



The Emergence of a New Record of *Scincella lateralis* Under the Canopy Layer of *Ligustrum vulgare* in Iran and the Similarity of the Ecological Niche with America

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ABSTRACT

Aims: The natural dependence between the habitats of certain plants and animals can be a factor in ecosystem stability. Canopies of *Ligustrum vulgare* on the edge of Mohammad Shahr's (Karaj) gardens in Iran are introduced as a new skink record habitat called *Scincella lateralis*.

Material & Methods: Direct observations of behavior in habitat and glass container; checking climatic records, and studying the morphological and ecological characteristics of the newly found species.

Findings: *Ligustrum vulgare* provides a suitable and safe canopy for the movement of *S. lateralis* due to climate change. *S. lateralis* lizards are omnivorous and feed on live insect larvae and small insects; the population of insects that were pests has been significantly reduced. It seems that changes in the transitional climate zone from cold and semi-arid to semi-cold and humid have created landscape fragmentation, which can be one of the reasons for the emergence of this species. The body length of the new adult *S. lateralis* is about 6.5 cm, which is shorter than the reported specimens. It crawls like a snake and behaves like a dinosaur.

Conclusion: The overlap of the *L. vulgare* vegetation map with the geographic distribution of *S. lateralis* in America and the repetition of this cooperation in Iran show that this type of lizard can be a valuable indicator for monitoring ecosystem changes. In addition, it is possible to take advantage of the coexistence of these two in the design and management of ecosystems.

Keywords: Biodiversity; Climate Change; Indicator; Landscape Fragmentation; Semi-Sempervirent; Transitional Climate Zone.

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Introduction

Skinks and the genus *Scincella* are considered as threatened species. Also, in 2016, New Jersey listed the ground skink as a species of “special concern” due to habitat loss. For this reason, they are to be kept in protected areas such as zoos. The *Scincella lateralis* population is very isolated. In the management strategies to protect skinks, it is tried to get help from the lifestyle of their populations outside the zoo^[1,2]. Skinks comprise 24% of the world’s lizard diversity, and their normal body temperature is lower than non-skinks^[3]. Small reptiles such as *S. lateralis* have problems with temperature regulation and water balance because their body surface-to-volume ratio is high; therefore, they exchange heat quickly, and the evaporation rate of their body moisture is high. Their body temperature is 28°C from autumn to winter and 29°C from spring to summer, and their metabolic activity in summer is more than twice that of winter^[4].

Ligustrum vulgare is a privet species of native plant to Iran^[5]. Positive roles of this species have been mentioned in other areas where they have been endemic. For example, the canopy of *L. vulgare* has been proposed as a suitable habitat for ecosystems in the Czech Republic in the sense that *L. vulgare* is one of the bush trees that can prevent erosion, increase biodiversity, and serve as a shelter for small animals such as birds and insects or produce wood^[6]. The *L. vulgare* plant and the *S. lateralis* lizard together on the flora and fauna listed in Russell Cave National Monument (RUCA), one of North America’s most important prehistoric sites^[7].

Diversity Factors of Lizards: Habitat and Climate Change (Epigenetic Factors), Genetics and Natural Selection

S. lateralis is called Ground Skink. These lizards are diurnal and common in various habitats throughout the southeastern United

States. This species occurs from southern New Jersey to the Florida Keys and from west to eastern Kansas and central Texas^[8]. Small isolated populations are also found in Illinois, northeastern Missouri, and Coahuila, Mexico^[9]. *S. lateralis* is found in humid-deciduous forests, terrestrial regions, scrub forests, urban, suburban, and riparian^[12]. In the biodiversity of Maryland, a small land lizard called *S. lateralis* is mentioned in a large part of South America and Eastern America, which passes inconspicuously among the leaves and the forest floor, and in Maryland, it lives only in the coastal plains^[13].

A list of Iranian lizards and seven genera of Scincidae was introduced in 2017, but they did not introduce *Scincella lateralis*^[14]. These lizards, called ground skinks, have differences from other lizards; for example, like all Scincidae lizards, the length of their legs is not proportional to their body and is shorter. They have a smooth dorsal surface that varies in color from golden to brown and have a pair of dark brown stripes on their back. Their mysterious colors often blend in with their surroundings, making them difficult to spot. The lower part of their body is cream to yellowish white. The ground skink is one of the smallest reptiles in North America. Their adult size, including the tail, is 7.5-14.5 cm (3.5-3.5 in)^[9, 8].

It was found that from 1995 to 2015, Karaj’s climate changed from dry and semi-arid to dry conditions^[15]. Also, the climate of Karaj, which was dry and cold, has started to change since 2010. The temperature parameters have increased from 2.9 to 7 degrees, and the relative humidity has decreased, and this trend will continue for several decades^[16].

The characteristics of their habitat determine the evolution of lizards, so the phenotypic traits, especially the shape of their heads, depend on the type of their fossorial (dry or wet ground)^[17].

Through biotic and non-biotic environmental changes, climate changes impose severe and new pressures on natural selection and force living organisms to change ^[18]. The response of organisms to climate change is very broad. On the one hand, due to climate change, new phenotypic traits related to evolutionary adaptation become stable and cause species change. On the other hand, genetic and epigenetic factors cause the expression of new genes, and with natural selection, they stabilize phenotypes that are compatible with climate change and cause speciation. In general, it is unclear whether plastic genetic change or a combination of these two causes the adaptation of the organism to the environment ^[19].

Adaptive Evolution: Climatic changes can create flexibility in gene expression and cause phenotypic plasticity, i.e., by affecting the phenotype of living organisms, they can adapt to the environment or vice versa. If changes in phenotypic plasticity occur in the same direction as adaptive evolution, genetic variation due to the expression of new genes in a changed climate can be strongly stabilized towards a phenotypic with an optimal value, i.e., the new phenotypic trait will last. However, if the plasticity change occurs in the opposite direction to the adaptive evolution, the genetic change creates the reverse primary plasticity and has a negative effect ^[20]. Therefore, the initial phenotypic plasticity may affect evolution in two possible opposite ways ^[21].

Coevolution: One of the factors that occurs in the habitat is coevolution between some plants and animals. Sometimes, the animal lives with a particular plant species or community that can suit the animal in two ways: nutrition and shelter or habitat. These allow for growth and, ultimately, suitable natural selection. On the other hand, by providing suitable biological conditions, such as hunting plant pests, the animal

facilitates a particular development path for the plant. In this regard, Taghavizad et al. (2009) found the role of the honey bee to be influential in the development of plants by recognizing and making sure that the pollen grains are in the final stages of development, the honey bee collects them, and thus initiates successful pollination that leads to fertilization, this long-term relationship has led to the coevolution of plants and bees ^[22].

Monitoring Ecosystem Changes: Examines how ecosystem change affects natural resources and requires evidence-based management. Monitoring can be numerous. There are three classifications for monitoring: targeted, supervisory, and landscape monitoring. At the same time, the place and time of ecosystem changes should be considered. Also, a classification system should be flexible in its monitoring ^[23]. Therefore, monitoring ecosystem changes is a way to investigate ecosystems.

Landscape Fragmentation: This phenomenon is seen due to global warming. Urban and peri-urban forests are exposed to fragmentation for various reasons. Fragmentation is more likely in areas with less forest cover ^[24]. Fragmentation is sometimes associated with isolation and loss of habitat and sometimes with climate change, but overall, it can have positive or negative dual effects ^[25]. Sometimes, small patches of areas created by chance have a valuable role in species conservation ^[26].

Biological Indicator: A species or a group of species selected as representative of the state of an ecosystem or a specific process, such as climate change in that ecosystem, is called an indicator species ^[27]. A biological indicator can be a species or a biological community. Factors such as abundance or sensitivity to pollution can create biological indicators because these factors cause changes in environmental conditions such

as temperature, salinity, and greenhouse gases. These factors ultimately change the species composition and can be evaluated this way. Therefore, biological variables and indicators are diverse, from cells, tissues, and organs to the complete organism (single cell, plant, and animal). Therefore, monitoring methods are essential ^[28,29].

Small Habitat Patches are more Critical in Biodiversity: In regions where the ecosystem has been destroyed and fragmented, species richness and biodiversity are higher in smaller patches ^[30].

This study aims to introduce a new lizard, *Scincella lateralis*, for the first time in Iran, which is found under the vegetation of *Ligustrum vulgaris* in a common ecological niche in a small area of the northern part of Iran (Alborz Province). This emergence is due to climate change, the fragmentation of this region, and the emergence of a particular climate in a region with a semi-tropical side (with newly created moisture), which has caused speciation. The analysis that was carried out in this study to prove it is to find out whether this occurrence happened through the change of gene expression due to environmental factors such as heat and humidity or by chance and through natural selection. This analysis considers the possibility of changing gene expression due to the region's epigenetic factors, such as heat and heat, to be more likely.

Materials & Methods

Specifications of the Sample Collection Area:

Ground skink was found on the southern slopes of the central Alborz Mountain range, south of Karaj and northeast of MohammadShahr. Its longitude is 50°, 55', 26", east, and its latitude is 35°, 45', 29", north. Its height is 1237 m a.s.

Features of MohammadShahr

The average annual rainfall in Mohammad-

Shahr is 230 mm. It has a moderate semi-arid climate based on the Amberge exponential climate system. Its average maximum temperature is 21°C, but it reaches 40°C on hot days of the year, and the minimum average is 9°C, but it reaches -10°C on cold days, and its average is 15°C. The average air humidity is 51%, which is different in the hot and cold seasons. The mean maximum relative humidity is 1.73%, the highest mean in January. The mean minimum relative humidity was 5.31% in June, so the humidity level reached 17% this month.

There are two types of wind currents in the region. One type is general streams that flow in two ways in the region. The general current blows from the Atlantic Ocean to Manjil and the studied area, and its direction is from northwest to southeast and east to west. It is associated with humidity and flows from the beginning of autumn to the end of spring. Most of the autumn and winter rains in the region are related to these winds. Another form of general currents is the warm south-westerly winds. In summer, these winds generally blow from the plains of Iraq and Syria to the Zagros highlands, and after passing through the Zagros highlands, their branches enter the study area from Saveh. These winds make the air in the region warmer. The second type of wind flow is the local wind that blows from the southern slopes of Alborz towards the studied area. The area has alluvial soils ^[31].

The current study monitored ecosystem changes in vegetation, temperature, and humidity at a specific time and place. Standard meteorological data and field observations were used in the monitoring method. From 2023 to 2024, skink lizards were observed and morphologically and behaviorally investigated in the green space of Imam Khomeini Higher Education Center located in the northeastern region of

Mohammad Shahr Karaj, with an area of 120 hectares.

Methodology, Sample Collection

The new lizard has been observed in the region for two years (from 2023 to 2024) (Figure 1). First, it was investigated in nature. Then, 30 samples were collected from the area and identified by identifying morphological features with the help of identification keys (Virginia Herpetological Society) ^[32]. Also, the lizards were kept in a glass container for 4 months while adjusting the humidity necessary for living; food such as live larvae and small live and dead insects of different sizes were provided to the lizards, and their eating behavior was observed. The average size of the lizard's body was determined. Because the

lizard's tail is sensitive and quickly torn off, wide-opening glasses placed horizontally in the lizard's movement were used to catch the lizard. The lizard would move towards the glass and enter by closing the other ways and stimulating with sound. Other data were obtained from observation in nature.

Taxonomic Characteristics of the New Species of *S. lateralis*:

Phylum: Chordata

Class: Reptilia

Order: Squamata

Family: Scincid

Genus: *Scincella*

Species: *lateralis*

Scincella lateralis

Common Name: Ground Skink



Figure 1) Small lizard: *Scincella lateralis* in Mohammad Shahr Karaj (Iran).

Synonym: *Hombronina fasciolaris* GIRARD)

The lizard found for the first time in Iran is reported by Mohammad Shahr Karaj; it lives on the edge of gardens and under the hedges of *L. vulgare* and is seen moving fast through and under the dry leaves (Figure 2). Taking refuge in warmer places, such as the greenhouse in winter, made it a hunt for this research and provided the ground for further study. Further, a comparison was made between the distribution of *L. vulgare* in Iran and *S. lateralis* presence in its habitat in America. In America, *Scincella lateralis* is mainly found where *ligustrum* lives, especially *Ligustrum vulgare* (Figures 3-A, B). After *Ligustrum vulgare* was imported to America, this plant became invasive, and its seedlings appeared near the same places as before (Figure 3-B). This is one of the reasons for *ligustrum vulgare* dependence on the habitat with a specific climate (Figure 4).

Taxonomic position of the plant (*Ligustrum vulgare*) that the lizard has chosen as its habitat and shelter:

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Oleales

Family: Oleaceae

Genus: *Ligustrum*

Species: *vulgare*

Ligustrum vulgare L.

Common Name: Wild privet

(cabidigitallibrary.org/doi)^[50]

The genus *Ligustrum* belongs to the Oleaceae family. In Iran, an evergreen shrub plant called *L. vulgare* is used as a hedge in gardens and houses^[5]. Throughout the eastern United States, the *Ligustrum* genus is a highly invasive non-native plant that invades forested areas^[33], but it is a native plant for Iran^[5].



Figure 2) The habitat where the skink was seen (under the *L. vulgare*).

Findings

It seems that the northeastern area of Mohammad Shahr, which has a green space of about 120 hectares, has more rain in winter and summer, which is caused by climate change, and the warming and humidification of this area have created a separate microclimate. In other words, it has provided a microclimate and microhabitat that brings it close to a humid subtropical region (like what it has in America) because it has more humidity and a lower temperature increase than the surrounding environment, and has provided the living conditions for this lizard and its evolutionary adaptation. Therefore, this is One of the reasons for the appearance of the new record of *Scincella lateralis*.

The skink of this research was observed among leaves and humus soil at the foot of the planted privet on the edge of the garden, which disappeared quickly, but when the weather got cold, it took refuge in the greenhouse and was studied better. This very small lizard is shiny brown with black stripes on the sides of the body, extending from the snout to the end of the tail. A small tail compared to other genera was a practical help in identifying it. Also, instead of being spherical, the cross-section of the tail is a rectangle with a small side on the ground.

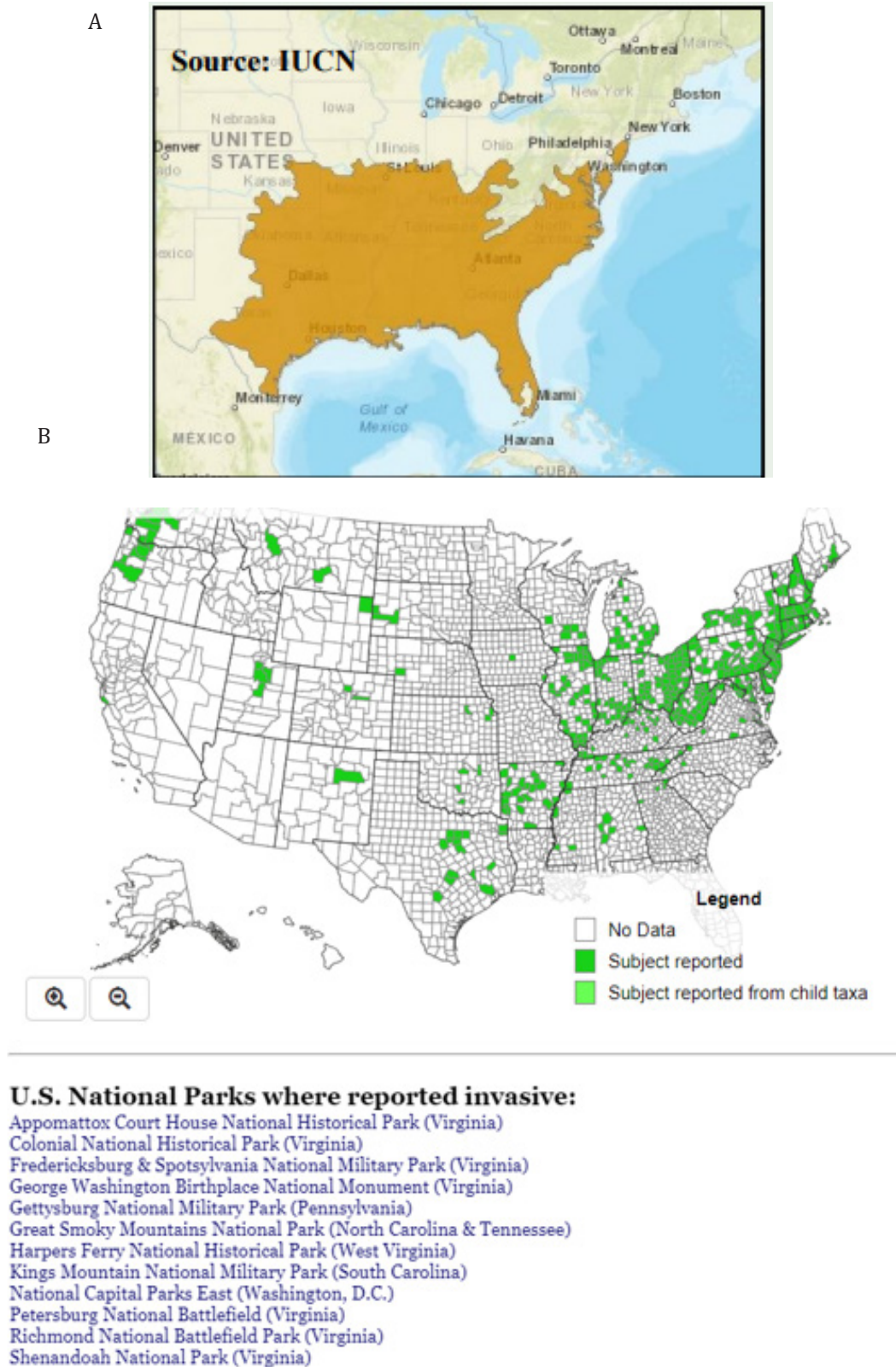


Figure 3) Map of America: A, distribution, and habitat of *S. lateralis* in the east and southeast of America; B, *L. vulgare* distribution in the east, southeast, southwest, and south of America. *Ligustrum vulgare* invasive seedlings appeared again in the parks of the same places. (Taken from Little Brown Skinks and the Department of Defense ^[34]) <https://www.invasiveplantatlas.org/subject.html?sub=3036> ^[51].

The head, neck, and trunk diameter is almost the same. Also, the diameter of the tail to the end does not change much. The length of the body from head to tail is 6.5 cm. The length of the hind legs is 1 cm, and the length of the front legs is 0.7 cm. Although it is scaly and lives in almost semi-arid places, the scales are so small and shiny that they appear to be without scales and look moist.

With a shortfall period and being semi-sempervirent, the fall of the leaves of the wild privet (*L. vulgare*) occurs slowly and creates a suitable cover on the soil so that this type of lizard can move under it safely. With the increase in the population of *S. lateralis* in the area of study, the population of

pests has been dramatically decreased, and insects such as willows, small garden beetles, and white-winged pests have decreased because, in our observations, the mentioned lizards were feeding well on the larvae of these insects. Among other ecological effects, the habitat plant, i.e., *L. vulgare* itself, has a pest called *Macrophya punctumalbum* (Hymenoptera), which was found in the area of study but with the abundance of *S. lateralis* lizards in the area. This rare pest indicates a symbiosis between *S. lateralis* and the privet plant. It has been proven that climate change increases the population of plant pests, especially in urban areas [20]; in this case, the emergence of an anti-insect species, such as

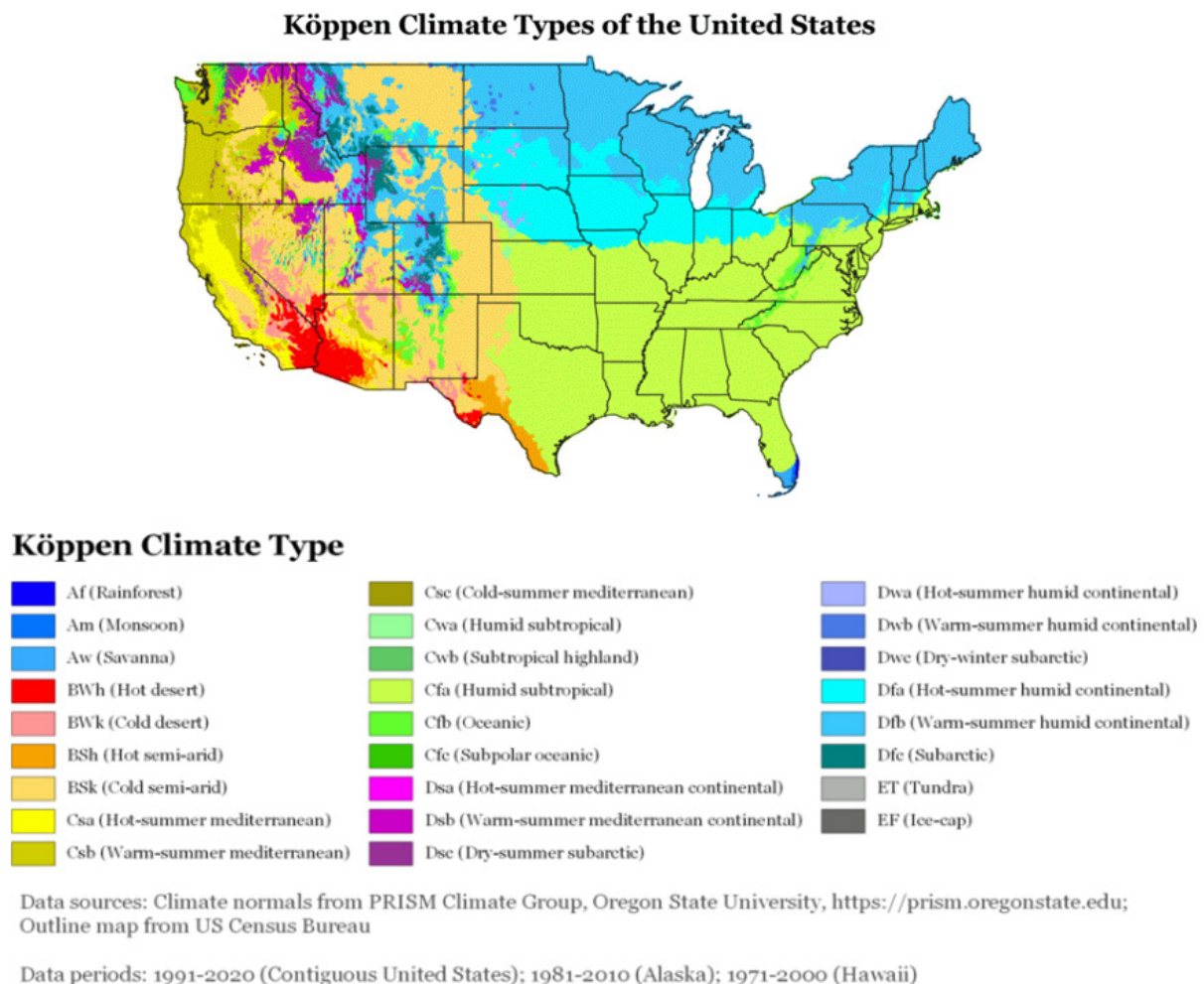


Figure 4) The area shown in green is the humid subtropical climate in America, which overlaps with the exact coordinates in Figure 4-B (privet vegetation and *S. lateralis* habitat) .(Köppen Climate Types) [35].

S. lateralis, which has been able to reduce the population of pests, is considered a kind of a natural ecological struggle. Therefore, obtaining food and destroying pests is determined by direct observation: 1) In nature, 2) in a glass container.

Behavior

Nutritional Behavior, Evolutionary Behavior

In the present investigation, it was observed that the *S. lateralis*, like some other reptiles, soon became habituated to its enclosure. When the weather got cold in the natural environment, it either went underground to hibernate or entered the human living environment, which it was very fond of. We also observed that the sense of learning is high in them so that during feeding times in the glass enclosure of its residence, it would come to the place from where it was fed on a stage and wait. There was much interest in humidity and where the water accumulated. In the natural environment, the interest of *S. lateralis* in wandering among the mixed leaves of privet and plantain was evident. The creeping and snake-like movement specific to this species and the dinosaur-like behavior during hunting (by raising its head to the middle of its body, pulling back, and jumping) makes it different from other lizards and close to its ancestors. These characteristics indicate the age of the origin of this species or the re-emergence of ancestral traits that were formed with the help of climate change and unique plants. Because these new lizards feed on insect larvae and live insects, the population of pests that interfered with the growth of plants, such as willows, flies, and tiny beetles, has been significantly reduced. This species of lizard's behavior has been observed to feed on live insects and has no desire to feed on dead insects. Even if the insect dies while hunting, it leaves it. Despite its small size, it can easily swallow a one-cm-long insect.

Discussion

Comparing two distribution maps of *L. vulgare* and *S. lateralis* in America showed an exciting point: the distribution of the lizard often corresponds to the distribution of the privet in the region. Another point is that the climate of the region where the lizard and the American privet plant live (semi-tropical) differs even from the neighboring climates (temperate or desert). In other words, the climate map overlaps with the *S. lateralis* scatter map and the *L. vulgare* scatter map (Figure 4). Also, in the current research in Iran, the distribution of *S. lateralis* is compatible with the distribution of *L. vulgare* and the new climate, although in a small range and can be a biological indicator. Researchers such as Glynne and Adams (2024) consider shrinking body size in reptiles as a factor in maintaining performance and facilitating survival^[36]. In this research, in the area where ground skink was found, climate change has now occurred, and the coldness of the area has decreased over the years, in a sense that estimated the average annual temperature in this area to be about two °C higher than in the past^[15]. They have reported 13% less rainfall. Also, this region, which used to have a cold and humid climate, is now reported to be cold and semi-arid^[37]. In other words, the climate change process is from arid and semi-arid conditions to arid conditions^[15]. Khordadi et al. (2014) reported that the climate of Karaj has started to change since 2010, and the temperature parameters have increased from 2.9 to 7 degrees^[16]. It seems that climate change is still in transition, and these changes can be proof of the new biodiversity in the region. Maybe in the future, we will see many kinds of plants and animals that were not there before. In this regard, Gautam et al. (2014) considered global warming as the cause of the increase in rainfall, floods, increasing atmospheric water vapor content,

and possible changes in drought patterns^[38]. Kouhi and Erfanian (2020) strongly confirmed the effect of temperature and climate change on the spread of two invasive plant species in Iran^[39].

This research showed that the appearance of *S. lateralis* depends on the type of habitat, and it tends to live under hedges of *Ligustrum vulgare* shrubs. In this regard, Brownscombe et al. (2023) reported that walleye occupy mostly shallow habitats with little vegetation cover in Toronto waters, while largemouth bass are more present in shallow habitats with high vegetation cover^[40]. It is also reported that the Great Bustard tends to live in the marginal habitats of the area like Sutav and Yngijeh Alblagh of Iran^[41].

Many behaviors and habitat selection by *S. lateralis* are done to maintain body temperature and body water balance so that the amount of heating and cooling of the body of these lizards in humid weather is the same. However, in dry weather, this heating and cooling is evaluated differently, in such a way that their body gets cold faster in dry weather and warms up later^[4]; in other words, in dry weather, they warm up more slowly than they cool down. Of course, according to Moreno-Lara et al. (2023), the vegetation type is essential as a living environment for *S. lateralis*. Vegetation can even sometimes provide suitable living conditions for them regardless of the climate^[42], in a sense that in their research, habitat structures such as biological canopy (such as leaves falling on the ground) are considered to be a suitable factor for the protection of *Scincella* genus. However, these lizards have no climatic compatibility with the habitat required. Therefore, plants like *L. vulgare*, which have leaves throughout the year and slowly drop their leaves, provide a suitable ecosystem for these lizards to live. Although researchers believe that urban lizards are more significant than their non-

urban counterparts due to greater access to food^[43], other researchers believe that the shrinking size of lizards is considered a sign of adaptation and survival^[24]. Considering that the lizard found in this research is smaller than its American counterpart, we can agree with the second opinion that shrinking is a counteraction to non-extinction. These characteristics indicate the age of the origin of this species or the re-emergence of ancestral traits that were formed with the help of climate change and noteworthy plants.

Another one of the reasons for the appearance of the new record of *Scincella lateralis* is landscape fragmentation. Most of the negative aspects of landscape fragmentation are considered because fragmentation often happens due to climate changes, human interference in building villas, and the extent of urbanization, and it causes a decrease in biodiversity. However, at the same time, as in the current study, there is also the possibility of the emergence of new species. In this regard, Fromm et al. (2024) stated that the factors that can threaten biodiversity and may stimulate the positive response of species and their adaptation are climatic warming and landscape fragmentation. Therefore, the presence of this lizard in Iran in a particular area or landscape fragmentation depends on the type of specific microclimate or microhabitat. It is in line with the report (Civantos et al. 2020), which stated that the distribution of scincid lizards in a limited place is not random and indicates that they use a specific microhabitat that is done by choosing a spatial niche^[45]. The evidence shows that we are facing a spatial niche that is similar to that in America for *S. lateralis*, which may be due to natural selection or may be due to plasticity and phenotypic change, which itself is caused by climate change; it seems that the second case is more likely, but in any case, this event is significant from

an ecological point of view.

Even though climate change often has the role of reducing biodiversity, in cases like the present study, climate change has been able to establish a species with the emergence of new phenotypic traits in order to be more stable and compatible with the environment that is effective in repelling plant pests and has a positive role on the ecosystem through adaptive evolution. Since the ecosystem is a dynamic system and tries to protect itself, its occurrence is plausible. One of the new evolutionarily compatible phenotypic traits in the skink lizard is its very small size, even smaller than the American specimens, which makes it suitable for passing under dry leaves to stay away from predators. The fast learning of *S. lateralis* in the experiment of this research to take food on the stage inside the glass chamber was impressive, and it was in line with the report (Paulissen 2008), which announced the localization of *S. lateralis* through spatial learning ^[46]. The understanding of the spatial position, the speed of action, and, at the same time, high accuracy have made this lizard an intelligent creature with evolutionary traits so that Rubbo et al. (2001) have reported that they recognize their predators like wolves, spiders, before attacking and use sedentary behaviors to escape ^[46].

There are various reports about the habitat of *S. lateralis*, such as deciduous/coniferous forests, river banks, and ponds. However, what is certain is that a thick substrate of leaves makes its environment more suitable (Brooks GR (1975)). In the current research, a combination of *L. vulgare* and *Platanus orientalis* leaves has provided this substrate massively ^[46] (Figure 2).

Conclusion

Climate change and the identification of this new record teach us that we should take seriously the existence of microhabitats that are

created due to climate change rather than being ignored because they are limited. Because although the level of life is limited, the organisms that arise in microhabitats and microclimates can have a significant impact. Also, vegetation plays a vital role in protecting the soil and helps with the evolutionary adaptation of animals. It is true that the first climate change, by disturbing the conditions that have prevailed in the environment for years and centuries, narrows the field for the life of some organisms. However, it should be known that ecosystems are dynamic environments. If humans allow, they have the power of self-regulation, so it is not out of mind to witness new species diversity in limited environments that can transform the ecosystem. Since plants are an essential part of the habitat of animals, the protection and care of natural and native plant species of many regions should be considered.

In many cases, a new species in an area that did not exist before indicates some ecological need for that species, such as the need for stability and adjustment of fauna and flora. As seen in the studied area in the current research, climate change first occurred, followed by an increase in the population of insects that are pests of plants. A new lizard (*S. lateralis*) appeared, and the insect population was reduced with the help of a shelter like *L. vulgare*. This result is in line with the materials published by the Czech Academy of Sciences, and they even consider the emergence of a new species and evolution to be closely related to ecology, behavior, and habitat selection ^[49]. With the results and available evidence, *L. vulgare* can be considered a biological and ecological indicator for the presence of *S. lateralis*, and the presence of *S. lateralis* can be a spark of hope for nature's automatic biological fight. Therefore, this feature can be used in environmental management and protection and shows evolutionary ecology.

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