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MASSIVE SETTLEMENTS OF THE ALIEN OYSTER *ISOGNOMON BICOLOR*, RAPIDLY SPREADING IN MEDITERRANEAN

INSEDIAMENTI MASSIVI DELL'OSTRICA ALIENA ISOGNOMON BICOLOR*, IN RAPIDA DIFFUSIONE NEL MEDITERRANEO*

Abstract - *This paper reports updated records of the tropical West Atlantic oyster* Isognomon bicolor *from the Tyrrhenian coasts of Sicily, together with first data on its population density and biomass in the Gulf of Milazzo. Hard bottom samplings carried out facing the wastes of the local industrial pole, showed very high values of densities (421±294 specimens/400cm^2) and biomasses (163±103 g) from 0 to 1.5 m of depth, demonstrating a high invasive potential. Evidence of a possible competition with the naturalized Lessepesian mussel* Brachidontes pharaonis *have been also reported.*

Key-words*: Invasive species, spreading, biomass, population density, Mediterranean Sea.*

Introduction - The colonization of the Mediterranean Sea by the tropical genus *Isognomon* [Lightfoot], 1786, has a complex and controversial history that began with an isolated report of *I. ephippium* (Linnaeus, 1758) from Israel (Mienis, 2004). In the same area, starting from the record of a single shell assigned to the Indo-Pacific *I. legumen* (Gmelin, 1791), the westward spreading of this oyster has been thwarted by repeated misidentifications, e.g., with the co-occurring *Malleus regula* (Forsskål in Niebuhr, 1775) (Crocetta, 2018).
Only recently, conclusive molecular investigations clarified that all Mediterranean reports of *I. legumen*, as well as of other congeneric Indo-pacific taxa, belong to the western Atlantic *I. bicolor* (C.B. Adams, 1845) (Garzia *et al*., 2023). This small oyster (Fig. 1A), which initially settled in the eastern Mediterranean, has spread westward in accordance with the sea surface circulation, rapidly reaching the Ionian coasts of Sicily (Fig. 1B). Between 2020 and 2021, records from both Calabrian and Sicilian Tyrrhenian coasts testified the ingression of the species in the western Mediterranean through the Strait of Messina (Garzia *et al*., 2023) (Fig. 1C).
The aim of this paper was to report on the recent spreading of this invasive species, and to present the first available data on the density and biomass of a population in the Gulf of Milazzo (north-eastern Sicily).

Materials and methods - To verify the presence and spread of *I. bicolor* along Sicilian and Calabrian Tyrrhenian coasts, a survey was carried out in 12 coastal sites, in each of which *I. bicolor* populations were found (Tab. 1). Particularly, the population living in Milazzo, a highly impacted area of North-Eastern Sicily (D'Alessandro *et al.,* 2016), was investigated to evaluate *I. bicolor* density and biomass. At this scope, hard bottom quantitative samplings have been carried out in December 2022, facing the wastes of the local industrial pole. Three stations have been considered, named W (westernmost), C (central), and E (easternmost). Each station included two replicates, one facing the waste and one in the open sea. For each replicate, a 20X20 cm hard bottom surface was accurately scraped, and all material directly stored in a 0.5 mm mesh net. Samples were rapidly transferred in laboratory, where they were frozen at -20°C. As soon as possible, the collected macrofauna was sorted under stereomicroscope, and mollusks were determined at the species level and counted.

Fresh undecalcified biomass of *I. bicolor* and of other most abundant species was evaluated (approximation ±0.5 g).

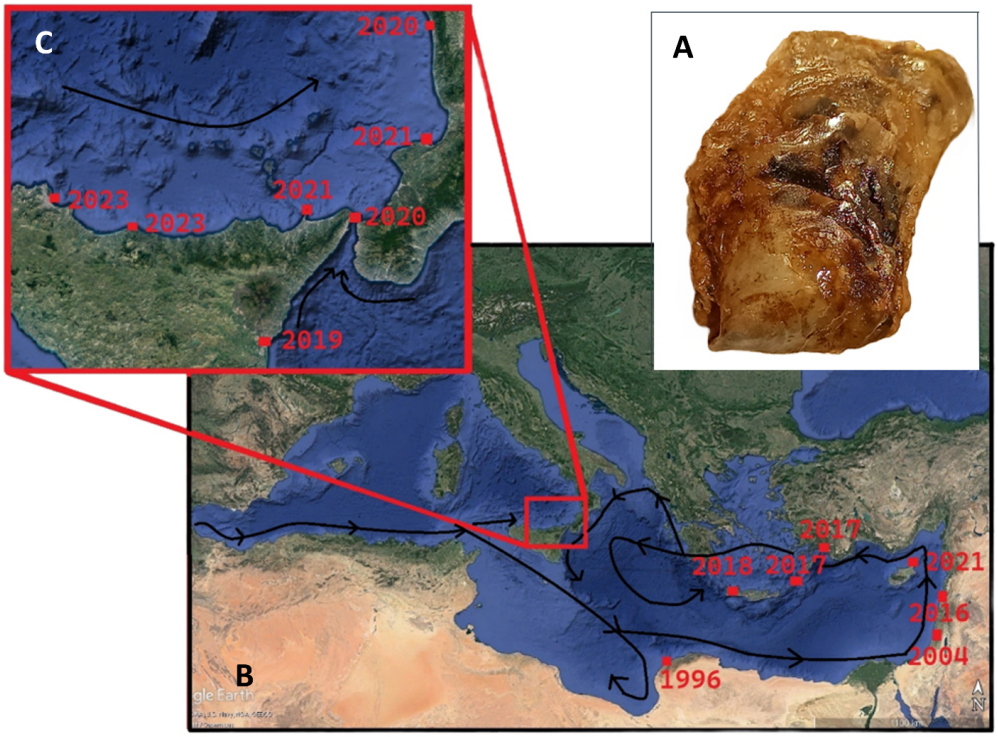

Fig. 1 - A. Specimen of *I. bicolor* from Gulf of Milazzo. B) Previous Mediterranean records of *I. bicolor* compared with the prevalent Mediterranean Sea surface circulation. C) Updated distribution of *I. bicolor* in the central Mediterranean.
A.Esemplare di I. bicolor *del Golfo di Milazzo. B) Precedenti segnalazioni mediterranee di* I. bicolor *rispetto alla prevalente circolazione superficiale del Mar Mediterraneo. C) Distribuzione aggiornata di* I. bicolor *nel Mediterraneo centrale.*

Tab. 1 - Investigated coastal sites where the occurrence of *I. bicolor* was detected.
Siti costieri investigati in cui è stata rilevata la presenza di I. bicolor.

Localities	**Coordinates**
Capo Vaticano (VV)	38°37'7.77"N; 15°49'36.59"E
Bagnara Calabra (RC)	38°17'9.69"N; 15°48'1.24"E
Scilla (RC)	38°15'8.11"N; 15°42'14.83"E
Capo Rasocolmo (ME)	38°17'47.34"N; 15°31'5.21"E
Milazzo (ME)	38°12'56.87"N; 15°14'56.25"E
Capo Tindari (ME)	38° 9'7.32"N; 15° 2'42.05"E
Patti (ME)	38° 9'9.41"N; 14°58'18.97"E
Capo D'Orlando (ME)	38° 9'54.59"N; 14°44'49.67"E
S.Agata di Militello (ME)	38° 4'30.20"N; 14°37'35.08"E
S.Stefano di Camastra (ME)	38° 1'8.62"N; 14°20'42.84"E
Cefalù (PA)	38° 2'24.36"N; 14° 2'3.80"E
Palermo	38° 7'43.59"N; 13°21'50.60"E

Results - Monitoring of the species led to first records in Cefalù and Palermo harbors (Fig. 1C), where *I. bicolor* showed remarkable populations. However, among all the investigated localities, the Gulf of Milazzo showed the widest colonization, especially on artificial hard bottoms exposed to industrial wastes (Fig. 2). Almost all surfaces from 0 to 1.5 m depth were entirely covered by compact *I. bicolor* beds (Fig. 2 A and B), except for rare patch affected by grazing of the sea-urchin *Arbacia lixula* (Linnaeus, 1758) (Fig. 2 C). An average density of 421±294 specimens/400cm^2 was evaluated, coresponding to 163±103 g of undecalcified wet biomass.

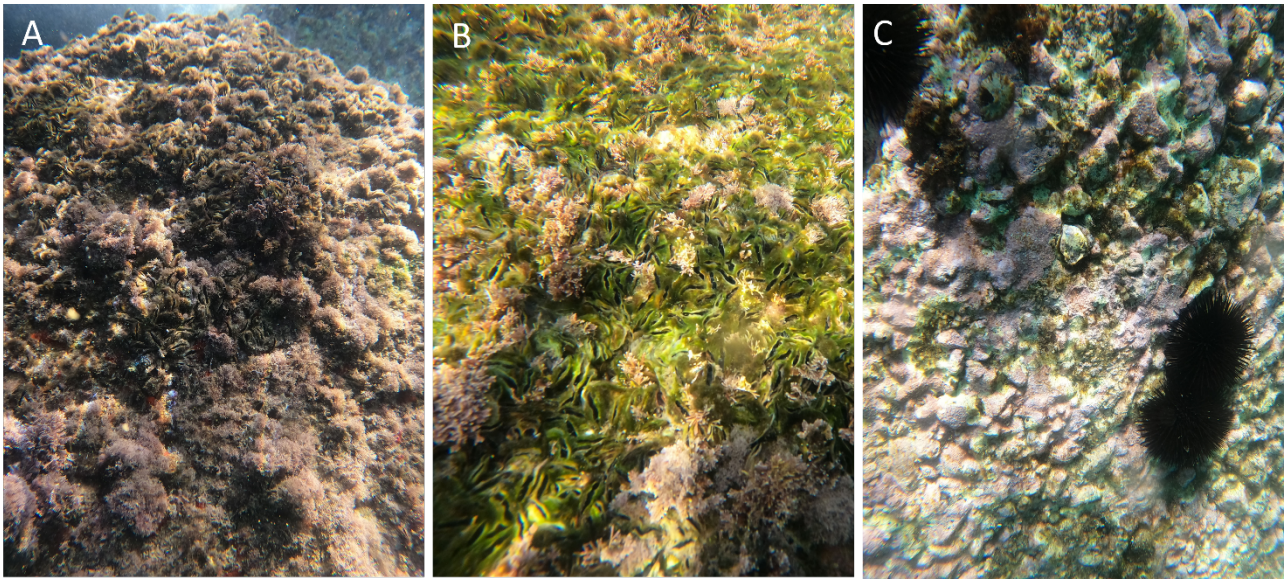

Fig. 2 - *I. bicolor* beds in the Gulf of Milazzo: A) directly and B) not directly facing the waterwastes. C) Hard bottom denudated by sea urchin grazing.
Banchi di I. bicolor *nel Golfo di Milazzo: A) direttamente e B) non direttamente esposti ai reflui. C) Fondo duro denudato dal pascolo dei ricci di mare.*

The highest densities (Fig. 3A) and biomasses (Fig. 3B) were found on substrates that were not directly exposed to the industrial wastewaters. More in detail, densities showed a marked increasing gradient moving away from the industrial plants (Fig. 3A). A similar, but less evident gradient was found for the related biomasses (Fig. 3B).

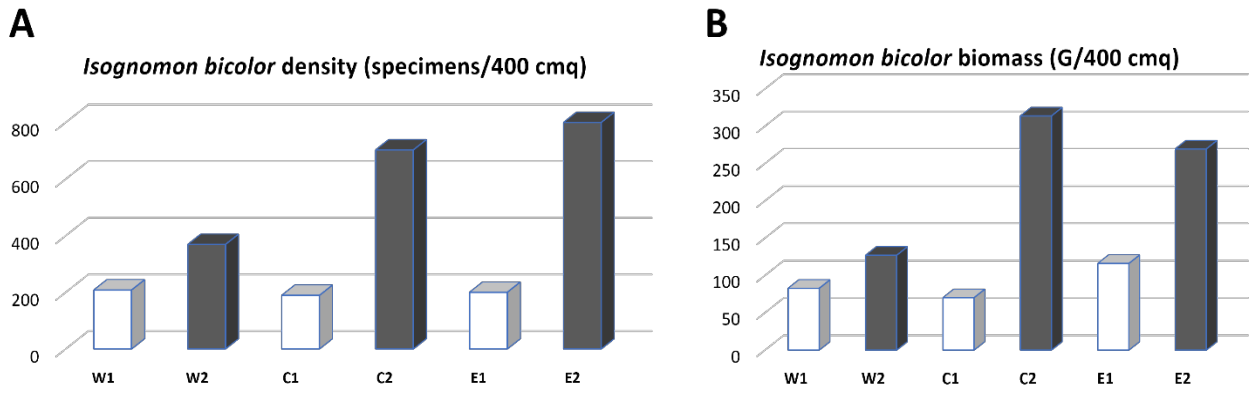

Fig. 3 - A) Density (ind./400 cm^2), and B) undecalcified wet biomass (g/400 cm^2) of *I. bicolor* in waste exposed (white coloumns) and not exposed (gray columns) station replicates.
A) Densità (ind./400 cm^2), e B) biomassa non decalcificata (g/400cm^2) di I. bicolor *nelle repliche di stazione in ambiente esposto (colonne bianche) a non esposto (colonne grigie) ai reflui.*

Among the other mollusc species (here not discusses), only *Brachidontes pharaonis* showed remarkable densities, although notably lower than *I. bicolor* and apparently following an opposite trend (Fig. 4).

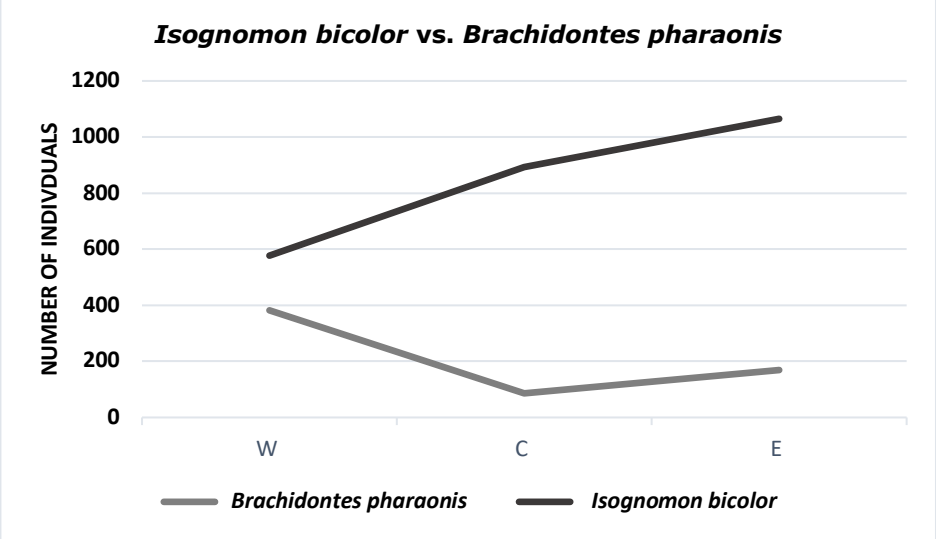

Fig. 4 - Densities of *I. bicolor* and *B. pharaonis* in the tree sampled stations (pooled replicates). *Densità di* I. bicolor *e* B. pharaonis *nelle tre stazioni esaminate (repliche aggregate).*

Conclusions - First data here provided on density and biomass of *I. bicolor* in the Central Mediterranean Sea demonstrated how this alien species of tropical origin is at the same time invasive, infesting, and capable of colonizing moderately stressed environments, to the detriment of indigenous or long-time naturalized species. Based on such evidence, *I. bicolor* should be considered a new menace for the Mediterranean coastal biodiversity and added to the now largely outdated list of the World's worst invasive alien species (Lowe *et al.*, 2000).

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