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Communication

Distribution and naturalisation of *Heterotheca subaxillaris* (Asteraceae) in Morocco

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Abstract

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Floristic records are essential for refining national plant inventories and filling gaps in global biodiversity databases. During a recent floristic survey of the Maamora Cork Oak Forest in northwestern Morocco, the species *Heterotheca subaxillaris* (Lam.) Britton & Rusby was found to be widespread, particularly in the western and central regions. This species grows primarily on red sandy clay soils, in both open spaces and beneath the canopy of *Quercus suber* and *Eucalyptus* trees. *Heterotheca subaxillaris* is native to North America and had previously been recorded in Morocco, but no details had been provided regarding its occurrence and distribution. During this study, we confirmed that the Moroccan population represents the type subspecies, *Heterotheca subaxillaris* subsp. *subaxillaris*. Field observations suggest that the plant has become naturalised in the region. Plants form locally abundant populations and flower throughout most of the year.

Keywords: alien species, chorology, ecology, flora, North Africa, taxonomy.

INTRODUCTION

The Asteraceae family is one of the most diverse in Morocco, with at least 540 species currently recorded (Fennane et al., 2023). Subsequent revisions of the Asteraceae family in Morocco have increased this figure to 553 species. This number includes the recently discovered *Cotula australis* Hook.f., *Ambrosia psilostachya* DC. and *Senecio angulatus* L.f., all of which have recently been recorded in Morocco (Jbilou et al., 2023; Tanji, 2023; Khamar & El Bakhouch, 2024). Introduced species currently represent 2.3% of the recorded vascular plant species in Morocco (Dobignard & Chatelain, 2011).

According to POWO (2025), the genus *Heterotheca* Cass. comprises 69 accepted species. Of these, *Heterotheca subaxillaris* (Lamarck) Britton & Rusby is currently the only species found in Morocco (Fennane et al., 2014) and on the African continent (POWO, 2025). It is native to the USA and Mexico, and has been introduced in Argentina, Cyprus, Australia, Palestine, and Germany.

This study aimed to analyse the distribution and naturalisation of *Heterotheca subaxillaris* populations recorded in northwestern Morocco and to clarify the taxonomic identity of the plants.

MATERIALS AND METHODS

Study area

The Maamora Forest (Fig. 1) is located in northwestern Morocco. It comprises three large sections (Western, Central, and Eastern Maamora) divided into five parts (El Boukhari et al., 2015). The forest covers 60 000 hectares between Salé and Kenitra (Aafi et al., 2005). It extends approximately 40 km from north to south and 70 km from east to west, spanning the latitudes 34.18833° N to 34.39972° N and the longitudes –6.21583° W and –6.99722° W. According to the biogeographical subdivision of the terrestrial regions of Morocco (Fennane & Ibn Tattou, 1998), Maamora is part of the North Atlantic Moroccan region.

Maamora is located in a semiarid region, with temperate winters in the east and mild, subhumid winters in the west (Aafi, 2007). The soils of the forest originate from relatively recent sedimentary deposits resting on a Palaeozoic substratum (Aafi et al., 2005). The thickness of the sediment layer varies, reaching up to 20 m in places. The diverse vegetation cover of the Maamora Forest is due to edaphic and geomorphological factors. This woodland ecosystem is characterised by relatively uniform rainfall throughout the year (Jbilou et al., 2023).

Field studies

The distribution of *Heterotheca subaxillaris* was studied in the Maamora Forest, located alongside the Rabat-Kenitra motorway, as well as behind the Kenitra provincial hospital in northwest Morocco, from April 2021 to January 2025 (Fig. 1). We followed a systematic sampling plan, selecting survey points based on our observations of the species during field visits. Fourteen

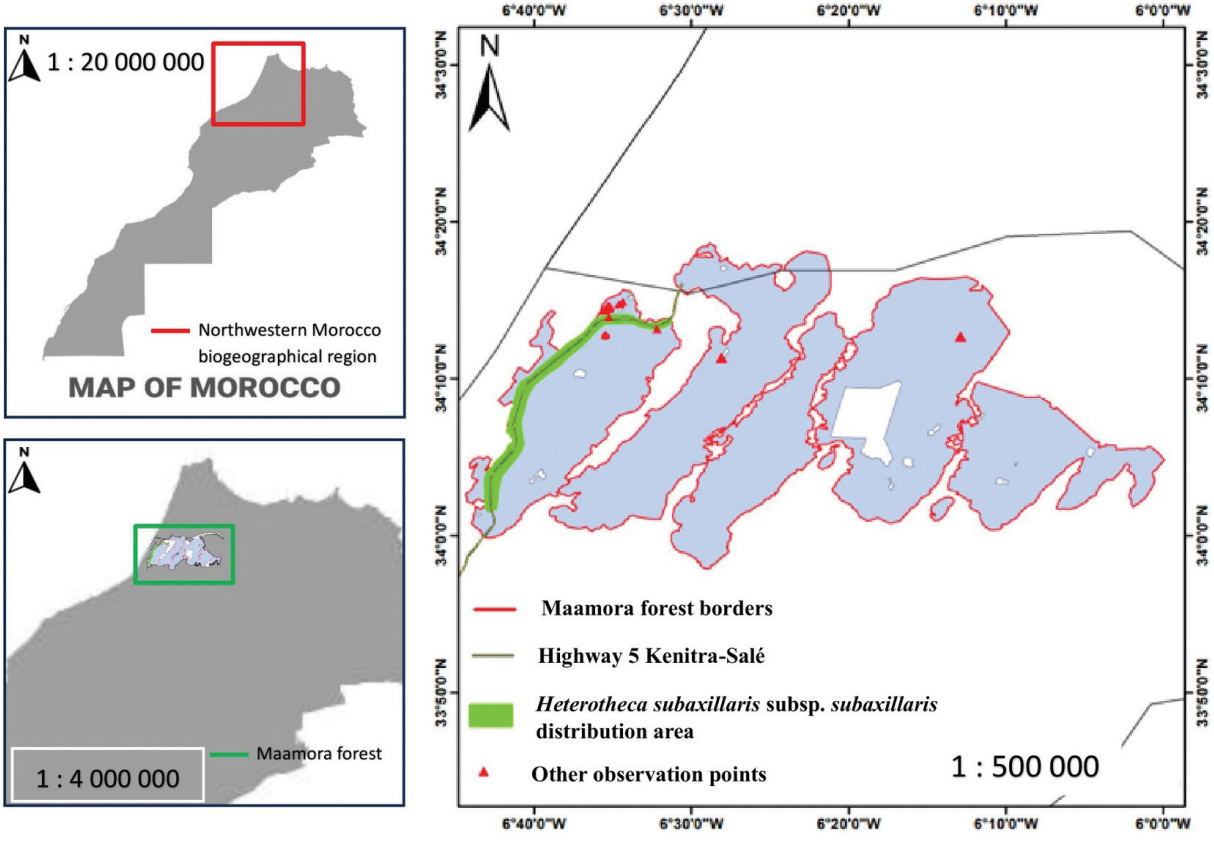

Fig. 1. Distribution map of *Heterotheca subaxillaris* within the northeastern Morocco biogeographical region (red square) with the sampling points: all localities are in Maamora between Salé and Kenitra.

sampling points were selected across the Maamora forest to assess the abundance and ecological preferences of *Heterotheca subaxillaris* (Fig. 2). These locations were spread over elevations between 33 m and 82 m above sea level (a.s.l.). They were distributed between 34.18833° N and 34.39972° N, and –6.21583° W and –6.99722° W. The soils were predominantly red sandy clay, except at sites P2 and P3, which had light beige sandy clay and sandy clay, respectively. This variability in soil texture and altitude provided a representative overview of the main ecological conditions under which the species occurs in the Maamora Forest. Each sampling unit covered an area of 400 m², which was considered sufficient to represent habitat conditions across zones where the species occurs. The number of individuals in the sampling area was estimated by counting flowering and non-flowering individuals.

During fieldwork, we collected information on the plants' geographical distribution, natural environments, and phenology at each site. We estimated species abundance using a direct counting approach to determine the number of individuals present. At each sampling point, we recorded the total number of individuals per square metre. To facilitate counting and improve accuracy, each sampling plot was subdivided into smaller sections. This allowed us to determine the area actually occupied by *Heterotheca subaxillaris* and calculate the total number of individuals across the entire sampling area.

During our fieldwork, we collected 14 samples of the study species for morphological analysis and identification purposes. One sample was selected and prepared as a voucher specimen (leg. A. Jbilou, No. 115; 9 February 2025; RAB114816), which was deposited at the Moroccan National Herbarium (RAB). Each plant sample was marked with a collection code, and all relevant information was recorded in a personal field notebook, including the date, the description of the sampling site, and the characteristics of the collected material. This ensures proper traceability in the event of any issues concerning plant identification.

RESULTS AND DISCUSSION

A total of 200 individuals of *Heterotheca subaxillaris* were recorded in the cork oak forest of Maamora, approximately 300 m from University Street in Kenitra (34.2377° N, – 6.5925° W; 40 m a.s.l.). The species formed dense stands in several parts of the surveyed area, with local patches containing up to 20 individuals per square metre. A few isolated plants were also recorded.

The species was found in several areas of the Maamora Forest, primarily between Salé and Kenitra. It was confirmed to be established at 14 sampling points on red sandy clay soils (Fig. 2). *Heterotheca subaxillaris* usually grows in sandy coastal areas and other disturbed habitats (Semple, 2025). Outside of its native range, the species has been declared an alien species in various parts of the world, particularly around the Mediterranean Basin, notably in Cyprus

Fig. 2. *Heterotheca subaxillaris* in open sand near the national highway between Kenitra and Rabat within the Maamora Forest. Photograph by A. Jbilou.

Table 1. Geographic coordinates, altitude, number of individuals, and soil characteristics of *Heterotheca subaxillaris* at study sites in the Maamora Forest (northwestern Morocco)

Sampling points	Coordinates (°N, °W)	Altitude (m a.s.l)	Number of individuals	Soil characteristics
P1	34.21806, –6.53667	50	160	Red sandy clay
P2	34.18833, –6.46500	65	176	Light beige sandy clay
P3	34.22056, –6.21583	82	32	Sandy clay
P4	34.39972, –6.99722	33	320	Red sandy clay
P5	34.24250, –6.58806	38	80	Red sandy clay
P6	34.21200, –6.59139	58	96	Red sandy clay
P7	34.24083, –6.58806	34	72	Red sandy clay
P8	34.23972, –6.58722	43	160	Red sandy clay
P9	34.24444, –6.57556	40	144	Red sandy clay
P10	34.24417, –6.57694	47	160	Red sandy clay
P11	34.24694, –6.57250	34	160	Red sandy clay
P12	34.24278, –6.58667	37	80	Red sandy clay
P13	34.23889, –6.58750	44	96	Red sandy clay
P14	34.23778, –6.59250	40	200	Red sandy clay
Total			1936	

(Hand et al., 2022), as well as in parts of southern Europe and the Middle East (POWO, 2025; Greuter, 2006). Its spread is generally associated with human-mediated seed dispersal and its tolerance of disturbed environments. Over three years of monitoring, we observed this species between the cities of Sidi Yahya du Gharb and Kenitra in northwestern Morocco, where it behaved as an invasive plant alongside roads, near railway lines and in abandoned or disturbed areas. On a global scale, *Heterotheca subaxillaris* and related species are examples of North American taxa that have successfully naturalised in warm-temperate regions, where they can display invasive tendencies, particularly in ruderal and coastal ecosystems (Shmida & Fragman-Sapir, 2016).

A survey of 14 sampling points within the Maamora Forest revealed that *Heterotheca subaxillaris* primarily grows on red, sandy clay soils, which dominate almost all recorded sites (Table 1). Only two sampling points (P2 and P3) show variation in soil colour and composition: light beige sandy clay and general sandy clay, respectively. Altitudes range from 33 to 82 metres, corresponding to the species' known range in Morocco (Jbilou et al., 2025a) of between 38 and 127 metres above sea level. With the exception of P4 (33 m) and P7 (34 m), most sampling points fall within this range, suggesting that the plant may adapt to slightly lower elevations under favourable soil conditions.

The abundance of individuals varied markedly across the sites, ranging from 32 plants at site P3 to 320 plants at site P4, reflecting differences in local microhabitat suitability. The highest number of individuals was recorded at site P4 (320 individuals), while a relatively moderate number (between 160 and 200 individuals) was recorded at several other sites (P1, P2, P8, P10, P11 and P14). These results are consistent with field observations that verify the presence of multiple, visible *Heterotheca subaxillaris* populations throughout the Maamora Forest. However, isolated individuals of the species also exist, demonstrating a remarkable capacity to establish and spread from dispersed occurrences. The presence of *Heterotheca subaxillaris* in Morocco is probably the result of an unintentional introduction, as evidenced by the presence of other alien plants such as *Parietaria officinalis* L., which appeared in Kenitra region, most likely due to human transport (Jbilou et al., 2025b). Such introductions are also most commonly associated with the importation of agricultural products, construction activities or ornamental plants, particularly ruderal Asteraceae originating from North America (Pyšek et al., 2011). In this case, the occurrence of the species near the Rabat–Kenitra highway supports the transport-related dispersal hypothesis. The presence of the species across various parts of the Maamora Forest and its ability to grow in different soil types suggest notable ecological adaptability and the potential for wider distribution in the region.

The adaptability of this species is further illustrated by its capacity to persist on similar soil types under varied conditions, as well as its presence under different tree cover. Additionally, the environmental con-

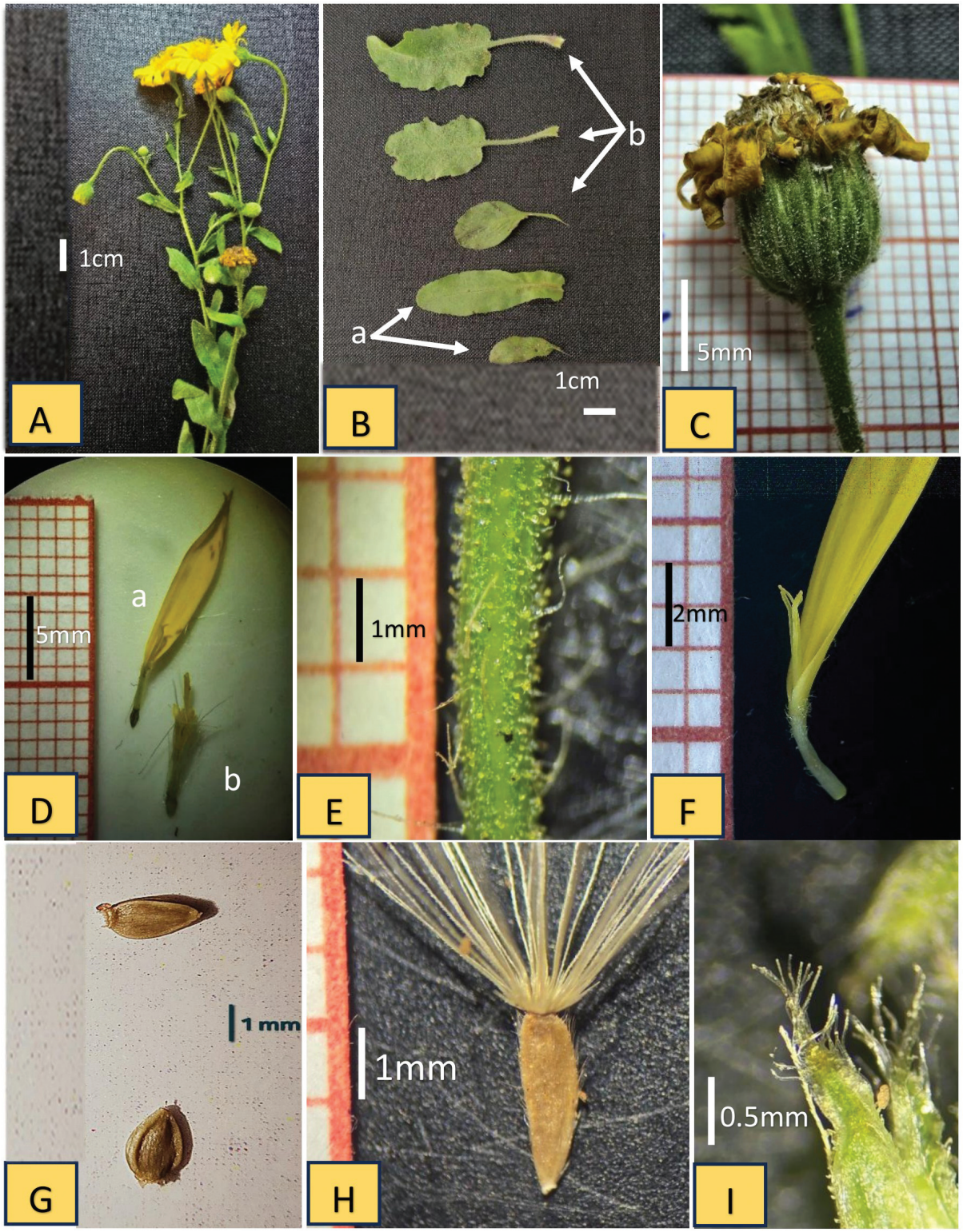

Fig. 3. General appearance and reproductive parts of *Heterotheca subaxillaris* subsp. *subaxillaris*. A – apical plant part; B – leaves: upper stem leaves (a), lower stem leaves (b); C – capitulum with peduncule; D – flowers: ligulate marginal floret (a), tubular central floret (b); E – hairs and subglandular trichomes; F – ligular floret; G – marginal achenes; H – central achene with pappus; I – tufts of apical hairs on bracts. Photographs by A. Jbilou.

ditions in the Maamora Forest vary across the region due to the local climate. The varying climatic factors between and within cantons seem favourable to the spread of *Heterotheca subaxillaris* and the other 55 taxa newly reported in the Maamora Forest (Jbilou et al., 2025a). The combination of red sandy clay substrates and uneven rainfall distribution over the past few decades, characterised by more frequent droughts, has disrupted the ecological balance in several areas, particularly in the western part of the region where our species was found (Challi et al., 2021). According to our observations, flowering occurs throughout the year, though it is less pronounced in winter. In Morocco, the species has been recorded under the canopies of *Quercus suber* L., *Eucalyptus camaldulensis* Dehnh. and *Pinus pinaster* Aiton across four provinces (Kenitra, Tiflet, Khémisset and Sidi Slimane) and the Salé prefecture. Data from the current survey support this distribution and suggest *that Heterotheca subaxillaris* is adapted to the Maamora Forest ecosystem and is in a colonisation phase.

An in-depth review of the relevant literature, alongside a comparative analysis with North American flora (Semple, 2025), enabled the accurate identification of the Moroccan specimen. Using the key in Semple (2025) for North America, we were able to distinguish between the two subspecies of *Heterotheca subaxillaris*, namely, *Heterotheca subaxillaris* subsp. *subaxillaris* and *Heterotheca subaxillaris* subsp. *latifolia*, based on the presence or absence of tufts of hairs on the tips of the involucral bracts (Harms, 1970; Semple, 2025). The diagnostic traits of recorded plants match those of *Heterotheca subaxillaris* subsp. *subaxillaris*, a determination further confirmed by Prof. M. Ibn Tattou and Prof. O. Benkhnigue (Department of Botany and Plant Ecology, Scientific Institute of Rabat). *Heterotheca subaxillaris* has previously been mentioned in Flore Pratique du Maroc (Fennane et al., 2014). This study confirmed for the first time that Moroccan plants belong to the type subspecies, *Heterotheca subaxillaris* subsp. *subaxillaris*.

Heterotheca subaxillaris is an annual or biennial plant that grows to between 15 and 170 cm in height. It has a strong odour and a taproot system, and its stems are usually erect with one to three branches. The stems and leaves are moderately to densely covered with glandular hairs. The phyllaries are arranged in four to six series (Fig. 3), and the outer ones have distinct apical tufts of eight to 15 coarse hairs. This is one of the key diagnostic features of the type subspecies.

The confirmation of *Heterotheca subaxillaris* in Morocco suggests that the species may also occur in Algeria and other Maghreb countries. Until now, the species had only been recorded in Moroccan flora (Jbilou et al., 2025a), and no detailed subspecific identification had been provided in previous literature (Dobignard & Chatelain, 2011; Valdés et al., 2002). This study contributes to the floristic and chorological data on alien plants in Morocco, filling a gap in major international databases which have not yet recognised this taxon from the region.

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Author contributions. AJ: conceptualisation, methodology, investigation, writing of original draft; HE, investigation; OB: conceptualisation, methodology, supervision, investigation; NB: supervision, visualisation, writing, reviewing and editing; JD: data curation; LZ: investigation; AC: software.

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