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REVİEW DERLEME

Checklist of marine dinoflagellates on the coast of Türkiye

Türkiye kıyılarındaki denizel dinoflagellatların kontrol listesi

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Abstract: Using the evaluations of 77 literature studies conducted along the Turkish coasts of the Black Sea, Marmara Sea, Aegean Sea, and the Mediterranean Sea, a checklist has been compiled. It has been observed that the dinoflagellate flora is represented by a total of 330 species belonging to 75 different genera. This literature study has determined that the number of dinoflagellate species reaches up to 181 in the Black Sea, 158 in the Marmara Sea, 206 in the Aegean Sea, and 192 in the Mediterranean Sea. This study has revealed that particularly in the case of new species records, the characteristic structural features, distributions, and photographs of the species are not provided. It has also been observed that many geographical points have not been investigated yet, and some species reported as new records have previously been reported in earlier studies. In future studies, updating the checklist becomes crucial in terms of forming a dataset.

Keywords: Black Sea, Sea of Marmara, Aegean Sea, Mediterranean Sea, marine dinoflagellat, check-list

Öz: Karadeniz, Marmara, Ege ve Akdeniz'in Türkiye kıyıları boyunca yapılan 77 literatür çalışması değerlendirilerek bir kontrol listesi oluşturulmuş ve dinoflagellat florasının 75 farklı cinse ait toplam 330 tür ile temsil edildiği gözlenmiştir. Yapılan bu literatür çalışması ile dinoflagellat tür sayısının Karadeniz' de 181, Marmara' da 158, Ege' de 206 ve Akdeniz' de 192 sayısına kadar ulaştığı saptanmıştır. Bu çalışma ile özellikle yeni tür kayıtlarında türlerin karakteristik yapısal özellikleri, dağılımları ve fotoğraflarının verilmediği, birçok coğrafi noktanın henüz incelenmediği ve bazı türlerin yeni kayıt olarak verilmesine rağmen daha önceki çalışmalarda rapor edildiği saptanmıştır. İleride yapılacak olan çalışmalarda kontrol listelerinin güncellenmesi veri seti oluşturması açısından önem kazanmaktadır.

Anahtar kelimeler: Karadeniz, Marmara, Ege, Akdeniz, denizel dinoflagellat, kontrol listesi

INTRODUCTION

Phytoplankton is a group that includes various prokaryotic and eukaryotic organisms that play an important role in primary production, and climate change (Vadrucci et al., 2008; Cermeño et al., 2008). Dinoflagellates constitute one of the taxonomic groups within the phytoplankton that have an important role in the food web. Dinoflagellates are among the most abundant marine organisms, with an estimated 8000 species of which approximately 2400 have been described to date (De Vargas et al., 2015; Janouškovec et al., 2017), 105 of which are considered toxic and harmful algae (Hallegraeff et al., 2021). Dinoflagellates adapt quickly to a variety of environmental conditions (such as temperature, salinity, light, nutrients, and water movements) that control their distribution, diversity, and migration (Levandowsky and Kaneta, 1987; Behrenfeld et al., 2006) and when environmental conditions are favorable, they can exhibit rapid proliferation within a short period of time, leading to eutrophication. (Delwiche, 2007; Richardson and Schoeman, 2004; Leterme et al., 2006).

Identification and classification studies of dinoflagellates in the world's seas and freshwaters were first started by Schiller (1931–1937). Later, Sournia (1973; 1978; 1982; 1990; 1993) added new taxonomic records of marine dinoflagellates to the literatüre but only at genus level. Comprehensive investigations of the world's dinoflagellates at the species level continued with several different studies (Kofoid and Swezy, 1921; Margalef, 1969; Rampi and Bernhard, 1980; Dodge, 1982; Balech, 1988; Anderson, 1989; Steidinger and Tangen, 1997; Faust and Gulledge, 2002; Gárate-Lizárraga and Verdugo-Díaz, 2007; Ignatiades and Gotsis-Skretas, 2010) including the ones by Gómez (2003; 2005; 2006; 2008; 2012a; 2012b; 2021).

Phytoplankton research in Türkiye started in the 1950s, and the first studies were conducted at the class or family level (Numann, 1955; Acara and Nalbantoglu, 1960). Species-level descriptions began to be made in the early 1960s, and as the time passed, studies on phytoplankton began to increase noticeably. The first study on phytoplankton in the Aegean Sea was carried out by Ergen (1967), in the Marmara Sea by Artüz (1974), in the Mediterranean Sea by Gökalp (1972), and in the Black Sea by Benli (1987).

This study aimed to compile research articles along the Turkish coastline that were approved by a specific referee committee and create a list of dinoflagellate species according to current rules.

MATERIALS AND METHODS

This study is based on the phytoplankton literature study carried out along all Turkish coasts. The total length of Turkey's coastline, including the islands, is 8.333 kilometers, of which

1.067 kilometers are island coasts. The distribution of this total according to the four seas is as follows: Black Sea: 1.701 kilometers (20.4%), Marmara Sea: 1.441 kilometers (17.3%), Aegean Sea: 3.484 kilometers (41.8%) and Mediterranean: 1.707 kilometers (20.5%) and each has its own typical coastal geomorphology in terms of a variety of oceanographic, geological and atmospheric conditions.

The literature review was composed with 77 references containing pelagic dinoflagellates within the scope of studies carried out in Turkish coasts, lagoon and estuary systems. Only articles published in peer-reviewed journals were evaluated in the references. Apart from these, master's theses, doctoral theses, compilation studies, environmental impact assessment reports, monitoring reports and project studies for the private sector were not included. In the literature studies used, it was observed that plankton net and Nansen bottle were used for phytoplankton sampling and formaldehyde and lugol were preferred for fixation of the samples. It has also been stated that standard light microscopy and phase-contrast objectives are mostly used in species determinations. The current nomenclature of the taxa reported in this study was made according to Guiry and Guiry (2024). Some species have been reported with different names depending on the final taxonomic rank. The taxa mentioned as "confer" and "sp." in the species lists have not been included in the list as they require confirmation. In addition, it was observed that in some studies, although the species was given as a new record, the species had been reported before. Therefore, the first records with the oldest date were taken into consideration. Very few studies have included morphological characteristics, pictures or drawings of the species which were reported for the first time. These studies are shown with an asterisk (*) for light microscopy and with two asterisk (**) for scanning elektron microscopy studies in Table 1.

RESULTS

Although Türkiye has a long coastline, there is a big gap on phytoplankton studies until 1990s. In the present study, a total of 77 literature sources have been utilized, with the Aegean Sea ranking first with 26 studies, followed by the Marmara Sea with 24 studies, the Mediterranean Sea with 19 studies, and the Black Sea with 13 studies (Table 1).

Table 1. List of literature used in this study. Black Sea (B), Sea of Marmara (S), Aegean Sea (A), Mediterranean Sea (M). ("*" refers to light microscopy studies, "**" refers to electron microscopy studies).

Literature	Sampling Period	Sampling Region	Literature	Sampling Period	Sampling Region
1. Ergen (1967)	1967	A	40. Feyzioğlu and Seyhan (2007)	1993-2002	B
2. Gökalp (1972)	1970	A, M	41. Polat and Koray (2007)*	1994-2004	M
3. Koray and Gökpınar (1983)	1983	A	42. Polat (2007)*	2004	M
4. Koray (1984)*	1980-1984	A	43. Çevik et al. (2008)	2000-2001	M
5. Koray (1987)*	1980-1984	A	44. Taş et al. (2009)	1998-2002	S
6. Benli (1987)	1983-1984	B	45. Deniz and Taş (2009)	2000	S
7. Koray and Büyükışık (1988)	1983	A	46. Balkıs (2009)	2000-2001	A
8. Kıdeyş et al. (1989)	1984-1985	M	47. Eker Develi and Velikova (2009)**	2006	B
9. Koray et al. (1994)	1990-1991	A	48. Baytut et al. (2010)	2002-2003	B
10. Koray and Kesici (1994)	1990-1991	A	49. Türkoğlu and Öner (2010)	2004-2005	S
11. Koray (1995)	1978-1990	A	50. Altuğ et al. (2011)	2006-2007	S, A
12. Uysal and Sur (1995)	1990	B	51. Küçük and Ergül (2011)	2009-2010	S
13. Alpaslan et al. (1999)	1997-1998	S	52. İçemer Tugrul (2012)	1999-2001	M
14. Metin and Cirik (1999)	1993-1994	A	53. Özsayman Say and Balkıs (2012)	2005-2006	M
15. Koray et al. (1999)	1999	A	54. Çolak Sabancı and Koray (2012)	2008-2010	A
16. Polat et al. (2000)	1994-1995	M	55. Taş (2014)*	2002-2004	A
17. Türkoğlu and Koray (2000)	1995-1996	B	56. Ağlaç and Balkıs (2014)	2003-2004	A
18. Eker and Kıdeyş (2000)	1995-1997	M	57. Balkıs and Toklu Alıçlı (2014)	2006-2008	S
19. Demir and Atay (2000)	1997	A	58. Güreşen and Aktan Turan (2014)	2009-2010	A
20. Balkıs (2000)*	1998-1999	S	59. Ağırbaş et al. (2015)	2009	B
21. Çolak Sabancı and Koray (2001)	1998-1999	A	60. Baytut and Gönülol (2016)	2007-2008	B
22. Demir (2001)	1999	B, S, A, M	61. Balcı and Balkıs (2017)*	2010-2011	S
23. Polat and Işık (2002)	1998-1999	M	62. Aktan Turan and Keskin (2017)*	2017	A
24. Polat and Koray (2002)*	1999	M	63. Ergül et al. (2018)	2015	S
25. Polat and Piner (2002)	1999-2000	M	64. Aslan et al. (2018)	2016	A
26. Polat and Piner (2002a)	2000-2001	M	65. Çolak Sabancı (2018)*	2017	A
27. Taş and Okuş (2003)	1995	S	66. Balkıs Özdelice and Peynirci (2019)	2012-2013	B
28. Balkıs (2003)	1998-1999	S	67. Uysal (2020)	2002-2003	M
29. Polat and Koray (2003)*	2000	M	68. Taş et al. (2020)*	2004-2007	S
30. Uysal et al. (2003)**	2001	M	69. Balkıs Özdelice et al. (2020)	2006-2008	S
31. Balkıs et al. (2004)	1993-1995	S	70. Şentürk et al. (2020)	2015-2016	B
32. Taş and Okuş (2004)*	1999	S	71. Dursun et al. (2021)	2018-2019	S
33. Polat (2004)*	2001	M	72. Ergül et al. (2021)	2020-2021	B, S
34. Çolak Sabancı and Koray (2005)	1998-2001	A	73. Balkıs Özdelice et al. (2021)*	2021	S
35. Aktan et al. (2005)	1999-2000	S	74. Kayadelen et al. (2022)	2013-2014	S
36. Balkıs (2005)*	2000-2001	A	75. Durmuş et al. (2022)*	2022	S
37. Eker Develi et al. (2006)	2000-2001	M	76. Taş (2023)	2009-2010; 2013-2014	S
38. Taş and Okuş (2006)	2004-2005	B	77. Semin et al. (2023)*	2018-2019	S
39. Taş et al. (2006)*	2006	A			

Based on the results of the researchs on phytoplankton in Türkiye's seas, it has been determined that Türkiye's dinoflagellate flora is represented by a total of 330 species belonging to 75 different genera (Table 2). These results were obtained from scientific studies published in peer-reviewed journals from 1955 to the present. According to the literature, the genera with the most species are *Tripos* Bory (60 species), *Protoperidinium* Bergh (46 species), *Dinophysis* Ehrenberg (23 species), *Gonyaulax* Diesing and *Prorocentrum* Ehrenberg (14 species). With this literature study, it was determined that the number of dinoflagellate species reached up to 181 in the Black Sea, 158 in the Marmara Sea, 206 in the Aegean Sea and 192 in the Mediterranean Sea so far.

Table 2. Check-list of dinoflagellat species reported from previous 77 papers. The numbers following a species name in the checklist refer to the list of literature. (*first new record for single sea, **first new record for the Turkish waters).

Türler	B	S	A	M
Aureodinium pigmentosum Dodge	**60			
Acanthodinium caryophyllum Kofoid		*28	*9	25
Akashiwo sanguinea (K.Hirasaka) Gert Hansen & Moestrup	17	22	22	18
Alexandrium minutum Halim	48	*28	7	
Alexandrium ostenfeldii (Paulsen) Balech & Tangen	59			
Alexandrium tamarense (Lebour) Balech	60	72	4	
Amoebophrya ceratii (Koeppen) J.Cachon		**75		
Amphidinium acutissimum J.Schiller	**60			
Amphidinium carterae Hulburt	**60	*75		
Amphidinium crassum Lohmann	**60	*75		
Amphidinium operculatum Claparède & Lachmann	**60	*75		
Amphidinium sphenoides Wulff	**60	57	64	
Amphidinium steinii (Lemmermann) Kofoid & Swezy	**60			
Amphisolenia bidentata B.Schröder			2	16
Amphisolenia globifera F.Stein	**60			
Amphisolenia laticincta Kofoid		**61		
Amphisolenia palaeotheroides Kofoid				41
Amphisolenia schroederi Kofoid			*9	
Amphisolenia truncata Kofoid & J.R.Michener			*10	16
Amylax triacantha (Jørgensen) Sournia	48	44		
*Archaeperidinium minutum (*Kofoid) Jørgensen	**60	32	14	
Azadinium caudatum (Halldal) Nézan & Chomérat			54	
Balechina gracilis (Bergh) F.Gómez, Artigas & Gast		**69		
Blixaea quinquecornis (Abé) Gottschling		61		
Borghiella pascheri (Suchlandt) Moestrup	**60			
Brachidinium capitatum F.J.R.Taylor			*10	
Centrodinium pavillardii F.J.R.Taylor			*9	41
Centrodinium punctatum (Cleve) F.J.R.Taylor				18
Ceratium contortum var. robustum (Karsten) Sournia			9	18
Ceratium cornutum (Ehrenberg) Claparède & J.Lachmann	60			
Ceratium furcoides (Levander) Langhans	60			
Ceratium gibberum var. *dispar* (Pouchet) Sournia			3	16
Ceratium gibberum var. *subaequale* Jorgensen			3	41
Ceratium hirundinella (O.F.Müller) Dujardin	38		3	
Ceratium pentagonum var. *tenerum* Jørgensen			3	8
Ceratium ranipes f. *furcellatum* (Lemmermann) F.J.R.Taylor			3	
Ceratocorys armata (Schütt) Kofoid		*28	*9	16
Ceratocorys gourretii Paulsen			*5	16
Ceratocorys horrida Stein			1	2
Citharistes regius Stein				**33
Cladopyxis brachiolata F.Stein				8
Cochlodinium archimedis (Pouchet) Lemmermann	**60		64	
Coolia monotis Meunier 1919		*75		
Corythodinium brunellii (Rampi) F.Gómez	17			
Corythodinium compressum (Kofoid) F.J.R.Taylor	17			41
Corythodinium constrictum (F.Stein) F.J.R.Taylor			5	41
Corythodinium diploconus (F.Stein) F.J.R.Taylor	17			
Corythodinium frenguellii (Rampi) F.J.R.Taylor		**74		
Corythodinium milneri (G.Murray & Whitting) F.Gómez	6		1	41

Table 2. (Continued)

Türler	B	S	A	M
Corythodinium tesselatum (F.Stein) Loeblich Jr. & Loeblich III		72	**39	
Cystodinium unicorne G.A. Klebs	6			
Dinophysis acuminata Claparède & Lachmann	6	27	34	
Dinophysis acuta Ehrenberg	6	13	1	18
Dinophysis amandula (Balech) Sournia			*10	41
Dinophysis argus (Stein) Abé			*9	41
Dinophysis caudata Kent	6	13	1	8
Dinophysis elongata (Jørgensen) Abé				41
Dinophysis fortii Pavillard	17	13	5	53
Dinophysis hastata F.Stein	6	13	1	16
Dinophysis infundibulum J.Schiller	17	77		
Dinophysis odiosa (Pavillard) Tai & Skogsberg		**20		23
Dinophysis operculoides (Schütt) Balech				8
Dinophysis ovum F.Schütt	6	28	5	41
Dinophysis parva J.Schiller				67
Dinophysis parvula (F.Schütt) Balech	6		5	23
Dinophysis pulchella (M.Lebour) Balech	**60			
Dinophysis punctata Jørgensen	17	*28		
Dinophysis recurva Kofoid & Skogsberg			1	23
Dinophysis rudgei G.Murray & Whitting	17	74		
Dinophysis sacculus F.Stein	6	13	5	
Dinophysis schroederi J.Pavillard	22		1	
Dinophysis schuettii G.Murray & Whitting			*5	41
Dinophysis sphaerica F. Stein	6	22	1	41
Dinophysis tripos Gourret		32	5	18
Diplopelta asymmetrica (Mangin) M.Lebour ex Balech		*75		
Diplopelta bomba F.Stein ex Jørgensen				41
Diplopsalis lenticula Bergh	17	*28	*5	16
Diplopsalopsis bomba J.D.Dodge & S.Toriumi, nom. inval.				43
Dissodinium pseudocalani (Gonnert) Drebes ex Elbrachter & Drebes		32		
Durinskia agilis (Kofoid & Swezy) Saburova, Chomérat & Hoppenrath	**60			
Glenodinium paululum Lindemann				37
Gonyaulax africana J. Schiller	40			
Gonyaulax birostris Stein, nom. inval.	17		1	16
Gonyaulax diacantha Athanassopoulos	17		*5	
Gonyaulax diegensis Kofoid	17	*31	*5	16
Gonyaulax digitale (Pouchet) Kofoid	40	61		18
Gonyaulax fragilis (Schütt) Kofoid		57	58	
Gonyaulax hyalina Ostenfeld & Schmidt		68		
Gonyaulax milneri (G.Murray & Whitting) Kofoid			*10	41
Gonyaulax monacantha Pavillard	17	28	5	16
Gonyaulax pacifica Kofoid				**42
Gonyaulax polygramma F. Stein	6	61	5	16
Gonyaulax scrippsae Kofoid	48	**74	64	
Gonyaulax spinifera (Claparède & Lachmann) Diesing	17	13	4	16
Gonyaulax turbynei Murray & Whitting	66		*5	16
Gotoius abei K. Matsuoka		50	50	
Gymnodinium agiliforme J. Schiller	**60			
Gymnodinium catenatum H.W.Graham	**60	44		
Gymnodinium elongatum (J.Schiller) Moestrup & Calado, nom. illeg.	**60			
Gymnodinium fuscum (Ehrenberg) F.Stein				37
Gymnodinium herbaceum Kofoid	22	22	19	
Gymnodinium neapolitanum J. Schiller	**60			
Gymnodinium wilczekii Pouchet	**60			
Gymnodinium wulffii J.Schiller	**60			
Gynogonadinium aequatoriale F.Gómez		**61		
Gyrodinium estuariale E.M.Hulbert	**60			
Gyrodinium fusiforme Kofoid & Swezy	6	35	58	18
Gyrodinium lacryma (Meunier) Kofoid & Swezy	60			18

Table 2. (Continued)

Türler	B	S	A	M
Gyrodinium nasutum (Wulff) J.Schiller	**60			
Gyrodinium pellucidum (Wulff) J.Schiller	6			
Gyrodinium pingue (F.Schütt) Kofoid & Swezy	**60		64	
Gyrodinium pusillum (A.J.Schilling) Kofoid & Swezy	6			
Gyrodinium spirale (Bergh) Kofoid & Swezy	60	28	50	
Heterocapsa minima A.J.Pomroy		*75		
Heterocapsa niei (A.R. Loeblich) L. C. Morrill & A. R. Loeblich		*75		67
Heterocapsa pygmaea Lobelich III, R.J.Schmidt & Sherley		*75		**30
Heterocapsa rotundata (Lohmann) Gert Hansen	**60	**61		
Heterodinium angulatum Kofoid & J.R.Michener				**29
Heterodinium inaequale Kofoid				**29
Heterodinium mediocre (Kofoid) Kofoid & Adamson				**29
Heterodinium mediterraneum Pavillard			1	
Heterodinium rigdeniae Kofoid		**69		
Histioneis depressa J.Schiller				**24
Histioneis elongata Kofoid & J.R.Michener				**24
Histioneis expansa Rampi				**24
Histioneis marchesonii Rampi				**24
Histioneis oxypteris J.Schiller				41
Histioneis para G.Murray & Whitting				**24
Histioneis striata Kofoid & J.R.Michener				**24
Kapelodinium vestifici (Schütt) Boutrup, Moestrup & Daugbjerg	**60			
Karenia brevis (C.C.Davis) Gert Hansen & Moestrup	**60		64	
Karenia mikimotoi (Miyake & Kominami ex Oda) Gert Hansen & Moestrup	60			
Karlodinium veneficum (D.Ballantine) J.Larsen	**60			
Kofoidinium velleloides Pavillard	48	13	5	16
Kryptoperidinium triquetrum (Ehrenberg) Tillmann, Gottschling, Elbrächter, Kusber & Hoppenrath	17	*28	55	
Lebouridinium glaucum (Lebour) F.Gómez, H.Takayam, D.Moreira & P.López-García		71		
Lessardia elongata Saldarriaga & F.J.R.Taylor	*47			
Lingulodinium polyedra (F.Stein) J.D.Dodge	6	13	4	16
Margalefidinium citron (Kofoid & Swezy) F.Gómez, Richlen & D.M.Anderson	**60			
Noctiluca scintillans (Macartney) Kofoid & Swezy	6	13	4	41
Ornithocercus carolinae Kofoid			*9	41
Ornithocercus francescae (G.Murray & WHitting) Balech			56	
Ornithocercus heteroporus Kofoid			*10	41
Ornithocercus magnificus F.Stein			*5	23
Ornithocercus quadratus Schütt		*28	5	8
Ornithocercus quadratus var. assimilis			21	
Ornithocercus schuettii T.Wilke & Hoppenrath			*5	
Ornithocercus splendidus F.Schütt			*9	41
Ornithocercus steinii Schütt			*9	41
Ornithocercus thumii (A.W.F.Schmidt) Kofoid & Skogsberg				41
Oxytoxum variabile J.Schiller			50	67
Oxytoxum viride Schiller				67
Oxytoxum adriaticum Schiller	17			
Oxytoxum areolatum Rampi				67
Oxytoxum caudatum Schiller		*75		67
Oxytoxum elegans Pavillard			*10	
Oxytoxum gladiolus Stein				67
Oxytoxum ligusticum Rampi				67
Oxytoxum longiceps Schiller		63	*5	41
Oxytoxum longum J.Schiller				67
Oxytoxum mediterraneum Schiller		*75		
Oxytoxum reticulatum (Stein) Schütt			10	26
Oxytoxum scolopax F.Stein	22	13	1	16
Pachydinium mediterraneum Pavillard			*9	
Peridinium cinctum (O.F.Müller) Ehrenberg	6			
Phalacroma rotundatum (Claparéde & Lachmann) Kofoid & J.R.Michener	6	13	15	25
Phalacroma cuneus F.Schütt			56	

Table 2. (Continued)

Türler	B	S	A	M
Phalacroma doryphorum Stein		61	1	16
Phalacroma favus Kofoid & J.R.Michener			15	41
Phalacroma mitra F.Schütt		61	5	16
Phalacroma ovatum (Claparède & Lachmann) Jørgensen		*28		
Phalacroma oxytoxoides (Kofoid) F.Gomez, P.Lopez-Garcia & D.Moreira	60	**20	*14	
Phalacroma porodictyum F.Stein			1	
Phalacroma rapa F.Stein			21	8
Podolampas bipes F.Stein		57	*5	16
Podolampas elegans F.Schütt		49	1	41
Podolampas palmipes Stein	48	**20	15	41
Podolampas spinifera Okamura	48		1	16
Polykrikos hartmannii W.M.Zimmermann	22	22	62	
Polykrikos kofoidii Chatton	48	44	64	
Polykrikos schwartzii Bütschli	6	28		18
Pronoctiluca pelagica Fabre-Domergue	6	73	46	
Pronoctiluca spinifera (Lohmann) Schiller	6			
Prorocentrum micans Ehrenberg	6	13	4	16
Prorocentrum aporum (Schiller) J.D.Dodge	17	13	21	
Prorocentrum arcuatum Issel		32		
Prorocentrum balticum (Lohmann) Loeblich III	17		46	
Prorocentrum cordatum (Ostenfeld) J.D.Dodge	6	13	34	18
Prorocentrum dentatum F.Stein	17	32		
Prorocentrum gracile F.Schütt	38	32	34	53
Prorocentrum lima (Ehrenberg) F.Stein		32	34	
Prorocentrum maximum (Gourret) J.Schiller	17		21	
Prorocentrum pyriforme (J.Schiller) Hasle ex F.J.R.Taylor	17			
Prorocentrum rotundatum J.Schiller	17		14	
Prorocentrum scutellum B.Schröder	17	13	5	
Prorocentrum shikokuense Y.Hada		**75		
Prorocentrum triestinum J.Schiller	17	13	*5	53
Prosoaulax lacustris (F.Stein) Calado & Moestrup	**60			
Protoceratium areolatum Kofoid	17		*10	41
Protoceratium pepo Kofoid & J.R.Michener				8
Protoceratium reticulatum (Claparède & Lachmann) Bütschli	6	*28	11	43
Protodinium simplex Lohmann	48	*28		
Protoperidinium bipes (Paulsen) Balech	38	*28		
Protoperidinium brevipes (Paulsen) Balech	17	*31		
Protoperidinium brochii (Kofoid & Swezy) Balech	17	13	1	16
Protoperidinium claudicans (Paulsen) Balech	17	28	*5	16
Protoperidinium conicoides (Paulsen) Balech	17	76		41
Protoperidinium conicum (Gran) Balech	17	13	1	16
Protoperidinium conicum var. concavum (Matzenauer) Balech	17			
Protoperidinium crassipes (Kofoid) Balech	6	13	*5	18
Protoperidinium curtipes (Jørgensen) Balech	40	32		
Protoperidinium curvipes (Ostenfeld) Balech		32		
Protoperidinium deficiens (Meunier) Balech	6			
Protoperidinium depressum (Bailey) Balech	6	13	1	8
Protoperidinium diabolus (Cleve) Balech	6	13	1	41
Protoperidinium divergens (Ehrenberg) Balech	6	13	1	16
Protoperidinium elegans (Cleve) Balech	**60	74		
Protoperidinium excentricum (Paulsen) Balech	40	61		
Protoperidinium globulus (F.Stein) Balech	17	*28	1	16
Protoperidinium grande (Kofoid) Balech	17	13	*5	16
Protoperidinium granii (Ostenfeld) Balech	6	13	5	18
Protoperidinium heteracanthum (P.A.Dangeard) Balech	22			52
Protoperidinium leonis (Pavillard) Balech	22	13	5	16
Protoperidinium longipes Balech	17	13	*5	67
Protoperidinium marielebouriae (Paulsen) Balech	17			
Protoperidinium mediterraneum (Kofoid) Balech	60	13	10	16

Table 2. (Continued)

Türler	B	S	A	M
Protoperidinium mite (Pavillard) Balech		45	21	41
Protoperidinium murrayi (Kofoid) Hernández-Becerril			21	8
Protoperidinium oblongum (Aurivillius) Parke & Dodge	59	44	46	18
Protoperidinium obtusum (Karsten) Parke & J.D.Dodge	72			
Protoperidinium oceanicum (Vanhöffen) Balech	38	13	*5	16
Protoperidinium ovatum Pouchet		32	56	
Protoperidinium oviforme (Dangeard) Balech				18
Protoperidinium ovum (J.Schiller) Balech				41
Protoperidinium pallidum (Ostenfeld) Balech	38	13	*5	16
Protoperidinium paulsenii (Pavillard) Balech	40	*28	*9	
Protoperidinium pedunculatum (F.Schütt) Balech			34	16
Protoperidinium pellucidum Bergh	12	28	1	18
Protoperidinium pentagonum	6	28	14	41
Protoperidinium punctulatum (Paulsen) Balech	17	32		41
Protoperidinium pyriforme (Paulsen) Balech	17	*28	*5	16
Protoperidinium pyriforme subsp. *breve* (Paulsen) Balech			14	
Protoperidinium quarnerense (B.Schröder) Balech			*5	16
Protoperidinium simulum (Paulsen) Balech		45	*5	
Protoperidinium solidicorne (Mangin) Balech	6		21	18
Protoperidinium sphaericum (G.Murray & Whitting) Balech			14	
Protoperidinium steinii (Jørgensen) Balech	6	28	4	16
Protoperidinium subinerme (Paulsen) A.R.Loeblich III	17	*28	*5	23
Pseliodinium fusus (F.Schütt) F.Gómez	**60	*69	*65	
Pseliodinium vaubanii Sournia			50	
Pyrocystis elegans Pavillard	17	13	*9	25
Pyrocystis fusiformis C.W.Thomson	72		*9	8
Pyrocystis hamulus Cleve		57	34	41
Pyrocystis lunula (F.Schütt) F.Schütt	**60		50	
Pyrocystis pseudonoctiluca Wyville-Thompson		*75		
Pyrocystis robusta Kofoid		13	*10	41
Pyrophacus horologium F.Stein	17	13	5	16
Pyrophacus steinii (Schiller) Wall & Dale	48	74	*5	8
Scaphodinium mirabile Margalef	70	**20		
Scrippsiella acuminata (Ehrenberg) Kretschmann, Elbrächter, Zinssmeister, S.Soehner, Kirsch, Kusber & Gottschling	6	22	4	23
Sourniaea diacantha (Meunier) H.Gu., K. N. Mertens, Zhun Li & H. H. Shin	60	61		
Spatulodinium pseudonoctiluca (Pouchet) J.Cachon & M.Cachon	**60	*75		
Speroidium fungiforme (Anisimova) Moestrup & Calado	60		64	
Spiraulax kofoidii H.W.Graham			1	16
Torodinium robustum Kofoid & Swezy	**60			
Torodinium teredo (Pouchet) Kofoid & Swezy			64	
Tovellia leopoliensis (Wołoszyńska) Moestrup, K.Lindberg & Daugbjerg	**60			
Triadinium polyedricum (Pouchet) J.D.Dodge	6		5	16
Triadinium sphaericum (G.Murray & Whitting) J.D.Dodge		50	5	16
Tripos aestuarius var. *pavillardii* (Rampi) F.Gómez	17			
Tripos arcuatus (Gourret) F.Gómez			3	16
Tripos arietinus (Cleve) F.Gómez	38	27	3	8
Tripos arietinus f. *gracilentus* (Jørgensen) F.Gómez			3	41
Tripos azoricus (Cleve) F.Gómez		*75		41
Tripos belone (Cleve) F.Gómez	17		*5	41
Tripos brevis (Ostenfeld & Johannes Schmidt) F.Gómez			21	18
Tripos candelabrum (Ehrenberg) F.Gómez	6	*28	1	16
Tripos candelabrum var. *depressus* (Pouchet) F.Gómez			3	8
Tripos carriensis (Gourret) Hallegraeff & Huisman		50	2	2
Tripos claviger (Kofoid) Hallegraeff & Huisman			21	
Tripos coarctatus (Pavillard) F.Gómez			3	41
Tripos compressus (Gran) F.Gómez	17		*10	18
Tripos declinatus f. *brachiatus* (Jørgensen) F.Gómez			*9	
Tripos declinatus var. *major* (Jørgensen) F.Gómez	17		3	16

Table 2. (Continued)

Türler	B	S	A	M
Tripos digitatus (F.Schütt) F.Gómez			*10	41
Tripos eugrammus (Ehrenberg) F.Gómez	17	13	3	16
Tripos extensus (Gourret) F.Gómez	17		46	8
Tripos falcatiformis (Jørgensen) F.Gómez			*10	
Tripos falcatus (Kofoid) F.Gómez		69	2	2
Tripos furca (Ehrenberg) F.Gómez	6	13	1	8
Tripos fusus (Ehrenberg) F.Gómez	6	13	1	2
Tripos fusus var. *schuettii* (Lemmermann) F.Gómez	17	45	*5	
Tripos gallicus (Kofoid) F.Gómez			3	8
Tripos gibberus (Gourret) F.Gómez	22	*31	3	2
Tripos gracilis (Pavillard) F.Gómez	17		1	18
Tripos gravidus (Gourret) F.Gómez			5	41
Tripos hexacanthus (Gourret) F.Gómez	6	*75	2	2
Tripos hexacanthus f. *spiralis* (Kofoid) F.Gómez			*10	8
Tripos hexacanthus var. *contortus* (Lemmermann) F.Gómez				16
Tripos inflatus (Kofoid) F.Gómez	17	*31	2	2
Tripos intermedius (Jørgensen) F.Gómez	17		2	8
Tripos karstenii (Pavillard) F.Gómez			2	2
Tripos limulus (Pouchet) F.Gómez			*10	16
Tripos lineatus (Ehrenberg) F.Gómez	17	32	14	41
Tripos longipes (Bailey) F.Gómez	6	22	3	16
Tripos longirostrum (Gourret) Hallegraeff & Huisman	6	*28	2	2
Tripos longissimus (Schröder) F.Gómez			34	41
Tripos macroceros (Ehrenberg) Hallegraeff & Huisman		22	1	2
Tripos massiliensis (Gourret) F.Gómez		61	1	2
Tripos massiliensis f. *armatus* (Karsten) F.Gómez, nom. inval.	17		21	
Tripos minutus (Jørgensen) F.Gómez		**20	46	
Tripos muelleri Bory	6	22	1	8
Tripos muelleri f. *atlanticus* (Ostenfeld) F.Gómez, nom. inval.	17	13	3	16
Tripos muelleri f. *parallelus* (Schmidt) F.Gómez				16
Tripos paradoxides (Cleve) F.Gómez			3	8
Tripos pavillardii (Jørgensen) F.Gómez			2	2
Tripos pentagonus (Gourret) F.Gómez	6	28	1	8
Tripos pentagonus var. *longisetus* (Ostenfeld & J.Schmidt) Gómez, nom. inval.			*5	
Tripos platycornis (Daday) F.Gómez	60		*9	41
Tripos pulchellus (Schröder) F.Gómez	17	13	1	8
Tripos ranipes (Cleve) F.Gómez			2	8
Tripos schroeteri (B.Schröder) F.Gómez			*10	41
Tripos setaceus (Jørgesen) F.Gómez	17	51	3	8
Tripos subcontortus (Schröder) F.Gómez				8
Tripos symmetricus (Pavillard) F.Gómez			1	8
Tripos teres (Kofoid) F.Gómez	17	51	3	8
Tripos trichoceros (Ehrenberg) Gómez	72	13	2	2
Tripos volans (Cleve) F.Gómez	17		3	8
Tripos vultur (Cleve) Hallegraeff & Huisman		*75	*9	
Triposolenia bicornis Kofoid			**36	

DISCUSSION

There are checklists published by various researchers in the past (Koray 2001; Balkıs 2004). In the checklist made by Koray (2001), a total of 396 phytoplankton species, 193 of which belong to the Dinophyceae class, were identified from the Turkish seas. In the same review study, 87 species belonging to the Dinophyceae class were compiled in the Black Sea, 133 species in the Aegean Sea and 107 species in the Mediterranean Sea. Balkıs (2004) recorded 73 species belonging to the Dinophyceae class out of total 168 species in the phytoplankton species list of the Marmara Sea. With the present study, total number of dinoflagellates recorded along Turkish coasts increased to 330, showing 137 more records of species. However, this number may increase if results of master and doctoral theses are published.

With the latest studies conducted on a regional basis, the number of species continues to increase day by day. Some of the recent studies on phytoplankton composition in distinct regions of Türkiye can be listed as following; the Black Sea (Taş and Okuş, 2006; Baytut et al., 2010; Balkıs Özdelice and

Peynirci, 2019), the Marmara Sea (Balkıs, 2003; Taş et al., 2020; Durmuş et al., 2022), the Aegean Sea (Koray, 1987; Koray, 1995; Çolak Sabancı and Koray, 2001; Çolak Sabancı and Koray, 2012) and Mediterranean Sea (Eker and Kıdeyş, 2000; Polat et al., 2000; Polat and Koray, 2007). By electron microscope analyses, Eker Develi and Velikova (2009) found one species as a new record for the Black Sea. Besides, in the study of Baytut and Gönülol (2016) conducted in the Black Sea, a total of 34 new records species were recorded for Turkish coasts, but the absence of drawings, photographs or morphometric measurements of these species cause that the species to remain as questionable. A total of 51 new records of species were recorded for the Marmara coasts, and 14 of them were noted as new records for the Turkish coasts (Balkıs, 2000; Balcı and Balkıs, 2017; Balkıs Özdelice et al., 2020; Kayadelen et al., 2022; Durmuş et al., 2022). While 2 of these species (*Corythodinium frenguellii* and *Gonyaulax scrippsae*) are only included in the species list, 12 species (*Amoebophrya ceratii*, *Amphisolenia laticincta*, *Balechina gracilis* (=*Gymnodinium dogielii*), *Dinophysis odiosa*, *Gynogonadinium aequatoriale*, *Heterocapsa rotundata*, *Heterodinium rigdeniae*, *Phalacroma oxytoxoides*, *Podolampas palmipes*, *Prorocentrum shikokuense*, *Scaphodinium mirabile*, *Tripos minutus* (=*Ceratium minutum*) were supported by morphometric measurements and photography. Additionally, 2 taxa were recorded as "sp.", 2 taxa were noted as "cf.", and 1 species was not included in the list as its record had been previously provided. It has been observed that out of the 58 new records of species for the Aegean coast, only a few are new records for the Turkish coastline. In the literature study, only *Triposolenia bicornis* and *Corythodinium tesselatum* species were found to be the new records for the Turkish coasts, and these records were reported with morphometric measurements and photography (Balkıs, 2005; Taş et al., 2006). *Tripos gallicus* (=*Ceratium deflexum*, *Ceratium macroceros* var. *gallicum*) and *Tripos longissimus* (=*Ceratium longissimus*) species have not been included in the list as new records since they have been recorded before. New records of 12 species in total have been reported for the Mediterranean, and all of them are the first records for the Turkish coasts (Polat and Koray, 2002; Polat and Koray, 2003; Uysal et al., 2003; Polat, 2004; Polat, 2007). The studies conducted by Polat and Koray (2002) (*Histioneis depressa*, *Histioneis elongata*, *Histioneis expansa*, *Histioneis marchesonii*, *Histioneis para*, *Histioneis striata*), Polat and Koray (2003) (*Heterodinium angulatum*, *Heterodinium inaequale*, *Heterodinium mediocre*), Uysal et al., (2003) (*Heterocapsa pygmaea*), Polat (2004) (*Citharistes regius*), and Polat (2007) (*Gonyaulax pacifica*) have contributed significantly to the flora of Türkiye at both genus and species levels. These studies provide valuable contributions by presenting the characteristic structural features, distributions, and photographs of the species.

CONCLUSION

According to the results obtained from research on phytoplankton, the dinoflagellate flora of Türkiye is represented by 330 species belonging to 75 genera. A total of 2377 species of dinoflagellates belonging to 259 genera have been identified in the world's oceans (Gómez, 2012b). The Mediterranean is represented by 673 species belonging to 104 genera (Gómez, 2003), while the Black Sea is represented by 267 species belonging to 54 genera (Gómez and Boicenco, 2004). The oligotrophic conditions of the Mediterranean lead to an increase in dinoflagellate diversity, whereas the lower salinity (~ 17) of the Black Sea, coupled with its richer organic matter, result in lower species diversity (Gómez, 2003; Gómez and Boicenco, 2004).

Pelagic dinoflagellates show a lower percentage of endemic species compared to macroscopic or benthic species, and studies have concluded that pelagic dinoflagellates cannot be considered endemic (Bianchi and Morri, 2000; Gómez and Boicenco, 2004; Gómez, 2006). In this study, the number of species detected in a single sea constitutes approximately 34.5% of the total species given in the literature. Accordingly, when the single-celled microplankton species compositions of the Black Sea, Marmara, Aegean and Mediterranean were evaluated, it was determined that 40 species in the Black Sea, 19 species in the Marmara, 21 species in the Aegean and 34 species in the Mediterranean were seen in a single sea. It is quite surprising that there are very few endemic species in phytoplankton, and even though most of the species are cosmopolitan, only 20% of the species identified in the literature study are represented in all seas of Türkiye. Variables such as sampling period, sampling method and differencies between salinity levels may be effective in observing this difference between Turkish coasts in the studies conducted, it is also necessary to take into account the possibility of incorrect taxonomic definitions and missing small species during the examination. Detailed studies carried out with electron microscope and DNA sequence analyses can definitely help to identify species correctly. In addition, the species diversity given in the checklist may not accurately reflect reality, since the studies carried out so far have generally been repeated in the same regions and many geographical points have not been investigated. Therefore, it would be more appropriate to plan future studies as ecosystem-wide comprehensive and long-term monitoring studies, and to provide the characteristic structural features, distributions and photographs of the species, especially in new taxonomic descriptions. This study is significant for compiling marine pelagic dinoflagellates from Turkish coasts, reported in 77 differeent literatüre sources and updating their nomenclature, thus serving as a dataset for future research endeavors.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest or competing interests.

ETHICS APPROVAL

No specific ethical approval was necessary for the study.

DATA AVAILABILITY

For any questions, the corresponding author should be contacted.

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