Distribution, habitat preferences and status of *Thladiantha dubia* Bunge (Cucurbitaceae) in Croatia

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Abstract

Two previously known localities of *Thladiantha dubia* in Zagreb (Botanical Garden of Faculty of Science and Savica) were confirmed and four new localities (village Medinci near Slatina, Lateral Channel Adžamovka near Vrbova, village Zvonimirovo and channel Stara Savica in Zagreb) were recorded between 2015 and 2020. In Medinci and Zvonimirovo, male populations were registered, while in all other localities female populations of *Th. dubia* were discovered flowering and bearing seedless fruits. Since there were no mixed populations found, and specific pollinators of this dioecious and entomophilous species are absent from Europe, the fruits are most likely parthenocarpic. According to our observations, *Th. dubia* can be classified as a naturalized, non-invasive alien weed in Croatia.

Keywords: alien species, naturalized species, parthenocarpy, Savica, Slatina, Slavonia

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Sažetak

U razdoblju od 2015. do 2020. godine potvrđene su dvije ranije poznate lokacije vrste *Thladiantha dubia* u Zagrebu (Botanički vrt PMF-a i Savica u Zagrebu) te su pronađene četiri nove lokacije (selo Medinci kod Slatine, Lateralni kanal Adžamovka kod Vrbove, selo Zvonimirovo i kanal Stara Savica u Zagrebu). U Medincima i Zvonimirovu zabilježene su muške populacije, dok su na svim ostalim nalazištima pronađene ženske populacije u cvatu i plodu, ali plodovi nisu sadržavali sjemenke. Budući da nisu pronađene miješane populacije oba spola, a u Europi ne dolazi ni specifični oprašivač, plodovi ove dvodomne i entomofilne vrste najvjerojatnije su nastali bez oplodnje partenokarpijom. Na osnovu naših opažanja, *Th. dubia* se može klasificirati kao naturalizirani, neinvazivni strani korov u Hrvatskoj.

Ključne riječi: naturalizirana vrsta, partenokarpija, Savica, Slatina, Slavonija, strana vrsta

Introduction

Thladiantha dubia Bunge is a perennial herbaceous climbing species from *Cucurbitaceae* family, native to the northern parts of China. Like many other fast-growing climbing lianas with conspicuous large flowers, it became a common garden plant in Russia and Central Europe. In 1884 it began its naturalisation through garden escape in Germany (Krausch 2007) and subsequently spread across Europe and Russia. So far, it has been recorded in Central Europe (Hungary, Poland, Czechia, Austria, Slovenia, Germany and Slovakia), Western Europe (Belgium, France, United Kingdom and the Netherlands), Northern Europe (Sweden, Norway, Estonia, Lithuania and Latvia), Southern Europe (Italy) and South-eastern Europe (Croatia, Serbia, Romania, Ukraine, Belarus and European Russia) (see the references in Alegro et al. 2010, GBIF 2021).

In North America, it is known from the western states of the USA and Canada, while outside its native range in Asia, it is recorded in Kazakhstan, Japan, North and South Korea and Bhutan (GBIF 2021). The genus name comes as a combination of Greek words *thladias,* meaning eunuch and the word *anthos* meaning flower (Burras 1994). This unusual name probably originates from Bunge's belief that the plant does not produce fruit because he either observed only female plants (Santanna 2013) or seedless parthenocarpic fruits. Word *dubia* comes form latin *dubius,* meaning doubtful. Common Croatian names of the genus are *tikvašica* (Nikolić 2019) and *zgnječeni cvijet* (Anonymous 2021), while the species *Th. dubia* is known as *mandžurijska tikvašica* (Nikolić 2019).

Materials and methods

The fieldwork was performed during the vegetation seasons between 2015 and 2020 as a part of several independent projects focusing either on (1) aquatic and riparian vegetation of the watercourses and lakes and covering the majority of the continental part of Croatia, or (2) mapping of alien plant species in a more restricted area of Brod-Posavina, Požega-Slavonia and Virovitica-Podravina counties. In the latter, the emphasis was on ruderal habitats, rural and urban areas and disturbed habitats in general, as well as riparian habitats, where the occurrence of alien species could be expected (Fig. 1, Tab. 1).

Thladiantha dubia was identified using several identification keys (Tutin 1972, Martinčić et al. 2007, Nikolić 2019), and the specimens were deposited in the herbarium collection Herbarium Croaticum (ZA) (herbarium abbreviation follows Thiers 2021). Furthermore, accompanying species and corresponding vegetation types were recorded in all localities. Plant taxa nomenclature follows Flora Croatia Database (Nikolić 2005-onwards), while the syntaxonomical system proposed by Mucina et al. (2016) and Škvorc et al. (2017) was applied for the vegetation types.

Results and discussion

Thaldiantha dubia was recorded for the first time in Croatia in 1985 (Ilijanić et al. 1985) in the immediate vicinity of Botanical Garden of the Department of Biology (Zagreb County), forming dense stands along a high fence between the garden and the railroad. Having this in mind, the escape from the cultivation might have been a possible scenario of its introduction. However, since there is no information on the purchase or cultivation of the species in the garden, there is a reasonable possibility that a railroad, possibly from Slovenia, could have served as a pathway for the introduction. The first published Croatian record of *Th. dubia,* however, is relatively recent. A stable population comprised solely of female individuals and spreading across ca. 100 m^2 was discovered in 2006, during floristic research of seminatural marshland area Savica,

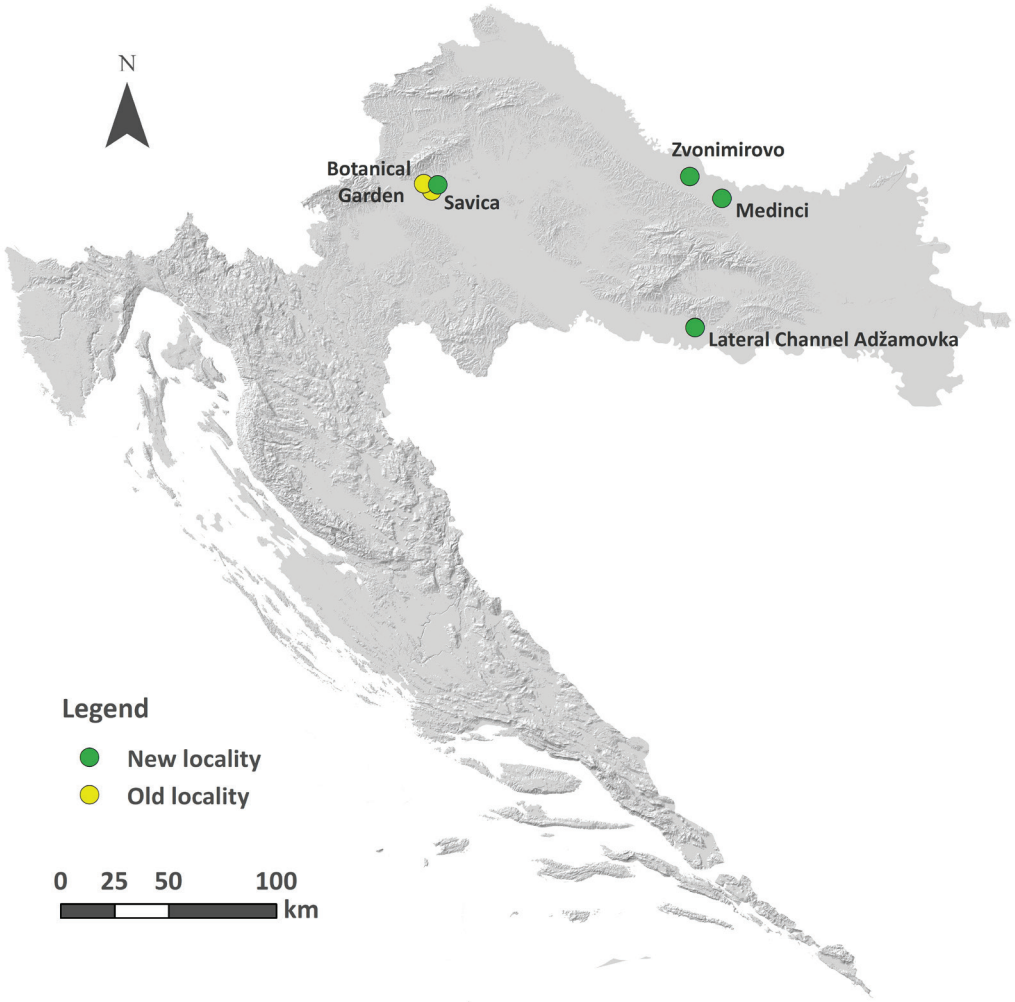

Figure 1. Distribution map of *Thladiantha dubia* Bunge in Croatia.

located in the eastern part of Zagreb (Alegro et al. 2010). This area represents a complex of small eutrophic lakes and strongly changed, degraded and eroded stands of alluvial willows and poplar forests (*Salicion albae* Soó 1951).

We have confirmed both known localities in Zagreb (Botanical Garden and Savica) and additionally recorded four new localities of this alien species in continental Croatia (Fig. 1, Tab. 1). The population growing on fences between Botanical Garden and the railroad is stable, but its abundance varies from year to year, depending on gardening practices since this area is mainly used as a composting site. We have detected the abundant population in mid-September 2017, while a similar situation was photographed in mid-July 2019 (Borovečki-Voska in Flora Croatica Database Gallery).

In the middle of July 2015, *Th. dubia* was recorded in the unmaintained yard of an abandoned family house in village Medinci, near the settlement Slatina (Virovitica-Podravina County) (Fig. 1, 2a). The species was here most likely cultivated as an ornamental plant and has eventually spread throughout the yard, extending over ca. 400 m^2 with coverage of about 80%. The population was made of only male individuals (Fig. 2c), which were in full bloom during our first visit. *Thladiantha dubia* was here accompanied by species characteristic of anthropogenic and ruderal vegetation such as *Chenopodium album* L., *Chenopodium hybridum* L., *Cirsium arvense* (L.) Scop., *Daucus carota* L., *Setaria pumila* (Poir.) Roem. et Schult., along with several invasive alien species, such as *Ambrosia artemisiifolia* L., *Conyza canadensis* (L.) Cronquist, *Erigeron annuus* (L.) Desf., *Phytolacca americana* L.

and *Robinia pseudoacacia* L. This locality was revisited in 2017 when a considerably different situation was encountered. Namely, invasive *C. canadensis* completely overtook the yard that was only two years ago overgrown with *Th. dubia*. The population of *Th. dubia* persisted but was now represented with only a negligible cover being almost unnoticeable among tall and highly competitive *C. canadensis*.

In 2017, another naturalized population of *Th. dubia* was discovered along the steep banks of Lateral Channel Adžamovka and a nearby wild landfill, both south of the settlement Vrbova (Brod-Posavina County). Only female individuals were recorded, flowering and bearing ripe red fruits (Fig. 2d, e) at the end of August. The species occupied only ca. 20 m^2 with coverage of around 50%. The situation was not significantly changed in 2019 when the locality was revisited in the middle of August. On the banks of the channel, *Th. dubia* was associated with species characteristic of disturbed habitats and steep banks of regulated water bodies, such as invasive *Ambrosia artemisiifolia*, *Amorpha fruticosa* L., *Bidens frondosa* L., *Conyza canadensis*, *Echinocystis lobata* (Michx.) Torr. et Gray, *Xanthium strumarium* L. ssp. *italicum* (Moretti) D. Löve, *Sorghum halepense* (L.) Pers. and *Abutilon theophrasti* Medik. Apart from invasive alien species, which dominated the vegetation of the locality, native species of wet, anthropogenic and ruderal habitats were present as well, with the highest proportion of the species characteristic of the class *Epilobietea angustifolii* Tx. et Preising ex von Rochow 1951 (*Urtica dioica* L., *Aristolochia clematitis* L., *Cruciata laevipes* Opiz, *Symphytum officinale* L., *Angelica sylvestris* L.), followed by *Bidentetea* Tx. et al. ex von Rochow 1951 (*Echinochloa crus-galli* (L.) P.Beauv., *Bidens frondosa*, *Chenopodium polyspermum* L.) and *Sisymbrietea* Gutte et Hilbig 1975 (*Chenopodium album* and *Convolvulus arvensis* L.).

In early September 2019, a new male population was discovered in village Zvonimirovo (Virovitica-Podravina County) ca. 18 km from the record of male plants in Medinci. This population was growing on the edges of the small black locust (*Robinia pseudoacacia* L.) forest of the class *Robinietea* Jurko ex Hadač et Sofron 1980, occupying

Table 1. Localities of *Thladiantha dubia* Bunge in Croatia. Coordinates are given in the WGS84 coordinate system, X – longitude, Y – latitude.

	Locality	X	Y	Observation year	Record type
1.	Zagreb, Botanical Garden of the Department of Biology	15.9737°E	45.8043N°	1985	known
2.	Savica, near Lake Plitka, Zagreb	16.0220°E	45.7748N°	2006	known
3.	Village Medinci	17.7499°E	45.7382N°	2015	new
4.	Lateral Channel Adžamovka near Vrbova	17.5794°E	45.2014N°	2017	new
5.	Village Zvonimirovo	17.5600°E	45.8309N°	2019	new
6.	Channel Stara Savica, Savica, Zagreb	16.0268°E	45.7862N°	2020	new

ca. 10 m long and 3 m wide belt along the village road (Fig. 2b). We believe the species was cultivated here as an ornamental plant as was eventually released into the wild as an excess of plant material left after yard maintenance, which is a bad practice common in both rural and urban areas of Croatia.

In 2020, a comprehensive survey of aquatic and riparian vegetation of seminatural marshland Savica (Zagreb County) was carried out and on this occasion, a new locality of *Th. dubia* was recorded ca. 1.5 km from the previously known locality (Fig. 3a, b). This whole area is a complex of 12 interconnected eutrophic lakes, former armlets and meanders of the Sava River, situated on the left side of the river, and receiving cooling water from the Cogeneration Plant Zagreb (TE-TO Zagreb). The whole area is protected as a significant landscape extending over 75 ha, with the lakes occupying 30 ha. During our research, we revisited a locality reported earlier by Alegro et al. (2010) and determined that no further spread of this completely female population has occurred, but this time the plants were bearing almost fully ripe fruits. Furthermore, a dense new female population of *Th. dubia* was discovered flowering and bearing fruits (Fig. 3e, f) along the steep bank of the channel Stara Savica (former meander of the Sava River) that is receiving cooling water from the

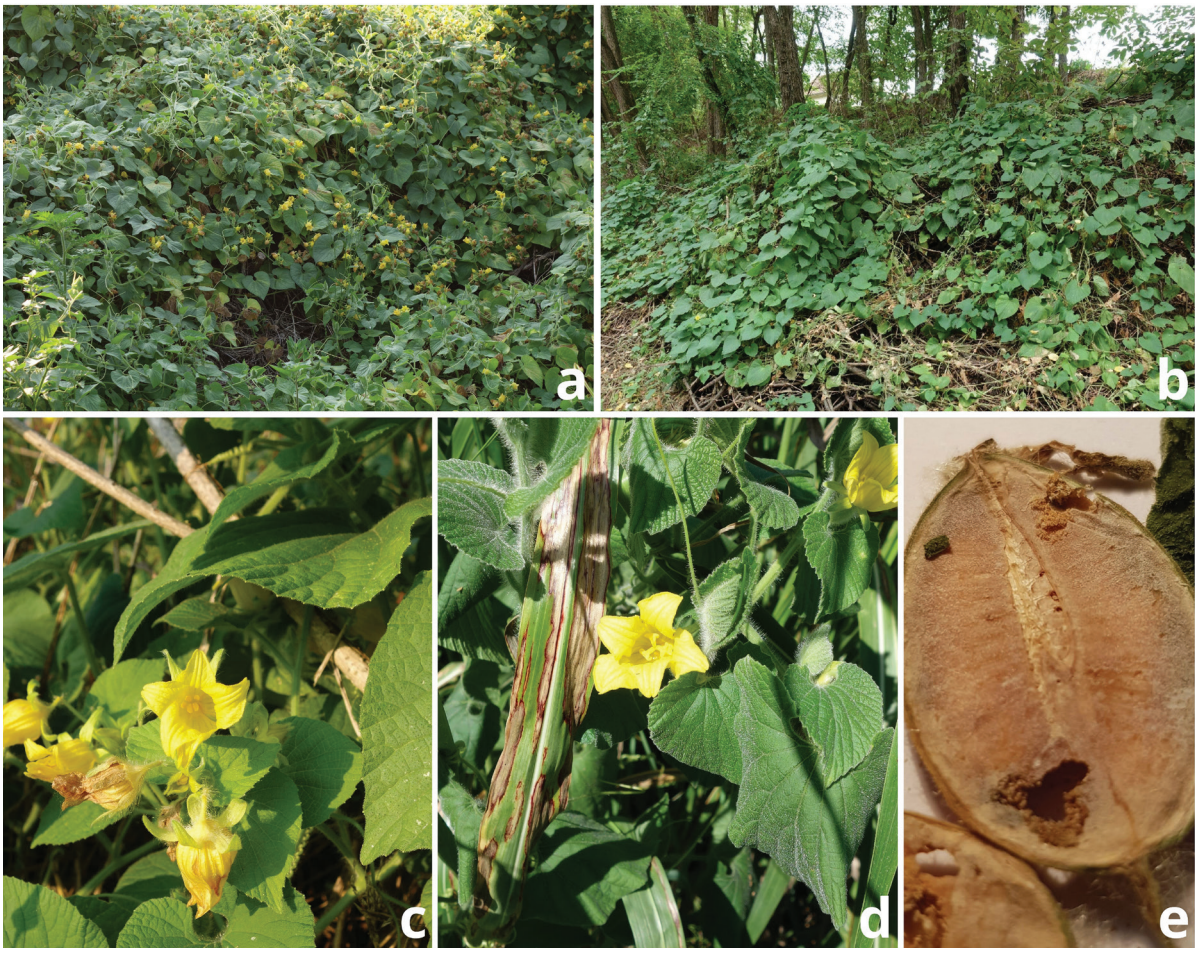

Figure 2. *Thladiantha dubia* Bunge. population in an abandoned yard in village Medinci (a), population along the road in village Zvonimirovo (b), male flowers (Medinci) (c), female flowers at Lateral Channel Adžamovka (d), longitudinal section of a parthenocarpic fruit from Lateral Channel Adžamovka (e) (Photos: D. Prlić, M. Doboš and N. Koletić).

powerplant. The population was also spreading into the arable field, where it was most abundant in the vicinity of the abandoned house and adjacent greenhouses (Fig. 3c, d), occupying ca. 600 m^2, with coverage exceeding 90%. Along ca. 250 m of the channel bank, coverage of *Th. dubia* was ca. 80% and the species was climbing over *Sambucus nigra* L., *Cornus sanguinea* L., *Arctium lappa* L., *Rosa canina* L. and invasive *Helianthus tuberosus* L. In general, vegetation in this locality was similar to that of previous localities, with a high proportion of nitrophilous, ruderal and weed species, as well as aliens. The majority of the species are characteristic of the class *Epilobietea angustifolii* Tx. et Preising ex von Rochow 1951, such as *Echinocystis lobata*, *Humulus lupulus* L., *Helianthus tuberosus*, *Calystegia sepium* (L.) R. Br. and *Urtica dioica*. Furthermore, *Chenopodium album*, *Artemisia verlotiorum* Lamotte and *Leersia oryzoides* (L.) Sw. were recorded, as well as alien *Parthenocissus quinquefolia* (L.) Planchon and invasive *Abutilon theophrasti* and *Sorghum halepense* (L.) Pers.

To conclude, regarding the habitats occupied by *Th. dubia*, a situation found in other European countries is very similar. This species is usually reported growing in shrubs, along railways, riverbanks, in maize fields, on the borders of vineyards and landfills (Chrtková 1983, Leute & Sembach 1984, Mosyakin & Yavorska 2002, Święs & Wrzesień 2003).

Regarding the reproductive biology, the species is dioecious and entomophilous and the pollination is closely related to its specific pollinator, a tiny wild bee of the genus *Ctenoplectra* (family *Apidae*), absent from Europe according to Atlas Hymenopotera (2021). Female flowers of *Th. dubia* produce oil instead of nectar, which is not attractive for European pollinators. Kuluev et al. (2019) argued that native bees, bumblebees and wasps pollinating the *Cucurbitaceae* (cucumbers, melons and pumpkins) usually do not notice the flowers of the *Th. dubia* plants. On the other hand, mostly male populations were recorded across Europe so far (Gribel 2020), which is another reason why vegetative propagation via tubers is predominant over the propagation by fruits and seeds at least outside the native range of *Th. dubia* (Tokarev & Ageeva 2013). Even when both sexes exist in a population and are visited by honey bees, only a small number of fruits are developed, since large bushes are mainly represented by a single clone of the male or female plant, thus disabling the abundant pollination and fertilisation (Kuluev et al. 2019). Furthermore, the suitable temperature range for seed germination is rather high, from 25 to 35°C (Zhao et al. 2013).

The majority of the Croatian populations are female, which is quite rare in Europe, wherefrom mostly male plants were reported so far (Gribel 2020). However, in these populations, we noticed rather frequent development of fruits, while section and inspection of ripe red fruits from Lateral Channel Adžamovka and Savica revealed no seeds (Fig. 2e). This can be explained by parthenocarpy, a development of fruits without fertilisation, where fruits resemble a normally produced fruit but are seedless. Parthenocarpy is not an unusual phenomenon in *Cucurbitaceae* and has been widely used in agricultural production. It is becoming an essential trait for off-season greenhouse production of *Cucurbita pepo* L. and *Cucumis sativus* L., promoted by auxins (De Ponti & Garretsen 1976) and was observed in melon and squash production in non-heated greenhouses during the cool season in Israel (Rylski & Aloni 1991). Parthenocarpic cultivars can be grown in greenhouses and the field without staminate flowers and also increase fruit set under unfavourable pollination conditions (Le Deunff et al. 1994, Robinson & Reiners 1999).

Although the species was not considered a garden plant earlier (Matulec 2006, Alegro et al. 2010), two of our new records are most likely of garden origin. On the new locality near Lateral Channel Adžamovka, the plant might have been discarded on a wild landfill or might have come on wheels or caterpillars of the machines maintaining the embankment.

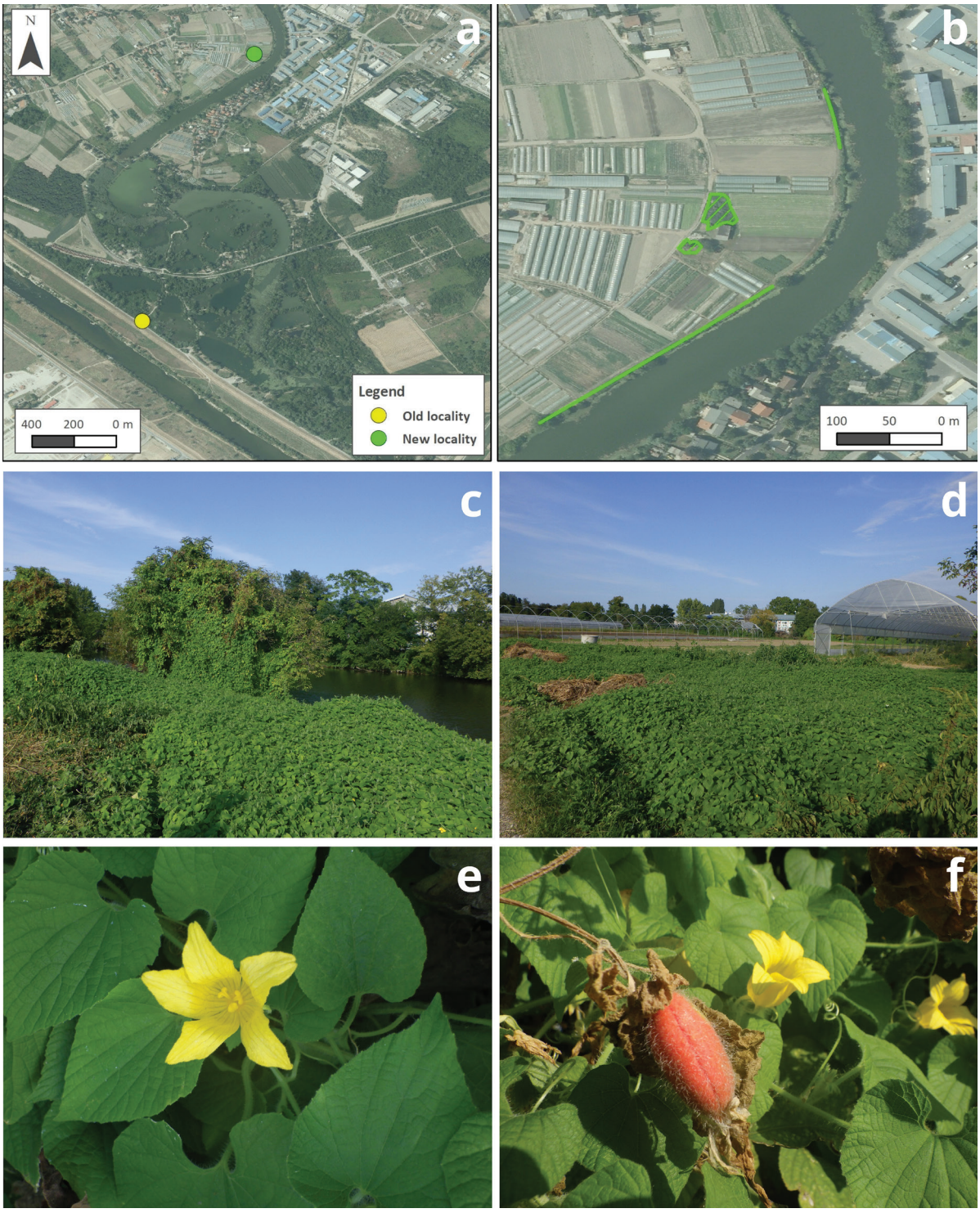

Figure 3. *Thladianta dubia* on Savica: distribution map (a), detailed map of the new locality (b), typical habitats dominated by *Th. dubia* (c, d), female flower (e), fruit (f) (Photos: A. Rimac).

According to the Croatian national system of classification of alien flora proposed by Mitić et al. (2008), *Th. dubia* can be classified as a naturalized, non-invasive alien weed. From previous findings and our research, it can be concluded that Croatian populations are self-sustaining for a period long enough to experience extreme climatic events in the occupied area and reproduce vegetatively by tubers without the direct intervention of people. Furthermore, at least some of them have persisted over ten years and therefore meet the proposed temporal qualifier of the naturalization as well. As the species occupies and can be undesirable on agricultural, urban and suburban areas and banks of water bodies, it can be classified as a weed, as well.

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