© Environmental Toxicology and Ecology
2025, Vol. 5 (1)
ISSN: 2757-9719

Research Article

Winter Activity of Reptiles in the Anatolian Peninsula

Tuna BATUM [1*], Mehmet Kürşat ŞAHİN [1] Muammer KURNAZ [2]

ABSTRACT

The effects of global climate change and the related temperature increases on the behavior and life adaptation of organisms are a significant concern for ectothermic species. In this study, the winter activities of reptiles in the Anatolian Peninsula were examined by considering the potential effects of climate change on their behavior. In this context, the importance of thermal fluctuations was emphasized by focusing on the responses of different reptile species to sudden changes in winter conditions. For this purpose, 23 reptile species showing winter activity in Anatolia were evaluated by considering the data obtained from social media platforms and online sources. Among these species, 9 are snakes, 13 are lizards, and 1 is a tortoise. Cluster analysis was performed using the UPGMA method to reveal the models in the geographical distribution of the evaluated species. Winter activity for many reptile species was reported for the first time. As a result of the obtained findings, important information was provided on how reptile species are affected by winter warming in temperate regions and the unusual winter behaviors of different species. As a result, it is shown that understanding the effects of climate change on ectothermic species is essential for correctly predicting the biological responses of species and creating conservation strategies.

Anadolu Yarımadasındaki Sürüngenlerin Kış Aktiviteleri

ÖZET

Küresel iklim değişikliğinin ve buna bağlı sıcaklık artışlarının, organizmaların davranışları ve yaşam uyumları üzerindeki etkisi, ektotermik türler için büyük bir endişe kaynağıdır. Bu çalışmada, Anadolu Yarımadası'ndaki sürüngenlerin kış aktivitelerini, iklim değişikliğinin davranışları üzerindeki potansiyel etkileri dikkate alınarak incelenmiştir. Bu doğrultuda, kış koşullarındaki ani değişimlere karşı farklı sürüngen türlerinin tepkilerine odaklanılarak termal dalgalanmaların önemi vurgulanmıştır. Bunun için, sosyal medya platformları ve çevrimiçi kaynaklardan elde edilen veriler dikkate alınarak, Anadolu'da kış aktivitesi gösteren 23 sürüngen türü değerlendirilmiştir. Bu türlerin 9'u yılan, 13'ü kertenkele, 1'i ise kaplumbağadır. Değerlendirilen türlerin coğrafi dağılımındaki modeller ortaya konularak kümeleme analizi UPGMA yöntemi ile gerçekleştirilmiştir. Birçok sürüngen türünde kış aktivitesi ilk kez rapor edilmiştir. Elde edilen bulgular neticesinde, sürüngen türlerinin ılıman bölgelerdeki kış ısınmalarından nasıl etkilendiklerine ve farklı türlerin alışılmadık kış davranışlarına dair önemli bilgiler sunulmuştur. Sonuç olarak, iklim değişikliğinin ektotermik türler üzerindeki etkilerinin anlaşılmasının türlerin biyolojik tepkilerinin doğru tahmin edilmesi ve koruma stratejileri oluşturması için önemli olduğunu göstermektedir.

Article Info

Corresponding Author e-mail: **tuna.batum@gmail.com**

Institution: [1] Hacettepe Unıversıty, Faculty of Science
[2] Gümüşhane Unıversıty, Department of Medical Services and Techniques, Kelkit Sema Doğan Vocational School of Health Services

Article history

Received: 30/12/2024

Accepted: February 10/02/2025

Available online:02/05/2025

Keywords:

Winter warming, Lizard, Snake, Tortoise, Türkiye

Anahtar Kelimeler:

Kış ısınması, Kertenkele, Yılan, Kaplumbağa, Türkiye

How to Cite: T. Batum, M.K. Şahin, M. Kurnaz "Winter Activity of Reptiles in the Anatolian Peninsula", *Environmental Toxicology and Ecology, c. 5, sayı. 1, ss. 1-10, 2025.*

DOI: 10.59838/etoxec.1609886

1. INTRODUCTION

Temperature increases associated with global warming have significant implications for the fitness of organisms. In contrast to endothermic species, which maintain a stable body temperature, ectothermic species depend physiologically on the surrounding environment to regulate their behavior, development, and reproduction [1,2]. Consequently, these species are particularly susceptible to anticipated thermal fluctuations. Most studies investigating the effects of temperature changes have primarily focused on temperature fluctuations during active annual periods—specifically when mean temperatures surpass the minimum thresholds necessary for growth and reproduction—. However, thermal conditions can also profoundly affect ectotherms during periods of inactivity or dormancy, such as winter [1,2]. According to the Intergovernmental Panel on Climate Change (2014), winter temperatures have increased more than summer temperatures. Failing to account for potential biases introduced by asymmetric warming patterns could undermine the validity of climate change research findings [3]. The phenomenon known as "winter warming," which has conventionally been investigated in the context of cold-adapted mammals and high Arctic species, is expected to have significant but previously overlooked consequences for species inhabiting temperate zones as well [4]. Moreover, it could be a critical vulnerability factor for ectotherms [5]. In temperate regions, winter marks the onset of colder temperatures, diminished food sources, and limited thermoregulatory opportunities for reptiles. The majority of reptiles are capital breeders, fueling reproduction in the spring with conserved energy [6]. An optimal overwintering strategy should optimize opportunities to replenish and conserve energetic reserves while minimizing the risk of cold exposure [7]. The general patterns observed in the winter season for reptiles are hibernation, brumation, seeking warmth, and burrowing. However, the specific winter behaviors of reptiles can vary significantly among species and are influenced by factors such as geographic location, climate, and the reptile's adaptations. In this study, we aim to collect data on the unusual winter activities of many reptile species observed in the Anatolian Peninsula.

2. MATERIALS and METHODS

2.1. Study area

The Anatolian Peninsula, also known as Anatolia, is a vast landmass located in Western Asia, forming the majority of the territory of Türkiye. It is bordered by the Aegean Sea to the west, the Mediterranean Sea to the south, and the Black Sea to the north. The climate of Anatolia varies significantly across the regions. Coastal areas generally experience a Mediterranean climate, characterized by hot, dry summers and mild, wet winters. In contrast, the inland areas, particularly in the central plateau, have a more continental climate with hot summers and cold winters [8]. For this study, we comprehensively searched various social media platforms, such as Facebook, Instagram, iNaturalist, and Twitter. This search examines our friend lists as well as the public group "Türkiye Wildlife Association" on Facebook. Additionally, amateur naturalists and students (as mentioned in the Acknowledgements section) frequently shared relevant information from their Facebook profiles with the first author between November 2020 and March 2021.

2.2. Data collection

To assess the winter activity of reptiles, individuals who uploaded photos on social media were requested to provide the location data. If GPS coordinates were inaccessible, contributors were interviewed to obtain information that allowed for determining the position with an accuracy of at least ±0.5 km. Data on air temperature, soil temperature, cloudiness and moisture estimate rates were retrieved from a real-time online platform [9].

2.2. Data analysis

A grouping analysis of the observed species was conducted based on the Euclidian Distance to ascertain whether the species were geographically grouped. The UPGMA (Unweighted Pair Group Method with Arithmetic Mean) technique was used to verify if the species clustered by region.

3. RESULTS

A total of 29 observations from 23 reptile species were recorded, revealing a winter activity pattern (Figure 1). Among these species, 9 were snakes, 13 were lizards, and 1 was a tortoise. The records, along with their localities, are listed in Table 1. Eleven records were obtained from the western part of the peninsula, seven from the southeastern, six from the southern, and five from the northern regions. *Ophisops elegans* was the only species recorded from two different areas (western and southeastern). Additionally, winter activity was observed in six species in at least two distinct locations. The mean temperatures in western localities were 16.2 ˚C, 15.35˚C in the south, 16.8˚C in the north and 12.3 ˚C in the southeastern localities. Similarly, the mean soil temperatures in the west, south, north, and southeast were 18.06 ˚C, 17.6 ˚C, 18.3 ˚C and 14.4 ˚C, respectively. The cluster analysis revealed two major groups: southeastern and the rest (Figure 2). However, two inner Aegean observation records were also nested within the southeastern clade. Finally, no discernible classification pattern was observed based on the species' taxonomic hierarchy.

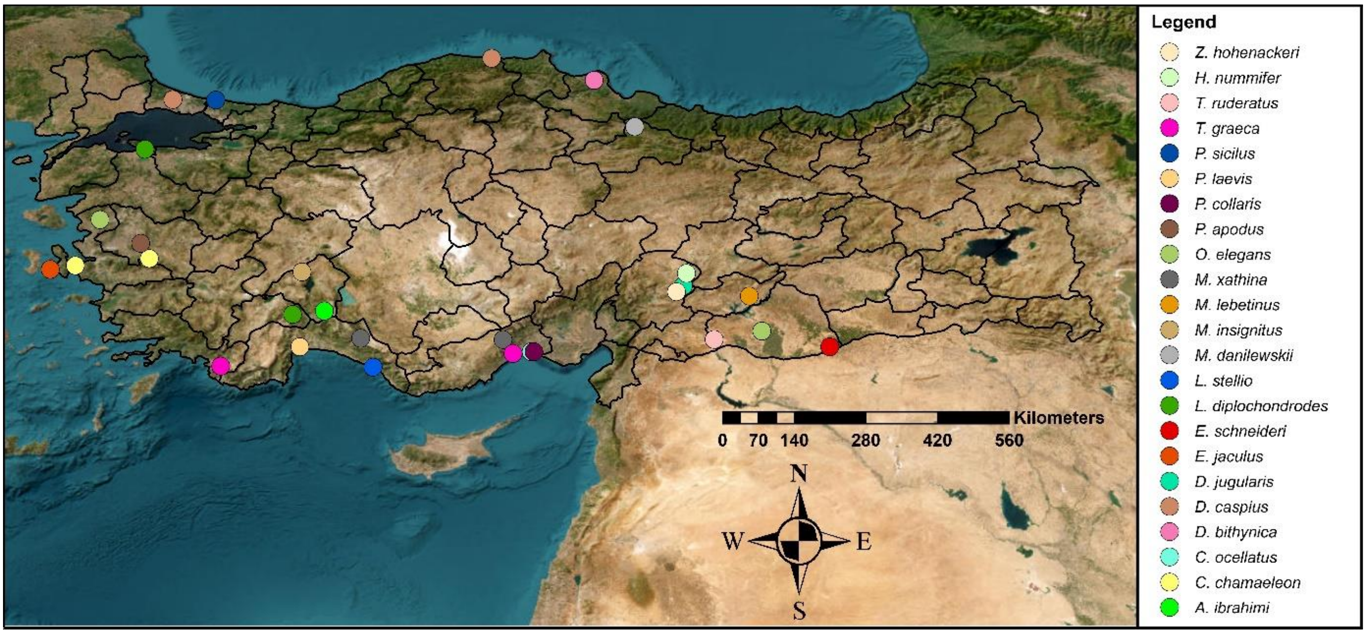

Figure 1. Distribution of reptile species exhibiting winter activity across in the Anatolian Peninsula

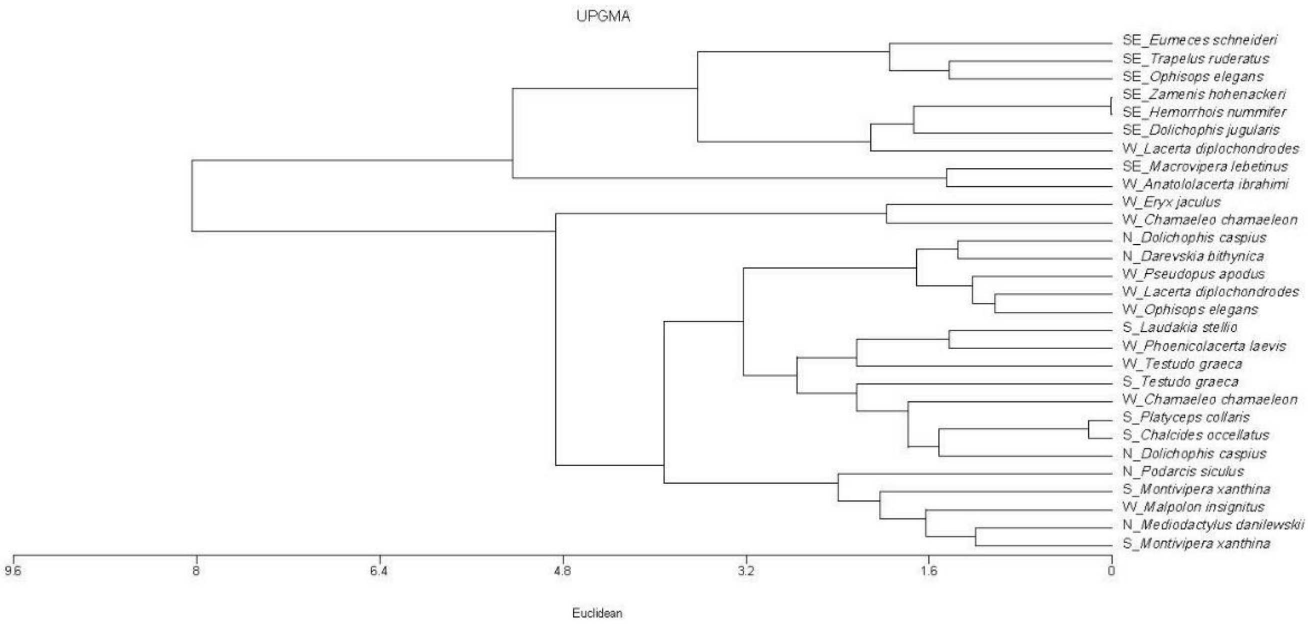

Figure 2. UPGMA cluster analysis for winter activity patterns based on geographic distribution

Table 1. Winter activity records of reptile species in the Anatolian Peninsula (T_{air}: air temperature, T_{soil}: soil temperature).

Family	Species	English name	Locality	Date	T_{air}	T_{soil}
Testudinidae	*Testudo graeca*	Common Tortoise	Muğla/Fethiye/Çaltıözü	08.12.2020	17.1	20.1
			Mersin/Çevlik	27.02.2021	15.2	19.2
Agamidae	*Laudakia stellio*	Starred Agama	Antalya/Alanya	30.01.2021	16.1	18.8
	Trapelus ruderatus	Horny-scaled Agama	Şanlıurfa/Birecik	14.02.2021	13.2	16.1
Gekkonidae	*Mediodactylus danilewskii*	Danilewski's Bent-Toed Gecko	Tokat/Erbaa/Karayaka	12.11.2020	15.9	17.1
Chamaeleonidae	*Chamaeleo chamaeleon*	Mediterranean Chameleon	İzmir/Urla	30.11.2020	19.4	21.4
			Manisa/Salihli/Gökköy	13.02.2021	17.3	18.7
Anguidae	*Pseudopus apodus*	European Glass Lizard	Manisa/Akpınar/Gölmarmara	12.01.2021	18.1	19.3
Scincidae	*Chalcides ocellatus*	Occellated Skink	Mersin/Tarsus	04.02.2021	15.8	17.3
	Eumeces schneideri	Orange-tailed Skink	Şanlıurfa/Ceylanpınar	07.03.2021	14.1	17.2
Lacertidae	*Ophisops elegans*	Snake-eyed Lizard	İzmir/Bergama	14.11.2020	17.8	18.3
			Şanlıurfa/Eyyübiye	07.01.2021	13.3	15.4
Lacertidae	*Lacerta diplochondrodes*	Rhodos Green lizard	Burdur/Bucak	13.12.2020	13.5	14.2
			Balıkesir/Bandırma	05.01.2021	18.1	19.5
	Podarcis siculus	Italian Wall Lizard	İstanbul/Riva	07.02.2021	15.2	16.7
	Phoenicolacerta laevis	Lebanon Lizard	Antalya/Konyaaltı	02.01.2021	17.2	20.7
	Anatololacerta ibrahimi	Anamur Lizard	Isparta/Sütçüler	13.11.2020	9.9	11.3
	Darevskia bithynica	Uludağ Lizard	Samsun/Bafra	15.01.2021	18.1	19.4
Erycidae	*Eryx jaculus*	Sand Boa	İzmir/Çeşme	30.01.2021	17.6	20.8
Colubridae	*Dolichophis caspius*	Caspian Whip Snake	İstanbul/Çatalca/Oklalı	13.11.2020	16.4	18.7
			Kastamonu/Abana	12.02.2021	18.4	19.6
	Dolichophis jugularis	Large Whip Snake	Kahramanmaraş/Nurhak	28.02.2021	11.2	12.8
	Platyceps collaris	Collared Dwarf Racer	Mersin/Tarsus	27.02.2021	16.6	17.7
	Hemorrhois nummifer	Coin-marked Snake	Kahramanmaraş/Nurhak	03.03.2021	12.5	13.7
	Zamenis hohenackeri	Transcaucasian Rat Snake	Kahramanmaraş/Nurhak	04.03.2021	12.4	13.6
Psammophiidae	*Malpolon insignitus*	Eastern Montpellier Snake	Isparta/Senirkent/Gençali	06.11.2020	12.1	14.4
Viperidae	*Montivipera xanthina*	Ottoman Viper	Between Antalya - Konya, Toroslar	03.11.2020	15.1	17.3
			Mersin/Toroslar/Arslanköy	03.11.2020	13.3	15.4
	Macrovipera lebetinus	Levantine Viper	Adıyaman/Kahta	02.12.2020	9.4	11.8

4. DISCUSSION

Although many organisms depend on photoperiodic cues to indicate seasonal transitions, underground-dwelling reptiles might not be significantly exposed to such stimuli. For most temperate reptiles, ambient temperature is the primary factor determining the onset and cessation of dormancy [10]. In other words, environmental temperature regulates their reproductive cycles and energy expenditure. However, sudden temperature fluctuations may also trigger the temporary awakening of the reptiles [11].

The investigation of biological reactions to climate change has significantly emphasised reptiles. A range of fitness responses has been linked to shifts in thermal maxima and minima [12,13]. To forecast the short- and long-term impacts of warming winters on temperate reptiles, it is crucial to establish direct correlations between winter temperatures and survival or reproductive success and identify temperature-sensitive biological processes. These processes must be integrated into a broader understanding of fitness [14].

For effective conservation efforts, information on the habitat and activity of tortoises during the winter months is crucial, as they spend over half of their lives in hibernation [15,16]. According to Özgül et al. (2022), *Testudo graeca* was observed in Bozcaada in February at an air temperature of 12 ˚C. Other observations of this species in Fethiye, Muğla (December) and Çevlik, Mersin (February) revealed higher air temperatures of 17.1˚C in Fethiye and 15.2 ˚C, respectively. In these locations, soil temperatures were consistently higher than the air temperatures, at 20.1 ˚C and 19.2, ˚C respectively [17]. This suggests that ambient temperature dynamics might trigger the winter awakening of the tortoises.

Cold climates significantly impact the hibernation patterns of lizards. According to Adolph and Porter (1993), low air temperatures negatively affect key functions, such as movement, food availability, and escape behavior. Temperature fluctuations in air temperature can prompt lizards to end their hibernation prematurely [11]. In this context, winter activity of the following lizard species has been documented: *Apathya cappadocica* [18], *Darevskia rudis* [19], *Lacerta media* [20], *Lacerta viridis* [21], *Hemidactylus turcicus* [22], *Mediodactylus kotschyi* [23], *Ophisops elegans* [24,25], *Podarcis erhardi* [26,27], *Podarcis muralis* [28 – 31], *Sceloporus jarrovi* [32] and *Zootoca vivipara* [33]. Our study contributes to the case of lizards' winter activity via the observations for *Anatolacerta ibrahimi*, *Chamaeleo chamaeleon*, *Lacerta diplochondrodes*, *Phonenicolacerta laevis*, *Pseudopus apodus*, *Darevskia bithnyica*, *Eumeces schneideri*, *Chalcides ocellatus*, and *Trapelus ruderatus* for the first time in the literature.

Winter activity in *H. turcicus* was previously reported in January – February at air temperatures ranging from 8.89 to 18.89˚C [22]. In the Anatolian Peninsula, similar temperature ranges were observed for geckos and agamids. For instance, *Mediodactylus danilewskii* was recorded in Tokat, North region (T_{air}: 15.9 ˚C, T_{soil}: 17.1 ˚C in October 2020) and, *Laudakia stellio* in Antalya, South region (T_{air}: 16.1 ˚C, T_{soil}: 18.8 ˚C in January 2021). Moreover, *Trapelus ruderatus* was observed in Şanlıurfa, Southeast region, at 13.2 ˚C air and 16.1 ˚C soil temperatures (February 2021).

Rock lizards, such as *D. rudis*, have shown winter activity in Trabzon, North region, at air temperatures of 10-16.5 ˚C [19]. Our findings for *D. bithnyica* in Bafra, Samsun, North region showed similar activity patterns at 18.1 ˚C air and 19.4 ˚C soil temperatures (January 2021). [25] revealed that *O. elegans* individuals were active between December and February with minimum T_{air}: 15.4 ˚C and minimum T_{soil}: 16.2 ˚C. Our observations for *O. elegans* were T_{air}: 17.8 ˚C, T_{soil}: 18.3 ˚C in Bergama, İzmir, West region (October 2020) and T_{air}: 13.3 ˚C, T_{soil}: 15.4 ˚C in Eyyübiye, Şanlıurfa, Southeast region (January 2021). Therefore, these findings demonstrated that this species was active at ~2 ˚C lower than the literature knowledge.

Chameleons and legless lizards exhibited activity at temperatures significantly above seasonal averages [34]. For example, *C. chameleon* was observed in Urla, İzmir, West region: (T_{air}: 19.4 ˚C, T_{soil}: 21.4 ˚C in November 2020, T_{season}: 11.04 ˚C) and in Salihli, Manisa, West region: (T_{air}: 17.3 ˚C, T_{soil}: 18.7 ˚C in February 2021, T_{season}: 9.4 ˚C); *P. apodus* was recorded in Gölmarmara, Manisa, West region (T_{air}: 18.1 ˚C, T_{soil}: 19.3 ˚C in January 2021, T_{season}: 8.9 ˚C). These observations indicate that poikilothermic animals awaken as microhabitat temperatures rise, enabling their vital activities [35]. Moreover, our results suggested that lacertids might still be active even in relatively low temperatures (i.e. *A. ibrahimi*: T_{air}: 9.9 ˚C, T_{soil}: 11.3 ˚C in Sütçüler, Isparta, West region, 13 October 2020).

To date, there has been no observed winter activity for the following snake species in the Anatolian Peninsula: *Montivipera xanthina*, *Macrovipera lebetinus*, *Eryx jaculus*, *Platyceps collaris*, *Dolichophis caspius*, *Dolichophis jugularis*, *Hemorrhois nummifer*, and *Zamenis hohenhackeri* up to date. Snake winter activity has primarily been associated with basking and movement behaviors, which incur costs such as increased energy expenditures during non-feeding periods and vulnerability to predators [36 – 39]. Various hypotheses propose that winter basking activity in snakes "enables the continuation of gonadal activity" [40] and could potentially serve as an indicator of the impending mating season [6]. The present study's findings showed that the winter activity could be seen in extremely low temperatures in snakes for this reason: i.e. *M. lebetinus* in Kahta, Adıyaman, Southeast region: (T_{air}: 9.4 ˚C, T_{soil}: 11.8 ˚C in 2 December 2020). In addition to this viperid species, similar low-temperature activity was recorded in other snake species in southeast region: *D. jugularis* (T_{air}: 11.2 ˚C, T_{soil}: 12.8 ˚C), *H. nummifer* (T_{air}: 12.5 ˚C, T_{soil}: 13.7 ˚C, *Z. hohenhackeri* (T_{air}: 12.4 ˚C, T_{soil}: 13.6 ˚C) in Nurhak, Kahramanmaraş in March 2021. Moreover, in the West region, *M. insignitus* from Senirkent, Isparta, was recorded in November 2020 (T_{air}: 12.1 ˚C and T_{soil}: 14.4 ˚C). However, snake activity in other parts of Anatolia was generally at higher temperatures. Therefore, it can be concluded that the soil temperatures were slightly higher than the air temperature in all cases.

Variation in winter activity arises from species-specific, thermoregulation behavior and geographic conditions [41]. Our cluster analysis demonstrated that air and soil temperatures and other meteorological and geographical factors may influence early awakening in reptiles. However, further data is required to confirm these patterns.

In conclusion, recent observations suggest that reptiles might exhibit increased winter activity due to global warming [20, 42 – 46]. Recognizing these atypical behaviors enhances our understanding of reptile biology and provides crucial initial data for evaluating climate change models.

Acknowledgements
The authors express their gratitude to Hacettepe University students and amateur naturalists who generously contributed their winter activity records and those identified from their personal social media friend profiles supporting the research. Ahmet Taşçı and Özgün Sipahioğlu established the "Türkiye Wildlife Association" Facebook group, which served as the primary repository for the majority of the information utilized in this paper. Lastly, we are thankful to the anonymous reviewers for their recommendations to improve the first draft of the manuscript. Part of this study was presented at the 7th National Zoology Congress (2024).

Funding
The author (s) has no received any financial support for the research, authorship or publication of this study.

The Declaration of Conflict of Interest/ Common Interest
No conflict of interest or common interest has been declared by the author.

Author's Contribution
MKŞ and MK wrote the main manuscript. TB collected the meteorological data. MK prepared the map. MKŞ did the cluster analysis. All authors contributed substantially to the final version of the manuscript. All authors have read and approved the manuscript.

The Declaration of Ethics Committee Approval
This study does not require ethics committee permission or any special permission.

Declaration of research and publication ethics
The authors of the paper declare that we followed the scientific, ethical and citation rules of Environmental Toxicology and Ecology in all processes of the paper and that we did not make any falsification of the data collected. Furthermore, we declare that ETOXEC and its Editorial Board are not responsible for any ethical violations that may have occurred and that this study has not been evaluated in any other academic publication environment than ETOXEC.

REFERENCES

[1] C A Deutsch, J J Tewksbury, R B Huey, K S Sheldon, C K Ghalambor, D C Haak, P R Martin, Impacts of climate warming on terrestrial ectotherms across latitude. PNAS, 105: 6668-6672, 2008. https://doi.org/10.1073/pnas.0709472105

[2] K P Paaijmans, R L Heinig, R A Seliga, J I Blanford, S Blanford, C C Murdock, M B Thomas, Temperature variation makes ectotherms more sensitive to climate change. Global Change Biology, 19: 2373-2380, 2013. https://doi.org/10.1111/gcb.12240

[3] C J Speights, J P Harmon, B T Barton, Contrasting the potential effects of daytime versus nighttime warming on insects. Current Opinion in Insect Science, 23: 1-6, 2017. https://doi.org/10.1016/j.cois.2017.06. 005

[4] F Johansson, G Orizaola, V Nilsson-Örtman, Temperate insects with narrow seasonal activity periods can be as vulnerable to climate change as tropical insect species. Scientific Reports, 10: 8822, 2020. https://doi.org/10.1038/s41598-020-65608-7

[5] K E Marshall, K Gotthard, C M Williams, Evolutionary impacts of winter climate change on insects. Current Opinion in Insect Science. *41*: 54-62, 2020. https://doi.org/10.1016/j.cois.2020.06.003

[6] R Shine, Life-history evolution in reptiles. Annual Review of Ecology, Evolution, and Systematics, 36: 23-46, 2005. https://doi.org/10.1146/annurev.ecolsys.36.102003.152631

[7] R B Huey, L Ma, O Levy, M R Kearney, Three questions about the eco-physiology of overwintering underground. Ecology Letters, 24: 170-185, 2021. https://doi.org/10.1111/ele.13636

[8] S Sensoy, M Demircan, Y Ulupinar, I Balta, Climate of Turkey. Turkish state meteorological service, 401: 1-13, 2008.

[9] Soil Temperature. Available online: https://soiltemperature.app/ (last accessed on 31 January 2024).

[10] J U Van Dyke, Cues for reproduction in squamate reptiles, In: Rheubert JL, Siegel DS, Trauth SE (eds) Reproductive Biology and Phylogeny of Lizards and Tuatara. CRC Press, Boca Raton, 109-143, 2014.

[11] M Kurnaz, B Kutrup, U Bülbül, An Exceptional Activity for *Darevskia derjugini* (Nikolsky, 1898) from Turkey. Ecologia Balkanica, 8: 91-93, 2016.

[12] E Bestion, A Teyssier, M Richard, J Clobert, J Cote, Live fast, die young: experimental evidence of population extinction risk due to climate change. *PLoS Biology*, 13: e1002281, 2015. https://doi.org/10.1371/journal.pbio.1002281

[13] M M Muñoz, K J Feeley, P H Martin, V R Farallo, The multidimensional (and contrasting) efects of environmental warming on a group of montane tropical lizards. Functional Ecology, 36: 419-431, 2021. https://doi.org/10.1111/1365-2435.13950

[14] J B Moss, K J MacLeod, A quantitative synthesis of and predictive framework for studying winter warming effects in reptiles. Oecologia, 200: 259-271, 2022.

[15] G R Ultsch, Ecology and physiology of hibernation and overwintering among freshwater fishes, turtles, and snakes. Biological Reviews, 64: 435-515, 1989. https://doi.org/10.1111/j.1469-185X.1989. tb00683.x

[16] E J Newton, T B Herman, Habitat, movements, and behaviour of overwintering Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia. Canadian Journal of Zoology, 87: 299-309, 2009.

[17] C N Özgül, D Kurtul, Ç Gül, M Tosunoğlu, Unusual Winter Activity of Some Amphibian and Reptile Species Living in Bozcaada (Çanakkale, Türkiye). Journal of Anatolian Environmental and Animal Sciences, 7: 244-250, 2022.

[18] M K Şahin, Unusual mating behavior of *Apathya cappadocica* in the winter season from southeastern Anatolia. SRLS, 2: 49-53, 2021.

[19] H Koç, U Bülbül, B Kutrup, Is the Spinytailed Lizard *Darevskia rudis* (Bedriaga, 1886) Active All Year?. Ecologia Balkanica, 10*:* 47-51, 2018.

[20] U Bülbül, H Koç, Y Orhan, Y Odabaş, B Kutrup, Early waking from hibernation in some amphibian and reptile species from Gümüşhane Province of Turkey. Sinop Üniversitesi Fen Bilimleri Dergisi, 4: 63-70, 2019.

[21] V Vongrej, R Smolinský, E Bulánková, E, J Jandzik, Extraordinary winter activity of the green lizard *Lacerta viridis* (Laurenti, 1768) in southwestern Slovakia. Herpetozoa, 20: 173, 2008.

[22] PA Stone, H M Marinoni, S Laverty, A M Fenwick, Winter Activity in a Northern Population of Mediterranean Geckos (*Hemidactylus turcicus*). Herpetological Conservation Biology, 16: 405-411, 2021.

[23] I Mollov, G Georgiev, S Basheva, Is the Kotschy's Gecko *Mediodactylus kotschyi* (Steindachner, 1870) (Reptilia: Gekkonidae) active during the winter?. ZooNotes, 84: 1-3, 2015.

[24] M Franzen, Zur Winterlichen Aktivität Einiger Echsen in der Südlichen Türkei. Herpetofauna, 8*:* 6-10, 1986.

[25] G Krastev, E Vacheva, B Naumov, Winter activity of the snake-eyed lizard *Ophisops elegans* (Reptilia: Lacertidae) in the northwesternmost part of its range. Historia naturalis bulgarica, 45: 83-88, 2023.

[26] I Buresh, Y Tsonkov, Untersuchungen über die Verbreitung der Reptilien und Amphibien in Bulgarien und auf der Balkanhalbinsel. I Teil: Schildkrötten (Testudinata) und Eidechsen (Sauria). Mitteilungen aus den Königlichen Naturwissenschaftlichen Instituten in Sofia, 6: 150-207, 1933.

[27] V Beshkov, Zimnite kvartiri na zaemnovodnite i vlechugite (The winter lodgings of the amphibians and the reptiles). Priroda i znanie, 28: 9-11, 1977.

[28] L Rugiero, Winter activity of a Common Wall Lizard (*Podarcis muralis*) population in central Italy. Russian Journal of Herpetology, 2: 148-152, 1995.

[29] V Beshkov, K Nanev, Zemnovodni i vlechugi v Bulgaria (Amphibians and Reptiles in Bulgaria). Sofia-Moscow. Pensoft, 2002.

[30] A Westerström, Some notes on the herpetofauna in Western Bulgaria, In Herpetologia Petropolitana, Proceedings of the 12th Ordinary General Meeting of the Societas Europaea Herpetologica, St. Petersburg, 2005; 241-244.

[31] N Tzankov, G Popgeorgiev, B Naumov, A Stojanov, Y Kornilev, B Petrov, A Dyugmedzhiev, V Vergilov, R Dragomirova, S Lukanov, A Westerström, Opredelitel na zemnovodnite i vlechugite v Priroden Park Vitosha (Identification guide of the amphibians and reptiles in Vitosha Nature Park). Directorate of Vitosha Nature Park. Bulgaria, 2014.

[32] D V Tinkle, N F Hadley, Reproductive effort and winter activity in the viviparous Montane Lizard *Sceloporus jarrovi*. Copeia, 272-277, 1973.

[33] C J Grenot, L Garcin, J Dao, J P Hérold, B Fahys, H Tséré-Pages, How does the European common lizard, Lacerta vivipara, survive the cold of winter?. Comparitive Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 127: 71-80, 2000.

[34] General Directorate of Meteorology. Avalaible on: https://www.mgm.gov.tr/. (accessed on 28 November 2023)

[35] M Kurnaz, M K Şahin, Unusual Winter Activity Observations of Two Newt Species (*Ommatotriton ophryticus & Triturus ivanbureschi*) from the Anatolian Peninsula. Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi, 7: 337-342, 2021.

[36] M A L Zuffi, M Macchia, P Ioalè, Giudici, F. Winter activity in a coastal population of *Vipera aspis* (Reptilia, Viperidae). Revue d'Écologie, 54: 365-374, 1999.

[37] R Duguy, Biologie de la latence hivernale chez *Vipera aspis* L. Vie et milieu, 311-444, 1963.

[38] M Aleksiuk, Reptilian hibernation: evidence of adaptive strategies in *Thamnophis sirtalis parietalis*. Copeia. 170-178, 1976.

[39] S H Girons, Les risques de prédation liés à la reproduction chez un Viperidae ovovivipare, *Vipera aspis* L., d'après les observations visuelles. Amphibia-Reptilia, 15: 413-416, 1994.

[40] J S Jacob, Painter, C.W. Overwinter thermal ecology of Crotalus viridis in the north-central plains of New Mexico. Copeia, 799-805, 1980.

[41] B W Grant, Trade-offs in activity time and physiological performance for thermoregulating desert lizards, Sceloporus merriami. Ecology,71: 2323-2333, 1990.

[42] J. M Kaczmarek, M Piasecka, M Kaczmarski, Winter activity of the smooth newt *Lissotriton vulgaris* in Central Europe. The Herpetological Bullletin, 144: 21-22, 2018.

[43] A, Altunışık, A case study on earlier activation of the variable toad, *Bufotes variabilis* (Pallas, 1769). Biological Diversity and Conservation, 12: 38-40, 2019.

[44] U Bülbül, H Koç, The unusual winter activity and negative effects of pollution on breeding of Ommatotriton ophryticus (Berthold, 1846) in Turkey. Sinopjns, 5: 77-83, 2020.

[45] A Altunışık, Unusual winter activity of Bufo bufo (Anura: Bufonidae). Turkish Journal of Biodiversity, 4: 105-107, 2021.

[46] H Özkan, U Bülbül, The Winter Activity of the Endemic Lizard Species, *Anatololacerta danfordi* (Günther, 1876). Journal of the Institute of Science and Technology, 11: 99-105,2021.