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The flight activity and population density of *Orthotomicus erosus* (Wollaston, 1857) in the Brutian pine (*Pinus brutia* Ten.) forests of İzmir Province, Turkey

Oğuzhan Sarıkaya[a]* Hüseyin Mahir İbiş[b] Özgür Toprak[c]

[a]Suleyman Demirel University, Faculty of Forestry, 32260, Isparta, Turkey

[b]Suleyman Demirel University, Faculty of Forestry, 32260, Isparta, Turkey

[c]Izmir Forestry Regional Directorate, Izmir, Turkey

[a]*Email: oguzhansarikaya@sdu.edu.tr*

[b]*Email: huseyinmahiribis@gmail.com*

[c]*Email:ozgurt10@gmail.com*

Abstract

This study is on the flight activity and population density of *Orthotomicus erosus* (Wollaston, 1857), which is one of the most important pests in *Pinus brutia* Ten. forests of Izmir Province. It was conducted between the years of 2010-2012 by using funnel-type pheromone traps and pheromone dispensers that contained 1500 mg methyl butanol + 100 mg cis-verbanol + 30 mg lpsdienol. For this aim, six experimental sites were established in different regions in consideration of different altitude levels. As the result of the study, it was seen that *O. erosus* adults started to fly in the beginning of March, when the average temperature was 7 °C, they continue to fly until the end of the second half of October depending upon temperature and elevation and there are 4-5 generations in a year according to the elevation in İzmir province. It was determined that only half of the beetles were trapped from early March to mid-July; in the following period there was a significant rise in the number of trapped beetles from mid-July in population density.

Keywords: *Orthotomicus erosus*, flight activity, *Pinus brutia*, İzmir, Turkey

1. Introduction

There are several factors regarding the diminishing number of forests and productivity in İzmir province. One of them consists of bark beetles [Scolytinae (Coleoptera: Curculionidae)]. These pests are one of the most effective defoliators in this region. They usually damage lignified parts of trees and live in the plant tissue, which they harm

*Corresponding author. Tel.: +90 246 211 39 64; fax: +90 246 237 18 10.
E-mail address: oguzhansarikaya@sdu.edu.tr

as they mature. Bark beetles play mostly a secondary role; however, within the biotic factors that cause physiological problems to trees they gain a primary character [1,2].

The Mediterranean pine engraver *Orthotomicus erosus* (Wollaston, 1857) (Col.: Curculionidae: Scolytinae) ranks high among the Scolytinae species and causes significant economic losses every year in İzmir Province. It is also one of the most damaging bark beetle species to pine forests at the Mediterranean shore latitude in Turkey. Generally a secondary pest, it can immediately gain a primary character especially after the arid periods in the Mediterranean and Aegean regions of Turkey. In these regions, the Brutian pine (*Pinus brutia*) is one of the most important and common host tree species. Studies have shown that this pest is distributed in Europe, Mediterranean countries, Northern Africa, Southern Russia and the U.S. [3,4,5,6,7]. This species can cause epidemy among pine forests during suitable conditions [8,9,10]. Depending on the climatic conditions, there can be 2 to 7 generations of *O. erosus* a year [3,7,11,12].

Orthotomicus erosus can be harmful to *Pinus brutia*, *P. halepensis*, *P. nigra*, *P. pinaster*, *P. pinea*, *P. radiata*, *P. sylvestris*, *Abies nordmanniana* subsp. *bornmuelleriana*, *Picea orientalis* forests in different regions of Turkey [6,13]. Along the Mediterranean belt of the country, the generation number of *O. erosus* can reach six [14].

İzmir province where this study was conducted has 1.184.070 hectares of total area. Forest accounts for 41% of this area (481.079 ha); 198.848,2 hectares of these forests are productive and the remaining 282.231 ha are degraded. The Brutian pine (*Pinus brutia*), Anatolian Black pine (*P. nigra*), Juniper (*Juniperus* sp.) species and Oak (*Quercus* sp.) species are the main tree species in forests of Izmir province [15]. It is reported that damage from *Orthotomicus erosus* occurs generally in *Pinus brutia* forests [13,14,16,17].

Despite previous research on *O. erosus* and its damage to regional forests, there is no detailed research about the monitoring of flight activity and population density of this insect according to the altitude levels and climatic conditions. However, to mitigate the estimated damage of bark beetle species, monitoring the flight periods and population of these species in local conditions is crucial. Thus this study examines flight activity and population density of *O. erosus* at different altitude levels of *Pinus brutia* forests in İzmir Province, and the results are evaluated with meteorological data.

2. Materials and Methods

Monitoring the flight activity and population density of *Orthotomicus erosus* occurred between the years of 2010-2012 in *Pinus brutia* Ten. forests of Izmir Province. For this aim, six experimental sites were established in different regions in consideration of different altitude levels (Table 1 and Figure 1).

Table 1. Locations and characteristics of experimental sites

No	Sites	Monitoring periods	Geographical position	Altitude (m)	Status of sites
1	Menderes-Çatalca	2010-2011-2012	38º 28´ K – 27º03´ D	850	Natural and mature *Pinus brutia* forest
2	Gümüldür-Karacadağ	2010-2011-2012	38º 08´ K – 27 º10 D´	400	Natural and young *Pinus brutia* forest
3	Torbalı	2011-2012	38º22´ K – 27º50´ D	460	Natural *Pinus brutia* forest
4	Narlıdere	2010	38º36´ K – 26º99´ D	290	Natural and young *Pinus brutia* forest
5	Cennetçesme	2012	38º34´ K – 27º04´ D	650	Natural and mature *Pinus brutia* forest
6	Urla	2012	38º24´ K – 26º60´ D	120	Natural *Pinus brutia* forest

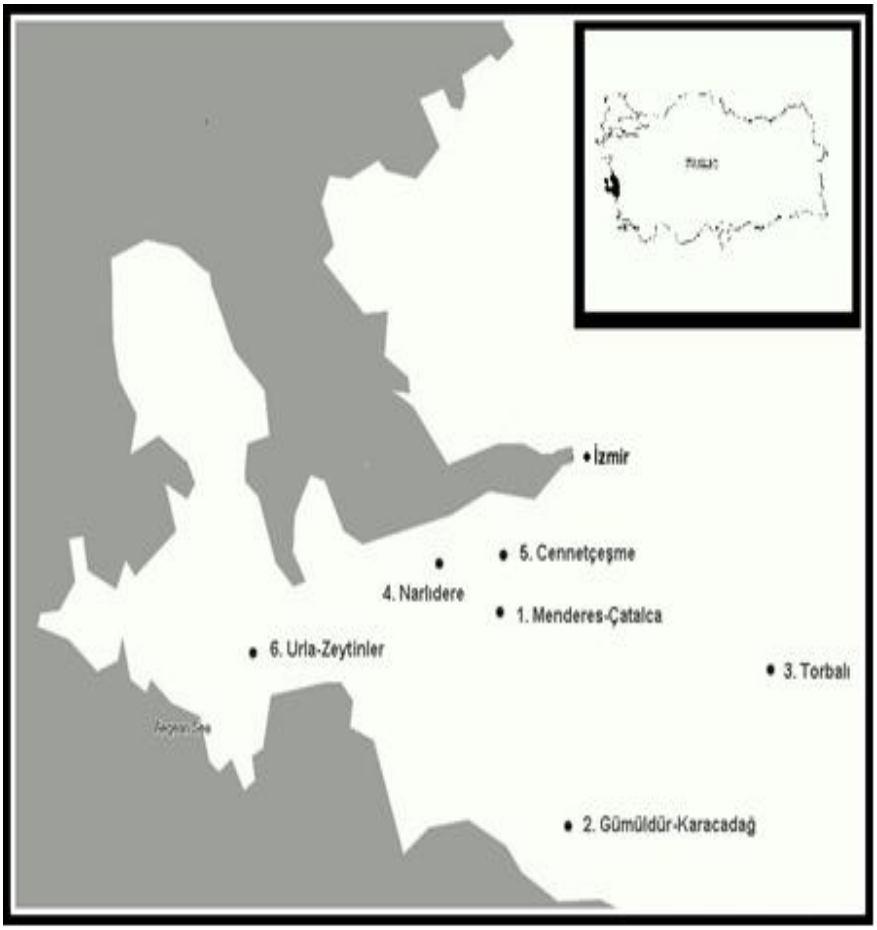


Fig. 1. Experimental sites in İzmir province

In experimental sites, funnel type traps and pheromone dispensers that contain 1500 mg methyl butanol + 100 mg cis-verbanol + 30 mg lpsdienol were used for monitoring of *O. erosus* flight periods and population density. Pheromone traps were placed at 80 meter intervals before flight periods and were controlled periodically. During controls, all insect materials were collected from pheromone traps and brought into the laboratory for counting. To mitigate loss of effects of dispensers in pheromone traps, new dispensers were installed every other month.

The daily data of average temperature, average moisture and total rainfall were obtained from Adnan Menderes, İzmir, Seferihisar and Bornova meteorological stations that are the closest stations to experimental sites during 2010, 2011 and 2012. These data were evaluated with adult numbers of *O. erosus* collected from pheromone traps. Regarding the relation between meteorological data about the days before the control date and adult numbers in pheromone traps, the average temperature (°C), mean relative humidity (%) and total rainfall (mm) data of the week between control dates were calculated and examined together with the number of adults from pheromone traps.

3. Results

The numbers of beetles trapped at each site during the studies from 2010 to 2012 in İzmir province are given in Table 2.

Table 2. Number of beetles captured in experimental sites during study

Sites	Year	Number of traps	Total number of beetles in traps	Average number of beetles per trap
Menderes-Çatalca	2010	10	1715110	171511
	2011	10	1183540	118354
	2012	16	2119888	132493
Gümüldür-Karacadağ	2010	9	964008	107112
	2011	10	370970	37097
	2012	12	1079328	89944
Torbalı	2011	7	486178	69454
	2012	6	594342	99057
Narlıdere	2010	5	44045	8809
Cennetçeşme	2012	6	381648	63608
Urla	2012	8	552184	69023

3.1. Menderes-Çatalca Experimental Site

During the studies conducted at Çatalca Experimental Site in 2010, 2011 and 2012, it was found that the first adults of *O. erosus* were trapped when the average temperature was over 8 ºC in the first week of March. A significant increase was observed in the number of adult beetles trapped when the average temperature was above 12 ºC, which usually corresponded to the second half of April. Depending on climate, it was observed that the number of beetles trapped increased significantly in the second week of June, in the last week of July and in the second half of September. According to the observations conducted over the three years, it is obvious that *O. erosus* has four generations in a year. Cumulative trapping results showed that, toward the end of June, the number of beetles trapped was only half or less than the total number of adult beetles. But in the following period of two months, it was observed that the rate of cumulative trapped beetles increased from 50% to 90%. To conclude, it is understood that the density of beetle population increases significantly in July and August and that their flight period lasts into the second half of October (Figure 2, Figure 3 and Figure 4).

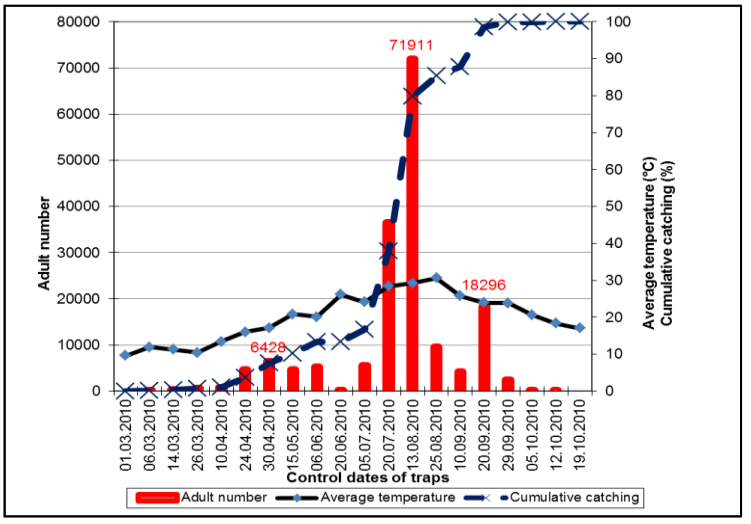
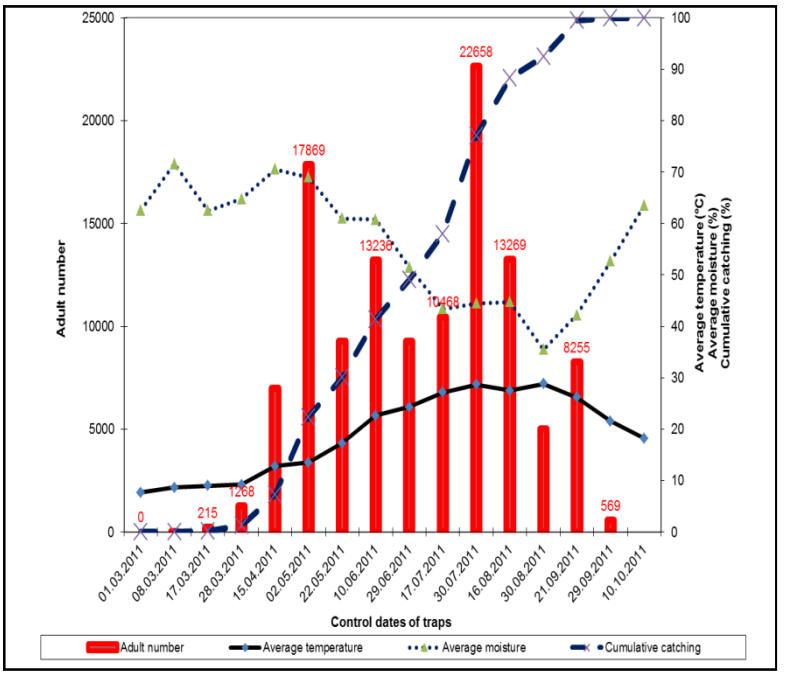


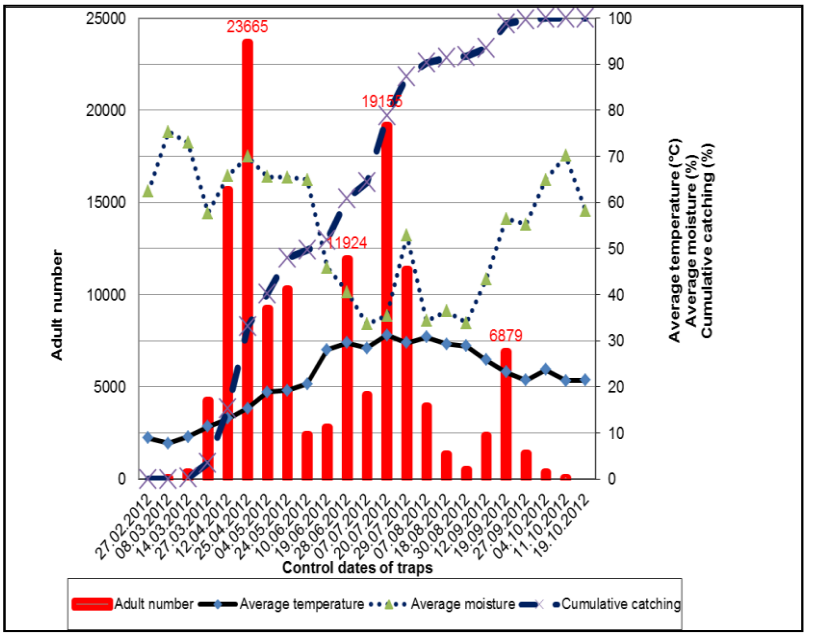
Fig. 2. Flight activity of *Orthotomicus erosus* in Menderes-Çatalca Experimental Site in 2010

Control Dates	Average number of beetle per trap	Cumulative catching (%)
01.03.2010	0	0
06.03.2010	79	0,046
14.03.2010	312	0,228
26.03.2010	664	0,615
10.04.2010	732	1,041
24.04.2010	4639	3,747
30.04.2010	6428	7,494
15.05.2010	4686	10,226
06.06.2010	5191	13,253
20.06.2010	209	13,375
05.07.2010	5548	16,610
20.07.2010	36570	37,932
13.08.2010	71911	79,860
25.08.2010	9529	85,416
10.09.2010	4171	87,848
20.09.2010	18296	98,515
29.09.2010	2365	99,894
05.10.2010	169	99,993
12.10.2010	12	100
19.10.2010	0	100



Control Dates	Average number of beetle per trap	Cumulative catching (%)
01.03.2011	0	0
08.03.2011	35	0,030
17.03.2011	215	0,211
28.03.2011	1268	1,283
15.04.2011	6985	7,184
02.05.2011	17869	22,282
22.05.2011	9265	30,110
10.06.2011	13236	41,293
29.06.2011	9265	49,122
17.07.2011	10468	57,966
30.07.2011	22658	77,111
16.08.2011	13269	88,322
30.08.2011	4997	92,544
21.09.2011	8255	99,519
29.09.2011	569	100
10.10.2011	0	100

Fig. 3. Flight activity of *Orthotomicus erosus* in Menderes-Çatalca Experimental Site in 2011

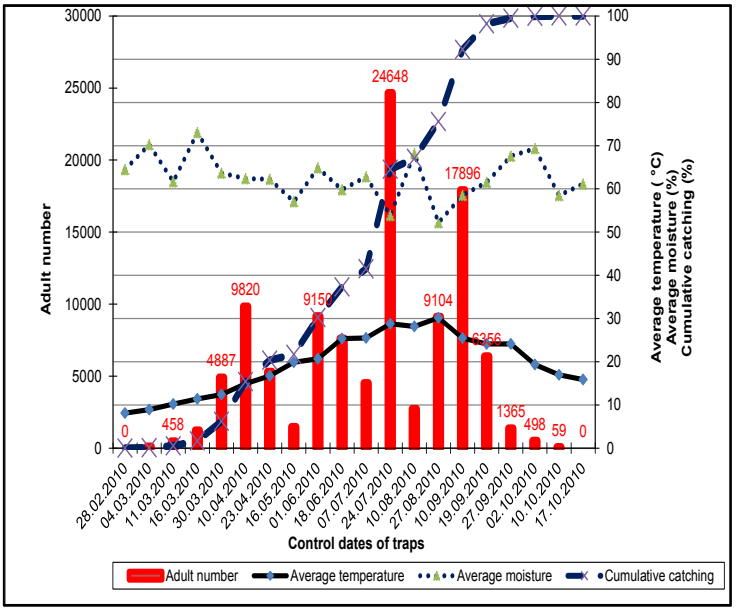


Control Dates	Average number of beetle per trap	Cumulative catching (%)
27.02.2012	0	0
08.03.2012	11	0,008
14.03.2012	359	0,279
27.03.2012	4256	3,492
12.04.2012	15689	15,333
25.04.2012	23665	33,194
04.05.2012	9240	40,168
24.05.2012	10311	47,950
10.06.2012	2397	49,760
19.06.2012	2788	51,864
28.06.2012	11924	60,863
07.07.2012	4563	64,307
20.07.2012	19155	78,764
29.07.2012	11356	87,336
07.08.2012	3957	90,322
18.08.2012	1336	91,331
30.08.2012	501	91,709
12.09.2012	2365	93,494
19.09.2012	6879	98,685
27.09.2012	1361	99,713
04.10.2012	365	99,988
11.10.2012	15	100
19.10.2012	0	100

Fig. 4. Flight activity of *Orthotomicus erosus* in Menderes-Çatalca Experimental Site in 2012

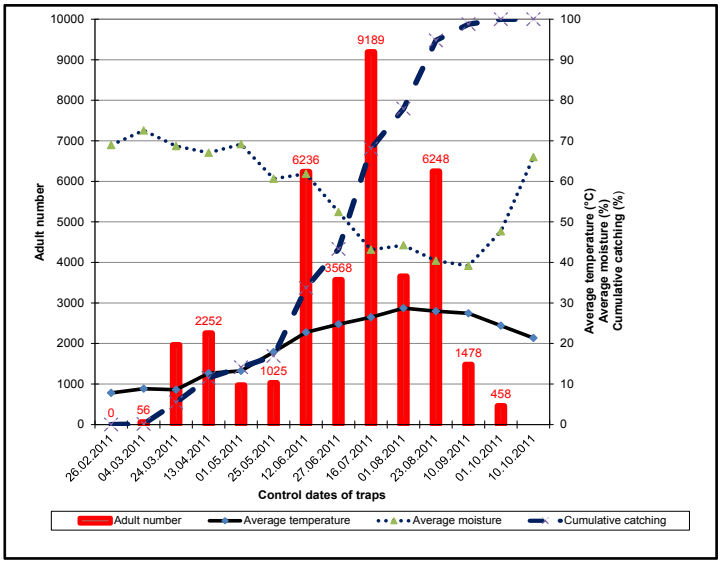
3.2. Gümüldür-Karacadağ Experimental Site

During the observations over three years, from 2010 to 2012 in the Gümüldür-Karacadağ Experimental Site, it was observed that the first adult beetles were strapped in the first week of March, when the average temperature was above 8.8 ºC. A considerable increase was seen in the number of adults above 12 ºC, and meaningful increases were observed in the second week of April, in the last week of May, in mid-July, in the last week of August and in the first week of September. Thus it may be possible to conclude that *O. erosus* has four generations in this experimental site, and a significant increase occurred in cumulative trapping from mid-July (Figure 5, Figure 6 and Figure 7).



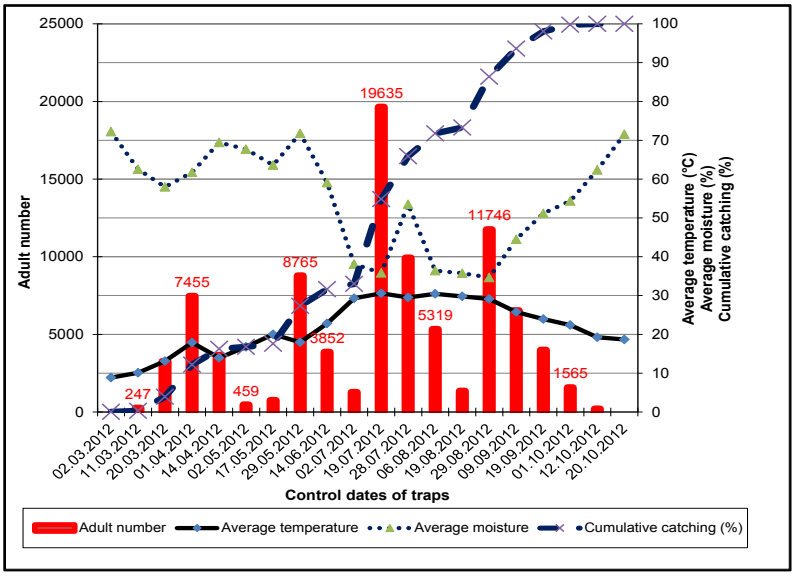
Control Dates	Average number of beetle per trap	Cumulative catching (%)
28.02.2010	0	0
04.03.2010	101	0,094
11.03.2010	458	0,522
16.03.2010	1215	1,656
30.03.2010	4887	6,219
10.04.2010	9820	15,387
23.04.2010	5290	20,325
16.05.2010	1452	21,681
01.06.2010	9150	30,223
18.06.2010	7596	37,315
07.07.2010	4500	41,516
24.07.2010	24648	64,528
10.08.2010	2717	67,064
27.08.2010	9104	75,563
10.09.2010	17896	92,272
19.09.2010	6356	98,206
27.09.2010	1365	99,480
02.10.2010	498	99,945
10.10.2010	59	100
17.10.2010	0	100

Fig. 5. Flight activity of *Orthotomicus erosus* in Gümüldür-Karacadağ Experimental Site in 2010



Control Dates	Average number of beetle per trap	Cumulative catching (%)
26.02.2011	0	0
04.03.2011	56	0,151
24.03.2011	1965	5,448
13.04.2011	2252	11,518
01.05.2011	968	14,128
25.05.2011	1025	16,891
12.06.2011	6236	33,701
27.06.2011	3568	43,319
16.07.2011	9189	68,089
01.08.2011	3654	77,939
23.08.2011	6248	94,781
10.09.2011	1478	98,765
01.10.2011	458	100
10.10.2011	0	100

Fig. 6. Flight activity of *Orthotomicus erosus* in Gümüldür-Karacadağ Experimental Site in 2011

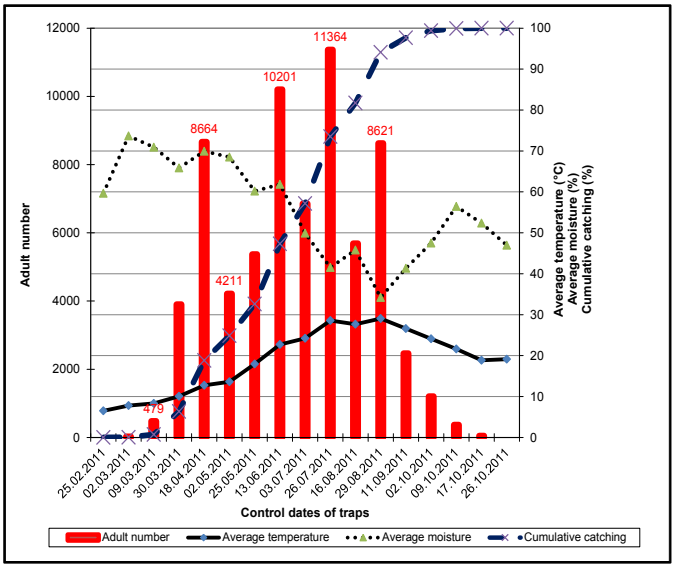


Control Dates	Average number of beetle per trap	Cumulative catching (%)
02.03.2012	0	0
11.03.2012	247	0,275
20.03.2012	3256	3,895
01.04.2012	7455	12,183
14.04.2012	3658	16,250
02.05.2012	459	16,760
17.05.2012	741	17,584
29.05.2012	8765	27,329
14.06.2012	3852	31,612
02.07.2012	1265	33,018
19.07.2012	19635	54,848
28.07.2012	9923	65,880
06.08.2012	5319	71,794
19.08.2012	1345	73,290
29.08.2012	11746	86,349
09.09.2012	6532	93,612
19.09.2012	3988	98,045
01.10.2012	1565	99,785
12.10.2012	193	100
20.10.2012	0	100

Fig. 7. Flight activity of *Orthotomicus erosus* in Gümüldür-Karacadağ Experimental Site in 2012

3.3. Torbalı Experimental Site

In the observations carried out at the Torbalı Experimental Site in 2011 and 2012, it was seen that adults began their flight in the first week of March, when the average temperature was above 7 ºC. Subsequently, it was observed that the number of adult beetles increased significantly when the average temperature was above 13 ºC and that there were four generations in the year, with flight periods in mid-April, the early days of June, the last week of June and in the last days of August. According to cumulative trapping results, it was seen that by mid-June, half of the trapping of adult beetles in a year was complete. In the following two month period, the rate of trapped adult beetles rose to a 90% level (Figure 8 and Figure 9).



Control Dates	Average number of beetle per trap	Cumulative catching (%)
25.02.2011	0	0
02.03.2011	25	0,036
09.03.2011	479	0,726
30.03.2011	3899	6,339
18.04.2011	8664	18,814
02.05.2011	4211	24,876
25.05.2011	5369	32,607
13.06.2011	10201	47,295
03.07.2011	6854	57,163
26.07.2011	11364	73,525
16.08.2011	5687	81,713
29.08.2011	8621	94,126
11.09.2011	2463	97,671
02.10.2011	1203	99,403
09.10.2011	369	99,935
17.10.2011	45	100
26.10.2011	0	100

Fig. 8. Flight activity of *Orthotomicus erosus* in Torbalı Experimental Site in 2011

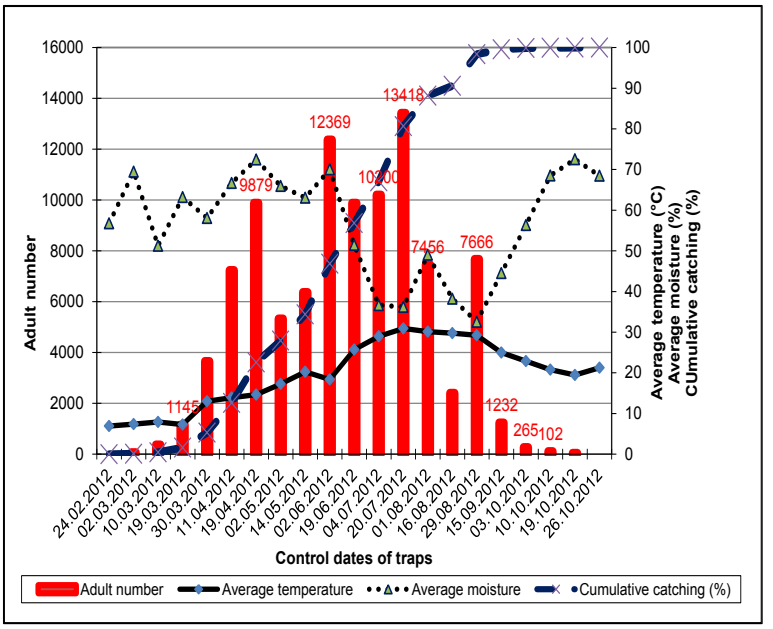
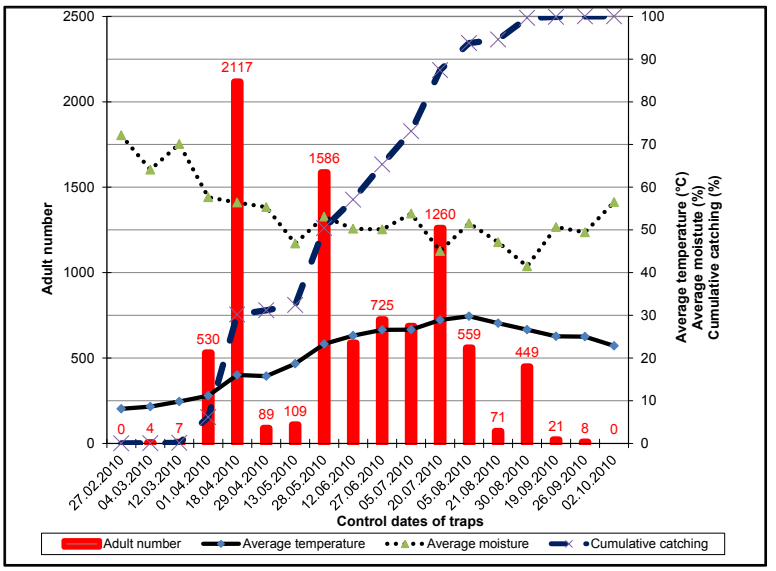


Fig. 9. Flight activity of *Orthotomicus erosus* in Torbalı Experimental Site in 2012

Control Dates	Average number of beetle per trap	Cumulative catching (%)
24.02.2012	0	0
02.03.2012	65	0,066
10.03.2012	368	0,437
19.03.2012	1145	1,593
30.03.2012	3654	5,282
11.04.2012	7233	12,584
19.04.2012	9879	22,556
02.05.2012	5325	27,932
14.05.2012	6369	34,362
02.06.2012	12369	46,849
19.06.2012	9877	56,820
04.07.2012	10200	67,116
20.07.2012	13418	80,663
01.08.2012	7456	88,190
16.08.2012	2398	90,610
29.08.2012	7666	98,349
15.09.2012	1232	99,593
03.10.2012	265	99,861
10.10.2012	102	99,964
19.10.2012	36	100
26.10.2012	0	100

3.4. Narlıdere Experimental Site

At the Narlıdere Experimental Site, the population of *O. erosus* was studied only in 2010. Flight activity of adults started in the first week of March, when the average temperature was 8.5 ºC. During four periods in mid-April, the last week of May, the second half of July and the last week of August, significant increases were observed in the trapped beetles. It is thought that the significant increase observed in the number of trapped beetles was because of the beginning of the flight activity in those four periods. *O. erosus* has four generations also at this site. Cumulative trapping results showed that half of the population completed the flight activity by the end of May; after this time, a regular increase was seen until the first week of October when beetles stopped flight activity (Figure 10).

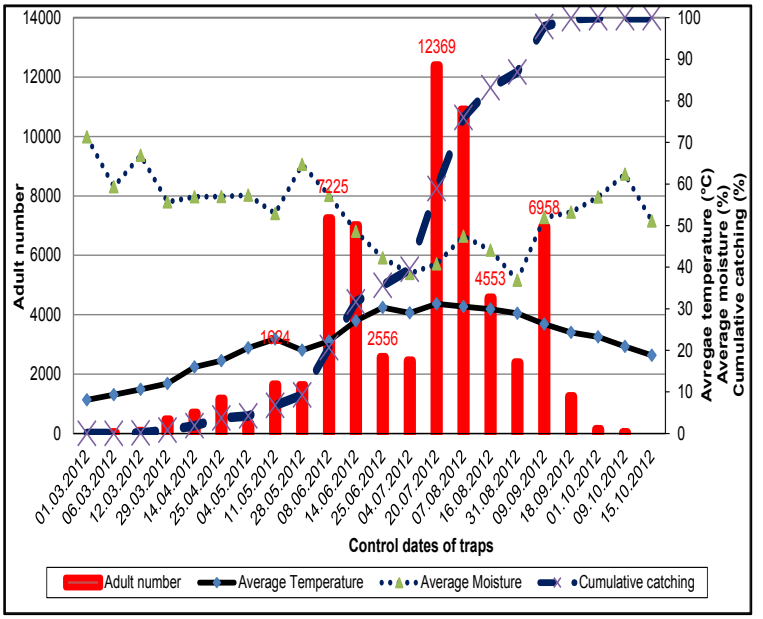


Control Dates	Average number of beetle per trap	Cumulative catching (%)
27.02.2010	0	0
04.03.2010	4	0,045
12.03.2010	7	0,125
01.04.2010	530	6,141
18.04.2010	2117	30,173
29.04.2010	89	31,184
13.05.2010	109	32,422
28.05.2010	1586	50,425
12.06.2010	588	57,101
27.06.2010	725	65,330
05.07.2010	686	73,118
20.07.2010	1260	87,422
05.08.2010	559	93,768
21.08.2010	71	94,574
30.08.2010	449	99,671
19.09.2010	21	99,909
26.09.2010	8	100
02.10.2010	0	100

Fig. 10. Flight activity of *Orthotomicus erosus* in Narlıdere Experimental Site in 2010

3.5. Cennetçeşme Experimental Site

Orthotomicus erosus began to fly in the first week of March when the average temperature was above 9 ºC at the Cennetceşme Experimental Site in 2012. It was also observed that the flight periods were in the last week of April, first week of June, second half of July and in the beginning of September. There were four generations in Cennetceşme, which is located on 600 meters above sea level. It was seen that only 40 % of the adult beetles were trapped by the beginning of July; in the following two-month period, the population density significantly increased (Figure 11).

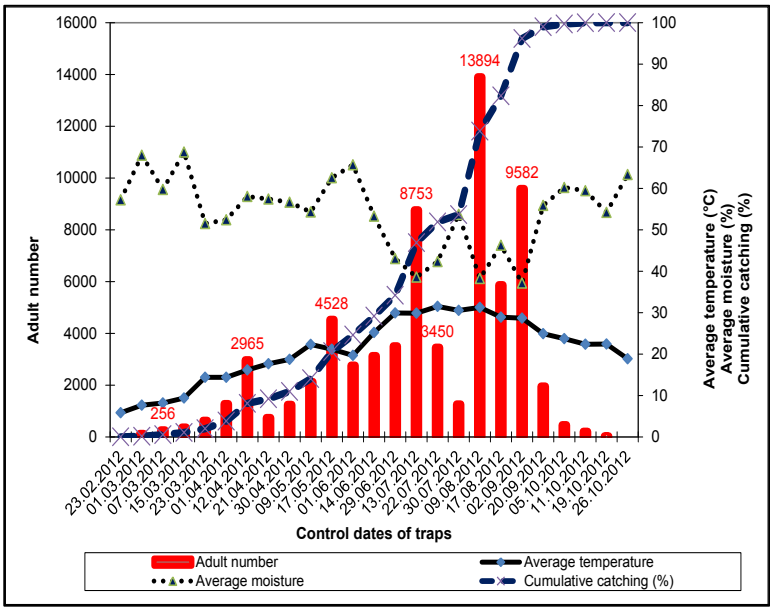


Control Dates	Average number of beetle per trap	Cumulative catching (%)
01.03.2012	0	0
06.03.2012	12	0,019
12.03.2012	65	0,121
29.03.2012	446	0,822
14.04.2012	678	1,888
25.04.2012	1146	3,690
04.05.2012	326	4,202
11.05.2012	1624	6,755
28.05.2012	1599	9,269
08.06.2012	7225	20,628
14.06.2012	6989	31,616
25.06.2012	2556	35,634
04.07.2012	2434	39,460
20.07.2012	12369	58,906
07.08.2012	10881	76,012
16.08.2012	4553	83,170
31.08.2012	2369	86,895
09.09.2012	6958	97,834
18.09.2012	1236	99,777
01.10.2012	126	99,975
09.10.2012	16	100
15.10.2012	0	100

Fig. 11. Flight activity of *Orthotomicus erosus* in Cennetceşme Experimental Site in 2012

3.6. Urla Experimental Site

At the Urla experimental site in 2012, *O. erosus* started its flight activity when the average temperature rose above 7.5 ºC and the number of trapped beetles reached a significant level in mid-April, in mid-May, the second week of July, in the first week of August and the second half of September, a total of five times. This experimental site has the lowest elevation, and the beetles spawned five generations. Results showed that half of the beetles were trapped by the second half of July and the other 50% continued to fly from July 20 to the second half of October (Figure 12).



Control Dates	Average number of beetle per trap	Cumulative catching (%)
23.02.2012	0	0
01.03.2012	114	0,165
07.03.2012	256	0,536
15.03.2012	362	1,060
23.03.2012	625	1,966
01.04.2012	1272	3,809
12.04.2012	2965	8,105
21.04.2012	735	9,169
30.04.2012	1239	10,964
09.05.2012	2123	14,040
17.05.2012	4528	20,600
01.06.2012	2756	24,593
14.06.2012	3125	29,120
29.06.2012	3500	34,191
13.07.2012	8753	46,873
22.07.2012	3450	51,871
30.07.2012	1253	53,686
09.08.2012	13894	73,816
17.08.2012	5865	82,313
02.09.2012	9582	96,195
20.09.2012	1950	99,020
05.10.2012	452	99,675
11.10.2012	198	99,962
19.10.2012	26	100
26.10.2012	0	100

Fig. 12. Flight activity of *Orthotomicus erosus* Urla Experimental Site in 2012

4. Discussion

In the studies conducted in six different experimental sites in Izmir province for three years, it was observed that *O. erosus* adults started to fly when the average temperature was above 7 ºC in the first week of March and depending on the temperature, elevation and flight activity continued until the second half of October.

Considering the different elevations, it was found that *O. erosus* spawned 4 to 5 generations in Izmir province. There were 4 generations in all the sites except Urla, which has the lowest elevation (120 m) among all sites, and hosted 5 generations. This suggests that the generation number changed according to elevation.

In previous studies conducted on *O. erosus* in Turkey and other countries, the data obtained about the biology of this species differ greatly. Tosun [18] found two generations in the forests of the Mediterranean region in Turkey. Özkazanç et al. [16] determined that the beetle has 3 to 5 generations in *Pinus brutia* forests, which are located at elevation 0 to 300 meters, 3 to 4 generations at 300 to 600 meters and 2 to 3 between 600 and 900 meters.

Çanakçıoğlu and Mol [19] reported 2 to 3 generations in a year and found that the first flight activity occurs in April, the second in June and July and the third one in autumn. Selmi [13] reported that *O. erosus* has 2 to 5 generations in a year. İnanç and Laz [20] conducted a study using pheromone traps in the Brutian pine forests in Andırın, Kahramanmaraş and found that *O. erosus* has three generations at an elevation of 800 to 900 meters. Sarıkaya [14] determined that the flight time of *Orthotomicus erosus* (Wollaston) varies according to elevation and that it has a generation of 3 to 6 in the Western Mediterranean region in Turkey.

Mendel [3] found that the beetle can have up to seven generations and that wintering lasts from mid-October to February. Lee et al. [21] found 2 generations in France and Morocco, 3 to 4 in Tunisia and South Africa and 3 to 5

in Israel and added that the flight activity lasts from March to October. Mendel [3] and Mendel and Halperin [11] conducted studies in Israel and reported that the beetle has an ability to adapt to higher temperatures and that its flight activity lasts until mid-October.

In this study, cumulative trapping results showed that only half of the beetles were trapped from early March to mid-July; there was a significant rise in the number of trapped beetles from mid-July. A majority of the beetles were trapped by mid-September and the flight activity continued until mid-October. The increase in the population density of the beetles occurred when the average temperature was above 25 ºC and average relative humidity was below 50%.

5. Conclusions

We conclude that *O. erosus* has 4 to 5 generations in İzmir province and that adults started to fly in the first week of March when the average temperature was above 7 ºC; flight activity continued until the second half of October.

Significant increase in the population density of a species occurs when there is a favorable climate, and the number of generations can vary depending on the temperature conditions. The fact that other geographical factors (aspect, elevation etc.) as well as climatic conditions can affect the flight activity and population density must be taken into account. Therefore, flight periods and population level should be determined in local conditions for planning control strategies of this pest.

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