Turk J Zool
29 (2005) 159-166

Crustacean Biodiversity of *Padina pavonia* (L.) Facies Along the Aegean Coasts of Turkey

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Received: 24.03.2004

Abstract: This research was carried out to determine the crustacean species associated with *Padina pavonia* facies distributed in the upper-infralittoral zone of the Aegean Sea coasts of Turkey and their bioecological features. The investigations were performed at depths of 2-5 m in 13 different stations chosen in the Aegean Sea in June and July, 1995. As a result of the study, a total of 3279 specimens belonging to 85 species were identified. Of these, *Ampithoe ramondi* was commonest with a dominance value of 21.47%, followed by *Elasmopus pocillimanus* with 13.94% and *Ericthonius brasiliensis* with 4.61%.

Key Words: Diversity, *Padina pavonia*, Crustacea, Aegean Sea, Turkey

Türkiye'nin Ege Denizi Kıyıları *Padina pavonia* (L.) Fasiesinin Crustacea Çeşitliliği

Özet: Bu araştırma Türkiye'nin Ege Denizi kıyılarının üst infralittoral zonunda dağılım gösteren *Padina pavonia* fasiesinin Crustacea türlerini tespit etmek amacıyla yürütülmüştür. Araştırmalar 1995 yılının haziran ve temmuz aylarında Ege Denizi'nde seçilen 13 farklı istasyonda 2-5 m derinliklerde gerçekleştirilmiştir. Sonuç olarak 85 türe ait toplam 3279 birey tanımlanmıştır. Bunlardan *Ampithoe ramondi* % 21,47' lik dominansi değeri ile en yaygın tür olurken, bunu % 13,94 ile *Elasmopus pocillimanus* ve % 4,61 ile *Ericthonius brasiliensis* izlemektedir.

Anahtar Sözcükler: Diversite, *Padina pavonia*, Crustacea, Ege Denizi, Türkiye

Introduction

Photophilic algae represent a substrate with a particular structure populated by a great number of animals. The mass of these photophil organisms makes a marked contribution to raising the productivity of the marine coast (Tiganus, 1972).

Padina pavonia is a representative of brown algae (Phaeophyceae), usually located on rocky substrates, various shell bottoms and coral fragments in shallow waters, and show a wider distribution in unpolluted enviroments. Peres and Picard (1964) indicated that *P. pavonia* facies usually occur in shallow waters due to its tolerance to variations in edaphic factors. In the Aegean Sea *P. pavonia* is a member of the genus *Padina*, which is represented by 4 species (*P. boergesenii*, *P. pavonia*, *P. tenuis* and *P. gymnospora*) in the Mediterranean Sea (European Register of Marine Species, 2003).

Bellan-Santini (1969) investigated the *P. pavonia* facies in unpolluted and calm waters of Marseilles Bay in the Mediterranean using qualitative and quantitative methods. Russo (1997) studied the epifauna associated with some algae species and *P. pavonia* on the coasts of Cyprus. Studies on the macrobenthic fauna inhabiting algae facies of the coastal hard substratum, especially *P. pavonia*, in the Turkish Aegean Sea are scarce. Studies were conducted by Kocataş (1978), Ergen (1980), Ergen et al. (1985), Ergen et al. (1994), and Öztürk and Ergen (2000), the majority of which concentrated on Mollusca and Polychaeta groups in the vicinity of İzmir Bay. The

most specific study on crustacean fauna within *P. pavonia* facies was carried out by Kocataş (1976).

Therefore, samplings in this study were made over a wider geographical range capable of representing the Turkish Aegean Sea coasts, and we aimed to examine the crustacean fauna associated with *P. pavonia* facies based on qualitative and quantitative data.

Materials and Methods

In order to determine crustacean assemblages within *P. pavonia* facies, samplings were performed at 13 different localities (1. Saros Bay-Güneyli, 2. Çanakkale-Monument, 3. Altınoluk, 4. Ayvalık, 5. Dikili, 6. Foça, 7. Urla, 8. Çeşme, 9. Sığacık-Seferihisar, 10. Kuşadası, 11. Bodrum, 12. Datça, and 13. Marmaris, from North to South) in the upper-infralittoral zone of the Aegean Sea.

Samples were collected according to the methodology proposed by Bellan-Santini (1969), and a 400 cm^2 unit area was sampled for *P. pavonia* facies. For this purpose, a metal frame (20 x 20 cm) covared with a bag made up of a plankton net was used.

The *P. pavonia* roots and leaves within the metal frame were excavated using a spatula, and the material collected was preserved in 4% formalin for further analysis back in the laboratory. The samples were washed through a 1 mm sieve and the crustacean specimens were sorted. The extracted fauna was separated into taxonomic groups, identified and counted under a stereomicroscope. Groups were identified and listed according to the revisions given by Bacescu (1951) (Cumacea), Riggio (1973) (Tanaidacea), Giordoni-Soika (1950), Holdich (1968; 1970) (Isopoda), Ruffo (1982, 1989, 1993, 1998) (Amphipoda) and Zariquiey Alvarez (1968), D'Udekem D'Acoz (1996) and Falciai and Minervini (1996) (Decapoda).

To eludicate the community structure, Soyer's (1970) frequency index (f %), Bellan-Santini's (1969)

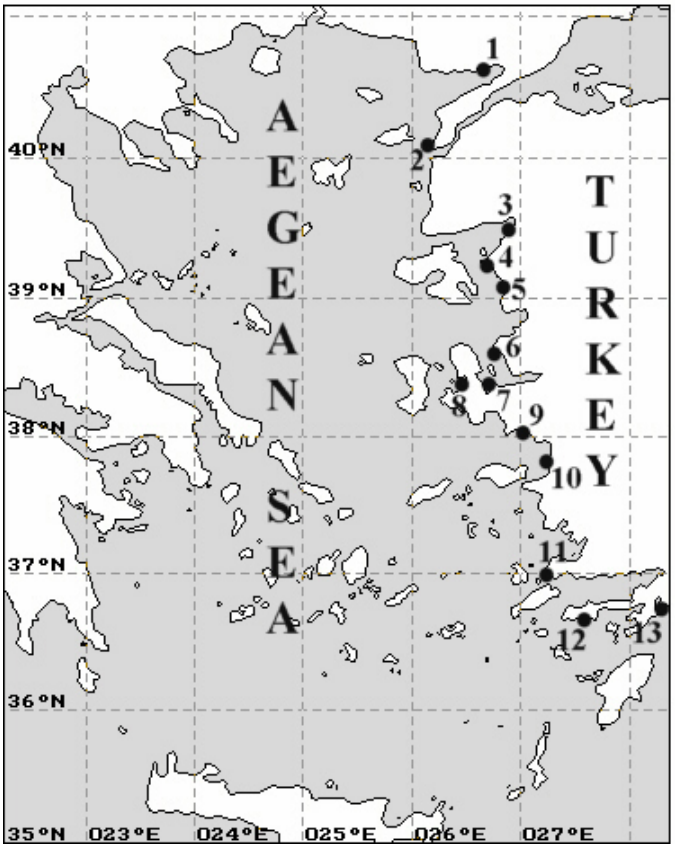

Figure 1. Map of study area.

quantitative dominance index (DI %), Shannon-Weaver's (1949) diversity index (H^1), Pielou's (1975) evenness index and Bray-Curtis's (1957) similarity index were calculated.

The frequency index of a particular species was estimated by

f = m / M x 100, where m = number of stations where the species was found and M = number of all stations.

The dominance index of a certain species was estimated by

DI = m / M x 100, where m = individual number of a species in the stations and M = total individual numbers of all species.

The Shannon-Weaver diversity index was estimated by

$$H^1 = - \sum_{1-0}^{n} \log pi \bullet \log_2 pi$$

$$pi = \frac{S}{N},$$

where S = total individual number of a species and N = total individual numbers of all species.

The Pielou evenness index was estimated by

$$J^1 = \frac{H^1}{\log_2 S},$$

where H^1= Shannon index value; S = species number

The Bray-Curtis similarity index was estimated by

$$S_{jk} = 100 \{1- \lfloor \Sigma | y_{ij} - y_{ik} | / \Sigma | y_{ij} + y_{ik} | \rfloor \}$$

Results

As a result of the study, carried out at 13 different stations along the Turkish Aegean Sea coast, a total of 3279 individuals belonging to 85 species (2 Cumacea, 2 Tanaidacea, 14 Isopoda, 18 Decapoda and 49 Amphipoda) were recorded (Figure 2, Table 1).

The highest number of species was observed at station 6 (Foça) with 32 species, was followed by station 7 (Urla-Karantina Island) with 27 species and station 9 (Sığacık) with 25 species, and the lowest number was at station12 (Datça) with 10 species. The highest number of specimens was at station 3 with 430 specimens, whereas the lowest value was recorded at station 4 (Ayvalık) (Figure 3).

The differences among the stations are in accordance with their substrate heterogeneity. At some stations *P. pavonia* constitutes a poor facies and its vicinity is surrounded with naked stones. However, at stations with both species and specimen richness at high values *P. pavonia* comprises dense facies and is covered with dense algae facies such as *Cystoseira* spp. and *Halopteris* spp. Crustacean species occur in dense populations in such biotopes.

Shannon-Weaver diversity index values (H^1) among the sampling stations did not show significant difference, and these values ranged between 4.32 and 2.56. The highest DI value was at station 6 (Foça) and the lowest DI value at station 8 (Çeşme) (Figure 3). The evenness index (J^1) values mainly ranged between 0.69 and 0.89, revealing that the distribution of species at the stations is regular. However, at station 8 (Çeşme), *Ampithoe*

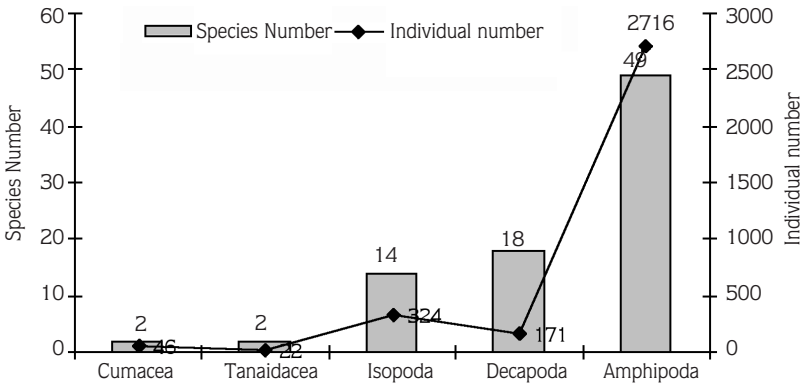

Figure 2. Numbers of species and specimens belonging to Crustacea groups.

Table. List of species, numbers of individuals at stations, values of dominance and abundance.

Species	Stations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	Σ	
Total individual	216	278	117	430	214	258	404	262	154	374	202	133	237	3279	
Total species	18	21	16	23	14	32	27	11	22	25	21	10	20	85	
Cumacea														*f* %	DI%
Bodotria scorpioides (Montagu, 1804)		2		1						2				23.08	0.15
Cumella limicola Sars, 1879	3	2	1		29	1			3		1		1	61.54	1.25
Tanaidacea															
Apseudes robusrus G.O. Sars, 1882				1										7.69	0.03
Leptochelia savignyi (Kroyer, 1842)	1	1	3		1	4			1		9		1	61.54	0.64
Isopoda															
Carpias stebbingi (Monod, 1939)	2	3				5	36	12	17	13	5	18	10	76.92	3.69
Bopyrus squillarum Latreille, 1802						1							2	15.38	0.09
Cymodoce emarginata Leach, 1818	6	3	2	3	4	3				21				53.85	1.28
Cymodoce spinosa (Risso, 1816)					4		5							15.38	0.27
Cymodoce truncata Leach, 1814					4			3			2	3		30.77	0.37
Cymodoce tuberculata Costa in Hope, 1851						3							3	15.38	0.18
Dynamene edwardsi (Lucas, 1849)						5					4		6	23.08	0.46
Dynamene magnitorata Holdich, 1968				3		2								15.38	0.15
Dynamene torelliae Holdich, 1968						22	31		6	7				30.77	2.01
Joeropsis brevicornis subsp. *littoralis* Amar, 1949		7				12							7	23.08	0.79
Uromunna petiti (Amar, 1948)									2					7.69	0.06
Paranthura costana Bate & Westwood, 1868				3					1					15.38	0.12
Synisoma capito (Rathke, 1837)		4		2		1								23.08	0.21
Synisoma appendiculata (Risso, 1816)	3												3	15.38	0.18
Amphipoda															
Ampelisca pseudospinimana Bellan-Santini & Kaim-Malka, 1977						2								7.69	0.06
Amphilochus neapolitanus Della Valle, 1893							11		1	17		12		30.77	1.25
Ampithoe ferox (Chevreux, 1902)						13								7.69	0.40
Ampithoe helleri Karaman, 1975			2											7.69	0.06
Ampithoe ramondi Audouin, 1826	55	55	22	130	50	50	101	90	27	47	27	25	25	100.00	21.47
Aora spinicornis Afonso, 1976				3		7								15.38	0.30
Apherusa bispinosa (Bate, 1857)	1		11											15.38	0.37
Apherusa chiereghinii Giordani- Soika, 1950				17							7			15.38	0.73
Apherusa vexatrix Krapp-Schickel, 1979						10			17	45				23.08	2.20
Atylus guttatus (Costa, 1851)					8		7			30				23.08	1.37
Atylus massiliensis Bellan-Santini, 1975										22				7.69	0.67
Caprella acanthifera Leach, 1814						3				25				15.38	0.85
Caprella grandimana Mayer, 1882		7								22				15.38	0.88
Caprella rapax Mayer, 1890	9	27		22	17		17	12					14	53.85	3.60
Colomastix pusilla Grube, 1861		3												7.69	0.09
Corophium acherusicum Costa, 1851		7												7.69	0.21
Corophium sp.			2											7.69	0.06
Cymadusa crassicornis (Costa, 1857		47	13	30										23.08	2.74
Dexamine spiniventris (Costa, 1853)	1	32	25	32	26	9	17	27	15	12	5	31		92.31	7.08
Dexamine spinosa (Montagu, 1813)						17	15			22		11		30.77	1.98
Elasmopus affinis Della Valle, 1893											67			7.69	2.04
Elasmopus brasiliensis (Dana, 1855)												6		7.69	0.18
Elasmopus pocillimanus (Bate, 1862)	80		15	120	50	20	40		12	30	40		50	76.92	13.94
Ericthonius brasiliensis (Dana, 1855)				22		12	22	75	12	8				46.15	4.61
Ericthonius punctatus (Bate, 1857)						12	12							15.38	0.73
Eusiroides dellavallei Chevreux, 1899			3											7.69	0.09
Gammarella fucicola (Leach, 1814)			1	12										15.38	0.40
Guernea coalita (Norman, 1868)		12	3	11				9						30.77	1.07
Hyale schmidti (Heller, 1866)			8				12			6			11	30.77	1.13

Table (contuened)

Species	Stations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	Σ	
Hyale stebbingi Chevreux, 1888											4			7.69	0.12
Leucothoe spinicarpa (Abildgaard, 1789)						4			1					15.38	0.15
Lysianassa caesarea Ruffo, 1987	10			10		4			4					30.77	0.85
Lysianassa costae (Milne-Edwards, 1830)		5			5					7			2	30.77	0.58
Maera grossimana (Montagu, 1808)						7								7.69	0.21
Maera inaequipes (Costa, 1857)						6	15			15			60	30.77	2.93
Melita palmata (Montagu, 1804)									6	6				15.38	0.37
Microdeutopus algicola Della Valle, 1893	20													7.69	0.61
Microdeutopus chelifer (Bate, 1862)			2								3			15.38	0.15
Microdeutopus gryllotalpa Costa, 1853		20												7.69	0.61
Microdeutopus sporadhi Myers, 1969												2		7.69	0.06
Microdeutopus stationis Della Valle, 1893						11							12	15.38	0.70
Orchomene humilis (Costa, 1853)									2					7.69	0.06
Peltocoxa marioni Catta, 1875												2		7.69	0.06
Peltocoxa mediterranea Schiecke, 1977						1								7.69	0.03
Pereinotus testudo (Montagu, 1808)	5	7			12	6	7			7				46.15	1.34
Phtisica marina Slabber, 1749		17									2			15.38	0.58
Podocerus variegatus Leach, 1814									13		1	23	13	30.77	1.52
Stenothoe monoculoides (Montagu, 1815)			4											7.69	0.12
Stenothoe tergestina Nebeski, 1881	8	16					15							23.08	1.19
Decapoda															
Acanthonyx lunulatus (Risso, 1816)							1		1	3	7		2	38.46	0.43
Achaeus gracilis O. G. Costa, 1839				1										7.69	0.03
Athanas nitescens (Leach,1814)	6				3	3	1	1			1		1	53.85	0.49
Eriphia verrucosa (Forskål, 1775)							1							7.69	0.03
Galathea bolivari Zariquey- Alvarez,1950									2		1			15.38	0.09
Hippolyte leptocerus (Heller, 1863)							7	26		2	7			30.77	1.28
Hippolyte sp.	2													7.69	0.06
Hippolyte garciarasoi D'Udekem d'Acoz, 1996							2							7.69	0.06
Liocarcinus pusillus (Leach,1815)		1									1			15.38	0.06
Lysmata seticaudata (Risso,1816)						1	17		6	2			7	38.46	1.01
Pagurus chevreuxi (Bouvier, 1896)				1					1		7			23.08	0.27
Palaemon longirostris (H. Milne Edwards,1838)					1		4	4	4					30.77	0.40
Pilumnus hirtellus (Linnaeus,1761)	1			2			1				1			30.77	0.15
Pilumnus hirsutus Stimpson, 1858										1				7.69	0.03
Pirimela denticulata (Montagu,1808)	3						1							15.38	0.12
Pisa hirticortis (Herbst, 1804)				1										7.69	0.03
Pisidia longimana (Risso,1816)				2		1	5	3		2			7	46.15	0.61
Sirpus zariquieyi Gordon,1953				1			1							15.38	0.06

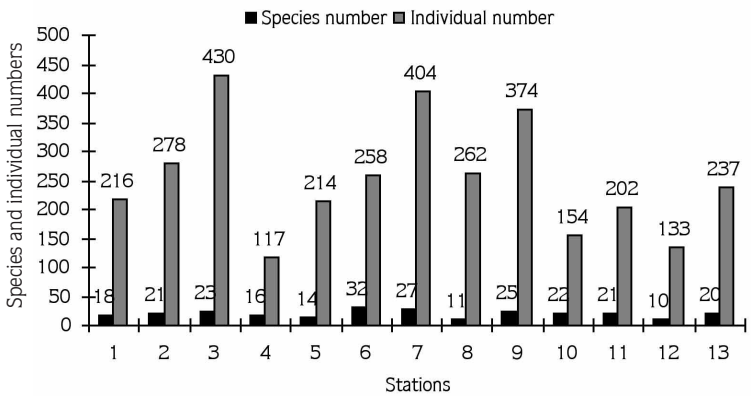

Figure 3. Numbers of species and specimens at stations.

ramondi and *Ericthonius brasiliensis* (Amphipoda), which are represented by 90 and 75 specimens respectively, lowered the evenness index value (Figure 4).

For the relative importance of crustacean species sampled from the 13 stations, the Soyer frequency index was computed and 9 species were designated as very common, 19 species as common and 57 species as rare. Four species, which had the highest values and are very common in *P. pavonia* facies, are *Ampithoe ramondi* (100%), *Dexamine spiniventris* (92.3%), *Elasmopus pocillimanus* and *Carpias stebbingi* (76.9%).

Apseudes robustus, *Uromunna petiti*, *Ampelisca pseudospinimana*, *Ampithoe helleri*, *Atylus massilensis*, *Colomastix pusilla*, *Corophium acherisicum*, *Corophium* sp., *Elasmopus affinis*, *E. brasiliensis*, *Eusiroides dellavallei*, *Hyale stebbingi*, *Maera grossimana*, *Microdeutopus algicola*, *M. gryllotalpa*, *M. sporadhi*, *Orchomene humilis*, *Peltocoxa marioni*, *P. mediterranea*, *Stenothoe monoculoides*, *Acheus gracilis*, *Eriphia verrucosa*, *Hippolyte* sp., *Hippolyte garciarasoi*, *Pilumnus hirsutus* and *Pisa hirticortis* were recorded from only 1 of the 13 stations and are rare species of this community. *A. ramondi* was the most dominant crustacean species with 771 specimens (21.48%) followed by *E. pocillimanus* with 513 specimens (13.9%) and *E. brasiliensis* 163 (4.6%) at *P. pavonia* facies (Figure 6).

According to results of the Bray-Curtis similarity index, 2 stations (station 1 and 5) with a value of 58%, and stations 7 and 8, and 10 and 12 with a value of 50% shared the same groups (Figure 7).

Discussion

A total of 3279 individuals belonging to 85 crustacean species were recorded from 13 different *P. pavonia* facies along the Aegean Sea coast of Turkey.

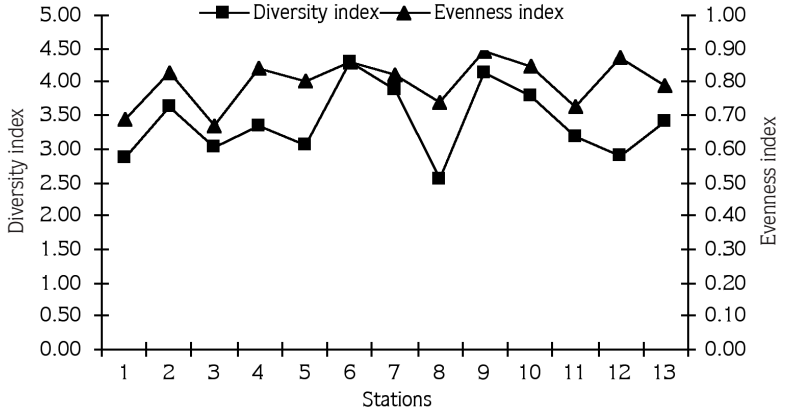

Figure 4. Comparison of eveness and diversity index values.

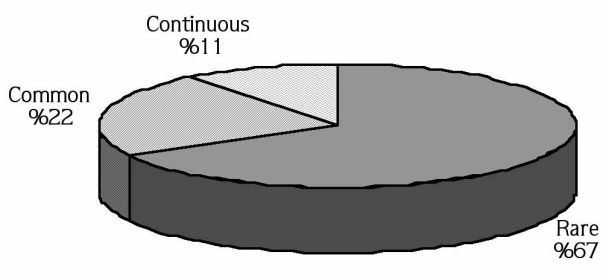

Figure 5. Dispersion of species as a result of 3 frequency index group values.

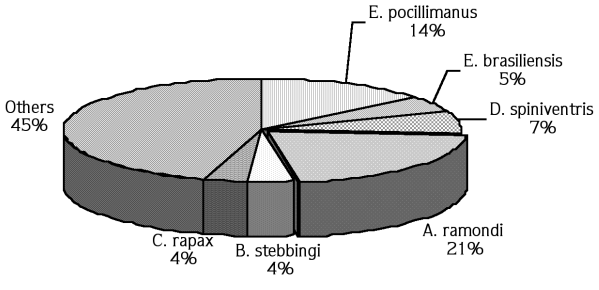

Figure 6. Dominance values of species.

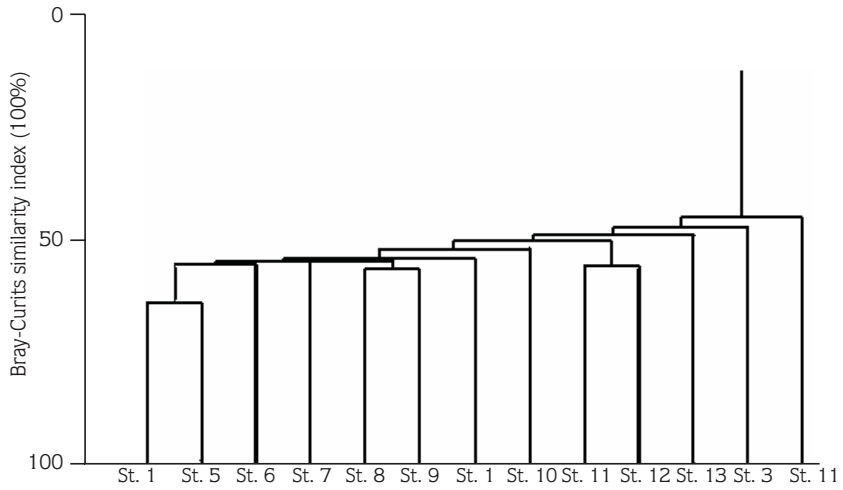

Figure 7. Similarity among the stations (Bray-Curtis).

In studies previously carried out on *P. pavonia* facies Bellan-Santini (1969) reported 115 species (25 algae and 90 animal species) from Marseilles Bay in the Mediterranean Sea. Ergen et al. (1985) recorded 91 species and 1156 individuals belonging to different benthic macrofauna groups at Urla (station 7 in this study) and recorded the rate of crustacean species as 31.9%. Kocataş (1978) indicated that 28 out of 48 amphipod species were recorded in *P. pavonia* communities from the rocky substrates in the upper-infralittoral zone of İzmir Bay. Kocataş (1978) reported that 65 crustacean species, from a total of 231 species, were recorded in *P. pavonia* facies during his investigations into benthic forms of rocky shores in İzmir Bay. Ergen (1980) recorded 48 Polychaeta species in *P. pavonia* facies during his study to 5 facies in İzmir Bay. Ergen et al. (1994) reported 57 crustacean species on soft and hard bottoms including *P. pavonia* facies at Gencelli Harbour (Aliağa-İzmir) Öztürk and Ergen (2000) reported 19 gastropod species in *P. pavonia* facies of 24 stations located on the Turkish coast of the Aegean Sea. When all the previous studies mentioned above are considered, our study includes the richest number of crustacea species.

A comparison of the sampling stations, in terms of the northern Aegean (1-8) and southern Aegean (8-13) revealed that the crustacean species diversity is somewhat higher in the southern Aegean Sea. This can be explained by the wider range of sampling stations that represent various habitats, and consequently by *P. pavonia* facies being exposed to different hydrographical conditions. In addition, the Aegean Sea, serving as a transition zone between the Mediterranean and Black Sea, also impacts on the wide distribution of marine organisms (Kocataş and Bilecik, 1992).

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