Herpetology Notes 19: 275–281, published on 16 May 2026

Distribution and microhabitat use of naturalised Common Chameleons, *Chamaeleo chamaeleon* (Linnaeus, 1758), in Malta

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Abstract. The Common Chameleon, *Chamaeleo chamaeleon*, was introduced to Malta in the mid-19th century and is now fully naturalised, yet detailed ecological information for the Maltese archipelago remains very limited. This study provides the first integrated assessment of its spatial and seasonal distribution, microhabitat use, and age-related patterns of variation using systematic field surveys across 13 sites. Abundance varied markedly among regions, with northern sites supporting the highest densities, likely reflecting greater availability of semi-natural and suburban vegetation. Seasonal differences in abundance were minimal, although winter surveys indicated reduced detectability. Chameleons showed strong associations with coniferous vegetation and mid-height perches (101–300 cm), with seasonal shifts consistent with thermoregulatory demands. Ontogenetic patterns indicated partial niche partitioning, with smaller individuals occupying lower and occasional peripheral branches, while larger individuals used higher and more central positions. Overall, the species' adaptability to fragmented landscapes and human-modified habitats explains its successful establishment in Malta, while emphasising the importance of maintaining tree-rich green spaces for long-term population persistence.

Keywords. Common chameleon, Maltese islands, spatial ecology, urbanisation, introduced species, ontogenetic variation

Introduction

The Common Chameleon, *Chamaeleo chamaeleon* (Linnaeus, 1758), is a widespread Mediterranean species native to North Africa and the Middle East (Andreone et al., 2016). It was introduced to Malta in the mid–19th century, reportedly by Protestant missionaries in St. Julian's, and has since continued to spread and establish stable populations (Baldacchino and Schembri, 2002; Chini, 2009). Its successful establishment has been attributed to favourable climatic conditions, the absence of natural predators, and repeated introduction events (Farrugia, 1999; Mahoney et al., 2014). Another reason as to why the species managed to establish stable populations in Malta is due to the lack of competition for its occupied niche, with no other local species being known to occupy the same habitat as *Chamaeleo chamaeleon* (Schembri and Lanfranco, 1996). Similar patterns have been reported across other Mediterranean regions such as southern Italy, Greece, and Spain, where populations, mostly introduced, persist in low-elevation coastal areas with Mediterranean climatic conditions and a mosaic of urban, shrubland, and agricultural habitats, highlighting the role of comparable environmental conditions in facilitating establishment (Serva et al., 2024). Over time, the species has become fully naturalised and is now legally protected under the *Reptiles Protection Regulations;* S.L. 549.02 (Malta, 1992), and the *Flora, Fauna and Natural Habitats Protection Regulations;* S.L. 549.44, Schedule V (Malta, 2006), which prohibit its capture, killing, disturbance, possession, or trade without a permit.

Although *C. chamaeleon* is now widely distributed across Malta, information on its local ecology remains very limited. Earlier contributions, notably Baldacchino and Schembri (2002), documented its introduction and general occurrence in the Maltese Islands, however, there are few detailed assessments of the species' spatial and seasonal patterns in abundance or habitat use. Understanding the species' distribution and habitat preferences is essential for guiding conservation measures, establishing ecological baselines for future monitoring, and assessing how ongoing landscape change may influence long-term population persistence.

This study provides the first detailed ecological assessment of *C. chamaeleon* in Malta, investigating the spatial distribution, microhabitat use, and behavioural ecology of the species using field surveys. Ultimately

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this study examined how abundance varies across northern and southern regions, exploring conditions such as levels of urbanisation and how these may influence abundance levels. Differences in abundance were also assessed between seasons. Additionally, we explored how vegetation structure influences perch height and position, as well as how body size and solitary vs non-solitary individuals relate to microhabitat selection. After analysing the data collected through night-time field surveys, we were able to provide a comprehensive overview of chameleon ecology in Malta, highlighting the species' adaptability to both natural and anthropogenic environments.

Material and Methods

Study site and field surveys. Transect surveys were conducted at 13 sites across Malta to assess the distribution, habitat use, and behaviour of *Chamaeleo chamaeleon*. Preliminary attempts at carrying out daytime surveys provided very erratic and unreliable results because of the species' relatively fast movement and camouflage, which hindered proper detection and counting of the chameleon individuals. Therefore, surveys were carried out at night, either before dawn or after dusk, when individuals are known to be inactive and perched on vegetation (Ibrahim, 2013).

Belt transects of approximately 100 × 10 m (total area covered = 1000 m^2) were established using Google Maps, to exclude unsuitable terrain (e.g., paths, roads, barren ground). A total of 37 transects were surveyed, with two or three replicates per site depending on habitat extent and expected abundance. During a survey, each transect was walked twice (forward and return); newly detected individuals were added to produce a corrected total per belt transect (1000 m^2) with care taken not to double–count individuals.

Surveys were conducted between July and October 2024, with additional visits during the winter months of January–February 2025 at l-Aħrax tal-Mellieħa, Kennedy Grove, and il-Miżieb, which were the sites of highest summer abundances. Winter surveys at l-Aħrax tal-Mellieħa, Kennedy Grove, and il-Miżieb followed the same protocol as that of the summer surveys. For each individual chameleon, the following data were recorded: growth form of the supporting plant, perch position in the plant (centre vs. periphery), perch height (in classes 0–100, 101–200, 201–300, 301–400, ≥401 cm), and whether the individual was perched solitary or non-solitary (within 3 m of another individual). No chameleons were caught or handled during this fieldwork. All data was collected through direct observations or through remote analysis of photographs that were taken in the field.

Data analyses. Data were entered into Microsoft Excel (v2502; Microsoft Corporation, 2025) and analysed in RStudio (v4.3.1; R Core Team, 2023). Snout-vent length measurements were made using Fiji ImageJ (Schneider et al., 2012) after calibration against measured objects in the image; these were assigned to classes: 1.5–2.5, 2.6–7.0, 7.1–10.0, 10.1–15.0, ≥15.1 cm. Abundances were standardised as individuals per 1000 m^2; data used for comparisons across sites and seasons were from two transects per site. At sites with three transects, the transect located furthest from the other two was excluded to standardise comparisons. One-Way ANOVA was used to determine whether abundances differed significantly between sites, whilst a paired *t*-test was used to assess if there were significant differences in abundances between seasons. Distances from transects to the nearest road, inhabited building, or cultivated land were measured in Google Earth Pro and related to abundance.

Microhabitat use was analysed by categorising vegetation as coniferous trees, non-coniferous trees, shrubs, low bush/herbs, and low dry/dead plants. Perch heights were examined in relation to plant type, season, and body size, whilst perch position was assessed between different size ranges. Social behaviour was assessed using solitary/non-solitary designations, comparing differences across body size ranges. Individuals observed within 3 m of another chameleon were classified as non-solitary, whereas those located more than 3 m apart were classified as solitary.

Results

Geographical distribution. Chameleons were recorded at all 13 surveyed sites with clear spatial variation in abundance (Fig. 1). The highest abundances occurred at Kennedy Grove (12.5 individuals/1000 m^2) and il-Miżieb (12 individuals/1000 m^2), with lower abundances at central and southern sites. Comparison of the three sites sampled in both summer and winter (Kennedy Grove, l-Aħrax tal-Mellieħa, and il-Miżieb) indicated a seasonal decline, with values of winter abundances consistently lower than those from summer (Fig. 2).

One–Way ANOVA indicated significant differences in summer abundances among sites ($F = 9.081$, $p < 0.00018$). Paired *t*–tests revealed no significant difference between summer and winter abundances for

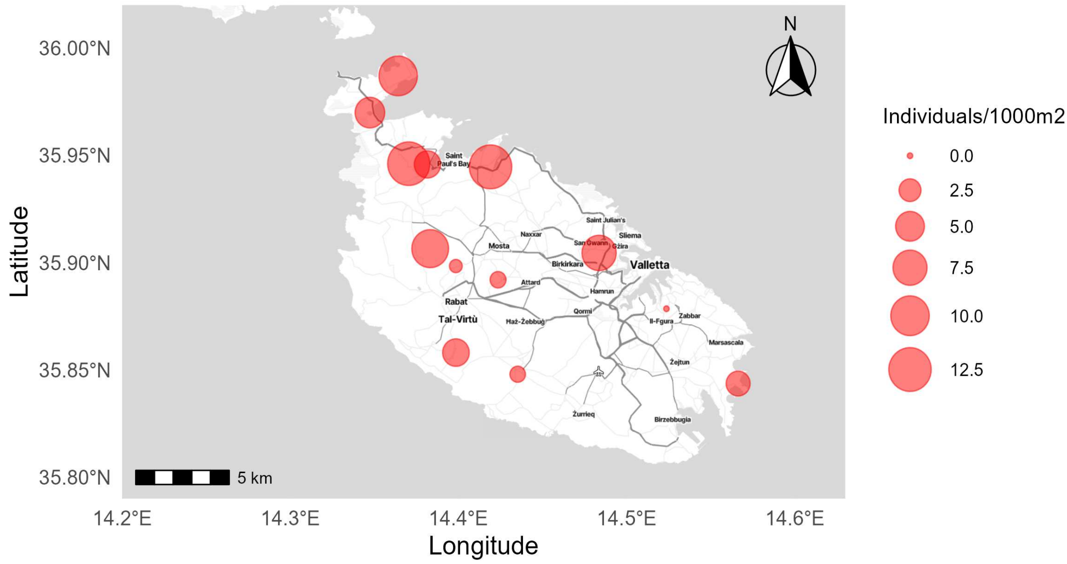

Figure 1. Map of sites sampled in summer showing abundance of *Chamaeleo chamaeleon* at each study location ($n = 2$ transects per site). Base map: Stadia Maps (R). A = l-Ahrax tal-mellieha, B = Ghadira nature reserve, C = il-Mizieb, D = Simar nature reserve, E = Kennedy grove, F = Dwejra lines, G = Chadwick lakes, H = Ta' qali, I = Buskett, J = Siggiewi, K = Xrobb l-ghagin, L = Bormla gardens, M = Wied ghollieqa.

the resampled sites ($t = 2.172$, $p = 0.162$). Chameleon abundance increased with distance from roads (Fig. 3A) and decreased with distance from inhabited buildings (Fig. 3B). Abundances also slightly decreased with distance from agricultural areas, showing higher values with proximity to agricultural land (Fig. 3C).

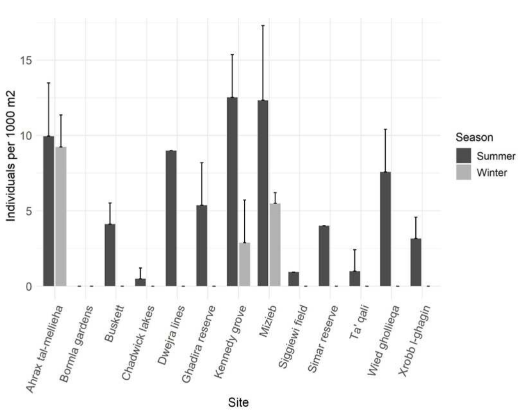

Figure 2. Abundance (per 1000 m^2) of *C. chamaeleon* at each site during summer and winter. Error bars represent +1 SD; $n = 2$ transects per site. Note that winter transects were only surveyed at Kennedy grove, l-Aħrax tal-mellieħa, and il-Miżieb.

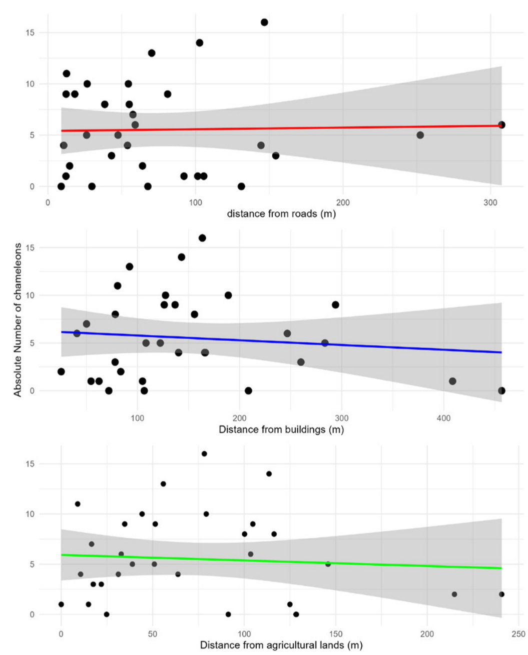

Figure 3. Absolute chameleon abundance versus distance from (A) roads, (B) inhabited buildings, and (C) agricultural lands. Lines represent the best-fit regression with 95% confidence intervals (shaded).

Habitat use. Vegetation types were not evenly represented across sites, with conifers being predominant at most locations, although other growth forms were included where present. Most chameleons were recorded on coniferous and non-coniferous trees, while shrubs, low bushes/herbs, and dry plants supported comparatively fewer individuals (Table 1).

Most individuals (90.45%) occupied peripheral rather than central positions on the vegetation, although individuals of intermediate size (2.6–10.0 cm) occasionally occurred closer to the centre (Table 2).

Vertical distribution. When assessing chameleon distribution on conifer and non–conifer trees, most chameleon individuals occurred at heights between 101–300 cm above ground (see Fig. 4 and Table 3). Coniferous trees supported the greatest perch heights overall (Fig. 4).

Seasonal variation at the three sites surveyed in both summer and winter (Kennedy Grove, l-Aħrax tal-Mellieħa, and il-Miżieb) was evident in non–coniferous trees: individuals in summer were concentrated at heights of 101 cm and 300 cm above ground, whereas in winter they were more frequently observed between 0–100 cm above ground (Table 3).

Perch height also varied with body size. Larger individuals (10.1–15.0 cm) were more often recorded at a height of 101–300 cm above ground, whereas smaller size classes (1.5–2.5 cm and 2.6–7.0 cm) were more frequently found at lower heights (Table 4).

Behaviour. Chameleons were predominantly solitary (Table 5). Non–solitary individuals were most often observed in the 2.6–7.0 cm size class, which was also the most frequently recorded group overall.

Table 1. Absolute number of chameleons per plant growth form, combining data from both summer and winter transects.

Site	Non-conifer tree	Conifer tree	Shrub	Bush herb	Dry plant
Total	54	120	19	1	3

Table 2. Absolute number of chameleons per size range (cm) at the centre vs periphery of the plant, including data for all plant types across both seasons.

	Placement on branch	
Chameleon body size range (SVL in cm)	Periphery	Centre
1.5–2.5	12	0
2.6–7.0	70	8
7.1–10.0	68	10
10.1–15.0	29	1
≥15.1	1	0

Discussion

Spatial distribution. *Chamaeleo chamaeleon* was introduced to Malta in the mid-19th century at St. Julian's (Baldacchino and Schembri, 2002; Chini, 2009). Its successful establishment since has been attributed to suitable habitats, repeated introductions (Andreone et al., 2016), a lack of major predators (such as birds of prey and snakes; see Drown et al., 2022), and a favourable Mediterranean climate resembling that of its North African native range (Farrugia, 1999; Mahoney et al., 2014). Genetic analyses of Maltese specimens show affinities with populations from Israel and Morocco, supporting multiple introductions from distinct sources (Andreone et al., 2016; Basso et al., 2019). The species' high fecundity (20–30 eggs per clutch) and ecological flexibility likely facilitate its persistence across both natural and modified landscapes (Farrugia, 1999).

Abundance varied markedly among sites, with northern localities supporting the highest densities. The heterogeneous distribution is consistent with Malta's fragmented landscape, where extensive urbanisation limits connectivity among vegetated areas. Isolated population clusters may also result from sporadic releases from captivity, a pattern documented for Malta and other introduced populations (Chini, 2009). Local climatic and structural variation probably further shape

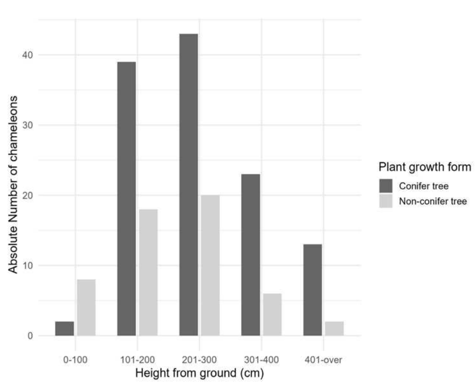

Figure 4. Absolute number of *C. chamaeleon* per height range (cm above ground) for conifer and non-conifer growth forms, combining both summer and winter data for all sites sampled.

Table 3. Absolute number of *C. chamaeleon* on conifer trees and non-conifer trees during summer and winter by height range (cm above ground). Data from the three sites sampled in both summer and winter was used.

		Height range (cm above ground)				
		0–100	**101–200**	**201–300**	**301–400**	**≥401**
Summer	Conifer tree	1	9	33	8	4
	Non-conifer tree	0	5	7	0	0
Winter	Conifer tree	0	4	2	8	5
	Non-conifer tree	7	1	1	3	1

Table 4. Absolute number of *C. chamaeleon* in each size range (cm) observed at different height ranges (cm above ground), combining both summer and winter data.

	Chameleon body size (SVL) range in cm				
Height from ground (range in cm)	**1.5–2.5**	**2.5–7.0**	**7.0–10.0**	**10.0–15.0**	**≥15.1**
0–100	3	11	4	2	0
101–200	6	31	26	7	0
201–300	3	18	27	16	1
301–400	0	11	14	4	0
≥401	0	7	7	1	0

Table 5. Absolute number of solitary and non–solitary chameleon individuals recorded across five size ranges (cm) during the transect surveys, combining both summer and winter data.

	Behaviour	
Chameleon size range (cm)	**Solitary**	**Non-Solitary**
1.5–2.5	12	0
2.6–7.0	70	8
7.1–10.0	76	2
10.1–15.0	28	2
≥15.1	1	0

habitat suitability. Ecological niche modelling has shown that annual precipitation strongly influences reptile habitat suitability, especially for low–altitude species such as *C. chamaeleon* (Qian, 2010). Northern Malta contains a higher proportion of semi-natural and cultivated habitats with denser tree and shrub cover, providing favourable conditions for an arboreal insectivore (Hódar et al., 2000; Serva et al., 2024).

Seasonal variation. Although chameleon abundance was higher in summer, seasonal differences were not statistically significant. Lower winter counts at Kennedy Grove and il-Miżieb may reflect reduced activity and increased crypsis during cooler months. This seasonal reduction in detectability aligns with thermal constraints typical of ectothermic reptiles (Ibrahim, 2013). Site-specific factors such as microclimate, vegetation structure, and reproductive state may explain local departures from this general pattern.

Anthropogenic influence. Relationships between abundance and proximity to human features were complex. A weak positive correlation with distance from roads suggests a potential negative road-effect, consistent with reports of mortality and habitat fragmentation in Spain (Hódar et al., 2000) and highway-associated exclusion zones in Andalusian populations (Farfán et al., 2025). Conversely, abundance increased near inhabited buildings, indicating that suburban vegetation such as gardens and ornamental trees, may provide suitable microhabitats, as observed in Portugal (Miraldo et al., 2005).

Higher abundances near agricultural land also mirror findings from other Mediterranean regions where orchards and cultivated fields offer perches and prey (Hódar et al. 2000). Nevertheless, agricultural practices may threaten populations through nest destruction and pesticide exposure (Pleguezuelos et al., 1998; Ibrahim, 2013).

Habitat use. *Chamaeleo chamaeleon* showed a strong association with coniferous vegetation. Conifers provide dense, evergreen foliage that offers year-round cover, thermal stability, and abundant prey (Pleguezuelos et al., 1998; Ibrahim, 2013). Although preference for conifers may have been partially influenced by their dominance at most sites, their structural attributes likely enhance suitability for this arboreal species.

Most individuals in this study perched 2–3 m above ground, a height balancing exposure and foraging efficiency (Keren–Rotem et al., 2006; Ibrahim, 2013). Seasonal shifts in perch height were evident, probably reflecting thermoregulatory needs: lower perches in winter for shelter from wind and higher perches in summer for basking (Andrews, 2008). Similar seasonal shifts in perch height were noted in Iberian populations by Miraldo et al. (2005), highlighting the species' flexible habitat selection in response to temperature and vegetation structure. The consistent use of peripheral branches across seasons further suggests a structural advantage, most likely optimising foraging and predator detection, as peripheral branches provide easier access to flying prey and improved visibility.

Ontogenetic differences in perch use and branch position indicate partial niche partitioning. Smaller individuals (< 7 cm) occupied lower, more peripheral branches, whereas adults occasionally perched higher and closer to trunks. These differences may reflect body-mass constraints as smaller individuals exert less weight on flexible branch tips and therefore reduce the risk of falling, and behavioural avoidance of adults, as juveniles reduce aggression and cannibalism risk through spatial segregation (Keren-Rotem et al., 2006; Tolley and Herrel, 2013). Juveniles avoid adults to reduce the risk of cannibalism, a behaviour documented in captivity and in the wild (Keren-Rotem et al., 2006; Tolley and Herrel, 2013). Juveniles can occupy higher perches when adults are absent, suggesting behavioural rather than physical limitation (Keren-Rotem et al., 2006).

Behaviour. Most chameleons were solitary, consistent with the species' territorial and cryptic nature (Cuadrado, 1998). Occasional aggregations of small individuals (2.5–7 cm) likely represent transient post–hatching groups. Overall, the solitary behaviour typical of *C. chamaeleon* appears maintained even within Malta's small, fragmented habitats.

Citizen Science data. Additional sources of information on the distribution and behaviour of *Chamaeleo chamaeleon* in the Maltese Islands that were explored, but not reported on here, are the records of such citizen science platforms as iNaturalist and local nature-focused groups on social media. Although such datasets lack a standardised systematic sampling effort, they may provide broader spatial and temporal coverage and can nonetheless contribute valuable observations on distribution, habitat use, and population dynamics of *C. chamaeleon* across Malta and Gozo. This is being explored and will be the subject of a future report.

This study provides the first ecological assessment of the behaviour, habitat use, and spatial distribution of *Chamaeleo chamaeleon* in Malta through the use of systematic, night-time, field surveys. Populations are unevenly distributed and concentrated in northern and eastern regions where semi-natural and suburban habitats provide structurally complex vegetation. Although no marked seasonal decline in abundance was detected, winter surveys suggest reduced activity linked to lower temperatures. Chameleons showed strong associations with coniferous vegetation and mid-height perches, with ontogenetic variation indicating partial niche partitioning.

The persistence of *C. chamaeleon,* as an established alien species, in fragmented Maltese landscapes demonstrates its adaptability to human-modified environments, but dependence on vegetated habitats underscores the importance of maintaining tree-rich green spaces for its long-term conservation. Continued structured field surveys of *Chameaeleo chamaeleon* will be essential for tracking population trends and informing management of this introduced, yet naturalised, reptile in Malta.

Acknowledgments. We would like to thank Rachel Farrugia for assistance during fieldwork. We are grateful to two anonymous referees and to the editor whose comments on a previous version of this report have greatly improved it.

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Accepted by Frederic Griesbaum