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Original article (Orijinal araştırma)

Biology of Citrus long-horned beetle, *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae) on hazelnut[1]

Turunçgil uzunantenli böceği, *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae)'in fındık bitkisindeki biyolojisi

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Abstract

Anoplophora chinensis (Forster, 1771) (Coleoptera: Cerambycidae) is an important quarantine pest causing significant economic losses. It was detected in hazelnut orchards in Trabzon province in 2017 and an eradication program continues. In this study, the population level and biology of the pest were determined by rearing it and conducting periodic surveys in hazelnut orchards in Trabzon province Maçka district between 2020 and 2021. It has been revealed that the adult emergence of *A. chinensis* takes place in the last weeks of June and adults are found in nature until the end of August. The oviposition period continued from the end of June to the beginning of September and the larval stage of *A. chinensis* was observed throughout the year. The pupal stage was observed in May and June. With this study, the biology of *A. chinensis* in Türkiye has been revealed in detail for the first time and obtained data guides the eradication and surveillance studies.

Keywords: *Anoplophora chinensis*, *Coryllus avellana,* hazelnut, invasive insects

Öz

Anoplophora chinensis (Forster, 1771) (Coleoptera: Cerambycidae) ekonomik kayıplara neden olan, önemli bir karantina zararlısıdır. 2017 yılında Trabzon ili fındık bahçelerinde saptanmış ve eradikasyon çalışmaları devam etmektedir. Bu çalışmada 2020 ve 2021 yıllarında Trabzon ili Maçka ilçesinde fındık bahçelerinde yürütülen periyodik sürveylerle zararlının popülasyon durumu ve kültüre alınarak biyolojisi ortaya konulmuştur. Ergin çıkışlarının haziran ayının son haftalarında gerçekleştiği ve erginlere doğada ağustos ayının sonlarına kadar rastlandığı, ovipozisyon süresinin haziran ayı sonundan eylül ayı başına kadar devam ettiği belirlenmiştir. *A. chinensis*'in larva dönemlerine yıl boyunca, pupa dönemine ise mayıs ve haziran aylarında rastlanmıştır. Bu çalışma ile Türkiye'de *A. chinensis*'in biyolojisi ilk kez detaylı olarak ortaya konmuş olup, elde edilen veriler eradikasyon ve sürvey çalışmaları için yol gösterici nitelik taşımaktadır.

Anahtar sözcükler: *Anoplophora chinensis, Coryllus avellana*, fındık, istilacı böcekler

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Introduction

Citrus long-horned beetle, *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae) is a polyphagous wood boring invasive insect that its native range is Asia, including China, Korea, Japan with occasional records from Indonesia, Malaysia, Philippines, Taiwan and Vietnam (Haack et al., 2010). Lingafelter & Hoebeke (2002) stated that *Anoplophora malasiaca* (Thomson, 1865) is a synonym of *A. chinensis* due to the similarity of the morphological features of its reproductive system. Besides, because of the significant differences in terms of life cycle, behavior and developmental characteristics of *A. chinensis* and *A. malasiaca* (Makihara, 2007), Fujiwara-Tsujii et al. (2016) describe the Japanese population of *A. chinensis* as *A. malasiaca*.

Wang et al. (1996) report *A. chinensis* as an important pest of fruit and ornamental trees in East and Southeast Asia, especially in China, causing serious damage to citrus trees and causing substantial economic losses. Larvae bore into the trunk and root resulting in the decay and death of the tree (Komazaki & Sakagami, 1989). *A. chinensis* has serious potential to invade other areas of the world through worldwide commerce in woody plants and wood products (Hansen et al., 2015). *A. chinensis* was given as a new record to Turkish invasive alien insect species fauna by Hızal et al. (2015). It was first recorded on *Acer palmatum* Thunberg*, Acer saccharum* Marshall (Sapindales: Aceraceae) and *Salix caprea* L. (Salicales: Salicaceae) trees in a nursey in Istanbul. Following the first record in Istanbul, *A. chinensis* was reported on *Acer negundo* L. (Sapindales: Aceraceae) trees in Antalya in 2016 (Topakçı et al. 2017), later reported on *Acer palmatum purperea* T., *Acer negundo flamingo* L. and *Acer platanoides* L. (Sapindales: Aceraceae) plants imported from China in Bartın province by Yıldız (2017). In the same year Eroğlu et al. (2017) reported *A. chinensis* on *A. palmatum* in Trabzon province. After the detection on ornamental trees in Trabzon, *A. chinensis* began to spread in hazelnut orchards surrounding the first infested area. Recently, this invasive pest was detected in Diyarbakır and Rize provinces in 2021 and 2022, respectively. Eradication programs are underway in Trabzon, Sakarya, Diyarbakır and Rize provinces. In addition to the eradication, determining the biology of *A. chinensis* is a very important data for the control measures. Hızal & Arslangündoğdu (2017) determined the brief life cycle and host plants of *A. chinensis* in Istanbul between 2014-2016. Eroğlu et al. (2017) determined the morphology, brief biology and damage of *A. chinensis* on *A. palmatum* and *A. negundo* plants in laboratory and a nursery. The biology and behaviours of *A. chinensis* on hazelnut *Coryllus avellana* L. (Fagales: Betulaceae) in the field conditions in Türkiye have been determined in detail for the first time in this study.

Materials and Methods

The biology of the Citrus long-horned beetle, *A. chinensis* was studied in hazelnut orchards of the Maçka District in Trabzon province and in the quarantine area established in Hazelnut Research Institute garden in 2020-2021.

Determination of adult stage and population level

Adult longevity, population level and temporal fluctuation of *A. chinensis* adult emergence were followed in hazelnut orchards in the Maçka district in Trabzon province in Türkiye. Surveys were conducted once every two weeks in April-May and once a week as of June in both years. In the hazelnut orchards, the adult emergence holes, sawdust debris caused by the larvae and adults on the trunk and all green parts of 100 hazelnut plants were examined by visual inspection method. Adults were recorded by their sexes in each followed garden every week for determining the population level. The adult stage was determined as the date between the first adult was seen in nature and the date when the last adult was observed in the surveys.

In order to determine the time-dependent variation of adult emergence, suckers of 60 hazelnut ocaks (traditional planting system of hazelnut) corresponding to 0.1 hectar area of different orchards in 2020 and 2021 were removed and the former adult emergence holes were marked with the help of red spray paint.

After the beginning of the adult emergence, new adult emergence holes in this area were determined and recorded weekly and then they were marked with a different color of spray paint. Some properties of adult emergence holes such as diameter, height from the ground level and the diameter of the stem where the emergence hole was found were determined.

Determination of pre-adult stage

Field studies to determine the pre-adult stages of *A. chinensis* were implemented once a month between January and April, once every two weeks between May and September and once a month between October and December in both years. In the studies on the larval and pupal stages, hazelnut branches showing wilting symptoms and sawdust on the ground level were cut with the help of saw or wood motor and larvae/pupae were searched in the galleries. The biological stages found in the galleries were recorded according to the survey date. In order to obtain information about larval stages, the larvae found in the surveys were brought to the laboratory and the larval length and head capsule width were determined by digital caliper.

In order to determine egg stage, T-shaped egg laying scars on the hazelnut branches were investigated by visual inspection method. In addition to the egg stage, oviposition and hatching periods were determined in the quarantine area constructed in the garden of the institute. Adults collected from the field in the first days of adult emergence were brought to the quarantine area in 5 lt plastic containers with ventilation holes. Fresh hazelnut shoots were placed in the containers to feed the adults during transportation. Adults brought to the quarantine area were grouped as 1 female + 1 male and placed in 5 lt plastic containers. Adults were reared with 5-6 hazelnut shoots with a length of 20-25 cm for feeding and a hazelnut branch with a diameter of about 5 cm and a length of 20-25 cm for laying eggs. In order to prevent moisture loss of branches and shoots, sterile perlite of 5 cm height was placed on the bottom of the plastic containers and moistened with distilled water in the controls made every 2 days. The hazelnut branches placed for oviposition were renewed once a week and the shoots were renewed every 2 days. In the controls performed every two days, the viability of the male and female individuals and the number of eggs laid were recorded. The *A. chinensis* eggs were removed from the branches with the help of a scalpel, taken into petri dishes and the dates of oviposition were recorded. To determine the egg stage longevity of *A. chinensis*, they were taken into the incubator (26±1^{o}C, %70 RH) according to their oviposition dates. The eggs were checked daily and hatched eggs were recorded by the hatching date and removed from the petries. Hatching rates of *A. chinensis* eggs were determined according to the oviposition date of the egg. Egg hatching rates were determined by the ratio of the number of hatched eggs to the total number of eggs laid on that date.

Results

Determination of adult stage and population fluctuations

In order to obtain data on the adult stage of *A. chinensis* and monitor the population fluctuations, surveys were conducted weekly in three selected hazelnut orchards in Esiroğlu town of Maçka District (Trabzon, Türkiye) in 2020 (Table 1).

Adult emergence of *A. chinensis* began in mid-June in 2020. It was observed that males were predominant in this period and this rate changed at the end of June. It was determined that the population started to decline from the beginning of August and the adults were last seen on 13 August 2020. According to the survey results, adult longevity was determined 58 days under field conditions.

Adult stage of *A. chinensis* was checked weekly in two orchards in Akmescit and Durali towns of Maçka District in 2021 (Table 2).

Table 1. *Anoplophora chinensis* adult population fluctuation over time in 2020

Survey dates	Location					
	Esiroğlu 1		Esiroğlu 2		Esiroğlu 3	
	♂	♀	♂	♀	♂	♀
16.06.2020	Emergence					
24.06.2020	1	0	6	1	10	3
26.06.2020	0	0	11	3	5	2
30.06.2020	0	0	2	4	8	8
03.07.2020	2	0	9	8	11	13
07.07.2020	4	3	3	1	4	5
16.07.2020	5	9	1	4	9	7
21.07.2020	5	4	2	5	6	4
04.08.2020	6	2	1	0	0	0
13.08.2020	1	0	0	0	0	0
20.08.2020	0	0	0	0	0	0
31.08.2020	0	0	0	0	0	0
Total	24	18	35	26	53	42

Table 2. *Anoplophora chinensis* adult population fluctuation over time in 2021

Survey dates	Location			
	Akmescit		Durali	
	♂	♀	♂	♀
11.06.2021	0	0	0	0
19.06.2021	0	0	0	0
22.06.2021	0	0	0	0
30.06.2021	4	1	0	1
06.07.2021	1	0	1	3
13.07.2021	0	4	1	3
27.07.2021	3	2	1	0
03.08.2021	0	0	0	0
12.08.2021	0	0	0	0
01.09.2021	0	0	0	0
19.09.2021	0	0	0	0
26.09.2021	0	0	0	0
Total	8	7	3	7

In the second year of the study, the first adult emergence took place on 25.06.2021, the last adult was seen on 12.08.2021 and the adult longevity was determined as 49 days in the field conditions.

In order to determine *A. chinensis* adult emergence fluctuations over time, adult emergence holes in an area of 0.1 ha were recorded weekly in one orchard whose population was observed every two years. Weekly fluctuation of adult emergence in 2020 is given in Figure 1 and 2021 is shown in Figure 2.

In 2020, a total of 84 adult emergence holes were found in an area of 0.1 ha where the weekly emergence of *A. chinensis* was followed. In the whole field (0.6 ha) a total of 42 adults (24 males and 18 females) were found during 2020 surveys. Adult emergence increased in the first week of July and continued by a decline until the last week of August.

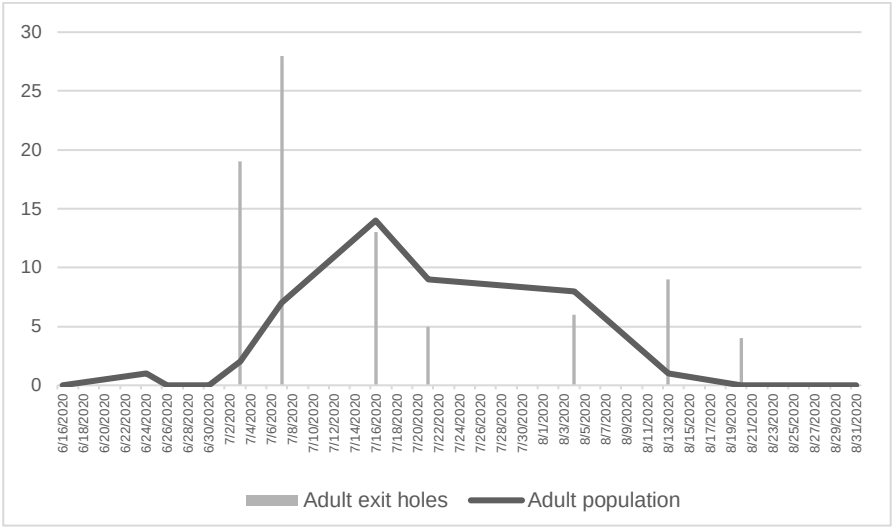

Figure 1. Weekly fluctuations of *Anoplophora chinensis* adult emergence hole and adult population in 2020.

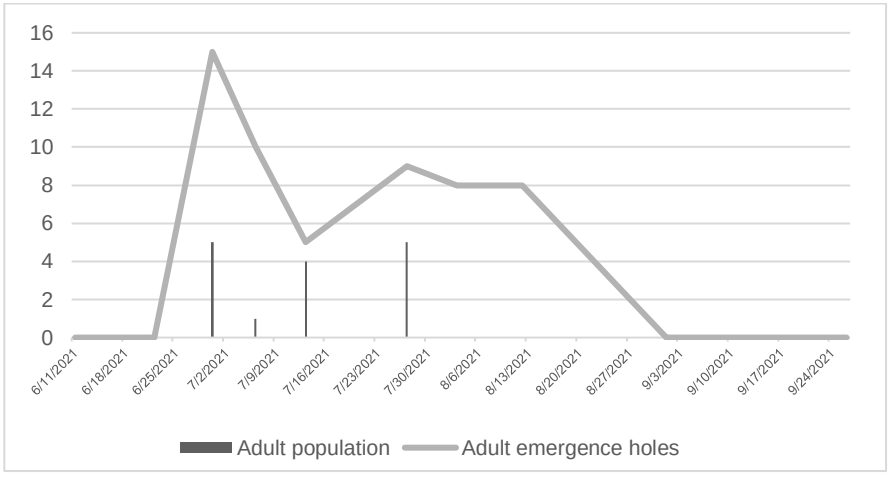

Figure 2. Weekly fluctuations of *Anoplophora chinensis* adult emergence hole and adult population in 2021.

A total of 55 adult emergence holes were found in the 0.1 ha area where the weekly adult emergence of *A. chinensis* were examined in 2021. A total of 15 adults (8 male and 7 female) were found in the whole garden. In 2021, adult emergence increased at the beginning of July and continued until mid-August. When the two-year data are evaluated, it is seen that the adult emergence begins towards the end of June, is highest in the beginning of July and the adult emergence begins to decline from the middle of August. The results obtained show that the population follow-up performed over the adult exit holes gives trusting information about the population of *A. chinensis*.

Determination of pre-adult stage

Surveys to determine the developmental stages of *A. chinensis* were conducted between 2020 and 2021. In the surveys, the larval stage was observed between January and June and both larval and pupal stages were observed in May, June and July. The lengths and head capsule widths of the larvae detected in the surveys were recorded according to the dates they were found (Table 3).

The newly hatched *A. chinensis* larvae are 5-6 mm in length and the width of the head capsule varies between 0.5-1 mm (Figure 3).

Table 3. Body length and head capsule widths of *Anoplophora chinensis* larvae at different dates between 2020 and 2021 (mm)

	Survey date	Length of larvae (mm)	Head capsule width (mm)	Survey date	Length of larvae (mm)	Head capsule width (mm)
1	13.03.2020	35.73	4.55	09.02.2021	55.35	6.23
2	13.03.2020	46.00	5.55	09.02.2021	45.37	5.57
3	22.04.2020	46.80	4.80	09.02.2021	51.03	5.49
4	24.06.2020	50.00	4.60	09.02.2021	40.74	5.40
5	24.06.2020	50.00	4.20	09.02.2021	45.79	5.73
6	24.06.2020	41.00	4.00	09.02.2021	52.38	5.36
7	24.06.2020	45.00	3.90	09.02.2021	48.65	5.30
8	20.08.2020	50.00	4.61	09.02.2021	52.69	5.40
9	04.11.2020	50.00	5.63	09.02.2021	44.66	5.44
10	04.11.2020	50.00	5.45	09.02.2021	50.50	4.74
11	04.11.2020	40.00	4.28	09.02.2021	50.10	4.71
12	04.11.2020	48.00	5.53	22.02.2021	41.35	4.44
13	04.11.2020	43.00	4.53	22.02.2021	54.11	5.32
14	04.11.2020	45.00	4.72	22.02.2021	39.90	5.22
15	04.11.2020	45.00	4.16	22.02.2021	44.14	4.66
16	04.11.2020	45.00	4.70	22.02.2021	49.55	5.03
17	04.11.2020	45.00	4.83	22.02.2021	46.31	5.11
18	04.11.2020	50.00	5.18	22.02.2021	37.80	4.45
19	04.11.2020	43.00	3.90	22.02.2021	27.85	3.21
20	04.11.2020	33.00	2.97	22.02.2021	30.69	3.91
21	04.11.2020	39.00	4.13	22.02.2021	45.04	4.50
22	04.11.2020	40.00	5.08	22.02.2021	39.90	4.87
23	04.11.2020	44.00	4.50	22.02.2021	35.20	4.58
24	04.11.2020	47.00	4.00	22.02.2021	40.11	4.16
25	04.11.2020	40.00	4.48	22.02.2021	39.51	4.24
26	04.11.2020	35.00	3.55	22.02.2021	45.84	5.25
27	04.11.2020	30.00	3.74	22.02.2021	40.59	4.39
28				22.02.2021	49.51	5.67
29				22.02.2021	58.79	5.96
30				22.02.2021	36.57	3.99
31				22.02.2021	54.32	5.69
32				22.02.2021	40.90	4.83
33				22.02.2021	36.95	5.25
34				22.02.2021	39.93	5.57
35				22.02.2021	37.18	3.74
Mean		43.58	4.50		44.27	4.95

Figure 3. Newly hatched *Anoplophora chinensis* larvae.

The maximum length of mature larva found in the galleries was 50 mm and the maximum width of head capsule was determined as 5.63 mm. While *A. chinensis* galleries were mostly found at lower parts of hazelnut stems near soil level, larger larvae were found in galleries that take place in the root parts. It was determined that the first instar initially fed under the bark for a while after hatching and then opened galleries into the wood tissue (Figure 4). The galleries are formed downwards, and mature larvae are usually found in the lower parts of the trunk close to the ground and in the roots.

Figure 4. *Anoplophora chinensis* larvae feed under bark tissue of hazelnut branch and frass.

Oviposition period of *A. chinensis*, egg stage duration and hatching rates of the laid eggs were determined in the quarantine area. The number of eggs laid by 17 *A. chinensis* females reared in 2020, hatching rate and egg stage duration are given in Table 4. Since the eggs are adhered to the tissue with a liquid and compressed between wood and bark tissues, they are damaged while being removed from the branch (Figure 5). For this reason, it is thought that the hatching rate under natural conditions is higher than the rates obtained in Tables 4 & 5.

Figure 5. Eggs of *Anoplophora chinensis* laid under the bark tissue of hazelnut branch and damaged eggs when the bark is removed.

Table 4. Total number of eggs, hatching rate (%) and egg stage duration (days) of 17 pairs of *Anoplophora chinensis* reared in quarantine area in 2020

Oviposition date	Total number of eggs/17 pairs	Hatching rate (%)	Egg stage duration (days)
29.06.2020	3	0	
01.07.2020	12	0	
04.07.2020	66	89.39	8-13
06.07.2020	46	91.30	7-11
08.07.2020	45	73.33	9-16
10.07.2020	41	46.34	7-14
13.07.2020	51	43.13	4-14
17.07.2020	49	18.36	10-12
20.07.2020	38	5.26	4-14
22.07.2020	26	3.84	14
24.07.2020	66	21.21	9-17
27.07.2020	48	14.58	11-14
29.07.2020	28	14.28	14-16
01.08.2020	53	22.64	9-14
03.08.2020	11	0	
05.08.2020	10	0	
07.08.2020	11	0	
10.08.2020	15	0	
12.08.2020	8	0	
14.08.2020	3	0	
17.08.2020	4	0	
19.08.2020	1	0	
21.08.2020	1	0	
26.08.2020	6	0	
28.08.2020	7	0	
04.09.2020	4	0	

In 2020, *A. chinensis* females began to lay eggs on 29.06.2020, and oviposition continued until 4.09.2020. The oviposition period was determined as 66 days. No hatching was observed in the eggs laid at the beginning of oviposition period. The egg stage duration was determined minimum 4 and maximum 17 days. The highest rate of hatching was recorded mostly on the 14th day. The highest egg hatching rate occurred in the first week of July. The eggs laid after the beginning of August have not been hatched.

The total number of eggs laid by 27 *A. chinensis* females reared in 2021, the hatching rate and egg longevity are given in Table 5.

In 2021, the oviposition period of *A. chinensis* began on 02.07.2021, and female individuals continued to lay eggs until 3.09.2021. The oviposition period lasted 63 days. Egg stage duration was determined minimum 5 and maximum 19 days. The highest hatching rate was generally recorded on the 14th day. Hatching rates were generally low and increased in the second week of August.

In the study, aimed to reveal the biology of *A. chinensis* on filbert, as a result of the observations that started in March 2020, only larvae of the pest was recorded in March and April while larvae and pupae were observed in May, and larvae, pupae and adults were observed in June. Adults, eggs and larvae were observed in July and August. Since September, only larvae have been encountered. The studies for 2021 started in January and only the larvae of *A. chinensis* were observed in January-April. In May and June, the larvae and pupae were recorded, as well as the adults began to emerge at the end of June. The adult, egg and larval stages were observed in July and August and the egg period continued until the first week of September. Larvae were recorded until the end of the year (Figure 6).

Table 5. Total number of eggs, hatching rate (%) and egg stage duration (days) of 27 pairs of *Anoplophora chinensis* reared in quarantine area in 2021

Oviposition date	Total number of eggs/27 pairs	Hatching rate (%)	Egg stage duration (days)
02.07.2021	31	35.48	10-17
05.07.2021	58	22.41	12-18
07.07.2021	41	58.54	10-15
10.07.2021	238	49.58	8-20
12.07.2021	78	70.51	7-10
14.07.2021	68	27.94	**5**-11
16.07.2021	31	58.06	9-13
19.07.2021	156	32.69	7-16
21.07.2021	49	30.61	**5**-11
23.07.2021	31	29.03	9-13
26.07.2021	33	6.06	11
28.07.2021	41	12.20	11-16
30.07.2021	34	23.53	9-17
02.08.2021	97	14.43	8-16
04.08.2021	49	10.20	12-14
06.08.2021	29	31.03	10-15
08.08.2021	86	69.77	9-19
11.08.2021	48	77.08	10-14
13.08.2021	14	64.29	10-14
16.08.2021	36	75.00	9-15
18.08.2021	38	44.74	9-13
20.08.2021	15	53.33	10-14
23.08.2021	26	34.62	11-14
25.08.2021	15	20.00	12-16
27.08.2021	4	0.00	0
31.08.2021	23	0.00	0
03.09.2021	4	0.00	0

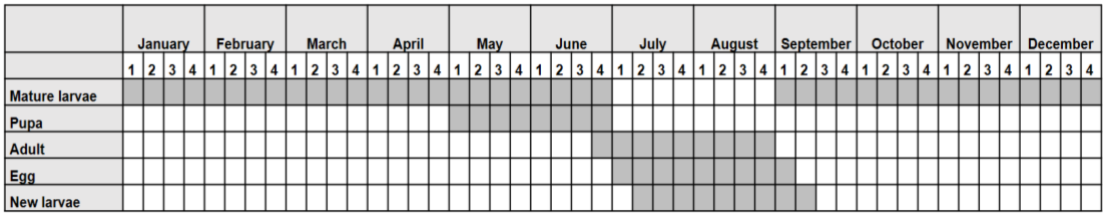

Figure 6. Biological periods of *Anoplophora chinensis* on hazelnut by months.

Discussion

Wang et al. (1996) report that *A. chinensis* gives offspring once a year and the adult stage is seen between April and June in China with reference to Hua (1982). Adachi has studied the biology of *A. malasiaca,* the synonym of *A. chinensis*. Adachi & Korenaga (1989) report that adult emergence begins in late May and lasts until late July and females survive for more than two months in Japan. Adachi (1990) reports that adult emergence starts in the beginning of June, reaches the highest level towards the end of June, and then starts to decline gradually. Iwaizumi et al. (2014) report that adults of *A. malasiaca* are seen between May and October. According to studies based on one-year observations on the biology of *A. chinensis* in Türkiye, Eroğlu et al. (2017) stated that adult emergence of *A. chinensis* starts in the second half of May and most of the adult emergence takes place in June-July in Trabzon. In this study, according to two-year survey results, the first adult emergence took place in June in accordance with Hizal & Arslangündoğdu

(2017) under the conditions of the Eastern Black Sea Region and the most intense adult emergence was observed in July. It was determined by gallery inspections that the pupae in the galleries have turned into adults since the end of May, but the adults did not leave the gallery before the last week of June. Hizal & Arslangündoğdu (2017) report as a result of the surveys they conducted in Istanbul that *A. chinensis* gives offspring once a year and the adults are seen from mid-June to mid-August. Results of this study showed that the adult stage of *A. chinensis* begins at the end of June and proceeds till the end of August in accordance with Eroğlu et al. (2017) in hazelnut orchards. Adult emergence mostly takes place in July and starts to decline as of August.

In the surveys conducted in hazelnut orchards, the adult lifespan of *A. chinensis* was determined as 49 and 58 days respectively between 2020 and 2021. If we look at the studies conducted where this pest is native, Adachi (1988) reports that female individuals of *A. malasiaca* reared on citrus plants survived between 47-109 days. Fujiwara-Tsujii et al. (2016) report the lifespan of *A. malasiaca* females cultured on mandarin, willow, and blueberry, respectively; 117±31 days, 82±19 days, and 32±9.2 days. It is known that the host plant affects the lifespan (Keena, 2002). Keena et al. (2021) showed that *A. chinensis* females from Italy and China, cultured with *Acer rubum* L. (Sapindales: Aceraceae) lived 272.7-5.1 days between 10-40ºC and reported that the survival time increased at low temperatures. Temperature and the origin of the insect were both significantly effective during this period. Considering the lifespan results of the adults obtained in this study, *A. chinensis* adults survive shorter on hazelnut than citrus, mandarin, willow and maple. Apart from the results obtained in this study, there are only observational data on the adult lifespan of *A. chinensis* in Türkiye.

Anoplophora species have obligatory sexual maturation feeding before oviposition. Adachi (1988) reports *A. malasiaca*'s maturation feeding is 10 days and Haack et al. (2010) report that *A. chinensis* and *Anoplophora glabripennis* Motschulsky, 1854 (Coleoptera: Cerambycidae) perform 10-15 days maturation feeding. On the other hand, Maspero (2015) reports this period as 5-7 days for *A. chinensis* and *A. glabripennis*. In the quarantine area, it was determined that the maturation eating period of *A. chinensis* was 4-5 days in both years, closer to Maspero (2015). Out of the results obtained in this study, there is no other information about the maturation feeding period of *A. chinensis* in Türkiye.

Lieu (1945) reports that oviposition period of *A. chinensis* takes place between June and August and according to the different time of oviposition during this period, development level of larvae can be very different before overwintering. It is reported that the larvae complete their development earlier or later in the following year or can not complete until the next year according to the level of development they reach before overwintering, therefore the larvae can be seen throughout the year. In both years of the study oviposition period of *A. chinensis* took place between the beginning of July and the beginning of September under Eastern Black Sea Region conditions. It is seen that adults laid most of the eggs in July and after the beginning of August oviposition declined.

Fujiwara-Tsujii et al. (2016) report that *A. malasiaca* eggs hatch in 7-10 days at 24ºC and 16:8 LD conditions. Ali et al. (2017) report *A. glabripennis* eggs hatch in 10-15 days at 25ºC, %55±8 conditions. Keena et al. (2021) determined that hatching occurred at 15, 20, 25, 30 and 35ºC in 31, 9, 5, 5 and 11 days respectively and 50% and 90% of *A. chinensis* eggs need 125.5 and 165.6 days.degrees to hatch respectively. In this study, at 26ºC and 16:8 LD, 65% humidity conditions, hatching took place between 4 and 20 days and the maximum hatching was recorded on the 14th day. These results are parallel with those of Fujiwara-Tsujii et al. (2016) and Ali et al. (2017).

Adachi (1988) stated that the hatching rate of *A. malasiaca* eggs was generally above 78% and an average of 90%. The most important factor in not hatching is unfertilization due to his observations. Keena et al. (2021) revealed that temperature is effective on hatching rate of *A. chinensis* eggs. Maximum hatching rate was observed respectively for the Italy and China population at 20ºC and 25ºC. In Türkiye there has

not been any study about hatching rate. We recorded maximum hatching 91.30% and 77.08% respectively in 2020 and 2021. As stated by Adachi (1988), unfertilized eggs are thought to play a role in low hatching rates, because eggs were kept at 25±1ºC, 65±5% RH in this study as Keena et al. (2021) revealed that the highest hatching rate of *A. chinensis* was 25ºC. It was observed that eggs of abnormal shape and color were laid on days when the daily temperatures were above the average and these eggs did not hatch.

Haack et al. (2010) report that the larvae of *A. chinensis* are legless, cream-colored and 30-50 mm long in the mature stage. In the surveys conducted, larvae were found between January and December. The maximum width of the head capsule in mature larvae was determined as 5.63 mm and the maximum larval length was determined as 50 mm in consistent with Haack et al. (2010). Head capsule widths of newly hatched larvae ranged between 0.5-1 mm and lengths of larvae varied between 5-6 mm. Keena & Richards (2022) state that head capsule widths of first instar larvae vary between 0.99-1.07 mm in individuals kept at different temperatures. Larval length and head capsule width values obtained from larvae of different stages in hazelnut orchards were found to be compatible with the literature. In this study, *A. chinensis* larvae were found in the surveys every month and detailed research needed about larval stages.

Anoplophora chinensis pupae are whitish and 27-38 mm long (Haack et al., 2010). Pupal stage lasts for 2-3 weeks depending on local temperatures and the color changes to light yellow towards the end of the pupal period (Maspero, 2015). In this study, *A. chinensis* pupae were encountered in May and June, and the length were 30-40 mm long. Shouping et al. (2016) reported that some of the *A. chinensis* individuals from Japan and China populations, kept at constant temperatures of 20-28ºC, could pupate without the need for a chilling period, while both populations could not enter the pupal stage without chilling period according to Keena & Richards (2022) and they thought this probably depend on the content of the food that the larva feeds on. Considering that the larvae were not fed during the last larval stage and that in some previous studies (Adachi 1994, Shouping et al., 2016) *A. chinensis* larvae could enter the pupal stage without chilling, Keena & Richards (2022) state that the temperature is not the only factor controlling the pupal stage. The factors controlling the pupal stage have not been clearly explained yet.

Keena (2005) and Haack et al. (2010) report that *A. chinensis* usually completes a generation within a year, and the larvae must reach a certain weight in order to pupate the next spring, otherwise completes one offspring in two years. In the light of the data obtained, it is seen that *A. chinensis* can complete one generation per year on filbert in the conditions of the Eastern Black Sea Region. The adult period starts at the end of June and continues until the end of August. It is observed that the adult period is shorter on filbert compared to other host plants. In order to decide whether hazelnut is a suitable host for *A. chinensis* as much as citrus or maple, further studies on the reproductive properties of individuals fed on hazelnut plants are needed.

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