



Contribution to the flora of the Maltese Islands: *Euphorbia* subg. *Chamaesyce* and *Euphorbia exigua* s. l. (Euphorbiaceae)

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Abstract

The identity and the taxonomic treatment of the species belonging to *Euphorbia* subg. *Chamaesyce* occurring on the Maltese Islands were not adequately studied both in historical and recent literature. Apart from the native sand dune species *Euphorbia peplis*, all records have been previously attributed to the cosmopolitan weedy species *E. maculata* and *E. chamaesyce*. This work provides the first taxonomic synopsis based on the examination of 53 specimens collected from Malta and Gozo between 2014 and 2017. The study ascertained the occurrence of six species, of which *E. serpens*, *E. prostrata* and *E. hypericifolia* are first reported from the Maltese Islands. Discussion on the taxonomy, origin, ecology and invasiveness of these species is provided, together with photos and an identification key. Moreover, taxonomic studies on *E. exigua* s. l., belonging to subg. *Esula*, sect. *Exiguae*, have been carried out on Maltese material and discussed. *E. exigua* var. *pyncnophylla*, originally described as endemic of the Maltese Archipelago and recorded afterwards on the Sicilian island of Lampedusa, bears no significant morphological trait which allows to clearly distinguish it from the nominal variety. No differences in fruit and seed morphology resulted when the two varieties were compared and the slight differences present in the habit of the plant and the arrangement of leaves has been judged to be of ecotypic origin, hence justifying the lumping of this variety into the single and variable taxon *E. exigua*.

Key words: *Euphorbia*, *Chamaesyce*, *Euphorbia exigua*, Flora of Malta, Mediterranean Flora

Introduction

Euphorbia Linnaeus (1754: 450) is a large and highly diversified genus represented by more than 2000 species worldwide (Heywood *et al.* 2007), ranging from succulent large trees such as *E. ingens* Meyer ex Boissier (1862: 87) to small prostrate herbaceous annuals, for example *E. peplus* Linnaeus (1753: 184). Smith & Tutin (1968) enumerate 105 *Euphorbia* species (and other 27 species of uncertain taxonomic status) plus 20 infraspecific taxa from Europe, whereas according to the Euro+Med Plantbase (2006-2017) 280 *Euphorbia* species occur in Europe and the Mediterranean region.

Sixteen species are recorded from Malta including the endemic species *Euphorbia melitensis* Parlato (1869: 478) and the Pelagian-Maltese subendemic *E. exigua* Linnaeus (1753: 184) var. *pyncnophylla* K.U. Kramer & Westra in Kramer *et al.* (1972: 59) (Minissale *et al.* 1988).

The genus originated in the Old World with many radiations in the New Worlds (Yang *et al.* 2012). According to the molecular studies carried out by Bruys *et al.* (2006), Riina *et al.* (2013) and Peirson *et al.* (2013), *Euphorbia* is at present divided into four subgenera: the ancestral subg. *Esula* Persoon (1807: 18), subg. *Athymalus* Necker ex Reichenbach (1790: 353), subg. *Euphorbia* and subg. *Chamaesyce* Rafinesque (1817: 119). This study mainly focuses on subgenus *Chamaesyce* which is the largest with its 600 species. It is characterised by non-succulent, leafy plants, but adapted to arid conditions due to the loss of monopodial branching and presence of C4 pathways (Pahlevani & Riina 2011, Yang *et al.* 2012). The species of this subgenus recorded from Malta are *E. peplis* Linnaeus (1753: 455), *E. maculata* Linnaeus (1753: 455) and *E. chamaesyce* Linnaeus (1753: 455) (Sommier & Caruana Gatto 1915, Borg 1927, Lanfranco 1969, Haslam *et al.* 1977, Weber & Kendzior 2006, Mifsud 2002-2014, Casha 2013).

The only native species reported from the Maltese Islands is the psammophilous species *E. peplis*. At least twelve populations of *E. peplis* were recorded from sand dune locations or nearby fields (Grech Delicata 1853, Sommier & Caruana Gatto 1915, Borg 1927, Haslam *et al.* 1977, Cassar & Stevens 2002, Tabone 2007, Mifsud 2002–2014), most

of which have made way for touristic or recreational development leading to a close extinction of the species from the Maltese Islands. *E. chamaesyce* has been reported to be the dominant species in urban areas, already recorded by Zerapha (1827) and reported as frequent by Sommier & Caruana Gatto (1915), hence indicating that it had been growing on the Maltese Islands for a rather long time. *E. maculata* was first recorded in 1913 by John Borg and was considered as a recent introduction by Sommier & Caruana Gatto (1915). This was also the opinion of Borg (1927) but adding that he observed it in Attard, Lia, Mosta, Floriana and Boschetto and so spreading quickly. However, during the study of the Maltese flora, the present author had found a different taxonomical interpretation and new species and consequently a study on plants belonging to the subg. *Chamaesyce* group have been carried out during the last three years.

Furthermore, the Maltese-Pelagian endemic *E. exigua* var. *pyncophylla* (subg. *Esula*, sect. *Exiguae* [Geltman] Riina & Molero in Riina *et al.* [2013: 337]) which was originally described as a form under the taxon *E. exigua* var. *retusa* f. *imbricata* Sommier & Caruana Gatto (1915: 258), has then been treated as a variety by Kramer *et al.* (1972), and elevated at the species level by Brullo & Brullo (2009). Preliminary morphological studies on *E. exigua* s. l. occurring on the Maltese islands has been conducted to investigate if the distinction of the endemic variety is justified, when considering that other infraspecific taxa have been all lumped up and hence synonymised with *E. exigua* (Euro+Med (2006–2017)).

Material and methods

Fifty-three specimens collected from different sites in Malta and Gozo, whose collection details are given in Table 1, have been examined. Representative specimens were later deposited at the National Museum of Natural History, Mdina, and Argotti Botanic Gardens [ARG] Malta. Their identification was based on eleven diagnostic morphological characters (listed in Table 2) obtained from standard keys and relevant publications namely Pignatti (1982), Smith & Tutin (1968), Jeanmonod & Gamisans (2007), Pahlevani & Riina (2011), Raab-Straube & Raus (2015). The most diagnostic characters are the bracts, fruit and seeds, and to a lesser extent the shape of the leaves, pilosity of the plant and the colour of the nectary glands. An identification key was then adopted and used to identify the material collected from the Maltese islands (Table 1). Characters were always checked on fresh material or up to 48 hours from collection. Mature fruit capsules were placed in a closed glass container with 20 g of Silica gel in a warm location which provided suitable conditions for dehiscence and availability of the seeds. Macrophotography using a Canon EOS 750D was used to provide close-up images of the seeds, while a stereo microscope was used to photograph and measure the seeds using the graphic measurement software Pixmetre (V5.9). Statistical measurements were carried out on a sample size of at least 15 seeds. Accepted names and synonyms were followed using the Euro+Med plantbase (2006–2017) which treats *Chamaesyce* as a subgenus, although the genus rank is broadly accepted by many authors (e.g., Benedi & Orell 1992, Pahlevani & Riina 2011, Tison *et al.* 2015, Sciandrello *et al.* 2016). In this overview, brief notes on the origin, distribution, ecology, invasiveness, and the taxonomy are given for each species whose occurrence has been ascertained in the Maltese Islands; data and observations refer to Maltese populations.

The species identified have been compared with local floras and local floristic works published to date to determine if any of the resulting species are new for the Maltese Islands. The following literature or sources were consulted: Sommier & Caruana Gatto (1915), Borg (1927), Lanfranco (1969), Haslam *et al.* (1977), Weber & Kendzior (2006), Tabone (2007 2008), Casha (2013), Bonnett & Lanfranco (2015) and Euro+Med plantbase (2006–2017). Besides that, collections at [ARG] have been examined on March 2018 for the same purpose.

The morphology of seeds is highly diagnostic for *Euphorbia* species (Smith & Tutin 1968, Pahlevani & Ahkani 2011, Silva *et al.* 2015), hence the seeds of eight collections of *E. exigua* var. *exigua* and eight collections of var. *pyncophylla* have been compared morphologically to determine if there were significant differences to support any taxonomic distinction between them. In addition, observations of the habit and habitat of these collections were taken to understand if there is a relationship such as ecotypism, or to find out if both varieties can be found growing in the same site and microhabitat.

TABLE 1. Date, location and habitat of the 53 specimens (EUP01-EUP53) collected from the Maltese Islands.

Spcmn. Code	Collection Date	Locality	Toponym	Habitat	Species
EUP01	01/09/2014	Għasri (Gozo)	Villa Almonds (San Pietru's area)	Private garden	<i>serpens</i>
EUP02	01/09/2014	Għasri (Gozo)	Hamlets Farm Houses (Għammar area)	Private garden	<i>serpens</i>
EUP03	02/09/2014	Qawra	Kennedy Grove	Traffic island and paved curb	<i>serpens</i>
EUP04	05/09/2014	Ta' Sannat (Gozo)	Street and open space near ta' Cenc Restau	Road side	<i>serpens</i>
EUP05	06/09/2014	Salini	Small valley aside Salini Hotel	Limestone rock at valley side	<i>chamaesyce</i>
EUP06	09/09/2014	Salini	Tas-Sikkursu canal	Disturbed ground in a pathway	<i>serpens</i>
EUP07	09/09/2014	Baħar iċ-Ċagħaq	Xatt il-Palm	Paved curb	<i>serpens</i>
EUP08	14/09/2014	Victoria (Gozo)	Road close to Wied Zejta (100m away from L	Road side	<i>serpens</i>
EUP09	24/09/2014	Floriana	Close to War monument in round about	Paved curb, road sides and top soil of embellishment areas	<i>maculata</i>
EUP10	24/09/2014	Santa Venera	Triq il-Batterija	Paved curb and roadsides	<i>serpens</i>
EUP11	30/09/2014	Baħar iċ-Ċagħaq	Road near the Evangelist chapel	Private paved terrace and roadside down the road	<i>prostrata</i>
EUP12	20/06/2015	Baħar iċ-Ċagħaq	White Rocks area	Wasteground (dumped construction material)	<i>prostrata</i>
EUP13	14/09/2016	Lija	San Anton gardens	Gaps between flagstones	<i>serpens</i>
EUP14	17/09/2016	Siġġiewi	Wied Hešri	Dry valley floor	<i>serpens</i>
EUP15	17/09/2016	Siġġiewi	Wied Hešri	Dry valley floor	<i>maculata</i>
EUP16	17/09/2016	Siġġiewi	Wied Hešri	Dry valley floor	<i>chamaesyce</i>
EUP17	17/09/2016	Siġġiewi	Wied Hešri	Dry valley floor	<i>prostrata</i>
EUP18	19/09/2016	iż-Żebbuġ (Gozo)	Triq ta' M'forn (near ta' Frenc rest.)	Dirt at side of road	<i>serpens</i>
EUP19	20/09/2016	iż-Żebbuġ (Gozo)	Main square opposite church	In a flower pot, humid soil	<i>serpens</i>
EUP20	24/09/2016	Mellieħa	Paradise Bay Hotel, Ċirkewwa	Embellishment area	<i>hypericifolia</i>
EUP21	24/09/2016	Mellieħa	Paradise Bay Hotel, Ċirkewwa	Embellishment area	<i>serpens</i>
EUP22	24/09/2016	Mellieħa	Paradise Bay Hotel, Ċirkewwa	Embellishment area	<i>prostrata</i>
EUP23	24/09/2016	St. Paul's Bay	Main road to Xemxija Bay	Paved curb	<i>serpens</i>
EUP24	25/09/2016	iż-Żebbuġ (Gozo)	Żebbuġ Primary School	Paved curb	<i>serpens</i>
EUP25	03/10/2016	Għasri (Gozo)	Road aside Wied il-Għasri and chapel	On disturbed parts of the road	<i>serpens</i>
EUP26	04/10/2016	Mellieħa	I/o Għnien Ingraw (Triq it-Tamuntana)	Footpath near farm house	<i>serpens</i>
EUP27	05/10/2016	Munxar (Gozo)	Road from Munxar to Sannat	Road side	<i>serpens</i>
EUP28	05/10/2016	Ta' Sannat (Gozo)	Square in front of Parish church	Tarmaced ground and roadsides	<i>serpens</i>
EUP29	09/10/2016	Dingli	Road triq nzul ix-xemx	Road side	<i>serpens</i>
EUP30	09/10/2016	Buskett	Pathway leading to public convenience	Road side	<i>serpens</i>
EUP31	11/10/2016	iż-Żebbuġ (Gozo)	Primary school and playing fields	Paved curb, embellishment soil	<i>maculata</i>
EUP32	11/10/2016	iż-Żebbuġ (Gozo)	Primary school and playing fields	Paved curb, embellishment soil	<i>serpens</i>
EUP33	13/10/2016	Ħamrun	Blata l-Bajda area (Anton Buttigieg statue and Spencer Gardens)	Roadside, paved curb and embellishment soil	<i>serpens</i>
EUP34	13/10/2016	Naxxar	Triq tal-Labour and playing fields	Roadside and paved areas	<i>serpens</i>
EUP35	13/10/2016	Bugibba	Main square and adjacent roads	Large planters	<i>hypericifolia</i>
EUP36	13/10/2016	Bugibba	Main square and road along promenade	Roadside and paved areas	<i>serpens</i>
EUP37	13/10/2016	Saint Paul's Bay	Xemxija promenade	Paved curb and roadsides	<i>serpens</i>
EUP38	16/10/2016	Munxar (Gozo)	Playing fields and square opposite parish c	Roadside and paved areas	<i>serpens</i>
EUP39	25/10/2016	Kalkara	Few streets close to church and coastroad	Roadside and paved areas	<i>serpens</i>
EUP40	25/10/2016	Żabbar	Streets near Hompesch arch	Curb and embellishment soil	<i>serpens</i>
EUP41	01/11/2016	Saint Julians	Several roads including coast road	Curb and paved areas	<i>serpens</i>
EUP42	03/11/2016	Lija	Wied Ħal-Lija	Footpath on open ground	<i>maculata</i>
EUP43	16/10/2017	Marsa	Ship Building Area	Disturbed area	<i>serpens</i>
EUP44	14/11/2017	Sliema	Capua Palace Hotel	Planters	<i>serpens</i>
EUP45	14/11/2017	Sliema	Capua Palace Hotel	Planters	<i>maculata</i>
EUP46	22/11/2017	Rabat	Entrance to Mdina (car park and garden)	Roadsides, paved curb, embellishment soil	<i>serpens</i>
EUP47	23/11/2017	Attard	Road close to Corinthia (near parking)	Paved curb	<i>maculata</i>
EUP48	23/11/2017	Qormi	Main road and garden near Pavi supermarket	Paved curb, roadside and top soil of a nearby garden	<i>serpens</i>
EUP49	23/11/2017	Birżebbugia	Pavement at the entrance to Għar Dalam museum	Paved curb	<i>serpens</i>
EUP50	25/11/2017	Għarb (Gozo)	Ta' Pinu Shrine	Parking lot and roadside	<i>serpens</i>
EUP51	26/11/2017	Għajn Tuffieħa	Golden Sands SAS Hotel	Planters, embellishment areas	<i>hypericifolia</i>
EUP52	30/11/2017	iż-Żebbuġ (Gozo)	Marsalforn parking and road beside valley	Roadside and open ground	<i>serpens</i>
EUP53	16/12/2017	Victoria (Gozo)	Garden inside the Ministry of Gozo premises	Paved curb and small garden	<i>serpens</i>

TABLE 2. Comparison of the diagnostic characters of *Euphorbia serpens*, *E. chamaesyce*, *E. prostrata*, *E. maculata* and *E. hypericifolia* from material collected and examined from the Maltese Islands.

Character	<i>Euphorbia serpens</i>	<i>Euphorbia chamaesyce</i>	<i>Euphorbia maculata</i>	<i>Euphorbia prostrata</i>	<i>Euphorbia hypericifolia</i>
Number code of the examined material	EUP:01–04, 06, 07, 08, 10, 13, 14, 18, 19, 21, 23–30, 32, 33, 34, 36–41, 43, 44, 46, 48–50, 52, 53	EUP:05, 16	EUP:09, 15, 31, 42, 45, 47	EUP:11, 12, 17, 22	EUP:20, 35, 51
Habit	Prostrate	Prostrate	Prostrate	Prostrate	Suberect to ascending
Stipule shape	Broadly deltate with minutely lacerated apex	Fimbriate with 2–3 linear branches	Fimbriate with 2–3 linear branches	Narrow triangular, longer than its width, usually acute-subulate with tiny branches at the base	Deltate, more or less as long as wide, with finely denticulate margin
Leaflet shape	Broadly ovate to suborbicular	Broadly ovate, asymmetrical	Oblong-elliptic	Broadly elliptic to lanceolate	Narrowly elongated oblong-elliptic
Leaflet margin	Entire	Crenulate	Minutely crenate-denticulate	Crenate denticulate	Crenate denticulate
Macula on leaflet	Absent	Small dots or short narrow stripe	Usually with a distinct large spot or flame-like marking	Absent	Absent
Leaflet indumentum	Glabrous	Glabrous	Scantly pilose at the abaxial surface	Densely pilose below, sparse above	Glabrous
Leaflet apex	Obtuse-truncate, distinctly retuse	Truncate, retuse or emarginate	Obtuse	Obtuse	Obtuse
Nectary glands colour	White with dark red-maroon glands	White fading into olive green to pale peach glands	Pinkish-white with dark red-maroon glands	White with peach-red glands	White or pink with miniscule (rudimentary) nectary glands
Fruit surface	Smooth with fine tubercles on the keel	Smooth with fine tubercles on the keel	pilose on the keel	Entirely pilose	Smooth with fine tubercles on the keel
Texture of seed testa	Smooth with fine tubercles on the keel	Smooth with three longitudinal narrow slits	Pitted, with 2–3 transversal ridges	Pitted, with 6–7 transversal ridges	Smooth to obscurely (shallowly) wrinkled
Seed length (mm) [n= sample size]	(0.85–)1.09(–1.25) [n=69]	(1.15–)1.24(–1.33) [n=31]	(0.85–)0.95(–1.05) [n=45]	(0.91–)1.03(–1.18) [n=67]	(0.84–)0.91(–0.96) [n=31]
Seed L/W ratio	1.68	1.56	1.65	1.88	1.43
Habitat	Urban	Rural to semi-urban	Urban	Urban to semi-urban	Urban

Results

Euphorbia subg. *Chamaesyce*

The characters of the examined specimens of *Euphorbia* subg. *Chamaesyce* are reported in Table 2. Six taxa have been identified; three of them result to be new to the Maltese Islands. The species of *Euphorbia* subg. *Chamaesyce* occurring on the Maltese islands are the following:

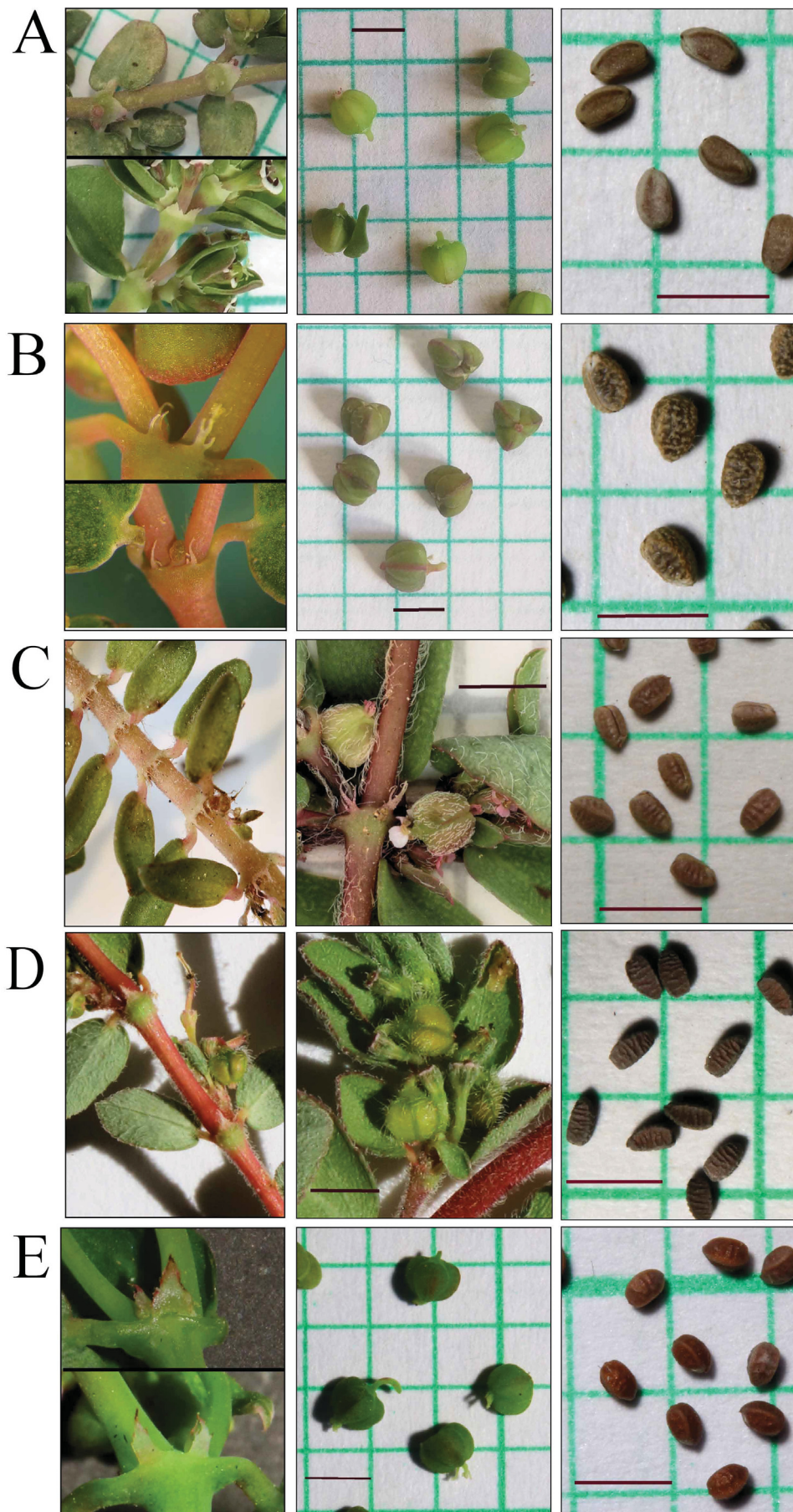


FIGURE 1. Photos of stipules (left), fruit capsules (centre) and seeds (right) of: A: *Euphorbia serpens* (EUP03); B: *Euphorbia chamaesyce* (EUP05); C: *Euphorbia maculata* (EUP15); D: *Euphorbia prostrata* (EUP 11); E. *Euphorbia hypericifolia* (EUP 20). Scale bar = 2mm.

***Euphorbia serpens* Kunth (1817:52) [Fig.1A]**

Origin: South and Central America but it has been spread extensively and became a pantropical weed (Smith & Tutin 1968, Steinmann *et al.* 2016, Hyde *et al.* 2017, Tropicos 2017).

Occurrences in Europe and the Mediterranean area: Israel, Turkey (European part), Aegean islands, Crete, Greece, Germany, Belgium, Italy, France, Corse, Spain, Balearic Islands, Portugal, Azores, Canary Islands (DAISIE 2008, Euro+Med 2006–2017).

Introduction in Malta: Remote and uncertain, but presumably as a contaminant in soil of imported agricultural and horticultural products in the past.

Habitat: Naturalised in urban areas and commonly found between flagstones of paved curbs or paved ground in city squares, roadsides, topsoil of traffic islands, public gardens and parks, planters and sometimes in waste ground of urban areas. It is estimated to represent at least 80% of the *Euphorbia* spp. in urban areas in Malta.

Invasiveness: Widespread and locally invasive in urban areas but least concern for natural habitats where it has not yet been observed to occur else for very casual examples.

First record: Not previously recorded, but probably confused with *E. chamaesyce* since its first report by Zerapha (1827). Previous records of *E. chamaesyce* from urban areas are most likely to refer to *E. serpens*. According to the examination of the few voucher specimens of *Euphorbia* sp. located at [ARG] on February, 2018, it resulted that none corresponded to *E. serpens* or *E. chamaesyce*.

Flowering: June–December (can persist all year round when winters are mild, as it was observed in the period 2015–2016).

Morphological observations: Easily identified from its glabrous fruit (the entire plant is glabrous), the unpitted smooth seeds bearing a narrow longitudinal slit and its rooting at the leaf nodes especially if in contact with humid soil. Moreover, their gently curved leaf rachis with numerous, opposite and closely packed, but evenly spaced leaflets which gradually decrease in size up the leaf, form mats of unique elegant symmetrical patterns by which the trained eye could tell the species even without examining finer details of the fruit and seeds. However the length and the leaf arrangement is very variable and consequently exhibit itself in a dimorphic habit; with some examples shifting away from the normal aspect and deceitfully look as an *E. chamaesyce* owing to a habit with shorter leaves (4–5 cm) and with few variably-sized leaflets. However the important diagnostic characters of the fruit, seed and stipules are constant. According to Tison & Foucault (2014) two varieties are recognised; var. *serpens* with entire deltate stipules, and var. *fissistipula* Thellung (1907: 755) with lacerated or deeply lobed stipules. In Malta, both varieties occur, and these two taxa do not seem to deserve a separate taxonomic rank (Pignatti 1982, Pahlevani & Riina 2011, Tison *et al.* 2015, Euro+Med 2006–2017).

Chromosome number: $2n = 22$ (Benedi & Orell 1992).

***Euphorbia chamaesyce* [Fig.1B]**

Euphorbia massiliensis DC. in Candolle & Lamarek (1815: 357); *Tithymalus nummularius* Lamarek (101: 1779)

Origin: Native to the south and central Europe and the entire Mediterranean region (Smith & Tutin 1968, Euro+Med 2006–2017).

Occurrences in Europe and the Mediterranean area: Native throughout the Mediterranean-Macaronesian region and south east Europe, but regarded as an introduced species in central Europe namely in Ukraine, Czech Republic, Slovakia, the Netherlands, Germany, Austria, Switzerland, Belgium, Portugal and Balears according to DAISIE (2008) and Euro+Med (2006–2017).

Habitat: Rocky ground at valley sides and dry exposed valley beds.

First record: Recorded in historical Maltese literature since Zerapha (1827) from urban areas, but it must have been confused with *E. serpens* (see discussion above). The first substantiated record of *E. chamaesyce* in natural habitats from Malta is reported in this account from a small valley side near Salini on the 6th September 2014.

Flowering: June–October.

Morphological observations: Two varieties are described and mentioned in some local floras (e.g., Haslam *et al.* 1977): var. *chamaesyce* and var. *massiliensis* (DC.) Thellung (1917: 457). They differ in the shape of the nectary glands (see key below) and only var. *chamaesyce* has been identified from the material examined. Many authors treat these two taxa as synonyms.

Chromosome number: $2n = 42$ (Benedi & Orell 1992)

Euphorbia maculata [Fig.1C]

Origin: eastern and northern America, but introduced in south America, Europe, Asia and north Africa (Smith & Tutin 1968, Euro+Med 2006–2017, Steinmann *et al.* 2016, Tropicos 2017).

Occurrences in Europe and the Mediterranean area: An alien species occurring throughout entire Europe according to DAISIE (2008) but according to Euro+Med (2006–2017) it occurs only in Crete, Ukraine (including Crimea), France, Spain, and Portugal.

Introduction in Malta: Imported from horticulture products, namely potted trees and large plants. Given that it has been first recorded by Borg in 1913 (Sommier & Caruana Gatto 1915), it can be assumed that it had been introduced in Malta sometime close to that date.

Habitat: Paved curbs and between flagstones in city squares, roadsides, less frequent in public gardens, parks or planters. Naturalised in urban and suburban areas, locally frequent but generally not common.

Invasiveness: Spreading readily in urban areas but not alarming - not observed in natural habitats.

First record: 1913 by John Borg cited by Sommier & Caruana Gatto (1915)

Flowering period: June–November.

Morphological observations: The species is well known and distinct by its deep red markings on the leaf, hence the epithet *maculata*. However this marking gradually disappears in late-growing individuals, typically from October onwards, and is less prominent in plants which are in the shade.

Chromosome number: $2n = 42$ (Benedi & Orell 1992).

Euphorbia prostrata Aiton (1789: 139) [Fig.1D]

Origin: North America but nowadays widespread as a pantropical and subtropical weed after being introduced in many parts of the Old World (Smith & Tutin 1968, Steinmann *et al.* 2016, Hyde *et al.* 2017, Tropicos 2017)

Occurrences in Europe and the Mediterranean area: Throughout most of south Europe (from the Azores and the Canary islands to Crete and Israel) but apparently missing in north Africa and north Europe (Smith & Tutin 1968, Euro+Med 2006–2017, DAISIE 2008).

Introduction in Malta: Likely through import of potted plants for horticulture purposes.

Habitat: Roadsides, curbs and paved ground, naturalising locally in urban areas, scarce, but possibly misidentified with other closely related species such as *E. serpens*.

Invasiveness: Casual occurrence and naturalised locally in few areas but likely increasing where it is found. Invasive potential low, not observed in natural ecosystems.

First record: Not previously recorded, with the exception of Weber & Kendzior (2006) who reported it by mistake (illustration in fact shows a glabrous plant of *E. serpens*). Observed by the present author at Bahar iċ-Ċaghaq on 18 September 2014.

Flowering: June–November.

Morphological observations: Density of pilosity varies, but always present as a longitudinal band at the corners of the fruit leaving a glabrous area in between. The seeds with 6–7 transversal ridges is very distinctive for the species.

Chromosome number: $2n = 18$ (Benedi & Orell 1992).

Euphorbia hypericifolia Linnaeus (1753: 454) [Fig.1E]

Origin: tropical and subtropical America (Steinmann *et al.* 2016, Tropicos 2017).

Occurrences in Europe and the Mediterranean area: Aegean islands, Greece, Crete, Belgium (Raab-Straube & Raus 2015, Euro+Med 2006–2017), NE Sicily (Sciandrello *et al.* 2016) and Spain (Raab-Straube & Raus 2015).

Introduction in Malta: contaminated soil of imported plants or trees used to decorate roads, traffic islands, hotels and public spaces.

Habitat: Naturalised in soil for embellishment at roadsides and traffic islands, large planters, outdoor gardens and terraces. So far not observed on or beside curbs or paved ground.

Invasiveness: Weakly invasive, spread readily within the area it occurs but it is not able to disperse. Increased records during last three years are likely cases of new introductions. Not yet encountered in natural ecosystems, strictly urban species.

First record: The present record (Marsa, October 2009) is the first one for the Maltese islands.

Distribution: Scattered individuals in traffic islands (Manuel Dimech Street, Qormi), soil of embellished areas (e.g. il-Menqa, Marsa; Paradise Bay Hotel, Mellieħa) and large potted plants (Dragonara, St. Julians)

Flowering: June–December.

Morphological observations: Suberect to erect habit with glabrous leaves and flowers. Leaflets variable in shape and of little diagnostic value, ranging from broadly ovate to narrow-lanceolate with a shallowly serrulate margin, usually lacking red markings. It is closely related to *E. nutans* Lagasca (1816: 17) and possibly confused with it locally, although the presence of both species in Malta is not excluded. *E. hypericifolia* differs from *E. natans* in having fruit up to 1.4 mm high and green (1.5–2.0 mm reddish or green in *E. nutans*); completely glabrous (slightly pubescent at the leaf nodes and base of stem in *E. nutans*) and usually some stipules are deltate and conspicuous (mostly vestigial or linear in *E. nutans*).

Chromosome number: $2n = 42$ (Benedi & Orell 1992).

Euphorbia peplis

Origin: Native to the south and central Europe and the Mediterranean-Macaronesian region (Smith & Tutin 1968, Euro+Med 2006–2017).

Occurrences in Europe and the Mediterranean area: Throughout all the Mediterranean region and south Europe including the United Kingdom and Ukraine (Euro+Med 2006–2017). Considered as an alien occurrence in Azores and Belgium (Hyde *et al.* 2017).

Habitat: Drift line zone of sand dunes sometimes escaping in sandy soil of neighbouring fields. This species is very rare and facing extinction in Malta where only two sporadic occurrences in two sites have been reported in the last 10 years, one at Ramla tat-Torri in Marfa, Mellieħa by Tabone (2007) and a new population observed by the author in Comino on June, 2012, both of which have not been seen again in the last six years. Maltese populations have been and are greatly disturbed with sand cleaning activities, over-trampling during summer season and illegal sand dune reclamation by operations related to touristic activities as for example that witnessed by the author at Santa Marija Bay, Comino during the end of Spring of 2017.

First record: Zerapha (1827) without any location, while Grech Delicata (1853) reports it from Marsaxlokk.

Flowering: June–October.

Morphological observations: The population examined from Comino shows typical morphological traits.

Chromosome number: $2n = 24$ (Benedi & Orell 1992)

Key to the species of *Euphorbia* subg. *Chamaesyce* occurring in Malta (bold type) and closely related species

- 1 Plants suberect or procumbent; leaflets more than 16 mm long, well-spaced2
from each other along the rachis3
- Plants completely prostrate; leaflets less than 15 mm long, close to each other3
- 2 Plant completely glabrous ; fruit up to 1.4 mm long; stipules developed *E. hypericifolia*
- Plant scantily hairy at leaf nodes and base of plant ; fruit 1.5–2.0 mm long; stipules rudimentary, inconspicuous, linear and short ..
..... *E. nutans*
- 3 Fruit glabrous ; seeds smooth4
- Fruit scantily villous, usually near the keel ; seeds rugose or ridged7
- 4 Capsule >3.5 mm long; seeds > 2.5 mm long; habitat sand dunes *E. peplis*
- Capsule <3 mm long; seeds < 2 mm long; habitat not sand dunes5
- 5 Leaves denticulate at the upper half, elongated ; stipules filiform *E. humifusa*
- Leaves entire, rounded, slightly longer than wide; stipules deltate in outline *E. serpens* s.l. >> 6
- 6 Stipule entire, deltate, scar-like **var. serpens**
- Stipule lacerated or deeply lobed **var. fissistipula**
- 7 Many leaves with conspicuous, central, elongated red markings *E. maculata*
- Leaves green or at most with a small or faded red spots or short stripe8
- 8 Fruit hairy on the keels only ; plant densely villous throughout *E. prostrata*
- Fruit hairy throughout or completely glabrous in rare cases ; plant glabrous or scantily hairy at the stem and leaf internodes9
- 9 Leaves oblong-lanceolate, circa twice as long as wide; seeds transversely grooved *E. maculata*
- Leaves more rounded-ovate (length:width <2) ; *E. chamaesyce* s.l.
seeds rugulose throughout 10
- 10 Nectary glands with an irregularly serrulate margin, wider than its length **var. chamaesyce**
- Nectary glands lobed with distinct sinuses, as long or longer than wide **var. massiliensis**

Euphorbia exigua

The detailed examination of the seeds of the two varieties of *Euphorbia exigua* (Figure 4), resulted in no significant differences between the two. The shape, colour, texture and size of the seeds were found to be similar, with very subtle and non-significant variations in the density of the papillae which do not appear specifically linked to any one of the two varieties in comparison. In general, the seeds are ash-grey with a light brownish tinge, measuring $(1.15\text{--}1.27\text{--}1.40) \times (0.72\text{--}0.81\text{--}0.94)$ mm in size, ovate-oblong with a subtruncate base and obtuse apex, having one longitudinal slit at the ventral side and a testa covered with tiny isolated rounded papillae, rarely two or three joined adjacently.



FIGURE 2. Individuals collected from Dingli Cliffs on 12/April/2014 with typical forms of *Euphorbia exigua sensu stricto* on the left, *E. exigua* var. *pycnophylla* on the right and intermediate forms in between.



FIGURE 3. *Euphorbia exigua* growing on arid rocky ground at Torre Salsa (Agrigento, S Sicily, 21/April/2014) attaining the same habit and form as var. *pycnophylla* Left: *in situ*; right: collection of few specimens over a graph paper (small gridboxes 2 mm/division; large gridboxes 2cm / box).

Discussion

The Maltese species belonging to *Euphorbia* subg. *Chamaesyce*

The results show a predominant occurrence of *Euphorbia serpens* in urban areas throughout the Maltese islands. The species prefers narrow cracks or gaps in pavement, roadsides, curbs and stoney paths. Although *E. serpens* was not previously recorded from Malta, it is presumed that most if not all of the previous records of *E. chamaesyce*, reported

as a frequent species in urban areas (Sommier & Caruana Gatto 1915, Borg 1927, Lanfranco 1969, Haslam *et al.* 1977, Weber & Kendzior 2006, Casha 2013, etc.), should be considered as misidentifications of *E. serpens*. Moreover, Weber & Kendzior (2006) report *E. prostrata* but the accompanying picture is clearly that of *E. serpens* causing further confusion about the species really occurring in the Maltese islands. *E. prostrata* and *E. hypericifolia* are here reported for the first time to occur on Maltese Archipelago, probably introduced in the last few decades.

The two populations of *E. chamaesyce* were found in natural ecosystems: one on a rocky bank of a small valley close to Salini (September 2014) and another in the dry valley bed of Wied Hēsri at Siggiewi (November 2010). The latter was found again four years later in a different area of the valley which was disturbed and full of dumped material. At least based on the former population in rocky ground, it is reasonable to assume that *E. chamaesyce* is native to the Maltese islands as it is reported in Sicily (Giardina *et al.* 2007) and the rest of Europe (Euro+Med 2006–2017). Noteworthy is the observation that both populations of *E. chamaesyce* had glabrous fruit, considering that the species usually have pilose fruit and only seldom it is found hairless (Smith & Tutin 1968, Pahlevani & Riina 2011, Tison & Foucault 2014). The var. *massiliensis* is reported in the Maltese Flora of Haslam *et al.* (1977) but its occurrence has not been confirmed. It is distinct by having a wider and much-lobed nectary glands (Jeanmonod & Gamisans 2007), but this morphology has not been observed in the material examined from Malta. Additionally, var. *massiliensis* is currently considered as a mere synonym of the species (Euro+Med 2006–2017, Tison *et al.* 2015).

The neophyte *E. hypericifolia* has been recently reported for the first time in NE Sicily by Sciandrello *et al.* (2016) and its spread in Europe has been reported by Raab-Straube & Raus (2015).

Taxonomical, morphological and ecological notes on *Euphorbia exigua sensu lato* on the Maltese Islands

Euphorbia exigua is a very variable species, as confirmed by the description of at least six varieties (ThePlantList 2013). The variety *pycnophylla* was described from Malta and differs from the type variety by the general habit and the shape, arrangement and size of the leaves, while as underlined by the authors themselves (Kramer *et al.* 1972), no distinction concerning the morphology of the fruits, seeds, nectary glands of the cyathium can be made. These are amongst the most important diagnostic characters to distinguish *Euphorbia* species (Smith & Tutin 1968, Pahlevani & Riina 2011, Yang *et al.* 2012, Tison *et al.* 2015). Much earlier than Kramer *et al.* (1972), Sommier (1908) and Sommier & Caruana Gatto (1915) also noticed this different morphotype of the *E. exigua* on both Lampedusa (Pelagian Islands, Strait of Sicily) and Maltese Archipelago, and they ascribed it to *Euphorbia exigua* L. var. *retusa* (Cavanilles) Gussone (1843: 534); moreover, they treated the Maltese populations as a new form - f. *imbricata* for its imbricated leaves. More recently, Brullo & Brullo (2009) raised it to a species level as *E. pycnophylla* (K.U. Kramer & Westra) C. Brullo & Brullo without adding any detail to justify this decision; nevertheless, this combination is illegitimate because the name *E. pycnophylla* had been already used by K. Koch (1846: 17) for a plant closely related and now in synonymy with *E. herniariifolia* Willdenow (1799: 902). When the seeds of 16 random samples of *E. exigua* var. *exigua* and var. *pycnophylla* were examined, photographed and placed side by side for direct comparison (Fig. 4) no relevant distinction was found. The measurement of seeds was similar between the two varieties: (0.9) 1.0–1.2 (1.3) × 0.6–0.8 mm [n=110] (var. *exigua*: mean = 1.08 × 0.71 mm [n=60]; var. *pycnophylla*: mean = 1.08 × 0.75 mm [n=50]). The fruit and stipules of the two varieties were also found to be identical when compared with each other.

Within the garigue colonising the rocky limestones of Malta, small pockets of thin “terra rossa” soil often allow the seasonal occurrence of little temporary rocks pools of karstic origin, plants with the typical habit of both varieties and even ‘intermediate individuals’ were found intermingled (Fig. 2). Typical ‘*exigua*’ individuals do prevail in more sheltered and damp areas close or at the border of rock pools, whereas ‘*pycnophylla*’ is more common in very arid and exposed micro-environments with deprived soil. The morphological transition from var. *exigua* to var. *pycnophylla* was a shorter plant and prostrate habit with fewer branches; redder and more fleshy leaves arranged close to each other, hence imbricated and appressed to the stem and a reduction of the inflorescence branches of the cyathia (Fig. 2). Coincidentally, *Euphorbia pinea* Linnaeus (1767: 333) is also known and observed to exhibit similar morphological changes in arid and coastal areas resulting in a short-branched somewhat shrubbier plant with a more compacted leaf arrangement bearing a striking reddish colour at the lower part of the leaf branches and smaller, uncrowded, shortly-pedunculated inflorescences.

Moreover, few plants similar to var. *pycnophylla* were observed in Agrigento Province (Torre Salsa, 21/April/2014) along the southern coast of Sicily (Fig. 3) and in addition images taken from Italy by Andrea Morio (10/4/2007) with the caption “Comune di Ponza, presso la località Le Forna, LT, Lazio, Italia” (Nimis *et al.* 2018) are very similar to this form. This evidence indicates that plants previously known as var. *pycnophylla* are not endemic to the Maltese Islands but widespread in Sicily and Italy. It is likely that they are also found under similar environmental conditions in Tunisia, Greece and other warm areas of the Mediterranean region where possibly they are not taxonomically

treated differently from *E. exigua*. Moreover, apart that Nimis *et al.* (2018) treat var. *pycnophylla* as a synonym of *E. exigua*, they provide two herbarium sheets from Hortus Botanicus Catanensis (CAT): Sheet No. 026193 representing a collection by Brullo, Minissale and Spampinato from Agrigento, Sicily, on 9-4-1988 and labelled as *E. exigua* L. and sheet No. 026229 representing a collection by Brullo, Minissale and Spampinato from Lampedusa, Sicily, on 10-4-1985 and labelled as *E. exigua* L. var. *pycnophylla* Kramer & Westra, with four and six plants each. On comparing the two herbarium vouchers aside, no major differences can be established apart from insignificant differences in the leaves, plant size and habit, while some plants on both sheets are on the whole identical to each other.

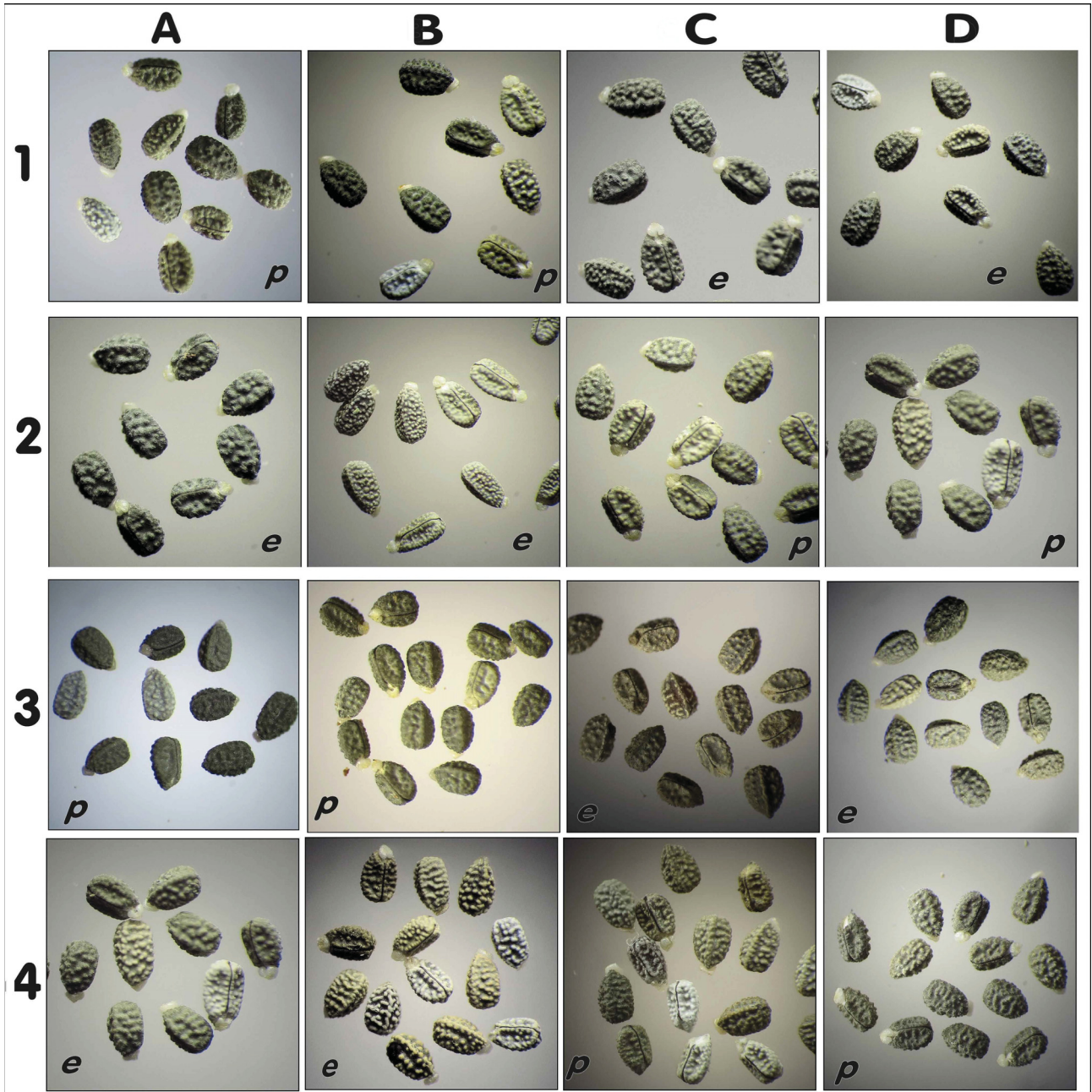


FIGURE 4. Comparison of the seeds of *Euphorbia exigua* var. *exigua* (e) and *E. exigua* var. *pycnophylla* (p) which essentially show no morphological differences in size, colour, outline shape and texture of the testa, hence no clear distinction can be made between the two forms. Collections. 1A–1D: Ġebel Ċiantar, Fawwara, Siggiewi; 2A: Mtahleb, Rabat; 2B: Marfa, Mellieħa; 2C: Red Tower area, Mellieħa; 2D: Binġemma, Mgarr; 3A: Pig farm area, Comino ; 3B: Ghallis, Bahar iċ-Ċagħaq, San Pawl il-Baħar; 3C: Agrigento, Sicily; 3D Modica; Sicily; 4A: Mgarr ix-Xini, Xewkija side, Gozo; 4B: Wied Babu, Żurrieq; 4C: Il-Wileġ, Qala Gozo; 4D: Ta' Ċenċ, ta' Sannat, Gozo. Seeds had the size of (0.9) 1.0–1.2 (1.3) × 0.6–0.8 mm [n=110] without any bias towards any of the two forms (mean size of var. *exigua*: 1.08 × 0.71 mm [n=60]; var. *pycnophylla* 1.08 × 0.75 mm [n=50]).

This brings about the conclusion that *E. exigua* is a variable species which, in arid and poor soil conditions, assumes particular ecotypic forms. Until molecular or long-term cultivation studies are carried out, a lumping approach is at present advocated. Hence, the Maltese-Pelagian endemic morphotypes previously referred to as forma *imbricata* sensu Sommier & Caruana Gatto (1915) and var. *pycnophylla* sensu Kramer *et al.* (1972) are synonymised and treated within a polymorphic *E. exigua*, following the same application as all its other infraspecific taxa (e.g., Euro+Med 2006–2017). If abiding with how infraspecific taxa should be employed in plant taxonomy as suggested by Stuessy (2009), the ranking of a forma, but combined directly under *E. exigua* (not under var. *retusa* as originally described) could be applied here, but following modern plant taxonomic treatments as recommended by Ellison *et al.* (2014), it is better not to create pointless taxa below the subspecies ranking for small morphological differences, especially in plastic species like *E. exigua*.

Conclusions

The synopsis on *Euphorbia* subgenus *Chamaesyce* allowed to identify six species for the Maltese Islands: *Euphorbia peplis* (native, very rare); *E. chamaesyce* (native, rare); *E. prostrata* (alien, infrequent), *E. maculata* (alien, scarce), *E. serpens* (alien, locally frequent) and *E. hypericifolia* (alien, casual). *E. serpens*, *E. prostrata* and *E. hypericifolia* are reported for the first time in the Maltese islands. Misidentification of *E. serpens* and *E. prostrata* as *E. chamaesyce* (reported in past literature as an urban alien) and *E. hypericifolia* as *E. nutans* has been highlighted. *E. peplis* is very rare and has not been observed in its last two stands during the last six years, hence it is probably facing extinction unless targeted conservation measures are taken seriously.

Euphorbia exigua var. *pycnophylla* is here considered a possible ecotype of *E. exigua* growing on very arid rocky ground and is therefore included within the variability of and synonymised with *E. exigua*. This lumping treatment is also adopted for the other varieties of this species described outside Malta. Further molecular investigations or cultivation experiments on the previously described infraspecific taxa of *E. exigua* would be recommended to advocate any taxonomic distinction currently treated within a single variable species based on morphological characters.

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