore that the resource might be under the pressure of climate change [11].

Beyond individual characteristics, data at a population level are still scarce. Genetics have long been recognized for its usefulness in identifying the populations structure and determining connectivity [12]. The identification of the structure of exploited stocks is fundamental for sustainable management of fisheries by determining appropriate spatial units [13]. Several genetic studies, based on microsatellite analyses and mitochondrial DNA sequencing, have revealed that, instead of forming a panmictic unit, the populations of *P. elephas* formed two distinct groups corresponding to the Atlantic and the Western Mediterranean basin [14,15].

The common spiny lobster focuses on certain environmental, societal and economic interests in the Mediterranean Sea. *P. elephas* is a species which has a high commercial value and represents an important economic interest for artisanal fishing. The selling price of spiny lobster fluctuates between 50 and 100 € per kilo depending on the period of year and the type of sale (fishmongers, restaurants or individuals). Despite of this, according to the International Union for Conservation of Nature (IUCN), overexploitation by professional fishing is a major threat to the spiny lobster which has been classified as a '' Vulnerable '' species in the Red List of Threatened Species. Indeed, the spiny lobster is highly vulnerable to fishing because of its life history features including its long life and low growth rate and it was recognized that fishing pressure can induce changes in evolutionary traits such as growth rate and age at maturity [1].

Regarding fishing at the global level, common spiny lobster landings have been in decline since the 1960s despite strong interannual variability. Official capture production statistics from the FAO for *P. elephas* in Europe showed a dramatic decline from 1100 tons in 1969 to 434 tons in 2017. For more than 50 years, commercial fisheries landings have experienced a 60% drop. While *P. elephas* were traditionally fished using traps, a selective gear, these latter devices were largely replaced in the 60s and 70s by trammel nets. This change suddenly increased the fishing pressure, but also the characteristics of the exploited populations.

P. elephas is an important marine resource in the Mediterranean Sea, and particularly in Corsica. However, Corsica was not exempted from the overall downward trend of catches as production decreased from an average of 300 tons per year in the 1970s to an average of around 80 tons per year in the 2000s [16]. Yet, Corsica is considered as an area where fishing pressure is low compared to the rest of the Mediterranean [17]. The fishing activity in Corsica is artisanal and relies on a multi-specific and multigear activity fleet of 166 units spread over 4 Prud'homies (Ajaccio, Bonifacio, Bastia-Cap Corse and Balagne) in 2019.

The opening period for lobster fishing in Corsica begins March 1st and ends on September the 30th, in order to avoid the mating and spawning period (in September). Corsican regulations also require that the total net length per vessel do not exceed 5000m. The 2006 European Council regulation (EC, No 1967/2006) on professional fishing prohibits to market grained females and sets the minimum catch size for P.elephas at 90 mm CL for the European Mediterranean Sea. The fishing effort is praticed mainly on the West coast and on a zone between 0 and 3 nautical miles. The most used fishing gear currently for spiny lobster in Corsica is the trammel net (nylon or braided), generally of mesh size between 4 and 6. The duration of fishing operations is variable, usually a minimum of two days. The spatial study of fishing zones shows that the spiny lobster is distributed in a heterogeneous way in Corsica [18]. It is generally observed that the lowest Catch Per Unit of Effort (CPUE) values are between 0 and 50 m deep while the maximum values are mainly between 50 and 200 m deep [19]. Sampled individuals showed a wide spectrum of capture in the artisanal fishery, ranging from juveniles to adults, from 20 mm to 157 mm in CL [19].

Despite the existence of data on the artisanal fishery of *P. elephas* in the Mediterranean Sea and particularly in Corsica, knowledge on the biology and life history traits of this iconic species is still lacking.

It is in this context that five partners (STARESO, CRPMEM, OEC/UAC, CY, Univ-Corse-CNRS) bringing together scientists, managers and fishermen, initiated the ALIGOSTA collaborative research program. The ALIGOSTA project (2020-2023) aims to improve the state of knowledge on the biology and population structure of *P. elephas* in Corsica. More precisely, the project objectives are to:

I. Explore the opportunities and the feasibility of new direct age determination techniques, by the detection and characterization of senescence markers (e.g: lipofuscin,

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β-galactosidase, oxidative stress). Investigate the relation between the rate of cell aging and the appearance of these markers according to the stages of spiny lobster development. Compare these age estimates with "classic" growth models (e.g. Von Bertalanffy, Bhattacharya, Powell-Wetherall).

II. Estimate the size-fertility relationship, the fertile biomass and the reproductive potential of *P. elephas* around Corsica, study primary/secondary sexual characteristics, test their reliability to determine the physiological, morphological and functional maturity of the species. Study the potential modifications of evolutionary/morphological traits both at macroscopic and microscopic level and the selection processes induced by fishing pressure.

III. Improve the understanding of connectivity and population dynamics using genetic markers (e.g. microsatellites). Estimate the extent of gene flow and connectivity among populations of *P. elephas* in Corsica. Evaluate the effect of different oceanographic barriers (currents, water masses) and protection measures (e.g. Marine Protected Areas) on the population structure. Examine whether the current genetic variability of *P. elephas* is affected by the current overfishing and/or by historical factors.

IV. Estimate population parameters such as abundance, survival, recruitment and movement using Capture-Mark-Recapture (CMR) methods. Study the movement skills (e.g. home range) and identify the spatial scale of these movements using techniques such as individual external marking (e.g. spaghetti tags). These methods could help to understand individual movements and potential exchanges between populations and complement the results regarding to the population structure identified by genetic markers.

Conclusion

The goal of this project is to provide essential elements in the life history traits of this species. These data could be used as a basis for assessing the state of the stock and modeling population dynamics in order to contribute to sustainable fisheries management in Corsica. The exploitation of fish stocks with Maximum Sustainable Yield (MSY) is a predominant objective of the Common Fisheries Policy (CFP). Determining the MSY and assessing the state of the stocks in relation to this target is based on demographic models which require knowledge of many parameters of the life cycle of fish species. These parameters are used in the analysis of yield per recruit, the estimation of fertile biomass, the stock-recruitment relationship and the age distribution of catches. This project will provide local stakeholders and decision-makers with a better understanding of the role of this species in the ecosystem and predict the possible ecological consequences of various management measures and / or the impact of climate change.

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