

**OCCURRENCE AND DISTRIBUTION RANGE OF *PARABLENNIUS PILICORNIS*  
(ACTINOPTERYGII: PERCIFORMES: BLENNIIDAE)  
ALONG THE FRENCH MEDITERRANEAN COAST**

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**Background.** This study was initiated by the first observations of a coastal and benthic Atlantic fish species—*Parablennius pilicornis* (Cuvier, 1829) on the southern coasts of France. This fish has been recorded in the Mediterranean Sea since 1963, until recently colonizing its entire western part as well as the Adriatic Italian coasts. The aim of this study is to analyse and understand the dynamics of this invasion of *P. pilicornis* and to report its most recent sightings along the Provencal coast, France.

**Materials and Methods.** The data on the geographic distribution of *P. pilicornis* were either extracted from the relevant literature (majority of records) or contributed by the present authors. For the French coast, particularly the coast of Provence, the latter were data from underwater visual censuses, conducted during various studies or monitoring programs. The data were critically selected, organised, and analysed.

**Results.** Two dispersal pathways seem to have been followed by *P. pilicornis*. The first follows the coast of Morocco, Algeria, and Italy. The second pathway goes through the Spanish and French coasts. The meeting point of these two ways may be located on the coast of Provence, where we lastly observed this species in 2006. The emergence of *P. pilicornis* in the Mediterranean Sea corresponds clearly to a marginal dispersal. Colonization of the western Mediterranean took 43 years.

**Conclusion.** Since *P. pilicornis* is already present on the Italian coast of the Adriatic Sea, the colonization of the eastern Mediterranean seems imminent. Global change, including rising temperatures, seem to be a factor promoting the repartition area of this fish with tropical affinities.

**Keywords:** Atlantic migrant, marginal dispersal, fishes, Mediterranean, establishment, ringneck blenny, Blenniidae

## INTRODUCTION

Ecosystem biodiversity is being altered at a worldwide scale by species loss due to extinction from human activities and species gain through intentional and accidental introductions (Sala et al. 2000). At the regional level, species gain usually equals or outpaces the losses due to extinction, suggesting that extinctions and invasions might offset one another with little net change in diversity (Sax and Gaines 2003). However, because different processes drive extinctions and invasion (e.g., overfishing versus ballast water transport), the types of species being gained and lost might differ (Byrnes et al. 2007). The combined effect of these two processes is altering the structure of coastal marine food webs, because most extinctions occur at high trophic levels, while most invasions are by species from lower trophic levels (Byrnes et al. 2007). Thus, introductions of exotic species affect plankton, macrophytes, shellfish, and crustaceans (Galil 2007).

The Mediterranean sea is currently facing dramatic changes, including change in native species distribution

due to climatic modification (Francour et al. 1994, Bianchi 2007), harmful algal blooms linked to increasing eutrophication (Heisler et al. 2008), fishing activity (Farrugio et al. 1993), habitat fragmentation and destruction (Airoldi and Beck 2007), and non-indigenous species invasion (Galil 2008). Consequently, Mediterranean food webs are considered to be in an advanced state of ecological degradation (Coll et al. 2008).

The Mediterranean Sea is a semi-enclosed area with limited connection to two oceans: the Atlantic Ocean through the Strait of Gibraltar, and the Indian Ocean, accessed across the Red Sea through the Suez Canal, which was dug in 1869. Ben Rais Lasram and Mouillot (2009) identified the Mediterranean Sea as “the recipient of the greatest number of exotic species in the world”, with an average of one introduction every four weeks over the past five years. Zenetos et al. (2008) mention one introduction every 9 days. According Streftaris et al. (2005), the majority of these introductions are due to fouling, the release of ballast water from ships, and aquacul-

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ture. However, other authors (Briggs 2007, Ben Rais Lasram and Mouillot 2009) observe that “the introduction of fish into the Mediterranean Sea by ships is surprisingly rare and fish aquaculture-mediated introductions do not occur”. In the Mediterranean, 127 fish species are exotic, comprising 65 lessepsian immigrant species (Indo-Pacific origin) and 62 of Atlantic origin; the last studies carried out in Mediterranean record a total of 664 fish species (Ben Rais Lasram and Mouillot 2009). The introduction of fish from both the Atlantic Ocean and the Red Sea may increase the intensity of interactions between exotic and endemic fish fauna (Ben Rais Lasram and Mouillot 2009).

Although the number of lessepsian species is equivalent to the number of Atlantic species in the Mediterranean, the former has attracted a higher interest of scientists. Probably because the Mediterranean has been naturally linked to the Atlantic Ocean for a very long time, its fauna and flora are originally subjected to a strong Atlantic influence. The connection to the Red Sea is much more recent and the emergence of new lessepsian species is being actively followed (Galil 2007, 2008, Belmaker et al. 2009).

The migration through the Strait of Gibraltar has not been affected by humans. This is not true for lessepsian migrations since the building of the Suez Canal. Throughout geologic time, species range extension is a natural phenomenon that has played an important role in speciation and structure of present populations, and it cannot then be regarded as a biologic introduction induced by human activity. There is typically the case for migration by the Strait of Gibraltar.

The emergence of a species in a region where it has not been present can be made by marginal dispersal (step-wise range extension) or by remote dispersal (when there is a spatial discontinuity between its area of origin and the new area; Crisp 1958). However, periodic fluctuations at the limits of its range may occur in relation to particular climatic episodes. In the northern hemisphere, for example, species range limits can move to the north during warm episodes and to the south during cold episodes.

The current episode of global warming (largely attributed to human action) is sometimes inferred to explain the extension of geographical area of some species, and several examples of changes in limits range of fish species with Atlantic origin may be indicated in the Mediterranean: *Acanthurus monroviae* (Acanthuridae) (Hemida et al. 2004, Luiz-Júnior et al. 2004), *Pomadasys incisus* (Haemulidae) (Pastor et al. 2008), *Seriola fasciata* (Carangidae) (Massuti and Stefanescu 1993, Bradai et al. 2004, Corsini et al. 2006), *Thalassoma pavo* (Labridae) (Francour 1994), and “*Kyphosus sectator*” (= *Kyphosus saltatrix*; Kyphosidae) (Francour and Mouine 2008). Some populations can then evolve independently and allow the emergence of endemic species (speciation).

In this study we focus on a species of Blenniidae—the ringneck blenny, *Parablennius pilicornis* (Cuvier, 1829). Several studies have mentioned its presence in the Mediterranean Sea (Zander 1969, Bath 1977, Almeida et

al. 1980, Catalano et al. 1985, Mercader 1988, Nieder 1988). Nevertheless, no work to date has put together these data to understand the dynamics of sightings of this fish in the Mediterranean. We propose to conduct a global study on existing observations in the literature, as well as the observations conducted in the field.

Since its description by Cuvier in 1829 (Froese and Pauly 2010) from a specimen captured on the Brazilian coast, *Parablennius pilicornis* has been currently renamed by several naturalists (see Bath 1977). *P. pilicornis* measures about 10 cm, is omnivorous, and reported as frequenting rocky habitats down to 5–6 m of depth (Zander 1988). The species is gonochoric. Like in the majority of blenniids, the eggs are benthic and are protected by the male. A highly developed social and spawning behavior has been observed. The duration of the larval stage of this fish is about 33 days (31–37, on the average) (Beldade et al. 2007), while the egg incubation time is some 70 h at 23°C (Almeida et al. 1980).

## MATERIAL AND METHODS

The data on the geographic distribution of *Parablennius pilicornis*, used in this paper were either extracted from the relevant literature (majority of records) or contributed by the present authors from other sources, including unpublished data. For the French coast, particularly the coast of Provence, these are supplemented by data from underwater visual censuses, conducted during various studies or monitoring programs that were not necessarily focused on this blenny. The data were critically selected, organised, and analysed.

## RESULTS

The known geographic distribution of *Parablennius pilicornis* includes the western Mediterranean Sea and the eastern Atlantic Ocean, from the Bay of Biscay to South Africa (Zander 1969, 1988, Bath 1977, Almada et al. 2001). In the western Atlantic, the range of *P. pilicornis* is limited to the southern South American region, including Brazil and Patagonia (Bath 1977).

Since the first description of *P. pilicornis* by Cuvier (1829), several major faunistic surveys were performed in the Mediterranean (e.g., Canestrini 1872, Gourret 1897, Gibert 1913). They did not mention the presence of *P. pilicornis*. Similarly, several literature reviews conducted on blennies in the middle of the 20th century did not report this species (Zander 1969, 1988, Bath 1977). *P. pilicornis* has been observed for the first time in the temperate Atlantic Ocean at Hendaye in the Biscay Bay in 1957 (Bath 1977). Then it was observed near the Strait of Gibraltar at Rabat (Morocco) in 1967 (Bath 1977) and Lagos (South Portugal) in 1978 (Almeida et al. 1980; Table 1). The first observation of *P. pilicornis* in Mediterranean was made in 1963, from Algiers (Bath 1977; Table 1). In 1968, the entire Algerian coast was colonized by this species (Zander 1969, Bath 1977). Presently, *P. pilicornis* occurs on the western part of the south coast of the Mediterranean, from the Strait of Gibraltar to Annaba in Algeria (Table 1).

Table 1

Year of first observations of *Parablennius pilicornis* in the Mediterranean and some observations in the temperate eastern Atlantic Ocean

Locality	Country	Year	Reference
Hendaye (Atlantic)	France	1957	Bath 1977
Lagos (Atlantic)	Portugal	1978	Almeida <i>et al.</i> 1980
Rabat (Atlantic)	Marocco	1967	Bath 1977
Capo Negro	Marocco	1967	Bath 1977
Oran	Algeria	1968	Zander 1969
Algier	Algeria	1963	Bath 1977
Tichy	Algeria	1968	Zander 1969
Annaba	Algeria	1968	Zander 1969
Torremolinos	Spain	1967	Bath 1977
Taramay	Spain	1965	Bath 1977
Ibiza	Spain	1985	Cardona and Elices 2002
Cabrera	Spain	1992	Ballesteros pers. com.
Menorca	Spain	1995	Cardona and Elices 2002
Palamos	Spain	1986	Mercader 1988
Banyuls/mer	France	1988	Zander (unpublished)
Cap d'Agde	France	1987	Louisy pers. com.
Fos/mer	France	1994	Harmelin pers. com.
Marseille Podetta	France	1998	Harmelin pers. com.
Porquerolles	France	2006	Harmelin pers. com.
Port-Cros	France	2006	This study
Cap-Roux	France	2006	This study
Monaco	Monaco	2006	This study
Scandola	Corsica (France)	2005	This study
Palerme	Sicily (Italy)	1982	Catalano <i>et al.</i> 1985
Finale Ligure	Italy	1988	Balma <i>et al.</i> 1989
Portofino	Italy	2003	Tunesi and Molinari 2005
Porto Cesareo	Italy	2004	Dufour <i>et al.</i> 2007
Torre Guaceto	Italy	2004	Dufour <i>et al.</i> 2007
Tremiti	Italy	?	Dufour <i>et al.</i> 2007
Ravenna / Venice	Italy	2005	Santin and Willis 2007

However it also occurs throughout the northern part of the western basin of the Mediterranean, from the Strait of Gibraltar to the entire Italian coast (western Mediterranean and Adriatic), including Balears, Sardinia, Corsica, and Sicily islands. No sighting was reported in Tunisia and in the eastern basin of the Mediterranean. In Adriatic, *P. pilicornis* reaches Venice in the north-west Adriatic Sea (Table 1), but it occurs only on the Italian side of the Adriatic Sea. Despite a regular monitoring on the Croatian coast, this species has not been reported yet (Marcelo Kovačić pers. com.).

Regular and annual monitoring performed in four marine protected areas along the French coast, allowed to date precisely the time of arrival of this species at Port-Cros, Cap Roux, Monaco, and Scandola (Corsica) (Table 1).

Our observations also provide new information on the bathymetric distribution of this species. Indeed, this fish was regarded as preferentially frequenting the area between 0 and 6 m depth (Zander 1988), whereas we have observed it at the depth of 25 m at Monaco, 15 m depth at Port-Cros

and Scandola, and at very high densities on artificial reefs in Le Barcarès (Gulf of Lion) at the depth of 20 m.

## DISCUSSION

The usual difficulty of the systematics of Blenniidae can explain the high number of names synonymous with *Parablennius pilicornis* and the difficulty to identify clearly the geographic distribution of this fish. The diversified colour patterns that this fish may display during its life cycle may further increase the confusion. Four colour patterns are described:

- The standard pattern: the fish displays a light brown colour with of a series of white „H“ drawings on the body;
- The dark pattern: only for the spawning males and characterized by an almost black body; A black spot is present at the front of the dorsal fin;
- The white and black pattern: the fish displays a very clear colour, almost white; A dark brown strip runs from the eye to the base of caudal fin; A third line is present along the dorsal fin in the middle of the back. Fish exhibit-

ing this pattern may be confused with *Parablennius rouxi* (Blenniidae), which is slimmer and smaller;

- The yellow pattern: the fish has a yellow uniform body. The identification of this species makes no doubt with this pattern.

Regardless of the pattern, the species can be identified based on the presence of honeycomb pattern on the cheeks. Apart from the dark pattern that characterizes the spawning males, no particular relation with the sex of the fish has been shown for other patterns.

*Parablennius pilicornis* was originally described (Cuvier 1829) from a specimen captured in Brazil. Since then, no study could decide between its eastern Atlantic origin or a western Atlantic origin. Nevertheless, Luiz-Júnior et al. (2004) suggested that this species was an amphi-Atlantic westward migrant. Indeed, it is commonly assumed that the place of origin of a particular species is where it reaches the largest area of occurrence (Joyeux et al. 2001, Luiz-Júnior et al. 2004). For *P. pilicornis*, the largest area of occurrence is clearly in the eastern Atlantic (Bath 1977, Zander 1988, Luiz-Júnior et al. 2004). Three hypotheses would allow explaining how *P. pilicornis* reached South American coast:

- The first hypothesis is that there was one population before the opening of the Atlantic Ocean. It was separated into two distinct populations during the formation of the mid-Atlantic ridge. At some stage the populations were continuous and subsequently separated by the formation of unsuitable habitats inside their distributional range, without speciation (Luiz-Júnior et al. 2004).

- *P. pilicornis* has a planktonic larval duration of about 37 days at most (Beldade et al. 2007). With extremely favourable conditions, these larvae could cross the Atlantic Ocean. Indeed, 3000 km separate the Brazilian and African coasts with the Ascension Island and St. Peter and Paul Rocks that could serve as an intermediate relay. According to a genetic study, Carlin et al. (2003) suggested that *Rypticus saponaceus* (Serranidae) larvae can cover distances of as many as 2000 km, while the larval stage is only 30 days. Finally, the oceanographic barriers to dispersal in the tropical Atlantic Ocean are expected to be variable in their effectiveness over geological time (Rocha 2003), and the effects of stochastic climatic events on the oceanic currents (Philander 1986, Joyeux et al. 2001, Carlin et al. 2003) could promote periods of favoured dispersion alternating with periods of isolation.

- Gerhardinger et al. (2006) warned that Brazilian blennies such as *P. pilicornis* were observed inhabiting ship hulls heading to Argentina and Africa. If this species is able to cross the Atlantic in holes or fouling of boats, this could explain its presence on both sides of the Atlantic Ocean. Indeed between 16th and 19th centuries, the maritime traffic between Africa and South America was very dense, especially because of the trans-Atlantic slave trade that could cause the introduction of *P. pilicornis* in the western Atlantic.

Although the last two hypotheses seem most likely, only genetic and phylogenetic studies would allow the

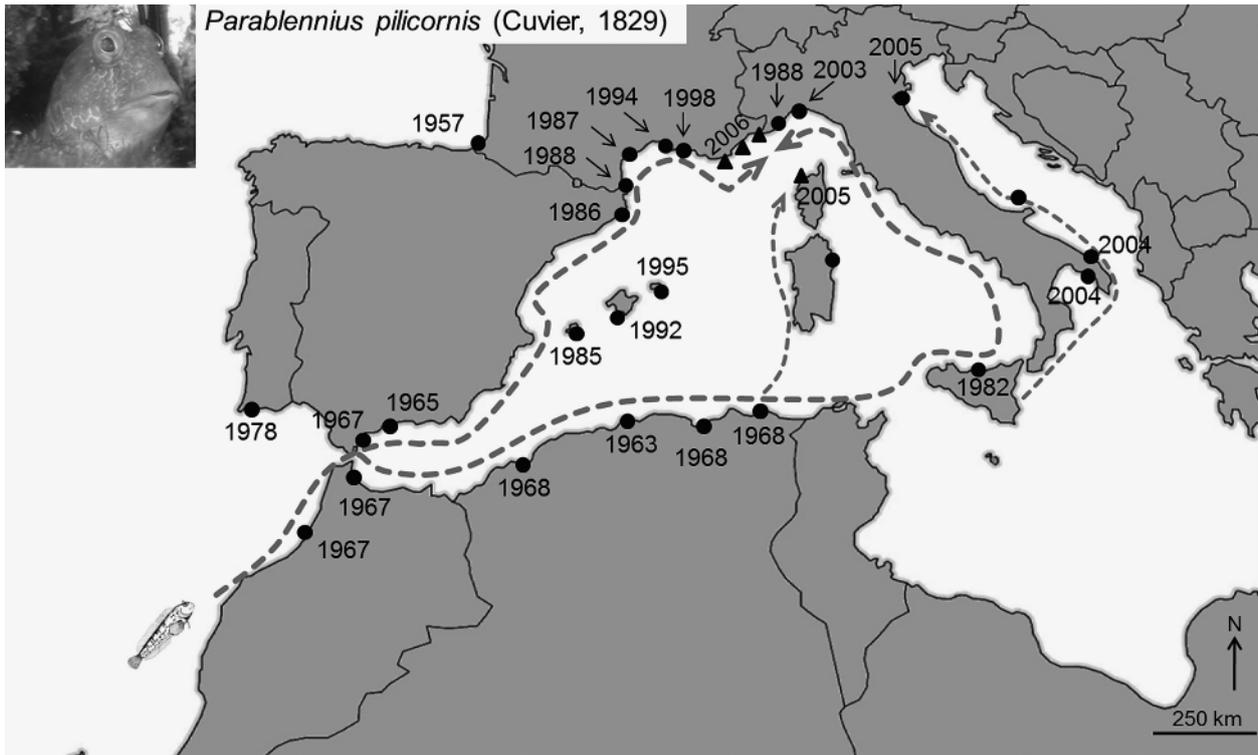
dating of the separation between *P. pilicornis* populations associated with the eastern Atlantic Ocean and the western Atlantic Ocean.

*Parablennius pilicornis* arrived in the Mediterranean Sea through the Strait of Gibraltar (Fig. 1), the first observation being made at Algiers in 1963 (Bath 1977). In 43 years, it has colonized the entire western basin of the Mediterranean Sea. However there is no information about the Tunisian coast. An inventory of blennies was conducted in 1997 (Gharred et al. 1998) using landing net and trawl as sampling tools, but no *P. pilicornis* was observed. This may be due to the inadequate sampling method of catching blennies on rocky habitats, as scuba diving is more effective to observe them.

According to available data, it appears that the colonization of the western Mediterranean followed two ways. The southern way, allowed the colonization of the coasts of Morocco, Algeria, then Sicily. Twenty years have been necessary to reach the Sicily (1600 km from the Strait of Gibraltar). This pathway was probably the starting route for the colonization of Sardinia and Corsica islands. From Sicily, the species has probably spread along the west coast of Italy up to the French border. Colonization continued from Sicily to the Adriatic Sea along the Italian coast. *P. pilicornis* have been observed during scuba diving monitoring in the marine reserves of Porto Cesareo (Ionian Sea), Torre Guaceto and Tremiti (Adriatic) (P. Guidetti; data published in Dufour et al. 2007). The northernmost observation was made near Venice (Santin and Willis 2007). The species is not yet present in Croatian waters (Marcelo Kovačić pers. com.). However, there is no doubt it will happen soon. The second pathway or northern route, allowed the colonization of Spanish and French coasts. It took more than 30 years for *P. pilicornis* to reach Marseille (1300 km from the Strait of Gibraltar) and the island of Minorca in the Balearic Islands (900 km from the Strait of Gibraltar). This pathway appears slower than the southern route, probably due to adverse currents from Gibraltar to Marseilles (Somot et al. 2006).

After observations made in Port-Cros, Cap Roux, and Monaco in 2006, this area seems to be the meeting point of these two routes. Since a monitoring on these three sites was performed each year, we are sure that *P. pilicornis* appeared in 2006 and not before. The spreading of *P. pilicornis* across the Mediterranean clearly corresponds to a marginal dispersal (Crisp 1958). Human activities have not been a direct vector in this establishment; it is therefore difficult to classify it as a biological invasion (Ruiz et al. 2000).

The dynamics of colonization of the western Mediterranean by *P. pilicornis* followed an almost perfect timing. The exception was the observation made in 1988 by Balma et al. (1989) at Finale Ligure in the Gulf of Genoa. This observation appeared too early compared to those made in Portofino in 2003 (80 km from Finale Ligure) and Monaco in 2006 (90 km from Finale Ligure), two of the nearest localities. In the study conducted in 1988, Balma et al. (1989) observed only one specimen. Moreover, the observation was conducted in the Finale



**Fig. 1.** Map of the western Mediterranean with dates of first observations of *Parablennius pilicornis*; The arrows indicate its potential dynamic of apparition in the zone; Triangles present data from this study

Ligure harbour. It is thus possible that in this case the introduction was only incidental. Indeed an introduction is only effective when the species is established. It is possible only if the entire fish life cycle can be completed, including reproduction, settlement and recruitment phases (e.g., Lodge et al. 2006). In 1988, *P. pilicornis* was present on the entire stretch from the Strait of Gibraltar to Sicily on the southern colonization route, reaching the Franco-Spanish border on the northern route. Given the ability of this fish to travel in/on the hull of ships (Gerhardinger et al. 2006), an introduction in the Finale Ligure harbour via a boat from a harbour already colonized (in Spain or in Sicily, for example) is then possible. There is no information on the future of this species in this locality. Fifteen years were needed, however, to colonize proximal areas (Monaco and Portofino), this would support our hypothesis of no establishment at that time.

We can try to explain why its arrival in the Mediterranean has begun not earlier than in the 1960s. Indeed, given the original distribution area of *P. pilicornis* in the tropical- and sub-tropical Atlantic Ocean (Bath 1977), the first possible explanation is that this species responds positively to the global change. As all other seas around the world, the Mediterranean Sea has currently been warming up. For the last 30–40 years, the temperature of the western Mediterranean Sea has been rising in its deep- (Bethoux et al. 1990) and surface waters (Diaz-Almela et al. 2007). We believe that *P. pilicornis* can now find a suitable environment in the Mediterranean Sea for its growth and expansion.

*Parablennius pilicornis* had a relatively slow dispersal in the Mediterranean. Several lessepsian immigrant species

showed high rate of dispersal; for example, *Fistularia commersonii* (Fistulariidae) have colonized the sea from east to west in less than 10 years (Dulčić et al. 2008). It is possible that the competition with other blenny species slowed down the dispersal of *P. pilicornis*. However, this species seems to benefit from the proliferation of artificial habitats. For example, on the French Catalan coast in the Gulf of Lion (Le Barcarès, France), *P. pilicornis* is the most abundant species on the newly (5 years) set up artificial reefs (Pastor unpublished data). This fish is highly opportunistic and can take advantage of new, artificial habitats that promote high densities.

The emergence of *P. pilicornis* in Mediterranean fish populations raises the question of its impact on other species of blennies, but also other small benthic fishes inhabiting rocky bottoms. Blenny inventories were very rare before the emergence of *P. pilicornis*, so it is difficult to track back its impact on the colonized ecosystems. The voracity of this fish and its strong territoriality make it a great competitor for other species from the same habitat. To answer the essential question of the response of an ecosystem to the introduction of a species, it may be possible to conduct monitoring in areas that have not been colonized yet. Croatian coast and Eastern Mediterranean can be good study sites in that regard and we think they will soon be colonized.

The first observation of a species will of course depend on the presence or absence of the species in the study site, but also on the monitoring intended to detect it. This could explain the fact that *Parablennius pilicornis* was observed in Algiers four years earlier than in the

Alboran Sea (Zander 1969, Bath 1977). This study emphasizes again the need of establishing a global monitoring activity across the Mediterranean to detect the arrival of new species in this sea. It is highly probable that in the next 10 years, we will observe the colonization of the eastern Mediterranean by *P. pilicornis*.

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