Title: Early-breeding Season Movements of the Yelkouan Shearwater (Puffinus yelkouan, Acerbi, 1827) at the Dardanelles Strait

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Early-breeding Season Movements of the Yelkouan Shearwater (*Puffinus yelkouan,* Acerbi, 1827) at the Dardanelles Strait

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Abstract

We aimed to make censuses of *Puffinus yelkouan* at the Dardanelles and to evaluate the movements at the Aegean and the Marmara Sea during the early breeding period. Field studies were carried out in the morning and afternoon for 40 days between 6 February and 22 March 2019. In the censuses, the highest number of birds, passing in both directions in a day was 78145 individuals; 56451 of them were counted in the direction of the Aegean Sea on 17 February, which is the highest number counted in one direction in a day. As a result, the number of birds crossing to the Aegean Sea through the Dardanelles in the afternoon is significantly higher than the number of birds crossing to the Aegean Sea in the morning. In the afternoon, the number of birds flying towards the Aegean Sea is significantly higher than the number of birds flying towards the Marmara Sea. Considering that the species visits the breeding colonies at night, this movement pattern could be related to the fact that the shearwater breeding population is predominantly found in the Aegean or in the Mediterranean Sea. In addition, some issues, such as how long the birds stay in these sea regions after flying to the Aegean Sea or the Marmara Sea, which route they follow or how the flocks mix require further investigation.

Keywords: Dardanelles, *Puffinus yelkouan*, breeding period, population census, movements

1. INTRODUCTION

Puffinus yelkouan species, which is included in the order of Procellariiformes, lives in the open seas outside the incubation period and almost all of its population is distributed in the Mediterranean, the Aegean and the Black Seas. According to the IUCN red list, it is reported to be in the status of vulnerable due to the decreasing trend of the population on a global scale. Fishing, illegal hunting, human-induced disturbance, light and noise pollution, increasing predator

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populations in breeding areas and habitat destruction are reported as the important factors in the decline in its population in recent years [1-7].

It has been reported that Yelkouan Shearwater individuals start to join the breeding colonies in November, mating takes place in February and lays eggs in March. Studies have shown that the young start to leave the nest in June and this process continues until July [8]. As breeding grounds, Yelkouan Shearwaters prefer hard-to-reach cavities under rock blocks, cavities they dig on soil surfaces, and sometimes human structures [9].

Islands, which contain suitable habitats for nest building, provide protection against external environmental conditions and predators, are preferred as breeding grounds [9-11]. Pair number in known breeding colonies reported; Italy (12,000–19,000 p.), Greece (7,000–10,000 p.), Malta (1,370-2,000 p.), France (627-1,044 p.), Croatia (300–500 p.), Tunisia (180–200 p.), Algeria (10–100 p.), Albania (1-10 p.), and Bulgaria (0–10 p.) [11].

In the studies carried out so far on the breeding areas of the species, it has been stated that most of the breeding population is concentrated in Malta, Italy, Greece, France, Croatia and Turkey, and there may be 10,815 to 53,574 breeding pairs in these areas [1]. Although it has been reported that a breeding colony is likely to exist in Turkey, a breeding site has not been determined yet [6, 12].

Radio-Telemetry studies carried out reveal that a large part of the population in the Mediterranean, which breed in Malta and France, migrate to the Black Sea to spend a few months outside the breeding period and are long-distance migrants [13-15]. In their study, Ortega and İsfendiyaroğlu [7] stated that the Black Sea is an important gathering area for the Yelkouan Shearwater populations in the Mediterranean, outside the breeding season.

Being a pelagic species, the activity of Yelkouan Shearwater in open sea is difficult to monitor from land. However, monitoring by boats causes problems in terms of cost and time. The areas where the water bodies narrow, such as the Dardanelles and the Bosphorus, are the most ideal points where the population can be monitored. As a matter of fact, in the observations made in the Bosphorus, it has been reported that over 90,000 Yelkouan individuals were counted in a short time. In the censuses made in the Bosphorus, it was reported that the lowest number of individuals was reached in September and October, and the highest number of individuals was reached in January and February [16].

The global population of Yelkouan Shearwater, a species endemic to the Mediterranean basin, is estimated at 15,337-30,519 pairs or 46,000-92,000 individuals [12, 17, 18]. Populations in known breeding colonies are either declining or have been poorly researched [19]. It has been reported that the global population will decrease by approximately 50% in 54 years (3 generations) if the decline in the population of the species included in the globally endangered Vulnerable species category continues at the current rate. Therefore, research priorities regarding the species have been reported as searching for new breeding colonies, monitoring the population in important breeding and bottleneck areas, assessing mortality rates and examining demographic parameters [12]. Considering the 75,000-90,000 individuals recorded during their pre-breeding mobility in the Bosphorus [16], more research is needed to confirm the breeding population sizes, especially in the Aegean Sea and Turkey.
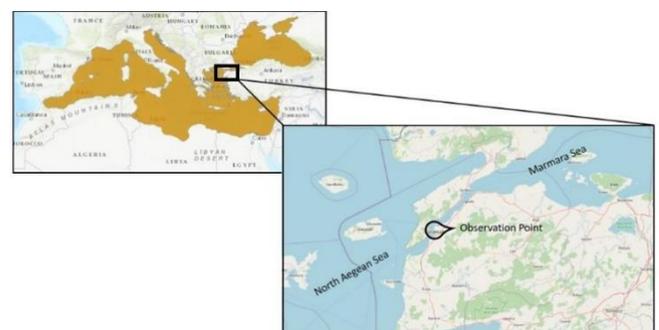

Figure 1 Distribution map of the Yelkouan Shearwater and the observation point in the Dardanelles

In the study, it was aimed to monitor and count the activity in the early breeding period in the Dardanelles Strait, which is one of the important

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bottlenecks in terms of monitoring the population of the species, and to compare the activity in the direction of the Aegean Sea and the Marmara Sea during the early breeding period. In this respect, the data obtained from the study will provide the opportunity to compare the population censuses of the species to be made in the future, help guide international conservation efforts and contribute to the research of possible breeding colonies in Turkey.

2. MATERIAL AND METHOD

Monitoring studies were carried out between 06 February and 22 March 2019 for a total of 40 days. No monitoring studies were carried out on dates when visibility made it impossible to monitor due to heavy fog. For this reason, the entire 40-day follow-up study was carried out on the dates when visibility was appropriate. During the monitoring studies, at least two observers participated in the counts every day and the counts were continued between the hours of sunrise and sunset. Bourgeois et al. (2008a) reported that the copulation behaviour of the species takes place in February and they lay eggs in March (Bourgeois et al. 2008a). In this respect, observation studies were determined as February and March, taking into account the mating period of the species.

On observation days, there was only a break between 12:00 and 13:00 between sunrise and sunset. Binoculars, telescopes, telephoto lenses and cameras were used in the monitoring studies, and observation data (such as transit time, number of individuals, transit direction) were recorded in pre-prepared registration forms. Monitoring studies were carried out between the Çimenlik Castle and Kilitbahir Castle, which is the narrowest point of the Dardanelles with 1500 m, in order to minimize the losses (Observation point coordinate: UTM 35 N 448852 4444480, 5m) (Figure 1).

2.1. Statistical Analysis

The data used in statistical analysis are the morning and afternoon counts of 40 days. The data set consists of the number of Yelkouans passing through the Dardanelles in the direction of the Aegean and Marmara Seas, their transit times, date and direction of passage. The hypothesis in this research was established to test whether there is a significant difference between the number of Yelkouans crossing the Aegean and Marmara Seas. The normal distribution of the data was tested before the analyses were made. Since the sample size was less than 50 (n=40), Shapiro-Wilk Test was applied. As a result of the test, the p value ($p < 0.05$) was found and it was accepted that the data were not normally distributed [20]. The log10 transformation was applied to the count data that did not comply with the normal distribution condition [21]. After the data transformation was completed, One Way ANOVA, Two Way ANOVA and interactions analysis were applied. With these tests, the numbers of Yelkouan moving between the Marmara and the Aegean Seas were examined in terms of time and direction, which are independent variables.

These tests are shown below;

- one.way<-aov(log10(tot_ind)~time, data=yelkouan)
- one.way<-aov(log10(tot_ind)~direction, data=yelkouan)
- two.way<-aov(log10(tot_ind)~time+direction, data=yelkouan)
- interactions<-aov(log10(tot_ind)~time*direction, data=yelkouan)

The dependent variable in the tests is the total number of individuals (tot_ind). The number of individuals in each Yelkouan flock were recorded separately. Time, which is one of the independent variables, was divided into two categories, namely morning and afternoon. The other independent variable was direction, and it was divided into two categories, the Marmara and the Aegean Sea. These tests were compared by looking at AICc values [22]. Binary interactions analysis with ΔAICc <2 was determined as the best explanatory analysis. Calculations to determine the AICc values were made using the 'AICcmodavg' package in the R program version 4.0.3 [23]. Then, Tukey HSD test was applied and the differences between the two groups were

compared (Table 1). It was found that the interactions between direction of passage and time of transition explained 98% ($R^2 = 98$) variability of the Yelkouan movements.

Table 1 Results of the Tukey HSD test (m=morning, a=afternoon, as=Aegean Sea, ms=Marmara Sea).

Comparisons	diff	lwr	upr	p-adj
m:as-a:as	-0.59	-0.85	-0.33	0.00
a:ms-a:as	-0.30	-0.57	-0.04	0.02
m:ms-a:as	-0.39	-0.65	-0.13	0.00
a:ms-m:as	0.28	0.02	0.54	0.03
m:ms-m:as	0.20	-0.06	0.45	0.20
m:ms-a:ms	-0.09	-0.35	0.17	0.82

3. RESULTS

Puffinus yelkouan species live in open seas except incubation period and almost all of its population is distributed in the Mediterranean and Black Seas. During the censuses in the Dardanelles during the early breeding period of the species, a total of 604956 individuals were counted in 892 passages during 40 days. 384678 of the crossings took place in the Aegean Sea direction and 220278 in the Marmara Sea direction. The highest

counts made in one day in both directions were 78145 individuals (in the direction of the Marmara Sea: 24815 individuals, towards the Aegean Sea direction: 53330 individuals) on 26.02.2019 and a total of 57829 individuals on 17.02.2019 (in the direction of Marmara Sea: 1378 individuals, 56451 individuals in the Aegean Sea direction) realized with. On 17.02.2019, 56451 individuals counted towards the Aegean Sea became the highest number of individuals counted in a single direction in a day. The lowest number of individuals was counted on March 13 with a total of 3697 individuals. The maximum number of individuals in one hour was reached between February 26, 13:00-14:00 (4160 individuals towards the Aegean Sea 19423, towards the Marmara Sea). In the censuses made within the 40-day period, it was determined that the intensity of the activity was concentrated in the afternoon (13:00 and sunset hours) and towards the Aegean Sea. The distribution of morning and afternoon passes in February and March is given in Figure 2 and hourly observation records are given in Appendices 1.
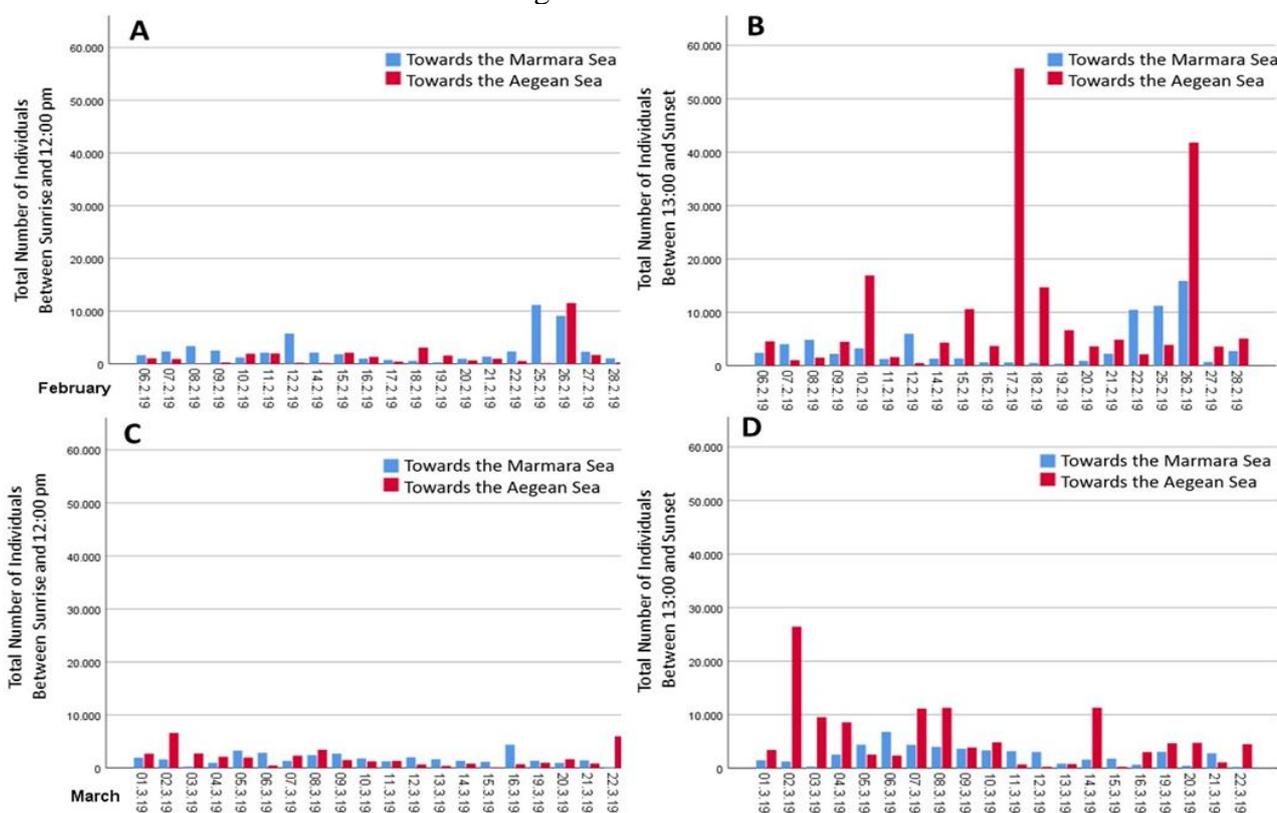

Figure 2 Number of individuals transiting (A: morning counts in February, B: afternoon counts in February, C: morning counts in March, D: afternoon counts in March

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A significant ($p<0.001$) difference was found between the number of birds crossing the Aegean Sea in the morning and the number of birds crossing the Aegean Sea in the afternoon. In addition, a significant ($p<0.05$) difference was found between the number of birds crossing the Marmara Sea in the afternoon and the number of birds crossing the Aegean in the afternoon. In addition, a significant ($p<0.001$) difference was found between the number of birds crossing the Marmara Sea in the morning and the number of birds crossing the Aegean Sea in the afternoon. It was found that the number of birds crossing the Marmara Sea in the afternoon was significantly different from the number of birds crossing the Aegean Sea in the morning ($p <0.05$) (Figure 3).
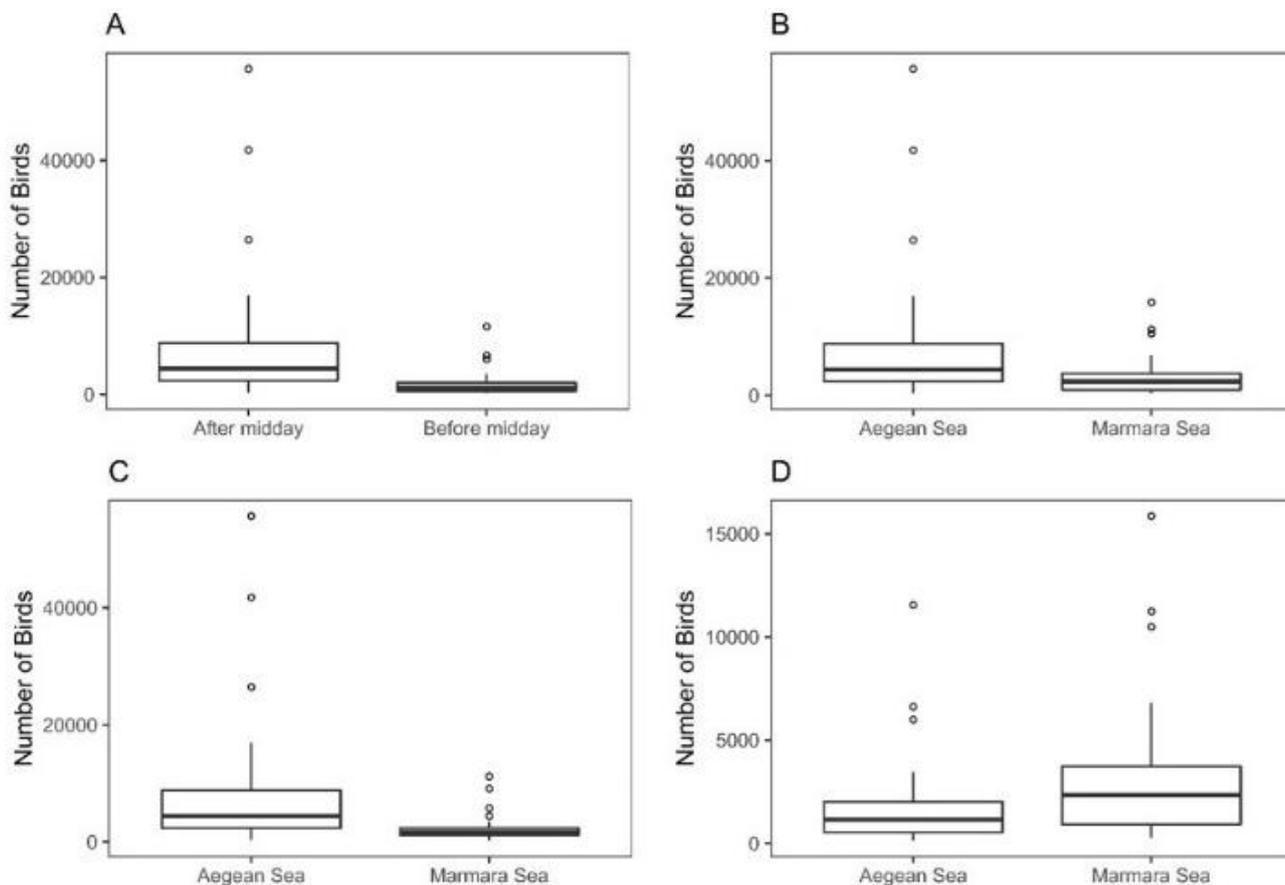
Figure 3. Tukey HSD test results

According to the results of the Tukey HSD test, the number of birds crossing from the Marmara Sea to the Aegean Sea through the Dardanelles in the afternoon is significantly higher than the number of birds crossing from the Marmara Sea to the Aegean Sea in the morning (Figure 3-A). In the afternoon, the number of birds flying towards the Aegean Sea is significantly higher than the number of birds flying towards the Marmara (Figure 3-B). The number of birds flying towards the Marmara Sea in the morning is significantly lower than the number of birds flying towards the Aegean Sea in the afternoon (Figure 3-C). The number of birds flying towards the Aegean Sea in the morning is significantly lower than the number of birds flying towards the Marmara Sea in the afternoon (Figure 3-D).

4. DISCUSSION AND CONCLUSION

This mobility direction and density during the breeding period shows that it would be appropriate to conduct monitoring in the Aegean Sea rather than the Marmara Sea in future studies to investigate the possible breeding colony.

It is reported that the populations of the Yelkouan species, which is endemic to the Mediterranean basin, in known breeding colonies are either in a decreasing trend or there is insufficient research

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[19]. A reliable estimate of the population size of the species and repeat counts at regular intervals are essential, as the population tends to decline on a global scale.

Data from regular censuses provide information on conditions such as reduced successful reproduction or reduced adult survival that could result in a decline in numbers. However, at the stage of data collection, records must be recorded in a standard and reliable manner. Data obtained in this way can play a role in determining the success or failure of the conservation actions carried out [24]. In the censuses made in the Bosphorus in 2012, it was reported that nearly 90,000 individuals were counted within a few hours [16]. In the censuses made by us in the Dardanelles, these figures could not be reached. The maximum number of individuals in one hour was reached between 13:00 and 14:00 on February 26 (4160 in the direction of the Aegean Sea 19423, towards the Marmara Sea). The highest count in a day was recorded on February 26 with 78145 individuals. In order to interpret the data in a healthier way, simultaneous long-term counts should be made in the Istanbul and Çanakkale Straits.

In studies in which the mobility of the species is monitored using telemetry, it is seen that the population in France, Italy and Malta mostly migrate to the Eastern Mediterranean and Black Sea [13-15]. In addition, it is stated that the Black Sea is an important gathering area for the Yelkouan populations in the Mediterranean, outside the breeding season [7]. The Dardanelles Strait, where observation studies are carried out, is a very important point for monitoring the mobility of the species between the Black Sea and the Mediterranean.

The Yelkouan Shearwater global population size has been estimated at 46,000 to 92,000 individuals [18]. It has been reported that over 90,000 Yelkouan individuals were counted in a short time that they were flying through one direction in the observations made in the Bosphorus [16]. In the observation studies carried out by us in the Dardanelles, 78145 individuals were counted on the date when the total number of crossings to the Marmara Sea and the Aegean

Sea directions was the highest (in the direction of Marmara Sea: 24815 individuals, in the direction of Aegean Sea: 53330 individuals). The distribution and the rate of mobility of the population outside the incubation period vary according to the nutrient abundance and meteorological conditions [25]. As a limitation of the study, the censuses made during the early breeding period should be evaluated by taking this issue into account. In addition, simultaneous censuses in bottlenecks where land censuses can be made can provide better data for comparison and to provide information about changes in the population of the species.

It is estimated that a large part of the breeding population is concentrated in Malta, Italy, Greece, France, Croatia and Turkey and there may be 10,815 to 53,574 breeding pairs in these areas [1]. Although it is likely to breed in Turkey, its breeding area has not been determined yet [12]. In order to investigate possible breeding sites of the species in the region, research studies should be conducted in areas containing suitable habitats for nest construction, such as cliffs and soil surfaces. However, in research studies that require intensive human resources, workforce and financial support, it is important to concentrate the areas to be researched with more probable areas. A pelagic species that makes long journeys in the sea during the breeding season, the Yelkouan travels an average of 428 km before returning to the colony to feed young [15]. In this respect, the records taken from the Dardanelles during the breeding period provided preliminary data for the investigation of a possible breeding colony.

Our findings showed that the number of birds that passed to the Aegean Sea in the afternoon was significantly higher than the number of birds that passed to the Aegean Sea in the morning. This may be related to the fact that the main breeding areas of the species are in the Aegean Sea region. In addition, the fact that the number of birds moving towards the Aegean Sea in the afternoon is significantly higher than the number of birds moving towards the Marmara Sea in the afternoon may be due to the fact that the main breeding areas are in the Aegean Sea. It is known that this species feeds in the open sea during the day and goes to

the land where there are colonies for breeding activities at night. However, the demographic characteristics of the birds counted in this study are not known. For this reason, it is difficult to explain comprehensively whether the movements of birds are for breeding purposes. The uncertainty of this situation cannot be investigated with this research method.

In addition, the fact that the number of birds flying towards the Marmara Sea in the morning is significantly lower than the number of birds flying towards the Aegean Sea in the afternoon suggests that this species may not be moving regularly between the two seas every day. Moreover, it is also among our findings that the number of birds flying towards the Aegean Sea in the morning is significantly lower than the number of birds flying towards the Marmara Sea in the afternoon. In addition, some issues, such as how long the birds stay in these sea regions after flying to the Aegean Sea or the Marmara Sea, which route they follow or how the flocks mix require further investigation. Extensive research would lead to a better understanding of the purpose of the bird's movements between the two seas and how the time spent in those two seas changes.

With the study, 40-day monitoring data was presented in February and March in the Dardanelles, which is one of the important bottlenecks in terms of monitoring the population of the species. In addition, in order to provide preliminary data in determining the probable breeding areas of the breeding population, which was also reported in previous studies where it could not be determined precisely in Turkey, a comparison of the movements in the Aegean Sea and the Marmara Sea during the early breeding period was made. In this respect, the data obtained from the study will provide the opportunity to compare the population censuses of the species to be made in the future, help guide international conservation efforts and contribute to the research of possible breeding colonies in Turkey.

5. GENERAL REQUIREMENTS

The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by the authors.

Authors' Contribution

The authors contributed equally to the study.

The Declaration of Ethics Committee Approval

This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics

The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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Appendices 1. Distribution of individual numbers according to observation dates and transit times (M: Marmara Sea, A: Aegean Sea)

Date	Total Individual	Toward the Marmara Sea	Toward the Aegean Sea	sunrise-08:59		09:00-09:59		10:00-10:59		11:00-11:59		13:00-13:59		14:00-14:59		15:00-15:59		16:00-16:59		17:00-17:59		18:00-sunset	
				M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A
06.2.2019	9695	4086	5609	15	109	189	310	530	369	913	253	370	1203	582	814	391	1353	483	820	288	196	325	182
07.2.2019	8352	6384	1968	173	90	821	376	678	295	661	158	912	487	440	199	832	220	730	107	815	31	322	5
08.2.2019	9912	8282	1630	226	39	1215	44	1058	21	883	9	838	245	420	287	724	200	992	411	912	290	978	84
09.2.2019	9492	4744	4748	472	49	1227	124	463	60	355	36	587	387	186	674	186	652	380	783	451	1138	437	845
10.2.2019	23308	4487	18821	376	40	310	453	113	656	428	770	470	4454	344	4770	379	3802	1080	1851	587	1625	400	400
11.2.2019	6979	3390	3589	492	252	477	722	431	412	730	583	249	273	296	472	180	439	355	270	121	83	59	83
12.2.2019	12466	11747	719	247	35	579	2	535	0	4390	184	1397	35	1320	47	867	160	964	104	908	120	540	32
14.2.2019	8013	3488	4525	178	39	271	36	456	6	1248	104	196	435	281	569	295	727	206	1191	74	855	283	563
15.2.2019	15886	3182	12704	165	126	438	173	678	1010	530	808	233	2335	371	4816	374	1241	179	731	191	1067	23	397
16.2.2019	6717	1704	5013	50	404	325	351	379	370	257	195	224	1014	79	847	43	806	36	555	50	201	199	270
17.2.2019	57829	1378	56451	99	198	269	103	232	107	151	15	138	13190	50	19370	48	12470	95	6662	179	3013	117	997
18.2.2019	18876	1102	17774	104	283	215	666	190	1329	55	800	14	2489	19	2708	65	2707	232	3312	108	2329	100	1151
19.2.2019	8919	698	8221	42	285	99	499	83	422	69	360	56	2199	13	1919	48	808	152	728	63	521	72	480
20.2.2019	6172	1886	4286	107	185	241	234	188	155	429	74	124	21	148	64	145	568	210	1495	214	1094	80	396
21.2.2019	9487	3634	5853	341	24	325	356	200	191	513	400	56	448	228	665	322	1426	587	1008	618	748	444	587
22.2.2019	15523	12820	2703	422	142	617	305	417	84	876	17	1703	338	2629	231	2189	384	1386	583	1828	512	753	107
25.2.2019	26461	22419	4042	0	0	375	4	2558	0	8246	144	4475	680	768	150	1722	407	2105	1054	1355	801	815	802
26.2.2019	78145	24815	53330	997	35	1746	913	1869	1070	4495	9529	4160	19423	4030	11242	3137	6822	1261	1349	1046	1687	2234	1260
27.2.2019	8373	3034	5339	360	340	860	515	600	493	473	340	294	388	84	1532	10	631	57	455	18	265	252	327
28.2.2019	9179	3801	5378	110	12	281	138	239	51	412	68	540	149	647	516	527	1093	387	1255	480	1384	178	712
01.3.2019	9543	3441	6102	456	216	446	901	605	875	449	705	571	792	214	24	256	156	197	552	107	968	140	913
02.3.2019	35943	2883	33060	117	285	492	594	294	398	719	5336	440	9292	318	5287	266	4138	181	3329	56	4176	0	225
03.3.2019	12824	584	12240	36	432	75	338	62	362	89	1595	68	2798	32	1028	30	1411	57	2061	34	1636	101	579
04.3.2019	13943	3223	10720	159	431	186	486	163	417	446	794	302	1608	379	1480	176	1542	386	1813	408	1494	918	655
05.3.2019	12215	7680	4535	478	339	756	758	938	451	1102	423	1335	362	1016	573	864	593	532	411	230	182	429	443
06.3.2019	12541	9672	2869	383	45	599	90	1001	163	878	190	1566	444	1833	502	1371	215	952	438	635	430	454	345
07.3.2019	19344	5703	13641	187	139	202	278	373	144	567	1769	638	1542	772	2059	895	2848	734	2072	758	1531	577	1096
08.3.2019	21144	6431	14713	182	521	211	676	844	824	1193	1426	1236	1582	818	2955	453	2042	548	2632	447	1059	499	996
09.3.2019	11736	6368	5368	230	284	225	525	323	420	1942	254	841	675	702	589	554	634	702	901	432	670	417	416
10.3.2019	11241	5147	6094	193	197	305	283	414	427	888	338	284	847	697	961	713	960	500	693	679	785	474	603
11.3.2019	6491	4432	2059	265	293	230	296	85	449	689	296	774	162	634	0	378	81	649	132	336	292	419	58
12.3.2019	6018	5072	946	437	100	319	113	172	97	1093	358	286	65	562	31	1148	83	670	10	298	71	87	18
13.3.2019	3697	2513	1184	512	208	345	40	404	80	371	57	233	197	84	61	55	83	143	175	140	164	226	119
14.3.2019	15103	2984	12119	412	176	353	91	265	468	324	91	310	346	280	1291	186	3175	263	3191	179	2152	412	1138
15.3.2019	3391	2968	423	398	34	237	27	254	24	281	57	276	46	203	11	219	41	351	36	300	54	449	93
16.3.2019	8833	5082	3751	764	565	859	60	1129	54	1653	40	143	596	116	424	60	467	200	528	77	607	81	410
19.3.2019	10093	4427	5666	331	22	324	27	332	18	383	928	135	416	333	941	863	1126	544	1066	317	747	865	375
20.3.2019	7817	1425	6392	317	448	176	220	167	845	301	125	117	1203	21	617	56	933	69	822	45	642	156	537
21.3.2019	6218	4250	1968	504	214	353	91	265	468	324	91	674	162	634	0	378	81	649	132	336	292	133	437
22.3.2019	10902	428	10474	25	1861	31	1292	15	1099	90	1735	2	813	38	1017	8	645	27	544	55	621	137	847