

First record of the red alga *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon in Greece

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Abstract

The red alga *Asparagopsis taxiformis*, a seaweed that is possibly introduced in the Mediterranean Sea, is recorded for the first time in Greece. Although no invasive behaviour was observed at any studied site, its spread seems to have been progressive during the last couple of years. However, the origin of the population on the Greek coasts remains uncertain.

Key words: alien algae, *Asparagopsis taxiformis*, Greece, Mediterranean

The genus *Asparagopsis* Montagne (Rhodophyta, Florideophyceae, Bonnemaisoniales, Bonnemaisoniaceae) includes tropical-subtropical red seaweeds, with heteromorphic diplohaplontic life cycles. The haploid, gametophytic phase is usually referred as *Asparagopsis*, while the diploid tetrasporophyte is known as the 'Falkenbergia' stage.

Today, the genus *Asparagopsis* is represented in the Mediterranean Sea by two species, *A. armata* and *A. taxiformis*. *A. taxiformis* is a typical tropical to warm temperate species which was first found in the Mediterranean Sea near Alexandria (Egypt) by Delile (1813); its distribution seems to be confined in the eastern basin (Sala and Boudouresque 1997). However, it has been recently dispersed towards the western basin, having been found along Italian coasts as well as in the Balearic Islands around the end of 1990s (Ballesteros and Rodriguez-Prieto 1996,

Barone et al. 2003). Similar sudden westwards dispersion has been observed for other alien marine macroalgae, such as *Caulerpa racemosa* var. *cylindracea* (Piazzi et al. 2005). In the Gulf of Naples (Italy) *A. taxiformis* exhibits an invasive pattern (Flagella et al. 2003) and it is generally considered to be an invasive species in the western Mediterranean basin (Verlaque et al. 2005).

The origin of *A. taxiformis* in the Mediterranean Sea is debatable. Some authors believe that it could be a possible introduced species from the Indo-Pacific via shipping or spreading via the Suez Canal (Boudouresque and Verlaque 2002), while others consider it to be a possible Tethyan relict (Cormaci et al. 2004) or a pre-lessepsian immigrant introduced into the Mediterranean Sea via waterways built during Pharaonic and/or Roman Times (Por 1978). The latter hypothesis seems to be the more probable

for the eastern Mediterranean records (Boudouresque 2005), while recent findings in the western basin probably correspond to recent introductions from the Indo-Pacific via shipping. The most likely scenario is that several strains of *A. taxiformis* co-occur in the Mediterranean Sea and that at least one of them is definitely introduced (Andreakis et al. 2004).

In Greece *A. taxiformis* (gametophytic stage) was first found in Rhodes Island (Southeastern Aegean – Figure 1) in January 2006 (Tsiamis et al. 2007 – misidentified as *A. armata*). The single specimen was observed on rocky substrate at 0.5 m depth on the far northern coast of Rhodes Island, inside the port marine area.

Later, *A. taxiformis* was collected in the inner part of Saronikos Gulf (South Aegean – Figure 1) in March 2006, during the national monitoring of pollution originating from the urban area of Athens and from the port of Piraeus (HCMR 2007 - misidentified as *A. armata*). The taxon was collected on rocky substrata at depths of 0,5m at the northeastern coast of Aegina Island (near Aegina's port), where it formed a relatively small population.

Few months later, in September 2006, a few specimens were found again in the inner part of Saronikos Gulf (HCMR 2007 - misidentified as *A. armata*). They were observed on rocky substrata at 1 m depth on the eastern coast of Salamina Island (Kaki Vigla bay). Since then, *A. taxiformis* has been present off Aegina Island and in Kaki Vigla Bay in Saronikos Gulf, exhibiting relatively low abundances. Finally, a cast ashore specimen of *A. taxiformis* was found on the southern coast of Salamina Island (Peristeria bay) in March 2007.

It is widely known that taxonomic differentiation of the two *Asparagopsis* species is problematic (Ni Chualáin et al. 2004), especially when it comes to the tetrasporophytic 'Falkenbergia' stages. Since most records of *A. armata* in Greek coasts (which date back to 1972, Koussouris et al. 1973) are based only on 'Falkenbergia' stages, some of them could correspond to *A. taxiformis*. However, among the records of *A. armata* on Rhodes Island and in Saronikos Gulf (Koussouris et al. 1973, Diapoulis et al. 1986, Salomidi et al. 2003 for Rhodes Island; Panayotidis and Chryssovergis 1998, Panayotidis and Montesanto 2001 for Saronikos Gulf), only one of them refers to the gametophytic stage (Salomidi et al. 2003 - Rhodes Island). Therefore, in our opinion, the presence of *A. taxiformis* can only be considered



Figure 1. Occurrence of *Asparagopsis taxiformis* in Greece until today (1 = Rhodes Island, 2 = Saronikos Gulf)



Figure 2. The red alga *Asparagopsis taxiformis* in Rhodes Island (Rhodes Port) (Photo by Maria Salomidi)

as recent in the above mentioned localities, especially when it comes to the gametophytic stage.

In conclusion, the spread of *A. taxiformis* seems to have been progressive during the last couple of years along the coast of Saronikos Gulf. With regard to native algae, it apparently does not show competitive behavior since its abundance has remained relatively low until now. Its recently recorded presence on Greek coasts could be attributed to recent introduction either from the southeastern populations of the Mediterranean Sea (maybe due to climatic changes) or from the Indo-Pacific via shipping. We conclude that *A. taxiformis* in Greek coasts should be considered as of questionable status regarding its origin and more detailed study of this species is necessary

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References

- Andreakis N, Procaccini G and Kooistra W (2004) *Asparagopsis taxiformis* and *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta): genetic and morphological identification of Mediterranean populations. *European Journal of Phycology* 39: 273-283
- Ballesteros E and Rodriguez-Prieto C (1996) Presència d'*Asparagopsis taxiformis* (Delile) Trevisan a Balears. *Bolletí de la Societat d'Història Natural de les Balears* 39: 135-138
- Barone R, Mannino AM and Marino M (2003) *Asparagopsis taxiformis* (Bonnemaisoniales, Rhodophyta): first record of gametophyte on the Italian coast. *Bocconea* 16(2): 1021-1025
- Boudouresque C-F (2005) Les espèces introduites et invasives en milieu marin. Deuxième édition, GIS Posidonie publications, Marseille, pp 152
- Boudouresque C-F and Verlaque M (2002) Assessing scale and impact of ship-transported alien macrophytes in the Mediterranean Sea. In: Briand F (ed) Alien marine organisms introduced by ships in the Mediterranean and Black seas, CIESM Workshop Monographs 20, Monaco, pp 53-62
- Cormaci M, Furnari G, Giaccone G and Serio D (2004) Alien Macrophytes in the Mediterranean Sea: A review. *Recent Research Development Environmental Biology* 1: 153-202
- Delile AR (1813) *Florae Aegyptiacae illustratio*. In: Anon (ed), Description de l'Égypte ou recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française (1798-1801), Histoire naturelle, Vol. 2, Paris: France (Commission d'Égypte), pp 49-82
- Diapoulis A, Haritonidis S and Koussouris T (1986) Spring benthic flora of Rhodos island, Greece. *Thalassographica* 9: 49-57
- Flagella MM, Guala I, Lorenti M and Buia MC (2003) *Asparagopsis taxiformis* and *Caulerpa racemosa*: interaction with algal community and ecophysiological traits. In: Proceedings of the third European Phycological Congress, Belfast (UK), 21-26 July, pp 37
- HCMR (2007) Monitoring of Saronikos Gulf ecosystem under the impact of urban waste pollution – the contribution of Psittalia Treatment Plant. Final Report, Hellenic Centre for Marine Research, Athens.
- Koussouris TH, Nikolaidou A and Bogdanos C (1973) Etude préliminaire du phytobenthos de la région de Lindos de l'île de Rhodos. *Hellenic Oceanology and Limnology* 11: 715-743
- Ni Chualáin F, Maggs CA, Saunders GW and Guiry MD (2004) The invasive genus *Asparagopsis* (Bonnemaisoniaceae, Rhodophyta): molecular systematics, morphology and ecophysiology of *Falkenbergia* isolates. *Journal of Phycology* 40(6): 1112-1126
- Panayotidis P and Chrysovergis F (1998) Végétation benthique des cotes est de l'Atique (mer Egée, Grèce). *Mesogee* 56: 21-28
- Panayotidis P and Montesanto B (2001) Occurrence and phytosociological study of *Caulerpa racemosa* in Saronikos gulf (Aegean Sea, Greece). *GIS Posidonie publ., Fr.*: 334-337
- Piazzini L, Meinesz A, Verlaque M, Akcali B, Antolic B, Argyrou M, Balata D, Ballesteros E, Calvo S, Cinelli F, Cirik S, Cossu A, D'Archino R, Djellouli AS, Javel F, Lanfranco E, Misfud C, Pala D, Panayotidis P, Peirano A, Pergent G, Petrocelli A, Ruitton S, Zuljevic A and Cecherelli G (2005) Invasion of *Caulerpa racemosa* var. *cylindracea* (Caulerpales, Chlorophyta) in the Mediterranean Sea: an assessment of the spread. *Cryptogamie Algologie* 26(2): 189-202
- Por FD (1978) Lessepsian migration. The influx of Red Sea biota into Mediterranean by way of the Suez Canal. In: Billings WD, Golley F, Lange OL and Olson JS (eds) *Ecological Studies. Analysis and Synthesis*, vol. 23, Springer-Verlag, Heidelberg, pp 228
- Sala E and Boudouresque CF (1997) The role of fishes in the organization of a Mediterranean sublittoral community. I: algal communities. *Journal of Experimental Marine Biology and Ecology* 212: 25-44
- Salomidi M, Pancucci-Papadopoulou MA, Hatiris GA and Panayotidis P (2003) Rapid assessment of the ecological status of a Greek coastal area based on phytobenthos: preliminary results. In: RAC/SPA (ed) Proceedings of the Second Mediterranean Symposium on Marine Vegetation, Athens, 12-13 December 2003, pp 211-216
- Tsiamis K, Panayotidis P and Montesanto B (2007) Contribution to the study of the marine vegetation of Rhodes Island (Greece). In: RAC/SPA (ed) Proceedings of the Third Mediterranean Symposium on Marine Vegetation, Marseille, 27-29 March 2007, pp 190-196
- Verlaque M, Ruitton S and Boudouresque C-F (2005) Algal introductions to European shores. 5th PCRD European Programme "Aliens". Final Report – UMR CNRS 6540 DIMAR, COM, Marseille, pp 27

AnnexRecords of *Asparagopsis taxiformis* in Greece

Map reference	Location	Depth	Substrate	Geographic coordinates *		Record Date	Collector
				Latitude, N	Longitude, E		
1	Rhodos Island (Port)	0,5m	Rocky	36°26'45"	28°13'52"	January 2006	Tsiamis K.
	Saronikos Gulf (Aegina Island)	0,5m	Rocky	37°45'42"	23°25'03"	March 2006	Tsiamis K.
2	Saronikos Gulf (Salamina Island – Kaki Vigla bay)	1m	Rocky	37°54'40"	23°30'46"	September 2006	Tsiamis K.
	Saronikos Gulf (Salamina Island – Peristeria bay)	-	Cast ashore	37°52'39"	23°27'22"	March 2007	Tsiamis K.

* Geographic coordinates are based on Google Earth data