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Research Article

Mapping the distribution of the European Red Wood Ant in Turkey and its key factors in conservation planning

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Abstract

In this study, 82 nests in the Thrace region, the only distribution area of the European redwood ant (*Formica pratensis* Retzius,1783) in Turkey, were identified and monitored for two years. A nest ID was created for each nest, showing nest features, strategic location, habitat characteristics and some morphometric differences of workers. The species ' living areas (area of occupancy, AOO) and extension of occurrence (EOO) calculations were also carried out. Statistical analyses were carried out to show the relationships between these features. The results demonstrated that the optimum distribution of the nests is between 300-600 m, and the nests are mainly located at a distance of 0-200 m close to the water source. Nests are mostly built facing south in open areas in fields or forests, and the B-shaped nest is the most frequently observed nest morphology. Moreover, colony individuals frequently visit oak and blackberry species, and the Thracian population tends to form monodomous nests at a rate of 95%. The relationship between the morphological characteristics of ants (NHLI, NBH, LBH and HW), nest altitude data, and the distance of nests to water sources and forest areas was tested with Spearman rank correlation analysis, and a weak reverse correlation was found between the averages of NBH data and nest altitudes (r: -0.300; $p<0.05$), at 95% confidence interval. Accordingly, the AOO of the species in the Thrace region was calculated as 50,176 m2 and the EOO was 3,682 km2. All nests are shown on political maps, and applicable maps have been created in which buffer zoning and conservation areas are suggested. In total, 36 conservation and awareness training types were also carried out in two years, reaching 1201 students, and 92% awareness was created. Our results indicate that the nests cannot remain stable for many years due to intense human pressure.

Keywords: Conservation biology, Conservation zones, *Formica pratensis,* red woo*d ants,* Geographic Information Systems

Introduction

Conservation of biodiversity is a global issue. Societies and states that attempt to restore damaged ecosystems and biodiversity elements often have to spend much more effort and money than protecting biodiversity. Although traditionally and culturally the consumption and use of biodiversity as textiles, medicine and food are for ethnobotanical purposes (Groenestijn et al. 2002), current scientific evidence shows that the benefits of biodiversity are directly indispensable for human health and well-being, and it is also a fact that protecting biodiversity will make ecosystem services sustainable. However, in many regions, the transformation of natural habitats into agricultural areas, settlements and industrial facilities continues unabated (Subasi, 2014).

Scientists have used the concept of conservation biology to characterize activities and research carried out to protect sustainable biodiversity at all levels. The science of conservation biology; Its scope has been expanded to include many other new disciplines such as conservation planning, landscape ecology, conservation genetics, restoration ecology and ecological economics (Groom et al. 2006). Studies in the field of conservation biology require a good knowledge of the biology and ecology of the target species, interdisciplinary work, and making realistic qualitative and quantitative predictions about the future by comprehensively researching the past (Dekoninck et al. 2010; Antonova & Marinov, 2021; Berberich & Berberich 2023). When their different ecological roles are evaluated together, ant species are assumed to be ecosystem engineers, keystones and good indicator species for terrestrial ecosystems (Cook, 2003; Frouz et al. 2016). Therefore, conservation studies to be carried out in the habitats of ants can guide us in monitoring the health and integrity of the entire ecosystem.

Data obtained as a result of national red list studies (Aksoy & Camlitepe, 2018; Camlitepe & Aksoy, 2019; Camlitepe et al. 2021) indicate that this species is in the Vulnerable (VU) category for the Thrace region and in the critically endangered (CR) category for Turkey even though this species listed as "Near Threatened (NT)" in the IUCN Red List globally. (IUCN Red List of Threatened Species, 2023). In Britain, *F. pratensis* is listed as “Endangered “EN” (Shirt, 1987) and the species is considered regionally extinct as it has not been seen in Britain since 1988 (Nicholson, 1997). In addition, the species is listed in the “VU" category in Belgium (Bonte et al. 2003; Dekoninck et al. 2010) and is known to be protected by law in the Netherlands and Germany. This study particularly aims to present a methodology developed to create the conservation zones needed for the effective conservation of the species through comprehensive studies on the conservation biology of the European red wood ant (*Formica pratensis* Retzius, 1783), which is distributed only in the Thrace region of Turkey.

Material and methods

The study was carried out in the provinces of Kirklareli and Edirne, where *F. pratensis* is known to have a natural distribution in the Thrace region. The nests were visited between May and October in 2020-2021, when the species was active, and qualitative and quantitative data about the nest and its surroundings were collected, and worker individual samples were collected from the nests for morphometric measurements. Morphometric measurements were carried out on worker individual samples collected during the field studies, nest cards were created in the light of the data obtained about nest morphology and habitat, and statistical evaluations were made on nest site preferences.

Morphometric measurements were carried out in a laboratory environment with 30 samples for each nest. In morphometric measurements; The number of hairs on the extensor profile of the posterior tibia (NHTI) and the number of hairs on one half of the occipital edge when viewed from the front (NBH) were calculated, the widest measurable part of the head (HW) and the length of the longest hair on one half of the occipital edge when viewed from the front (LBH) were measured. (Seifert, 1992; Camlitepe et al. 2021). The effect of the distance of the nests to agricultural areas, forest areas, settlements and water sources on the counting and measured characters of ants was tested with multiple linear regression analysis. The relationship between these characters and nest altitude values, distances of nests to water resources and forest areas were tested with Spearman rank correlation analysis.

It was aimed to verify the polydomous nests in the distribution area of the species by performing aggression tests between potential polydomous nests and control groups. A score table showing the scores to be given to behavioural responses has been prepared to be used in the evaluation of the tests to be carried out to verify the polydomy situation (Table 1). The methodology was prepared by modifying literature studies and taking into account the findings obtained from preliminary trials carried out in the field (Beye et al. 1998; Obin & Vander Meer, 1988; Stuart & Herbers, 2000; Aksoy & Camlitepe, 2018).

Table 1. Behavioural units and aggression scores

Score	Behavioural units
6	Remain unresponsive; Unresponsiveness after antennal contact for less than 2 seconds
5	Antennal contact for more than 2 seconds and short-term following
4	An immediate antennal contact longer than 2 seconds and following, staying still if the other ant is not moving.
3	avoidance, holding and vibrating the gaster in upright position.
2	Siding, antenna-leg biting followed by acid spraying.

1	Immediately fight, acid spraying, gaster in typical bent position of defense.

All statistical analyses were carried out using the IBM® SPSS® 22 package program. Long-term and annual meteorological data for Kirklareli and Edirne provinces, used as external data sources, were obtained from the General Directorate of Meteorology in excel form.

By examining the correlation relationship between the averages of morphometric measurement results (NHTI, NBH, HW and LBH) and the climatic characteristics of the nest locations, Spearman's Rank Correlation Analysis was performed at a 95% confidence interval due to the non-normal distribution of the data. The effect of the distance of the nests to agricultural areas, forest areas, settlements and water sources on the NHLI, NBH, LBH and HW morphology of ants was tested with Multiple Linear Regression Analysis. The relationship between the morphological characteristics of the ants, nest altitude data, and the distance of the nests to water sources and forest areas was also determined by Spearman Rank Correlation Analysis. Spearman's Correlation Analysis was performed with a 95% confidence interval in order to determine the relationship between volume changes and nest cover degree data between 2020 and 2021 for 35 nests that were active in both periods. In order to determine the population density, in field studies, the nest shape was accepted as half of the ellipsoid, and the large diameter (D) was measured from the widest part of the nest, the small diameter (d) perpendicular to it, and the height (h) from the ground level to the top part of the nest were measured, and nest volumes were calculated for both periods using the formula (Czechowski & Vepsäläinen, 2009, Fig. 1): $V = \frac{2}{3}\pi\frac{D}{2}\frac{d}{2}h$ (Czechowski ve Vepsäläinen, 2009)

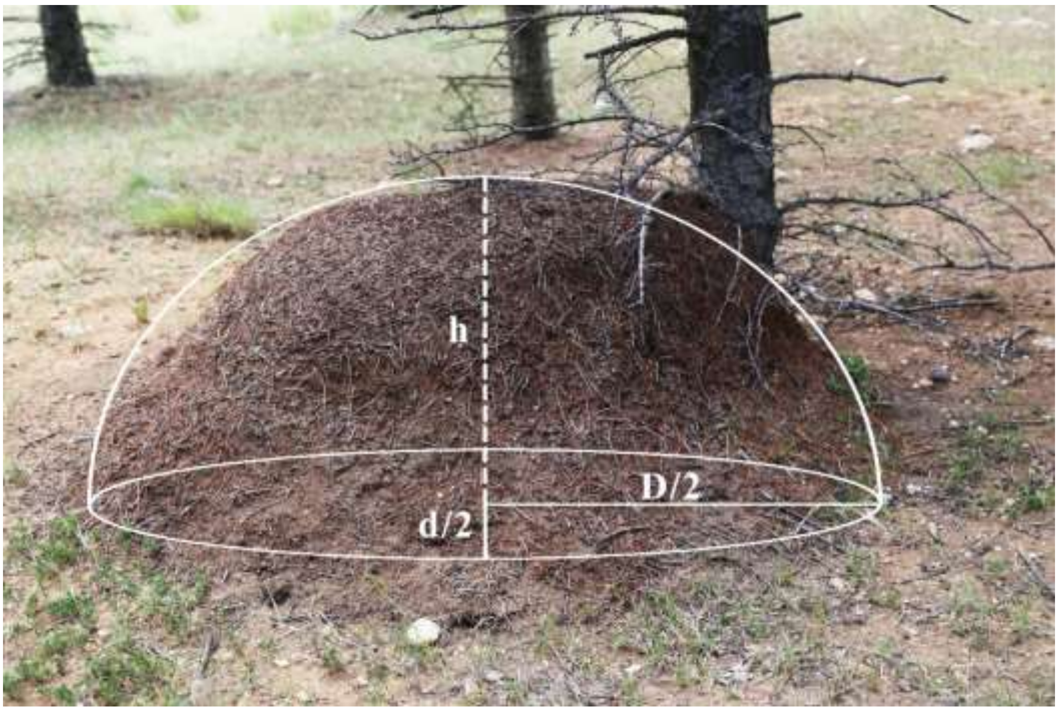

Figure 1. Parameters used in nest measurement; D/2: Large radius, d/2: Small radius, h: Height

Wilcoxon Test was performed to compare nest volume values calculated between 2020 and 2021 periods. Spearman's correlation analysis was performed with a 95% confidence interval in order to determine the relationship between volume changes and nest cover degree data between 2020 and 2021 for 35 nests that were active in both periods.

In order to statistically determine the change between the literature data of a MSc thesis (Gemik, 2020) carried out on the species in Kirklareli in 2018 and the average of nest volumes in 2020 and 2021, Kruskal-Wallis Analysis with a 95% confidence interval and nest volume data with average humidity and temperature for the same years and total Spearman's Correlation Analysis was performed with a 95% confidence interval in order to determine the relationship between the rainfall amount and the number of rainy days data.

In this context; Graphics of nest appearance, tree species visited, nest morphology distribution, distribution of nests according to elevational distribution of nests' proximity to water resources, distribution of nests according to stand types were created using Microsoft Office and Excel package programs. Canopy rates used in forest management were used to categorize the sun exposure of the nest. Accordingly, each nest is divided into classes as; If the closure ratio is less than 0.10, it is sparse canopy (0), if it is between 0.10-0.40, loose canopy (1), if it is between 0.41-0.70, semi-closed canopy (2), if it is between 0.71-1.0, closed canopy (3), and if it is more than 1.0 It is dense canopy (4).

The nests, for which field measurements were carried out in the 2020-2021 periods, were morphologically divided into 4 different morphological types. Capital letters A, B, C, D were assigned as symbols to code each type. The visual of nest morphology types drawn for the 4 different nest morphology types detected is presented in Figure 2.

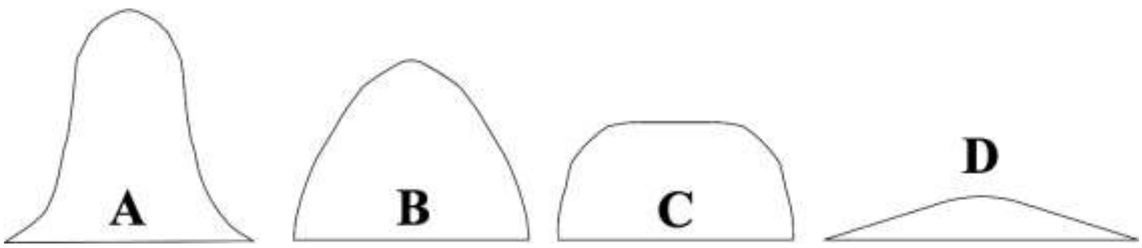

Figure 2. Different types of nest morphology detected in the field.

Altitude data of a total of 82 nests identified and recorded in Kirklareli and Edirne provinces were evaluated. In order to determine the relationship between the morphology types of the nests and the altitude levels of the nest locations, in addition to the chi-square ($\chi 2$) relationship test, this conservation success analysis of the nests that were previously surrounded by wire fences was also carried out**.**

Altitude data of a total of 82 nests identified and recorded in Kirklareli and Edirne provinces were evaluated. Chi-square ($\chi 2$) relationship test was conducted to determine the relationship between the morphology types of nests and the altitude levels of nest locations. On the other hand, conservation success analysis of nests that were previously fenced for conservation purposes was also carried out.

The trees and bushes visited by individuals belonging to 71 active nests during the 2021 period were identified and recorded. The tree species visited by *F. pratensis* individuals and the change in nest volumes were evaluated. In the light of this data, nest cards were created for all nests, all nests were identified, and a code indicating the name of the province, district, village and nest number naming each nest was created (For example: KKMe01.

For the purpose of sustainable conservation strategy of *F. pratensis*, information and awareness trainings were also held in the schools of Kirklareli province, which hosts approximately 88% of the nests identified. Within the scope of training; The biology of the species, its conservation category, the factors that endanger its extinction and the activities that can be done to protect the species were explained accompanied by a presentation prepared at the primary school level, and the questions of the students were answered. In order to measure the impact of training and awareness-raising activities, the success of the training was measured by conducting a survey on 50 secondary school students who had not previously received training on the conservation of the European Red Wood Ants in the 2022 - Spring academic period and 50 secondary school students who received training in the 2021 academic period.

Digital nest coordinates obtained with the GPS device during field studies ARCGIS® 10.4. It was transferred to the database created through the geographic information systems software package program, and all maps and the distribution area were prepared and calculated with this software (Fig. 3).

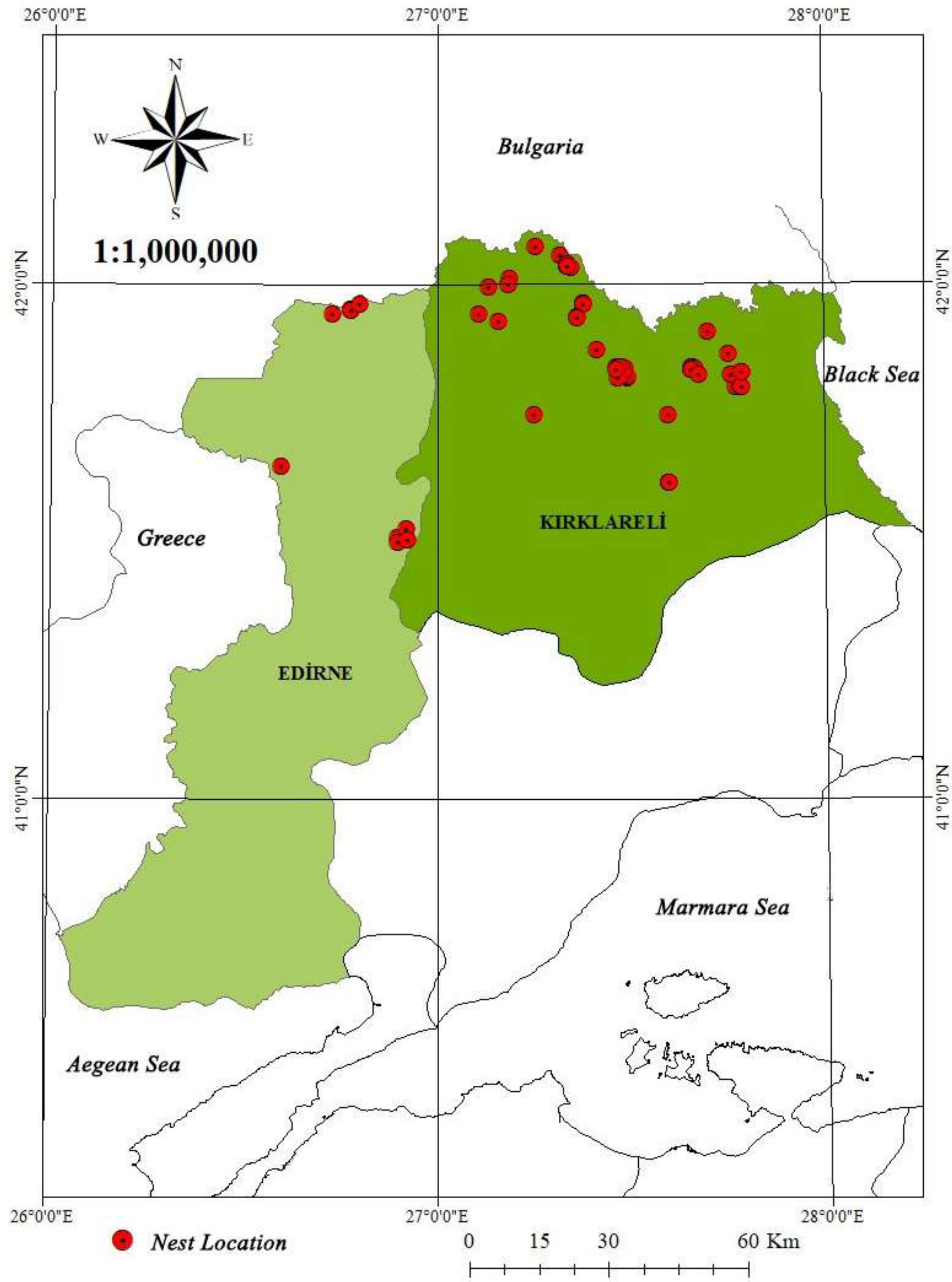

Figure 3. Distribution Map of the European Red Wood Ant *F. pratensis* in Turkey.

Since a scale appropriate to the unique biological characteristics of the taxon, the characteristics of the threats and the available information must be used to calculate the living areas (area of occupancy, AOO), the total area of the squares tangent to the circle with a radius of 16 meters (r) determined as the core zone from the centre of all nests active in the 2021 period and calculations were carried out accordingly. Since extension of occurrence (EOO) is the area created from the shortest boundaries that can be drawn to include all points of the known, predicted and inferred distributions of a taxon, the area of the convex polygon obtained by combining the end points of the European red wood ant distribution has been accepted as the distribution area of the species in Turkey. The selection of nests was based on 72 nests active in 2021.

Conservation zoning maps that will be a sustainable basis for nest conservation efforts; The nest zone is 208 cm, which is the largest nest diameter recorded quantitatively in field studies, a 16 m buffer zone from the nest centre, which is the farthest point where individuals move away from the nest, and a 50 m buffer zone from the buffer zone border to protect the nest from the edge effect. A buffer zoning strategy was developed for each nest (Fig. 4). In this context, maps showing conservation zones have been created.

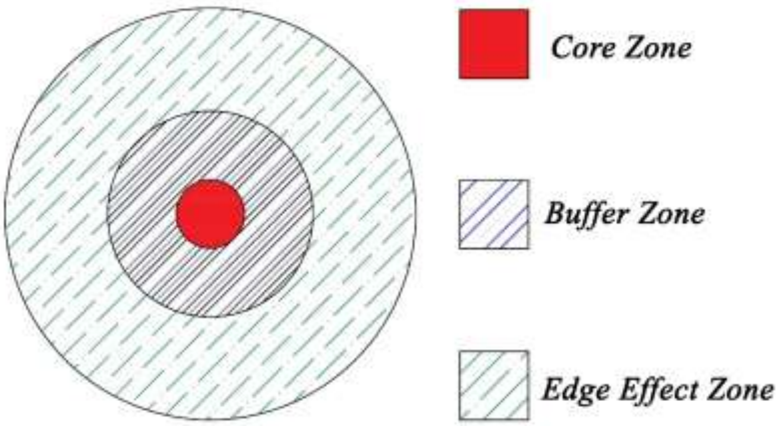

Figure 4. Hierarchical zoning model of a conservation zone

Results

It was determined that 50% of the nests were in form B, 34% in form C, 15% in form D and 1% in form A.

When the altitude data of a total of 82 nests recorded in Kirklareli and Edirne provinces were evaluated, it was revealed that the nest distribution was highest between 301-600 m (Fig. 5).

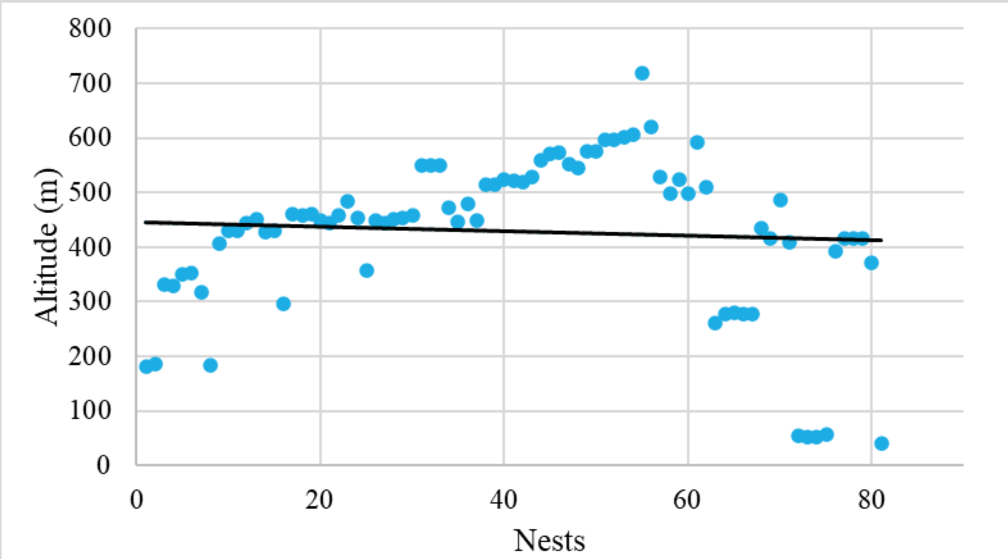

Figure 5. Distribution of nests by altitude

According to the chi-square (χ2) relationship test performed to determine the relationship between the morphology types of the nests and the altitude levels of the nest locations, it was determined that there was no significant relationship between the morphology type of the nests and the altitude levels of their locations (p>0.05) (Table 2).

Table 2. Cross-tabulation of nest morphology type and altitude level.

			Altitude					
			0-150m	**151-300m**	**301-450m**	**451-600m**	**601-750m**	**Total**
Nest morphology	**A**	**N**	0	1	0	0	0	1
		%	0	100	0	0	0	100
	B	**N**	2	3	13	23	1	42
		%	4,8	7,1	31	54,8	2,4	100
	C	**N**	1	5	10	8	3	27
		%	3,7	18,5	37	29,6	11,1	100
	D	**N**	2	0	4	6	0	12
		%	16,7	0	33,3	50	0	100
Total		**N**	5	9	26	37	4	82
		%	6,1	11	32,9	45,1	4,9	100

When the aspect data of a total of 82 nests detected and recorded in Kirklareli and Edirne provinces were evaluated, it was revealed that the dominant aspect was south, southwest and southeast, according to the data of 62 nests, although 21 nests did not have a distinct aspect. When the canopy cover classes and nest morphologies were compared, it was determined that while the number of nests of all morphs was highest in 0 and 1 closed canopy, the number of nests in B and C morphs increased and decreased inversely proportional to the canopy cover.

Examining the proximity of nest localities to water sources shows that, in optimum condition, nests tolerate an average distance of up to 200 m from the water resource (Fig. 6).

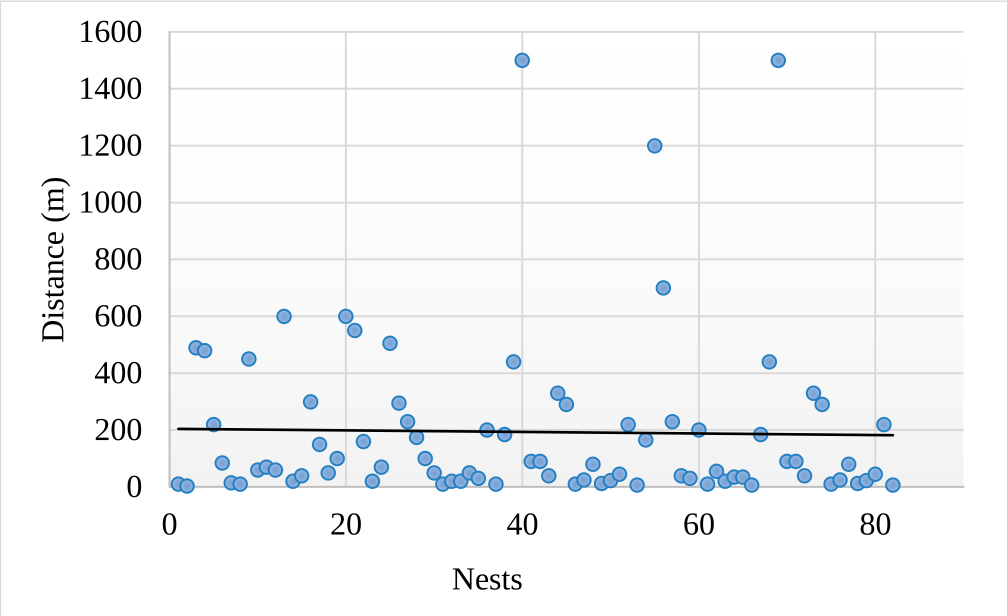

Figure 6. Relationship between nest localities and proximity to water resource.

When the distribution of the number of nests according to stand types, which was created to show the habitats preferred by stand types in the distribution of *F. pratensis* was examined, it was revealed that the most preferred stand type of the species was agricultural area.

The trees and bushes visited by individuals belonging to 71 active nests during the 2021 period were identified and recorded. Accordingly, *F. pratensis* individuals visited oak species the most, followed by blackberry, cedar, hawthorn and walnut. When the tree types visited by *F. pratensis* individuals and the change in nest volumes were evaluated, an increase was observed in the nest volumes of individuals visiting trees with succulent fruit, while a decrease in the volume of the nests of individuals visiting trees with coniferous and nux fruit seeds was detected.

The fact that the nests were damaged despite being surrounded by fences and with information signs, necessitated examining the source of this issue, and those who damaged the nests were divided into 2 categories: people and natural processes. Although surrounded by wire fences and with information signs, it was determined that 3 of the 4 damaged nests were destroyed by human causes and 1 by natural processes (wild animal destruction).

The effect of the distance of nests to agricultural areas, forest areas, settlements and water resources on the NHLI, NBH, LBH and HW morphology of ants was tested with multiple linear regression analysis. According to this; It was understood that the distance values of the nests to agricultural areas, forest areas, settlements and water resources were not significant predictors of the LBH and NBH values of the ants ($p>0.05$). In addition, the results of the analyses performed on NHLI and HW values were not evaluated due to violation of test assumptions.

The relationship between the morphological characteristics of ants (NHLI, NBH, LBH and HW) and nest altitude data, distances of nests to water resources and forest areas were determined by Spearman rank correlation analysis. Accordingly, it was determined that there was only a weak reverse correlation relationship between the averages of the ants' NBH data and their nest altitudes within the 95% confidence interval (r: -0.300; $p<0.05$) (Table 3).

Table 3. Spearman's rank correlation table showing the relationship between morphological features (NHLI, NBH, LBH and HW) and the altitude where the nests are located, distance to water resource and distance to forest areas (r: -0.300; $p<0.05$)

		NHTI	NBH	HW	LBH
Elevation	r	-0,180	**-0,300**	-0,081	0,203
	p	0,111	**0,007**	0,473	0,071
Distance of Water	r	-0,087	-0,097	0,033	-0,042
	p	0,444	0,394	0,772	0,710
Distance of Forest	r	0,212	-0,078	0,024	0,168
	p	0,059	0,489	0,834	0,136

r: Correlation Coefficient, p: Significance Value

The correlation relationship between the NHTI, NBH, HW and LBH averages and the climatic characteristics of the nest locations was examined, and since the distribution of the data was not normal, Spearman's correlation analysis was performed with a 95% confidence interval. According to this; It was determined that there was a weak positive correlation between humidity and temperature and the NBH average (p:0.001), a moderate and negative correlation between the LBH average and humidity, and a relatively weak negative correlation with precipitation (p:0.000). While a moderate positive correlation was observed between the HW average and temperature, it was determined that there was a moderate negative correlation with the annual rainy day average (p:0.000). There was no significant correlation between the NHTI averages of the nests and any climate parameters (p>0.05) (Table 4).

Table 4. Spearman's correlation analysis results between NHTI, NBH, HW and LBH averages and climatic characteristics of nest locations.

		Average Annual Humidity (%)	**Average Annual Temperature (°C)**	**Average Annual Rainfall (kg/m^2)**	**Average Annual Number of Rainy Days**
NHTI	r	-0,097	-0,112	-0,086	-0,146
	p	0,2	0,167	0,228	0,103
NBH	r	**0,351**	-0,077	**0,347**	**0,259**
	p	0,001	0,252	0,001	0,012
HW	r	0,105	**0,458**	0,093	**-0,545**
	p	0,181	0,000	0,21	0,000
LBH	r	**-0,444**	-0,067	**-0,393**	-0,119
	p	0,000	0,282	0,000	0,150

r: Correlation Coefficient, p: Significance Value

When the volumetric changes in nest volumes in the 2020 and 2021 periods were evaluated, an average decrease of 97.57 dm3 was detected in the 2021 period compared to the 2020 period.

Wilcoxon Test was performed to compare nest volume values calculated between 2020 and 2021 (Data does not show normal distribution). Accordingly, a significant difference was detected between the average volumes of the nests ($Z = 176.000$, $p < 0.05$). It was revealed that the calculated volume values of the nests in the 2020 period were significantly higher than in the 2021 period (Table 5)

Table 5. Comparison of nest volume values calculated between 2020 and 2021 periods.

Annual Volume Value	n	Median	Statistic Value (Z)	p
2020	35	184,21	176	0,023
2021	35	117,23		

Spearman's correlation analysis was performed with a 95% confidence interval in order to determine the relationship between volume changes and nest cover degree data between 2020 and 2021 for 35 nests that were active in both periods (Data is not normally distributed). According to this; It was determined that there was no significant relationship between volume increases and decreases between years and closure ($p>0.05$).

According to the measurements made in the 2021 period, it was determined that there was an increase in volume in 14 nests and a decrease in volume in 21 nests. Since the volume decreased in the 2021 period compared to the 2020 period, the volume data calculated with the size data collected in August and September 2018 of 12 nests in Kırklareli province (Gemik, 2020; Gemik & Camlitepe, 2023), which are recorded in the literature and studied within the scope of this study, were compared.

Kruskal-Wallis Analysis was performed with a 95% confidence interval to statistically determine the change between the averages of nest volumes in 2018, 2020 and 2021 (Data is not normally distributed). According to this; It was determined that there was no significant change between the average nest volumes according to the years specified ($p>0.05$).

Spearman's Correlation Analysis was performed with a 95% confidence interval in order to determine the relationship between annual nest volume data for 2018, 2020 and 2021 and average humidity and temperature, total precipitation amount and number of rainy days for the same years (Data is not normally distributed). According to this; It was determined that there was no significant relationship between the individual nest volume measured for the specified years and the meteorological data of the locality where that nest was located ($p>0.05$).

In the aggression tests, aggression tests were carried out within the selected polydomous colony, between polydomous colonies at close distances, between monodomous at close distances, between monodomous at long distances from each other, and between monodomous and polydomous nests at long distances, and a regression chart was created to reveal the relationship between the scores obtained and the distance (Fig. 7).

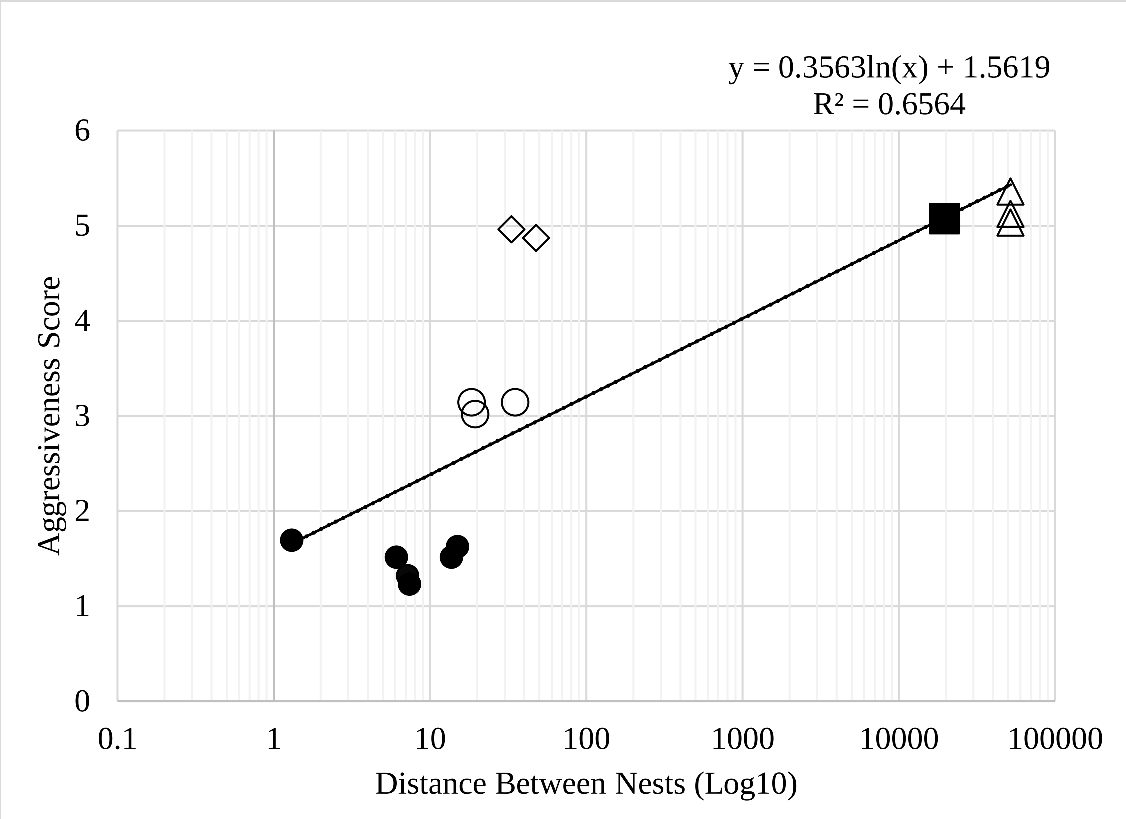

Figure 7. The relationship between distance, polydomy/monodomy and aggression; Solid circles: Aggression within polydomous colonies, Hollow circles: Aggression between polydomous colonies, Hollow rhombuses: Aggression between monodomous close to each other, Solid square: Aggression between monodomous far apart, Hollow triangle: Aggression between monodomous and polydomous far apart (n=10)

In the light of these data, while the level of aggression within the polydomous colony was observed to be quite low (1-2 points), it was recorded that the aggression between polydomous colonies in close proximity to each other was at a medium level (3 points). Since there are no polydomous colonies at long distances from each other, it was not possible to correlate the change in the level of aggression between polydomous colonies with distance.

The results of aggression tests carried out between monodomous nests located close to each other are very similar to the results between monodomous or polydomous nests located at long distances from each other and have high (5 points) aggression scores.

In the GIS analysis performed to calculate AOO (area of occupancy, the living area) was calculated as 50,176 m2, corresponding to 49 occupied squares in total. For example; The visual of the 16 cm radius core zones and the 32 x 32 cm grid used in the calculation of the living area in a region of Çukurpınar locality is presented in Figure 8.

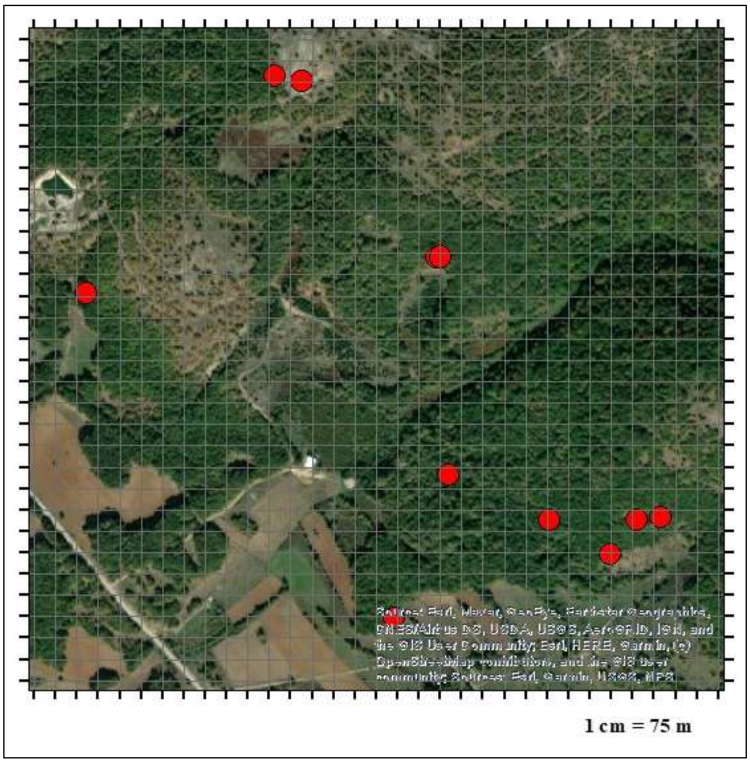

Figure 8. An example satellite image grid from Çukurpınar locality used in the calculation of AOO.

In the GIS analysis performed to calculate extension of occurrence (EOO), the EOO for 72 active nests was determined as $A = 3.682\ km^2$. The scale map showing the EOO of the *F. pratensis* is presented in Figure 9.

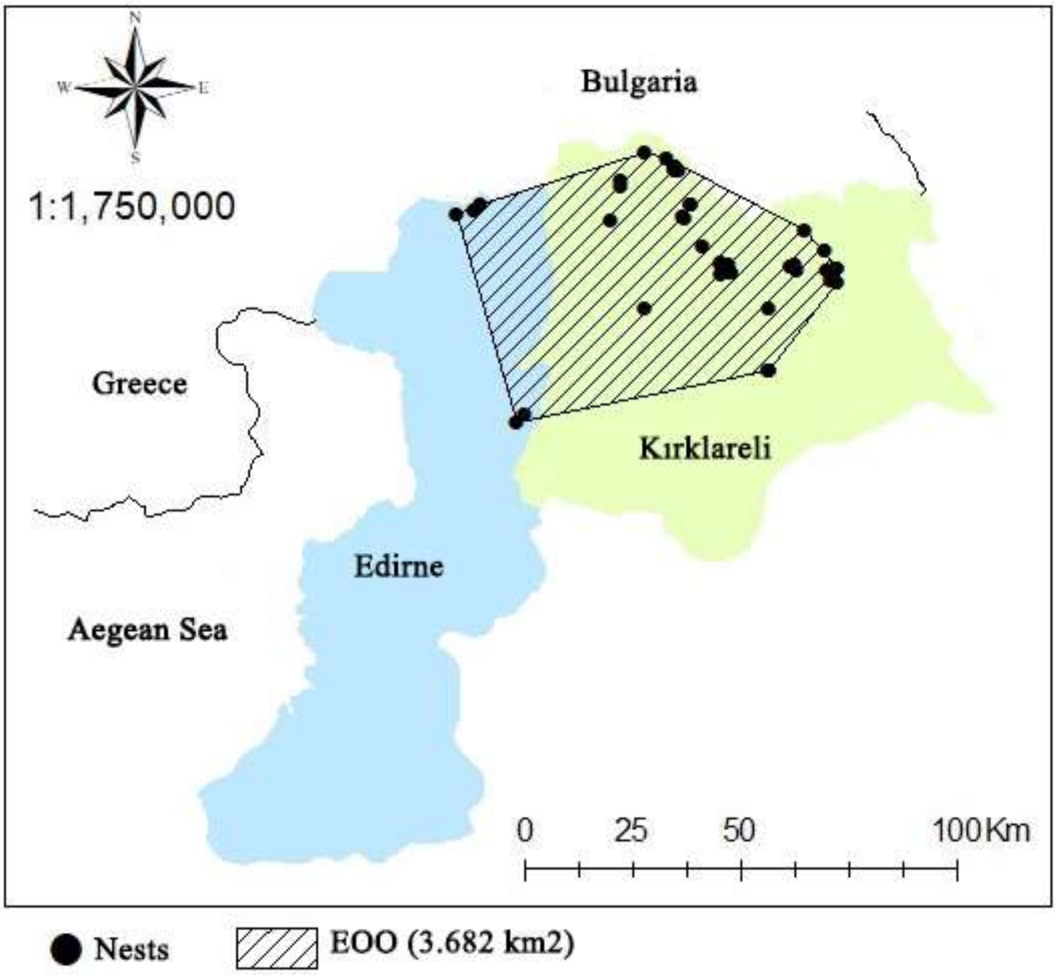

Figure 9. Extension of occurrence (EOO) map of the *F. pratensis* in Turkey.

An example of the buffer zoning map created for each nest is presented in Figure 10.

Figure 10. An example of buffer zoning map.

Discussion

The aim of this study is to determine the AOO and EOO of the European red wood ant *F. pratensis* in the Thrace region, which is the only known distribution area in Turkey. In addition, by creating the distribution, ecology and buffer zoning maps of the species, which will reveal its habitat preferences and form a road map in creating sustainable conservation strategies for the species, which is known to be under threat of extinction (Aksoy & Camlitepe, 2018; Camlitepe & Aksoy, 2018; Camlitepe et al. 2021).

In this context, direct communication has been established with all accessible private land owners for conservation of the nests on private lands in order to eliminate human pressure, which is the main factor in damaging the nests of the species. During the meetings, the importance of protecting the species for the continuity of the forest ecosystem was touched upon and it was aimed to give another purpose to the forest villagers, especially in Kirklareli province, to protect the species.

During these interviews, information was received that, especially in forest villages, the number of European red wood ant nests was much higher in the past decades than today, that family elders gave advice to young people not to damage the nests of the species, and that the species was attributed certain sacred duties, such as the nests found in the courtyards of the houses bringing abundance to the home. Moreover, it has been determined that the shepherds encountered in forest clearings and pasture areas are aware of the nests in the vicinity, know their locations, and are aware of the changes in nest volumes and morphologies over time.

In addition, primary education level training was given in schools in Kırklareli province, which hosts the highest number of nests in the Thrace region (88%), on the biology of the species, its conservation category, factors that endanger its extinction, and activities that can be done to protect the species. In this context, 1201 students were reached with 36 training sessions, and according to the measurement survey, the recognition of the genre, which was 8%, reached 86%. Trainings in schools and awareness-raising activities of local people play a major role in ensuring sustainable conservation and involving local people in the conservation process and taking an active part in identifying and recording new nests and protecting existing nests within the framework of citizen science (Dickinson & Bonney, 2012). It is thought that it will happen. So much so that 54 of the 60 nests identified and recorded within the scope of this study were reported and recorded by local non-governmental organizations, students receiving awareness training and conscious citizens who had the opportunity to speak in the villages, which also shows the importance of citizen science in species conservation studies.

The growth of the nest volume is expected to increase over time by associating it with the growth potential of the colony, but the increase in the nest volume is not always related to the growth potential and can be affected by various environmental factors such as biotope characteristics and temperature (Freitag et al. 2016). A study documented that heavy metal pollution causes redwood ant nests to shrink in volume (Eeva et al. 2004). No significant relationship could be detected as a result of statistical tests examining the effects of nest cover and climatic parameters on the change of nest volume over time. These results may indicate that annual changes in the volumes of nests in different localities may occur under the influence of random factors, and may also indicate that many different factors other than climatic factors may be effective together in order to reveal the effect of the dominant factor in the decreases and increases in nest volumes.

The habitats where the European red wood ant was most frequently detected were field borders at the forest edges, clearings within the forest and residential areas near forest villages. Our results are consistent with previous studies indicating that *F. pratensis* does not prefer closed/dense canopy or shady forest areas where the temperature is low. They build nests in very large volumes to provide the necessary nest temperature (Chen & Robinson, 2014) in areas exposed to sunlight (Domisch et al. 2008).

This study revealed that the polydomy situation for the species, which is 34% in a healthy population in Europe (Dekoninck et al. 2010), is only 5% in Turkey populations. It is thought that the fragmentation of dense forests and open-forest ecosystems in Kırklareli and Edirne provinces is effective in the short lifespan of polydomous nests and the minimal formation of new monodomous nests, detailed studies need to be conducted on the reasons for the predisposition to monodomous nests in the Turkish populations. This situation shows that the low polydomy level for Turkish populations differs from European populations in determining the regional threats of the species.

In our country, species conservation zones are planned for only mammal species in wildlife development areas; It is applied to create a habitat for the species, to protect that area and to facilitate inventory counting. Although it is quite difficult to determine conservation zones for invertebrate species compared to mammal species, it is possible to effectively protect the species by protecting smaller areas.

It is predicted that the future of the regional population of the species, which has previously been found to decrease in its habitat and distribution area in Turkey (Gemik, 2020; Gemik & Camlitepe, 2023), is in a downward trend when associated with its low polydomy ability. This situation once again reminds us of the importance of unique regional conservation efforts.

Conclusion

These buffer zones created for the European red wood ant *F. pratensis* can be integrated into long-term plans and projects, especially in public areas, to ensure collective conservation activities of the species. It would be the right decision to choose *F. pratensis*, an ecosystem engineer in the Thrace region, as a key species in order to demonstrate the success of ecosystem-based functional plans that guide the sustainable use of natural resources. It is hoped that this study will shed light on conservation biology studies in re-evaluating the species' current monitoring and conservation programs and deciding on the criteria to be used in creating new species conservation programs.

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