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DETERMINATION OF SOME MORPHOLOGICAL PARAMETERS OF *Anoplophora chinensis* (FORSTER) (COLEOPTERA: CERAMBYCIDAE)

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Abstract: The citrus longhorned beetle, *Anoplophora chinensis* (Forster), native to East Asia, poses a significant threat to various crops and tree species in our country, including hazelnuts, due to its invasive nature and wide host range. In this study, the morphological characteristics of *A. chinensis* collected from infested hazelnut fields in Arifiye district, Sakarya province in Türkiye, during June, July, and August of 2024, were examined. Various parameters, such as body size, antenna length, elytra structure, and pronotum length, were analyzed on 200 adult beetles (100 ♀, 100 ♂), and distinct differences in morphological parameters between the sexes were observed. Measurements revealed that the body length, width, and elytra length of female individuals averaged 30.94 mm, 11.50 mm, and 22.89 mm, respectively, while male individuals measured 27.68 mm, 10.02 mm, and 20.27 mm. The number of antenna segments was determined to be 11 in both sexes, with the antenna length averaging 38.18 mm in females and 47.85 mm in males. It was observed that females had larger body sizes than males, but males possessed longer antennae. These findings are provided descriptions of some morphological parameters related to the sexes of *A. chinensis*.

Keywords: Invasive species, Citrus longhorned beetle, Morphological analysis, Description

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1. Introduction

The Citrus longhorned beetle (CLB) [*Anoplophora chinensis* (Forster) (Coleoptera: Cerambycidae)], native to East Asia, has been reported in China, Japan, and Korea, as well as Vietnam, Taiwan, the Philippines, Myanmar, Malaysia, and Indonesia (Gressitt, 1951; Lingafelter and Hoebeke, 2002). CLB is a polyphagous, invasive species, and known as a pest of citrus, but over 100 tree and shrub species from 36 families have been reported as host plants (Haack et al., 2010). In the areas it invades, in addition to citrus (*Citrus* spp.) and hazelnut (*Corylus* spp.), CLB bores galleries into economically important trees such as *Acer* spp., *Betula* spp., *Malus pumila*, *Pyrus* sp., *Salix* sp., *Melia azedarach*, and *Casuarina equisetifolia*. It spends its pre-adult stages within these trees, consuming xylem tissue, and causing dieback in the affected areas (Hérard et al., 2006; Liu, 2013; Ge et al., 2014). Although CLB typically completes its life cycle within one year, this cycle can extend to two years depending on factors such as host species and environmental conditions (Adachi, 1994).

International plant trade eliminates biogeographical barriers, allowing invasive pest species like CLB to be rapidly transported to different regions of the world (Hulme, 2009; Venette and Hutchison, 2021). CLB was first detected outside its natural range in the Netherlands in 1980, and since then, it has spread to many countries via ornamental plants imported from areas where it naturally occurs and from regions with established populations (Haack et al., 2010; Loomans et al., 2013). The beetle was first added to the quarantine lists in the EPPO region in 1994 and is currently listed in the quarantine lists of many countries in Africa, America, Asia, and Europe due to the destructive damage it caused (EPPO, 2024). The pest has been detected in Croatia, Denmark, France, Germany, Guernsey, Italy, Lithuania, the Netherlands, Switzerland, Türkiye and the United Kingdom. Although eradication efforts have successfully controlled it in many countries, it still persists in some areas of Croatia, Italy, and Türkiye (Hérard and Maspero, 2019). CLB was first detected in 2014 at the Kumbaba Nursery in Şile, Istanbul, Türkiye (Hızal et al., 2015). Initial detections have also been reported in various provinces, including Bartın (Yildiz, 2017), Trabzon, Antalya (Eroğlu et al., 2017; Topakcı et al., 2017), Sakarya (TOB, 2021), and Diyarbakır (Özdikmen and Şeker, 2021). The pest was first detected in Turkish hazelnut orchards in 2018 and has been highlighted as a serious threat to sustainable hazelnut production (Bozkurt, 2018; Tuncer et al., 2020). Following the detection of CLB in hazelnut orchards in Türkiye, quarantine measures

were rapidly implemented, and as a result of eradication efforts carried out in hazelnut orchards infested with CLB, approximately 2 million dollars in compensation was paid to farmers (Turan and Erdoğan, 2022; Dogan et al., 2024).

In this study, the morphological characteristics of CLB populations in the Arifiye district of Sakarya province were examined, and various parameters such as body size, antenna length, elytra structure, and pronotum length were evaluated to reveal the differences between sexes of the insect.

2. Materials and Methods

2.1. Collection of Insects

As part of the research, healthy and alive adult individuals of CLB (100 ♀, 100 ♂) were collected from hazelnut fields in the Arifiye district of Sakarya province in Türkiye, which were found to be infested with the pest, during June, July, and August of 2024.

2.2. Morphological Parameters and Measurements

The identification of the collected adult CLBs was carried out with the help of literature (Gyeltshen and Hodges, 2005; EPPO, 2021). The collected insects were killed by placing them in a deep freezer at -20 °C for 5 minutes, then thawed for 5 minutes in the laboratory before being subjected to morphological examination. Any individuals with physical defects were excluded from the analyses. In the morphological analyses, parameters such as the sex of the adult individuals, body length, body width, antenna length, elytra length, pronotum length, number of antenna segments, number of spots on the elytra, and presence of tubercles were examined (Lingafelter and Hoebeke, 2002; EPPO, 2021). Measurements were taken using a digital caliper with ±0.01 mm accuracy.

3. Results

In this study, various morphological characteristics of adult CLB individuals collected from different hazelnut fields in the Arifiye district of Sakarya province were examined. According to the results, significant differences were identified between the sexes (Figure 1). The average body length of female individuals was recorded as 30.94±0.38 mm, while that of males was 27.68±0.32 mm. Additionally, the average body width of females was 11.50±0.18 mm, whereas in males, this value was recorded as 10.02±0.13 mm. The average antenna length was 38.18±0.46 mm in females, while it was found to be 47.85±0.69 mm in males. It was determined that the antenna length in females was 1.2 times the body length, while this ratio was 1.7 times in males. These results show that the antenna length of males is significantly greater than that of females, while males are shorter in terms of body length and width (Table 1).

Table 1. Sex-based morphological measurements of *Anoplophora chinensis*

Sex	Body Length (mm)	Body Width (mm)	Antennal Segment Count	Antenna Length (mm)	Elytra Length (mm)	Pronotum Length (mm)	Number of White Spots on Elytra	Number of Individuals (n)
Female	30.94±0.38	11.50±0.18	11±0	38.18±0.46	22.89±0.30	4.91±0.12	35±1	100
	Min: 17	Min: 7.1		Min: 25.7	Min: 13.5	Min: 3.6		
	Max: 36	Max: 16.7		Max: 45.8	Max: 29.1	Max: 9.1		
Male	27.68±0.32	10.02±0.13		47.85±0.69	20.27±0.26	4.31±0.09	34±1	100
	Min: 20.1	Min: 8		Min: 36	Min: 11.5	Min: 2.7		
	Max: 32.8	Max: 12.8		Max: 58.4	Max: 23.8	Max: 7.3		

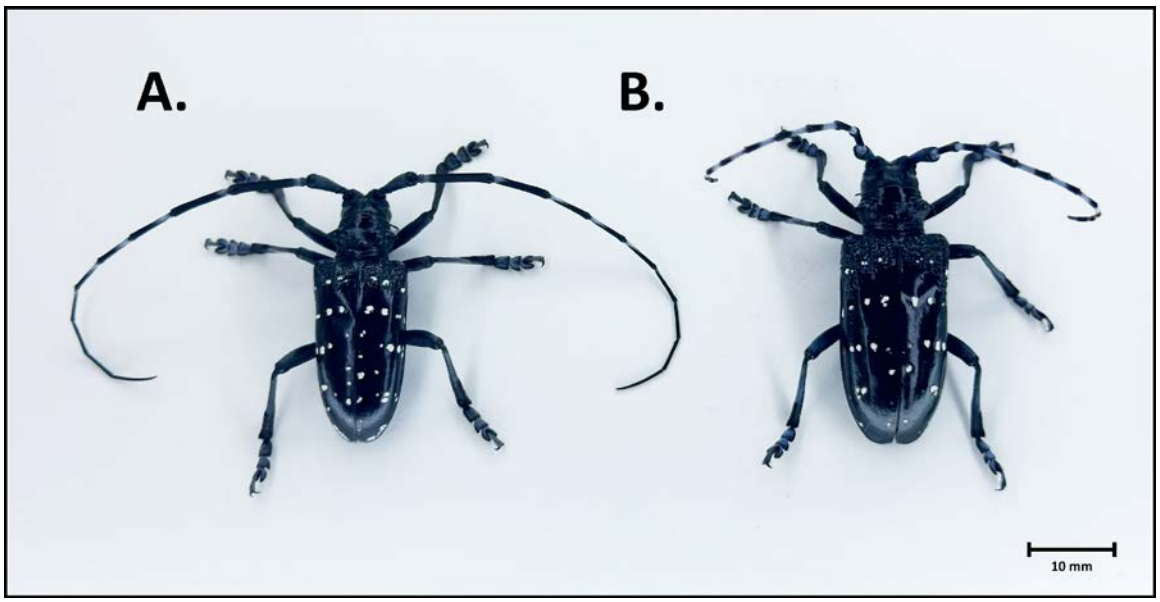

Figure 1. Adult male (A) and female (B) of *Anoplophora chinensis*.

The pronotum length in females was found to be an average of 4.91±0.12 mm, while in males it was 4.31±0.09 mm. Additionally, the elytra length was measured as 22.89±0.30 mm in females and 20.27±0.26 mm in males. An increase in elytra length was observed in correlation with the increase in body length. The number of white spots on the elytra was recorded as an average of 35 in females and 34 in males, with no significant difference between the sexes. Both sexes were found to have tubercles on the elytra (Figure 1).

4. Discussion

CLB adults were glossy black in color and have irregularly shaped spots on their elytra. It has been noted that the body length of adult beetle's ranged from 17 to 40 mm, that tubercles were present in the basal quarter of the elytra, and that there were 10 to 20 irregularly shaped spots on the elytra, though in rare cases, this number can exceed 60 (Lingafelter and Hoebeke, 2002; Haack et al., 2010). In the study conducted in Trabzon province in Türkiye, Eroğlu et al. (2017) measured 14 female and 9 male individuals and reported that females had an average of 11-12 spots and males had 14-15 spots on their elytra. They also found that the average body length of females was 28.6 mm (24-33.5 mm) and their body width was 10.3 mm, while the average body length of males was 25.4 mm (23-30.1 mm) and their body width was 8.9 mm. In another study, Hızal et al. (2015) reported that the sizes of adult CLBs collected from Istanbul ranged from 27 to 34 mm. Our data revealed a significant difference in the number of spots on the elytra compared to other studies. Although the number of tubercles did not recorded in this present study, the presence of these structures confirms that the beetle population is CLB. While our data on body length aligns with the findings of Hızal et al. (2015), the average body sizes we recorded 30.94±0.38 mm for females and 27.68±0.32 mm for males were larger than those reported by Eroğlu et al. (2017). These differences may be due to the smaller number of specimens examined in their study compared to ours. Additionally, a significant morphological differences were observed in terms of body size and antenna length. Female individuals were found to have a significantly larger body size compared to males, while males had longer antennae. These findings are consistent with previous studies on the morphology of CLB (Hızal et al., 2015; Eroğlu et al., 2017). The antennae of adult CLB are long and consist of 11 segments, with each segment having a white or light blue band at the base and black tips. Similarly, in our study, we found a maximum of 11 segments in the adult beetles examined, and the observed colors matched the white or light blue colors specified in EPPO (2021). According to previous studies, antenna lengths in females and males were reported to be 33.1 mm and 44.1 mm, respectively (Eroğlu et al., 2017). In our study, antenna lengths were measured as 38.18±0.46 mm in females and 47.85±0.69 mm in males, indicating that the antennae were longer in both sexes. Another difference between males and females is that in males, the tip of the abdomen is completely covered by the elytra, while in females, a portion of the abdomen is exposed (Lieu, 1945). This difference was also observed in the specimens examined in our study. Additionally, in adult CLB individuals, the pronotum narrows towards both the top and bottom and is characterized by sharp spines extending laterally.

5. Conclusion

This study revealed some morphological parameters of *Anoplophora chinensis*. The differences, particularly in antenna length and body size are elucidated important information for sex determination and thus aid in the identification of the species.

Author Contributions

The percentages of the authors' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	F.D.	İ.O.Ö.	S.K.
C	20	40	40
D	60	40	
S		100	
DCP	100		
DAI	70	30	
L	40	40	20
W	40	40	20
CR	20	60	20
SR	40	40	20
PM	40	40	20
FA	40	40	20

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study due to the use of research materials that did not fall under the definition of experimental animals (The Scientific and Technological Research Council of Türkiye, Animal Experiments Local Ethics Committee Directive, 2018, Article 3-c).

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