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THE CORSICA ALIEN NETWORK: A TOOL FOR MONITORING AND TRACKING MARINE EXOTIC SPECIES

Abstract
In the marine environment, the introduction of alien species, and the biological invasions that can result, constitute one of the main ecological, socio-economic and health threats. The identification of new marine exotic species in Corsica has encouraged regional partners (Office de l'Environnement de la Corse, Direction Régionale de l'Environnement, de l'Aménagement et du Logement) to extend the approach, initiated in 2003 for Caulerpale, to all alien species, by setting up, in 2015, the Corsica Alien Network (RAC). The aim of this network is to identify as early as possible any arrival of new species along the coasts of Corsica, and to monitor their spread, in order to propose appropriate management measures. A census of the available data has shown that about fifty alien species have already been reported in Corsica. Several communication tools have been developed (e.g. species descriptions, sighting report forms, etc.) and made available to inform RAC partners and the public of the presence and potential threats of these species, and to facilitate their identification. 50 observations of introduced marine species were recorded in 2017. While these observations concern mainly Caulerpa cylindracea*, which is present along almost the entire coastline, we note an increase in the presence of the invasive crab* Percnon gibbesi*. By means of regular monitoring of the areas likely to shelter it, 43 reported sightings were recorded and 124 individuals counted during the year 2017 (no individual was observed between December 2016 and May 2017), and weekly monitoring was introduced in June 2018. To facilitate the dissemination of information, the results are communicated at the end of the season to IUCN Mediterranean for integration within the MedMIS platform.*

Key-words: Monitoring, exotic species, invasive species, Corsica, *Percnon gibbesi*

Introduction
Marine biological invasions became more frequent and more widespread during the twentieth century with the increase in human activities (Streftaris *et al*., 2005; UNEP-MAP-RAC/SPA, 2011). These alien species, also known as "introduced, non-native or allochthonous species" (Otero *et al*., 2013), can cause the disappearance of native species, leading to the reduction and extinction of populations. These invasions are considered as the second leading cause of biodiversity loss after habitat destruction, and are one of the top four threats to the world's seas (PNUE-PAM-Plan Bleu, 2009).
The introduction of exotic species is a permanent phenomenon throughout the Mediterranean, although it appears to be more prevalent in the Eastern Basin, due to the proximity of the Suez Canal. In 2012, 986 exotic species were recorded in the Mediterranean sea (775 in the Eastern Basin, 249 in the Central Zone, 190 in the Adriatic Sea and 308 in the Western Basin; Zenetos *et al*., 2012). All exotic species are not problematic, but can become so when they establish populations and propagate in a new environment. In 2002, the Convention of Biological Diversity (CBD, 2002) defined an invasive alien species as "an alien species whose introduction and / or spread threatens

biological diversity". This highlights, inter alia, the need to prioritize prevention to fight the introduction of invasive alien species, both within and between countries. To this end, it is essential to detect invasive alien species as early as possible in order to take early action to prevent them from becoming permanently established.
Corsica's coastline is no exception to this problem, and for this reason in 2003, the *Office de l'Environnement de la Corse* (OEC) launched the Corsica Caulerpa Network, specifically dedicated to the monitoring of the introduced species *Caulerpa taxifolia* and *Caulerpa cylindracea*. In 2015, the observation of new alien species prompted the OEC to extend monitoring to all exotic marine species, setting up the Corsica Alien Network (RAC). This network is an original association of scientists (University of Corsica), divers (*Fédération Française d'Etudes et de Sports Sous-Marins*), trainers in environmental education (U Marinu) and Corsican stakeholders (*Direction Régionale de l'Environnement, de l'Aménagement et du Logement* & OEC). The purpose of the RAC is thus to identify as early as possible any arrival of new species along the coast of Corsica in order to alert the public to the potential threats related to these species, and to implement, if possible, management measures to restrict their negative impact on the environment or on human activities.

Materials and method

Among the numerous exotic species recorded in the Mediterranean, a first selection has been made on the basis of blacklists and available inventories, prioritizing species already observed in the Western basin, and then the focus was narrowed to species sighted along the Corsican coasts. Several communication tools have been made available for different audiences (e.g. public, recreational fishermen, divers, etc.) to facilitate the data collection, transmission of information and identification of species sighted.
A standardized form for sightings was produced for the purpose of collecting the data. This form presents essential information, such as (i) the observer's coordinates, (ii) the location of the observation, (iii) the species observed, and the manner of transmitting the data. To simplify the identification of exotic species, around twenty species identification sheets were produced and distributed in the various diving clubs of the island. Organized on the basis of the main taxonomic groups (Microalgae, Macroalgae, Ctenophora, Cnidaria, Bryozoa, Mollusca, Annelida, Crustacea, Tunicata and Pisces), they are identified by a color code and an icon. They include the scientific and common names of the species, its geographical origin and a summary of the important features: (i) identification of the species, (ii) its environment and / or way of life (substrate, depth, eating habits, behavior), (iii) invasiveness (mode of spread, hazards, potential risk), as well as significant differences from similar species (Monnier *et al*., 2017).
After receiving the forms, scientists and specialists registered within the RAC are responsible for confirming the authenticity of the sightings on the basis of photographs or samples sent in by the observers. If necessary, and if possible, the sighting is verified *in situ*. After this step, the sighting is indexed in a geographic information system (GIS), so that it can be viewed online or via Google Earth©, and shared by all the partners of the RAC. At the end of the year, all the validated data are sent to International Union for Conservation of Nature and uploaded in the Mediterranean Marine Invasive Species platform (MedMIS).
Following the increase in reported sightings of the invasive crab *Percnon gibbesi*, in 2016 (Monnier *et al*., 2017), active monitoring has been initiated, in the shallow rocky areas that constitute favorable habitats for this species. A visual inspection of these favorable

areas is performed, either with a bathyscope, or by observation by swimmers or divers (snorkeling or scuba-diving). For each sighting of *Percnon gibbesi*, the GPS coordinates of the observation, the depth, the temperature of the water, the characteristics of the specimen (size, sex) and of the habitat, are noted. In addition, following regular sightings of this crab on the East coast, monitoring has been initiated on the seawall of the harbour of Taverna, between June to October 2017, and weekly since June 2018.

Results

The sightings collected to date indicate that there are around 50 introduced marine species in Corsica. However, some old bibliographical sightings (*e.g. Sargassum muticum,* mentioned in 1992 in Diana lagoon) require confirmation. Most of the sightings are from scientists, due to the difficulty of identification of several taxonomic groups (*e.g.* micro-algae). In contrast, the sightings made by divers, in the framework of the RAC (50 reports collected in 2017), concern less than ten species, usually easy to recognise. Only 2% of these observations are not been validated due to a lack of information, 70% were validated from photographs and 20% by experts. The species sighted are: *Caulerpa cylindracea* (48%), *Percnon gibbesi* (22%), *Asparagopsis taxiformis* (16%), *Callinectes sapidus* (8%), and *Parabennius pilicornis*, *Codium fragile* & *Womersleyella setacea* (2% each).
Concerning the monitoring of *Percnon gibbesi,* 12 sites were surveyed in Corsica in 2017. No crabs were sighted until mid-May 2017, despite active surveys, notably since the end of March 2017. In the same way, in certain areas, favorable to the species and visited several times between mid-May and early October, no crabs were sighted. Overall, 43 reported sightings resulted in the observation of 124 individuals over the whole period. Most crabs are observed between the surface and 1 m depth, although some of them are found at down to 4 m depth. Each crab was sighted in a rocky environment, with dense cover of algae in the vicinity, although they are themselves positioned in unvegetated fissures. Moreover, the presence of the sea urchin *Arbacia lixula* is often noted. However, crabs seem also to be very common on the artificial substrate (concretes) of seawalls. Among the various methods of observation, the bathyscope was ineffective, but no significant differences were observed between snorkeling and scuba diving.
In 2017, the Taverna harbour seawall was noted for its impressive population of *Percnon gibbesi*, with a total of 63 individuals sighted between June and October 2017, and a maximum of 31 individuals in one survey, at the end of August. We observed an increase in the size of individuals during the observation period, and at the end of August, some juveniles are detected. In 2018, the frequency of monitoring was increased to once a week, in order to better monitor the presence of crabs along the seawall. Thus, 140 individuals, of ever-greater size, were observed between June and September 2018, with a maximum of 14 individuals in one survey at the end of July (Fig. 1). This size pattern trend is consistent with those observed the previous year, with the identification of the first juveniles at the beginning of September. Firstly, higher concentration of crabs is noted in July and August 2018, with respectively 33% and 34% of the individuals found in this season, with a peak of observations in the last two weeks of July (14 individuals observed by prospecting), while 19% of *Percnon gibbesi* were observed in September 2018, and 15% in June. Over the entire period, 53% of the individuals observed were females, and 36% were males (the sex of 11% of the specimens could not be determined). Furthermore, 82 % of the individuals observed were medium or large sized (between 2 to 3.5 cm), 8% small sized (between 1.5 and 2 cm), 6% of juveniles (< 1.5 cm) and 4% of very big (> 3.5 cm).

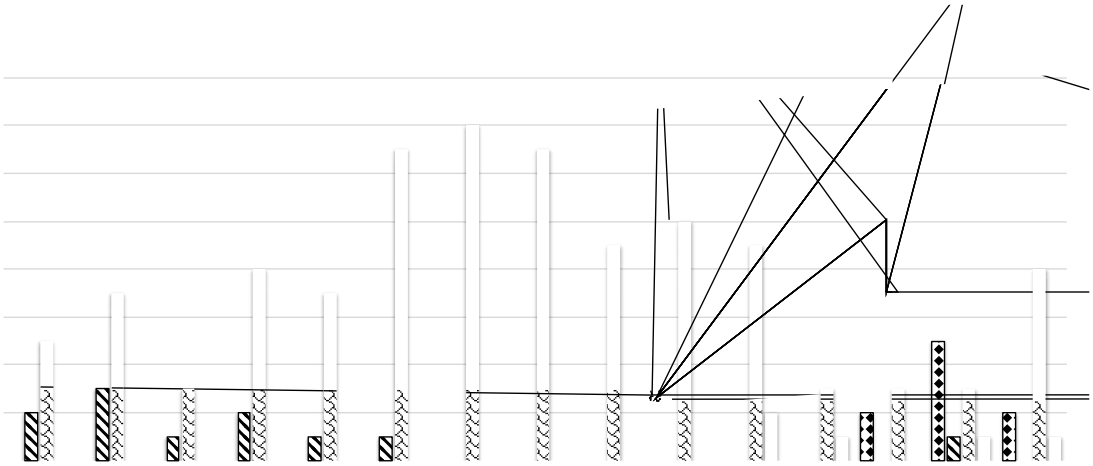

Fig. 1: Reported size / number of *Percnon gibbesi* by prospection

Discussion and conclusions

Compared to previous results (Monnier & Pergent-Martini, 2016), the number of reported sightings is rather similar in 2017. On the other hand, the species sighted differ somewhat. There was no sighting concerning *Fistularia commersonii* in 2017, although the species seems to be present along the entire coastline according to Bodilis *et al*. (2011). It is possible that the main partners of the RAC (FFESSM diving clubs) are not the best observers for this species; moreover, its resemblance to the Orphie *Belone belone* can lead observers to confuse them. The same remark is probably true for most of the fish species. For the species *Caulerpa cylindracea*, as in 2016 (Monnier *et al*., 2017), new sectors were surveyed, resulting in new reported sightings, which confirms the presence of the species on the whole of the Corsican coastline. The second most frequently reported species is the Crustacean *Percnon gibbesi*. While in 2015, the species was reported only at Balagne and the Gulf of Ajaccio (Monnier *et al*., 2017), it is present today at Cap Corse, on the east coast (Bastia, Taverna harbour) and in the south-east of Corsica (from Favona to Santa Gjulia), demonstrating a rapid spread along the Corsican coasts. It would seem, therefore, that the spread of the species along the Corsican coasts has been rapid. Sightings doubled in 2016 compared to previous years, and increased fourfold in 2017. Finally, the geographical distribution of these sightings proves that *Percnon gibbesi* has already colonized much of the coastline. The attempt to monitor this crab in 2017 resulted in a lack of sightings when the water temperature was less than 20°C. Landeira & Lozano-Soldevilla (2018) underline in their study the absence of larvae in February in the Canary Islands. It is likely that climate change plays an important role in the dispersal of the species (Felix Hackradt *et al*., 2010). We noted an increase in the number and size of crabs in phase with an increase in the temperature of the water. Similarly, an increase in the number of individuals was demonstrated during the summer of 2005 in the Gulf of Messiniakos (Greece), as well as a significant decline during the winter of 2005-2006 (Thessalou-Legaki *et al*., 2006). This decrease in the winter population may support the hypothesis that water too cold for *Percnon gibbesi* would influence its development. Moreover, before spreading throughout the Mediterranean, this species extended preferentially to areas with the warmest

temperatures, and was therefore absent from colder areas, which may indicate a need for higher temperatures in order to survive (Katsanevakis *et al*., 2011). We also note the absence of *Percnon gibbesi* at certain sites with conditions favorable to its presence. Knowing that a large number of species have developed behavioral strategies to minimize the exposure of larval stages to stressful conditions (Ji *et al*., 2010), and that *Percnon gibbesi* shows a preference for the high temperatures of subtropical seas (Manning & Holthuis, 1981), it is possible that the cold water in Corsica in winter prevents its total establishment. In 2018, monitoring revealed a decline in the number of individuals per survey, with a maximum reached in 2018 of 14 crabs, compared to 31 in 2017. This difference observed in the same area could be explained by the peak of very late cold conditions, observed in Corsica on 27 February 2018, as well as the lack of sunshine and snowfalls in the plains (Météo-France, 2018). Since this crustacean prefers waters between 16°C and 31°C (Galil, 2011), it is possible that the late increase of temperatures that year caused a delay in its propagation and a limited colonization. In general, the annual cycle of temperate decapod larvae has two peaks in abundance, one in spring and the other in summer (Pan *et al*., 2011). If we were not able to observe the juveniles in spring, the second breeding season was not however delayed because in both cases, juveniles were reported over the same periods (28 August 2017 and 7 September 2018). The only difference concerns the presence of very large crabs in September 2018 that were not be detected in 2017. Nevertheless, several other factors may be involved in larval release, such as temperature, phytoplankton proliferation, daylight duration and tides (Shirley & Shirley, 1989; Starr *et al*., 1990; Anastasia, 2008), and the little data concerning this species in its new biotope does not offer a sufficient basis for drawing any firm conclusions. It would be necessary to carry out more precise monitoring of both the patterns of change in the water temperature and the presence of crabs in order to verify these hypotheses.

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