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A revision of *Allium* subsect. *Allium* (*Amaryllidaceae*) for the Maltese Islands

Abstract

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A revision of species in *Allium* subsect. *Allium* occurring on the Maltese Islands was done on field and herbarium data. *A. ampeloprasum* L., the presumed endemic *A. melitense* (Borg.) Ciferri & Giacomini and *A. commutatum* Guss. are the three species mentioned in the Maltese floras within this group. The results clearly encompassed four different taxonomic units, corresponding to *A. polyanthum* Schult. & Schult. f. which has never been recorded for the Maltese Islands, two populations of *A. commutatum* and two forms (one sterile, one fertile) of their putative hybrid *A. commutatum* × *A. polyanthum* growing on few coastal areas. *A. ampeloprasum* is excluded from the Maltese islands while *A. melitense* is synonymised with *A. polyanthum*. All past records of *A. commutatum* (apart from a giant form) are referred to *A. polyanthum*. Moreover, *A. . commutatum* × *A. polyanthum* is reported from Sicily for the first time.

Key words: *Allium polyanthum*, *A. commutatum*, Malta, Central Mediterranean region.

Introduction

The classification of the genus *Allium* (*Amaryllidaceae*) has been intricate since the pioneer work of Don (1827) and subsequent treatments (Regel 1875; Vvedensky 1935; Feinbrun 1943; Omelczuk 1962), but recent classifications (Friesen & al. 2006; Nguyen & al. 2008; Li & al. 2010) divided the genus into three unnamed clades which are referred to as *lineages*, and which together form 15 different subgenera. These clades were raised to generic level (*Allium*, *Caloscordum* and *Nectaroscordum*) by Banfi & al. (2011) although this treatment is still questionable. Subgenus *Allium* is further divided into fifteen sections, of which section *Allium* is represented by some 115 species. This is further subdivided into two subsections (Hermann 1939): subsect. *Oenoprason* F. Herm. which is characterised with leaves having a semicircular or oblong cross-section and subsect. *Scordoprason* F. Herm. with flat, channelled or V-shaped leaves (Mathew 1996). According to the article 22.1 of the ICN (McNeill & al. 2012) subsect. *Scordoprason* is superfluous and should be corrected to subsect. *Allium*.

The following native species of *Allium* sect. *Allium* have been recorded for the Maltese Islands (Weber & Kendzior 2006; Mifsud 2002-2014; Casha 2013): *A. amethystinum* Tausch. (*Allium* subsect. Oenoprason)*, A. ampeloprasum* L., *A. melitense* (Sommier & Caruana Gatto) Ciferri & Giacomini (a putatively Maltese endemic) and *A. commutatum* Guss. The latter three species within subsect. *Allium* are dealt in this study.

The first *Allium* species recorded on the Maltese Islands was *A. ampeloprasum*, with the Maltese name "*Korrat selvaġġ*" (wild leek), flowering in June and growing in fields together with the cultivated *Allium porrum* "Korrat" (Zerapha 1827). Grech Delicata (1853) also listed *A. ampeloprasum* as the single species of wild leek in Malta, where he reports it from cultivated and uncultivated places as at Corradino.

Sommier & Caruana Gatto (1915) catalogue *A. ampeloprasum* in their flora which they reported it to grow in various locations on rocky ground, especially near the sea. Additionally, they described a new variety from Boschetto – *A. ampeloprasum* var. *melitense,* which they distinguished because of its smaller hemispherical inflorescences up to 3 cm accross and for being plants with a more delicate habit reaching only up to 25 cm in height. They state that this local variety is similar to *A. ampeloprasum* var. *hemisphericum* Sommier (= *A. hemisphericum* (Sommier) Brullo) from Lampedusa and to *A. preslianum* Schult. & Schult. f. (=*A. rotundum* L.), adding that it should be studied in a more taxonomic depth while retaining *A. ampeloprasum* var. *melitense* as a provisional name.

Borg (1927) classifies *A. ampeloprasum* into three varieties: *A. ampeloprasum* var. *ampeloprasum* (Maltese: Kurrat selvagg) which flowers in April-May and is very common in rocky places near the sea and near fields; *A. ampeloprasum* var. *porrum* (Maltese: Kurrat) which is widely cultivated and *A. ampeloprasum* var. *melitense* considered endemic to Malta. This variety was then elevated to a species level in the catalogue of Italian Flora by Ciferri & Giacomini (1950).

Subsequent floristic accounts and publications maintained Borg's treatment (Lanfranco G. 1960, 1969; Haslam & al. 1977), until Lanfranco (1989) put forward for the first time the species *A. commutatum* in the Red Data Book. He also quesioned the systematic status of *A. melitense*. Additionally, reference was also made to giant forms of '*A. commutatum*' occurring on the islets of Filfla and General's Rock (found by Michael Briffa). It was concluded that *A. ampeloprasum* complex required further critical investigations (Lanfranco 1989; Lanfranco & Bonnett 2015). Our preliminary field observations also confirmed that the species within *Allium* sect. *Allium* are not represented correctly in the Maltese florae and local floristic accounts and hence a taxonomic revision was carried out.

Materials and methods

The study on *Allium* subsect. *Allium* was carried out between 2014 and 2016 both in Malta and Gozo, mostly from wild samples but cultivated escapees were also included. In addition, material from Cava d'Aliga and Marina di Modica, Ragusa, Sicily; and a three specimens from Nantes, France (submited from cultivation by Errol Vela) were also studied for comparison purposes. A total of 165 specimens were examined in this study. Relevant Herbarium specimens are deposited in the author's personal herbarium and in the National Museum of Natural History in Mdina, Malta. Electronic Supplementary File

(ESF) 1 provides information about the material studied including the date of examination, location, (locality and toponym) and the habitat. According to keys and species descriptions by Stearn (1980), Mathew (1996), Aedo Pérez (2014), Tison & al. (2015) and Pignatti (2017), the following set of morphological characters were chosen *a priori* for this study: plant height; width of longest leaf; colour and size of leaf sheath; inflorescence size; proportion of the leaf-sheathing along the stem; presence and morphology of papillae on margin and keel of leaves; colour of tepals and their midvein; size and shape of tepals including the apex; presence and distribution of papillae on tepals; shape and size of tepal's papillae; shape of stamens (filaments and cusps); ratio of the length of the cusps with that of the lamina of inner stamens whorl; the protrusion of anthers from corolla and finally the shape, colour and size of the bulblets. The length of the beak of the spathe was found to be important and measured for a smaller sample of specimens. The most important diagnostic characters used to circumscribe taxa were the foliar and floral papillae, morphology of the stamens (protrusion, shape of stamens and length of cusps) and the shape and size of the bulblets. The flowering time, width of leaves, colour of tepals and length of spate were of additional support to carry out taxon circumscription.

Results

The character states recorded from 165 specimens are given in the ESF 2. On studying critically the diagnostic characters, four distinct groups (taxonomic units) from wild populations were circumscribed and referred to as P, C, G and Z. The fifth group consisted of cultivated specimens (or escapees) and was labelled as taxon K. A summary of the relationship of these characters and how they were employed to delimit these five taxa is summarised in Table 1, while a detailed account is given below.

Foliar papillae on leaf margins and keel

Seven types of leaf margins labelled A to G have been defined according to the presence, weathering, persistence, continuity, gruoping, regularity, size and shape of minute papillae lining the margins and keel of young leaves. Leaf papillae can be classified in two groups: i) types A to C with small, hemispherical or tuberculate papillae not longer than 75 µm and at various levels of weathering - completely weathered or absent in type A to partially preserved in Type C, not detected by the unaided eye (observed under ×40 magnification); and ii) types D to G composed of larger papillae, 100–400(–500) µm and usually visible by the naked eye or a lens; persistent even in old leaves during inflorescence, with various shapes including subspherical and rounded (Type D) to digitiform (Type E) or teat-shaped, hence with a broad base and slightly swollen tips (Type E and F). Leaf margins were found to have either simple and homogenous papillae (Types A to D and Type G) or complex, irregular and grossly heterogenous as in Type F and sometimes in Type E.

The seven types of leaf margins (type A to type G) are illustrated in Fig. 1 and described below:

A: Smooth; margin a narrow hyaline lining without any papillae (Fig. 1a).

B: Subcrenulate; margin almost smooth but with flattened, weathered papillae (≤ 25 µm long) not visible to the unaided eye (Fig. 1b).

Table 1. Main distinctive characters of the five groups recognized.

Diagnostic character	Group P	Group Z	Group G	Group C	Group K
Length of plants (cm)	(15–)50(–100)	(80–)120(–180)	(80–)120(–180)	(60–)100(–150)	70–120
Length of foliar papillae (µm)	25–75	150-250	150-250	100-200	300-450
Weathering of foliar papillae	Yes, leaf margin becomes smooth	No	No	No	No
Shape of foliar papillae	Homogenous, simple, subcylindrical	Heterogenous, various shapes simple and complex forms	Heterogenous, various shapes simple and complex forms	Homogenous, simple, hemispherical, or broadly conical	Homogenous, digitiform
Length of spathe beak (cm)	2–5	6–11	7–13	15–30	Not recorded
Flower colour	Lilac to pale purple	Dark purple	Dark purple	White or pale green	Light purple
Stamen protrusion	Included or partially exserted	Fully exserted	Fully exserted	Fully exserted	Fully exserted
No. of cusps on the internal stamens (Fig. 4)	1 Type A	1(–2) Type A & B	(1–)2–3 Type C & D	(2-)3 Type D (& C)	1 Type A
Papillae on internal tepals (Fig. 9)	Absent or very few	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal
Distribution of papillae on tepals (Fig. 9)	Type A	Type C	Type C	Type B	Type D
Bulblet shape and size (mm). (Figs. 10 & 11)	Type A, 4–9, homogenous	Type C, 8–18, heterogenous	Type C, 8–18, heterogenous	Type B, 15–35, homogenous	Type B, but less compressed 18–25, homogenous
Seeds	Fertile	Fertile	In majority sterile	Fertile	Not recorded
Flowering period	Beg May to end of May	End May to mid June	Beg/mid June to end of June	End of June to mid July	End May to end June

C: Irregularly subcrenulate-scabridulous; margin with short, narrow conical or subdigitiform papillae, 25–75 µm long, visible with a a magnyfing glass, often in an irregular or patchy distribution present towards the terminal part of leaf (Fig. 1c).

D: Regularly scabrid by subspherical or widely conical papillae,100–200 µm long simple, widely spaced, homogenous present along entire margin (Fig. 1d).

E: Regularly denticulate-scabrid by short digitiform to tuberculate papillae, 200–300 µm long, mostly simple, densely packed, homogenous or heterogenous, present along entire margin (Fig. 1e).

F: Irregularly denticulate-scabrid due to a mixture of large, cylindrical, digitiform or tuberculate papillae 200–300 µm long and small, hemispherical or subdigitiform papillae 50–75µm long, often with irregular and complex papillae, densely packed, heterogenous, present along entire margin (Fig. 1f).

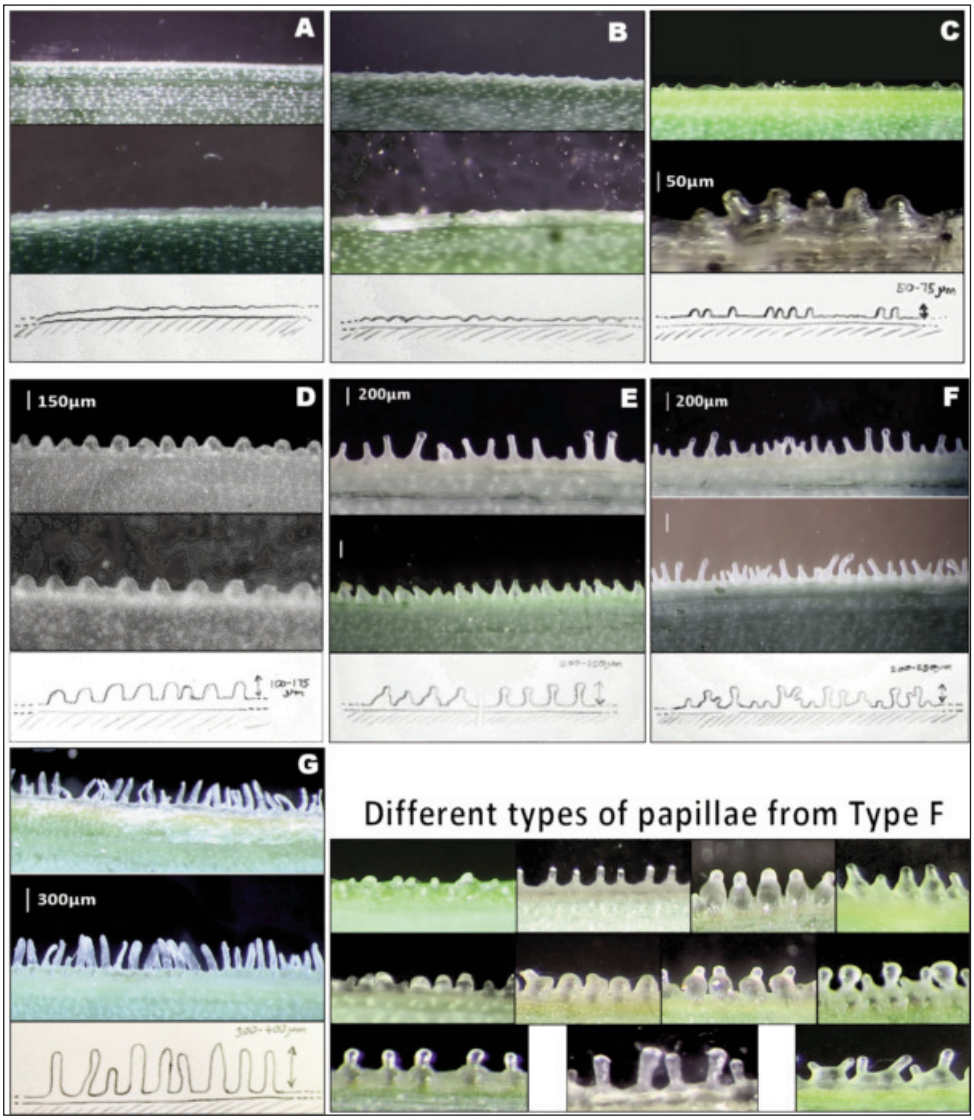

Fig. 1. Different types of leaf margins based on the presence and type of papillae. Type A: smooth (*A. polyanthum*: specimens AS523c, AS524a); Type B: subcrenulate with weathered flat papillae (*A. polyanthum*: specimens BS502b, AS601a); Type C: subcrenulate-scabridulous with small cylindrical papillae, 25–75 µm long (*A. polyanthum*: specimens AS513a, AS513b); Type D: scabrid with spherical papillae, 100–200 µm long (*A. commutatum*: specimen BS627a, CS625a); Type E: regularly denticulate-scabrid with short digitiform to tuberculate papillae, 200–300 µm long, homogenous morphology (*A. commutatum* × *A. polyanthum*: specimen AS601f & BS612a); Type F: irregularly denticulate-scabrid with variously-shaped papillae, 200–300 µm long, heterogenous morphology (*A. commutatum* × *A. polyanthum*: specimen AS601e & BS606a), where the various shapes of papillae observed are illustrated in the bottom right inset; Type G: dentate-subpilose with digitiform papillae, 300–400 µm long (*A. porrum* var. *kurrat*: specimen BS603b & BS606e).

G: Dentate-subpilose with relatively long, slender, digitiform papillae without swollen tips, 300–500 μm long, usually simple, densely packed, homogenous, present along entire margin (Fig. 1g).

Different shapes of papillae have been observed within the examined specimens, but plants in Taxon Z and G and had very heterogenous papillae (Type F) with variable shapes; either observed from different specimens of the same population or along leaf margins of the same specimen. Eight papillae forms have been in fact classified as shown in Fig. 1f: minute-pustulate; slender digitiform; swollen digitiform; hemispherical-doliform; hemispherical with eccentric narrow bulging ends; hemispherical with central wide bulging ends (russian dolls); subcapitate; capitate with swollen heads (teat-shaped); and complex forms with wide bases and 2 or 3 bulging or projecting ends. It is likely that these morphological combinations are the result of the merging of narrow digitiform or pustulate papillae (e.g. Type C) with broad, hemispherical-doliform papillae (e.g. Type D).

Based on foliar papillae, four unit were segregated as follows: taxon group P with type A, B, or C papillae (smooth or weathered); taxon group C with type D papillae (homogenous and persistent); taxon group Z and G with type E or type F papillae (persistent, heterogenous, simple or complex) and the cultivated taxon group K with type G papillae (very long and subpilose margin).

Plant, leaf and umbel sizes

The examined specimens can be divided into two groups based on the plant plant height, leaf width and inflorescence sizes. Taxon P made most of one group while taxon C, G, Z and K represented the other group.

Group 1 (taxon P): smaller plants with height of (16–)25–80(–105) cm (=55 cm), (2–)4–12(–20) mm wide(=8.5 mm), and smaller flower-heads measuring (11–)22–48(–66) mm wide (=35 mm);

Group 2 (taxon C, G, Z, and K): larger plants (65–)90–158(–181) cm long (=125 cm), leaves with a pale yellowish-green hue, (12–)16–28(–34) mm wide (=22 mm), and larger flower heads measuring (30–)42–72(–90) mm wide (=57 mm).

Group C from Sicily were at the lower range of group 2 and upper range of group 1. Groups G and Z had the largest plants in terms of plant size, leaf width and flower head diameter.

Stamens: cuspidate filaments and anther protrusion

All examined material was found to have tricuspidate inner stamens with the median cusp being firm and bearing a fertile anther, whereas the lateral cusps were much longer, thread–like, spindly, often found coiled, initially attached with a sterile anther which usually falls prematurely. The lateral cusps were longer than the median by (1.8)–2–4(–4.5) times and could not be used to segregate specimens in any distinct group. However, the ratio of the length of the filament's lamina to the median cusp was more useful, and specimens could be divided into two groups: one group had the lamina subequal or only slightly longer from the median cusp by (0.9–)1.5(–2.0) times; while lamina of the other group was in comparison longer by a ratio of (2.2–)3.0–4.0(4.5). The former group had a more distinct and longer median cusp resulting in the exertion of its anthers well out from the corolla mouth by 2 mm or more. Taxon group C, Z, G and K had this latter type of sta-

mens while taxon group P had shorter median cusps with their anthers at the level of the corolla mouth or just exserted by 1 mm. (Fig. 2).

The amount of protrusion of the anthers out of the urn-shaped or bell-shaped perigone is reported to be a very important character. In this study, it was found that this character is not very easy to assess or reliable because for instance, some flowers had their anthers protruding half-way through the orifice of the corolla mouth, whereas others had stamens protruding marginally by about 1 mm within the same specimen. For consistency this observation is carried out only at pollination. As described in the methodology, stamens had to be exserted by 2 mm or more from the corolla mouth to be classified as exserted anthers, otherwise they were classified as included anthers. Only taxon group P was found to have included anthers.

More important and much easier to evaluate was the variation in the number of cusps observed in the outer whorl of stamens. The studied material could be reliably divided into four groups based on four types of outer stamens labeled Type A, B, C and D as shown in Fig. 3. Type A consisted of specimens with an outer whorl of three simple, completely non-cuspidate, stamens bearing a fertile stamen. Some individuals had monocuspidate stamens but with a small and partial secondary tiny cusp, often detected by a hand lens or magnified images. This is indicated by an arrow in Fig. 3-B3 and 3-B4. Stamens with this morphology were grouped as Type B stamens. Type C stamens had a mixture of two or three cusps (rarely just one) and often with one of the cusps of half or partial length. Leeks with an

Fig. 2. Protrusion of stamens from corolla mouth. A: Included, partially exserted, or shortly exserted by 1 mm (*A. polyanthum*: left BS505a; centre AS524c; right BS512a); B: conspicuously exserted at least by 2 mm (left: *A. commutatum* (CS625a); centre: *A. commutatum* × *A. polyanthum* (BS609a); right: *A. commutatum* (BS627f)).

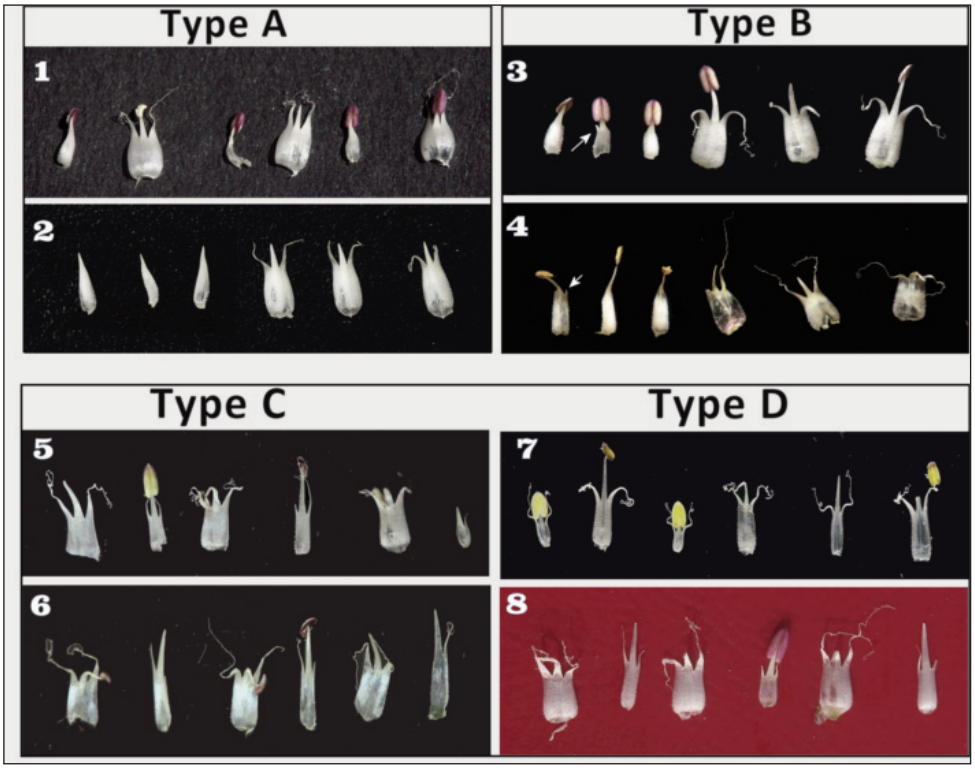

Fig. 3. Stamen morphology. Type A: inner and outer whorls simple and monocuspidate (*A. polyanthum*, top:AS509a; bottom:AS523c); Type B: inner whorl tricuspidate, outer whorl simple and monocuspidate sometimes with a partial lateral cusp (*A. commutatum* × *A. polyanthum*, top:AS601e; bottom:BS606c); Type C: inner whorl tricuspidate, outer whorl with two or three cusps, sometimes with a partial lateral cusp, rarely simple (*A. commutatum* × *A. polyanthum*, top:BS612b; bottom: BS609a); Type D: inner and outer whorls tricuspidate, rarely the outer whorl with a reduced lateral cusp (*A. commutatum*, top:BS627c; bottom:CS625a).

outer whorl of tricuspidate stamens, more or less consistently found so within different flowers were categorized as type D stamens. It is here hypothesized that individuals having Type B stamens with 1-2 cusps or Type C stamens with 2-3 cusps represent an intermediate morphological state between simple monocuspidate stamens (Type A) and tricuspid stamens (Type D).

All specimens within groups P and K had type A stamens, whereas group C and the cultivated specimens had type D stamens. Group Z mostly had type A and type B stamens while group G predominantly had type C stamens (occassionally type D).

Floral papillae

Two types of papillae have been detected: (i) small pustulate papillae 25–40 µm wide, not visible by the naked eye, subcylindrical, slightly longer or subequal to their diameter

and (ii) large papillae (80–)100–150(–170) µm wide, hemispherical, fusiform or compressed conical papillae, shorter than their length. The presence and distribution patterns of these two types of papillae on the external and internal petals are classified in four types as follows (Figs 4 to 8):

Type A: Internal tepals without papillae. External tepals with large papillae, 100–170 µm mostly present on the keel sometimes merging forming 'walls', with their frequency decreasing abruptly towards the margin, hence becoming absent at the lateral borders of the tepals. Papillae not numerous and visible to the naked eye mostly compressed spherical-fusiform in shape - Fig. 4 and Fig. 8.

Type B: Internal tepals with small, subcylindrical papillae 25–40um wide. External tepals also with similar small papillae, uniformly distributed throughout the entire surface of the tepal. Large papillae absent or few broad, large hemispherical papillae 80–110um wide restricted only at a small part of the keel - Fig. 5 and Fig. 8.

Type C: Internal tepals with small, subcylindrical papillae, 25–40 µm wide. External tepals with two types of papillae; small (25–40 µm wide) pustulate papillae uniformly dis-

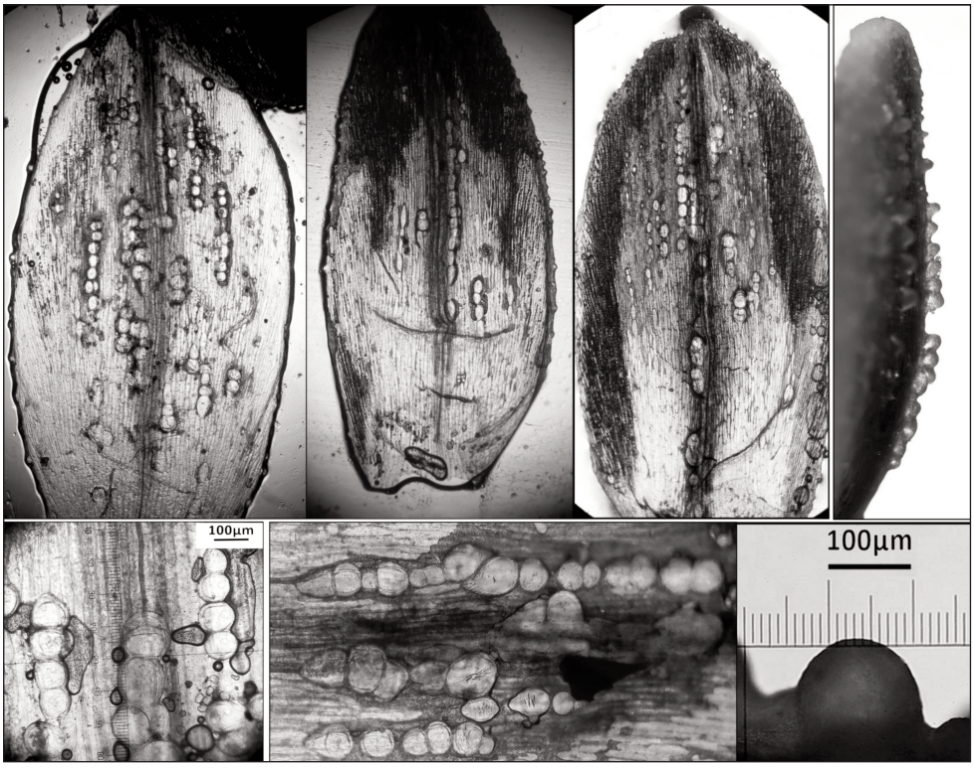

Fig. 4. Type A floral papillae on external tepals of Group P (*Allium polyanthum*), characterised by large hemispherical papillae distributed on and close to the keel, often subfused forming rows or walls, (100–)120–170 µm wide.

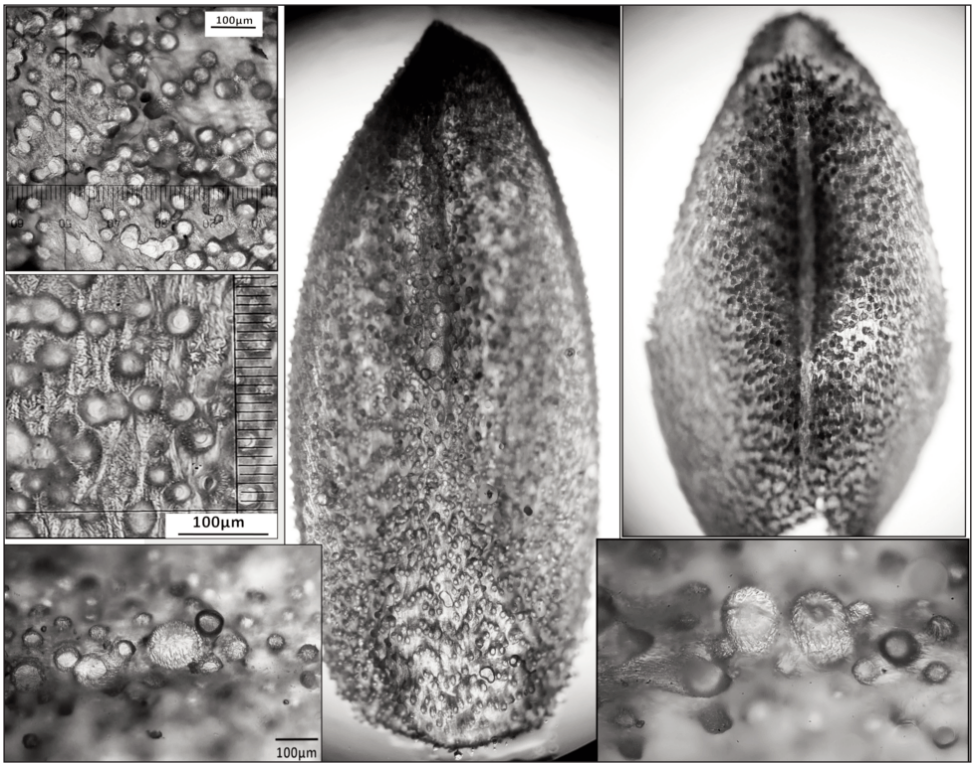

Fig. 5. Type B floral papillae on external tepals of Group C (*Allium commutatum*) characterised by small, 30–40 µm wide papillae evenly distributed throughout the entire surface and occasionally few larger hemispherical to conical papillae on the keel 80-110 µm wide.

tributed throughout the entire tepal and numerous large papillae mostly present on the keel, sometimes merging forming short walls and occupying one third or more of the length of the keel - Fig. 6 and Fig. 8.

Type D: Internal tepals with small, subcylindrical papillae, 25–40 µm wide. External tepals with two types of papillae: small, (25–40 µm wide), pustulate, papillae uniformly distributed throughout the entire surface and large papillae (80–140 µm wide) scattered throughout most of the central part of the tepal hence not restricted only on the keel, sometimes extending up to near the margin of the tepal but then decreasing in size. Papillae numerous and in various sizes with the larger ones present on or close to the keel - Fig. 7 and Fig. 8.

Type B and type C can generally be considered to be similar, but type C have more numerous and larger papillae on the keel, running along at least one third of its length.

The distribution of the papillae on the tepals corresponded with the four groups circumscribed above. All specimens in taxon P had type A floral papillae. Group C primarily had type B papillar distribution on its tepals while that of the cultivated group K was distinctly type D. Plants within taxon group Z and G had type C papillae but some specimens in

Fig. 6. Type C floral papillae on external tepals of groups G and Z (*Allium commutatum* × *A. polyanthum*) characterised by small, 30–40 µm wide papillae evenly distributed throughout the entire surface and several larger hemispherical to conical papillae on the keel, about 80-150 µm wide, sometimes fused at the base forming papillary walls.

group G occasionally possessed type B papillae but with a tendancy of being smaller.

On comparing the four types, here aided by a representative illustration (Fig. 8), it can be preassumed that type C and perhaps Type D are a result of a combination or superimposition of type A and type B papillae.

Bulblet shape

Two main bulblet shapes here referred to as helmet-shape and hemispherical or navicular have been met during this study and labelled as Type A and Type B. Type A bulblets are char-

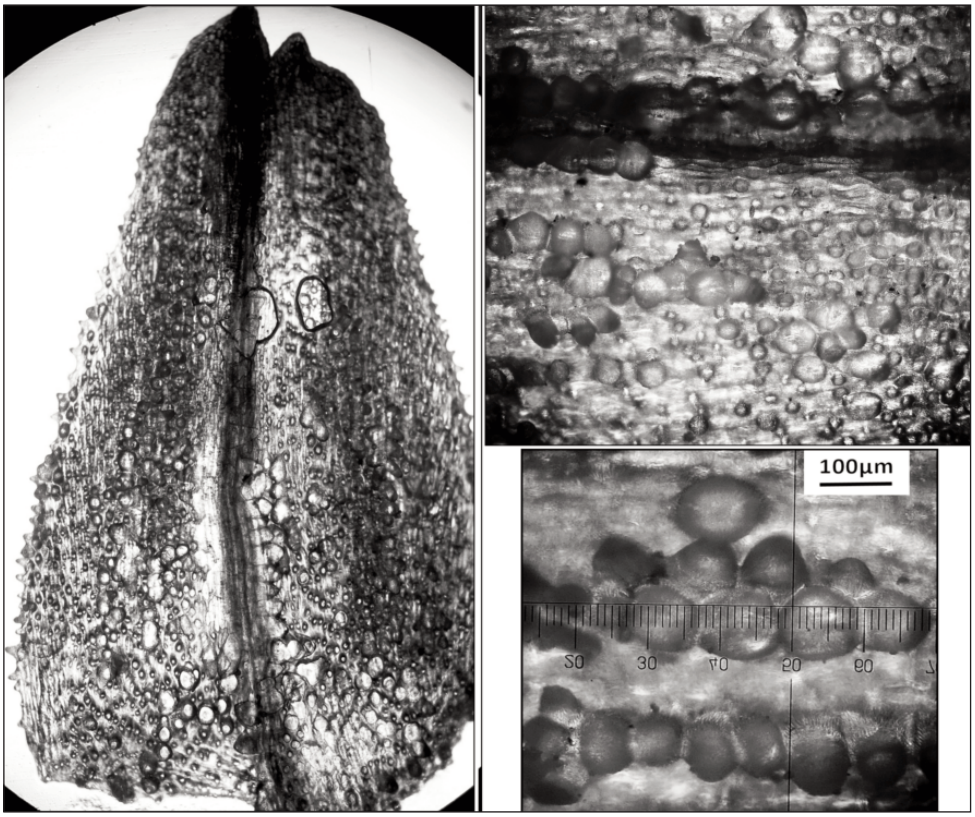

Fig. 7. Type D floral papillae on external tepals of group K (*Allium kurrat* and *A. ampeloprasum*) characterised by small (30–40 µm) and large (80–150 µm) papillae evenly distributed throughout the entire surface but with the large papillae more frequent on and close to the keel and gradually decreasing in size towards the margin.

acterized by sub-globular structures, 4–9 mm in diameter, with a short flattened side at the base hence forming a shape similar to a helmet. The flattened side is only 3–5 mm long and is always shorter from the height or longest diameter of the bulblet body. Type B bulblets have an elongated hemispherical or hemi-ellipsoid structure with acuminate or tapering ends, usually one end more acuminate than the other. The flattened side is longer than the height or width of the bulblet, and can be termed as navicular or compressed fusiform. They vary in size, usually between 10–30(–40 mm) long and 6–12 mm high. Both type A and type B bulblets are homogenous in shape and are illustrated in Fig. 9.

Moreover, a third bulbet morphology has been categorized as Type C which collectively are heterogenous and composed of a mixture of Type A and B bulblets and other bulblets which are considered as a range of intermediates between the two forms, usually hemispherical with a short acuminate end, sometimes compressed and measuring about 12 mm ± 5 mm (Fig. 10).

Specimens within group P produced helmet-shaped (Type A) bulblets whereas those forming group C produced navicular or compressed (Type B) bulbets. Group G and taxon

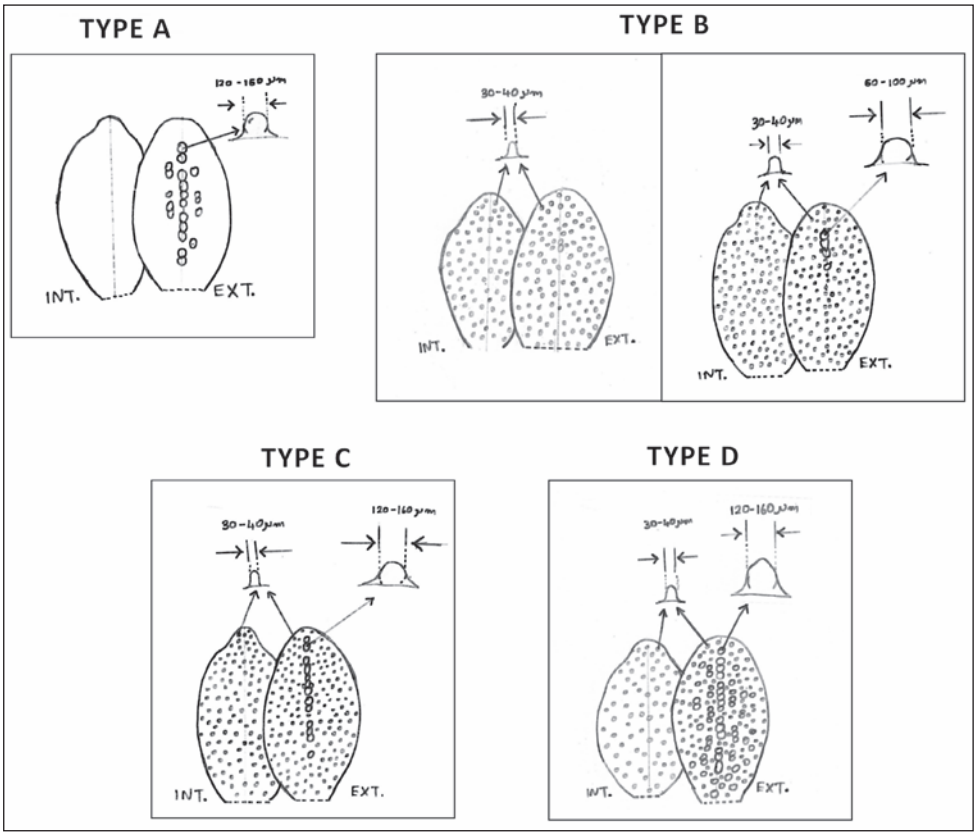

Fig. 8. Representative line diagrams of the four types (Types A to D) of flora papillae on the internal and external tepals.

group Z had heterogenous bulblets (Type C). It was further observed that the Sicilian specimens produced smaller bulblets thna the Maltese plants, and that group Z had an elevated number of helmet-shaped bulblets than group G.

Length of beak of the spathe.

Group P had the shortest beaks, typically 2–5 cm long; group C had the longest beaks, 15 cm up to 29 cm in some individuals and groups Z and G had intermediate lengths, normally between 7 cm and 13 cm. In all cases, the spathe splits open from one side and falls down soon after anthesis.

Summary of the circumscribed groups.

Combining the results above, five taxon groups have been circumscribed, four from the wild (groups P, G, Z, C) and one cultivated (group K). Their discriminating characters are summarised in the Table 1.

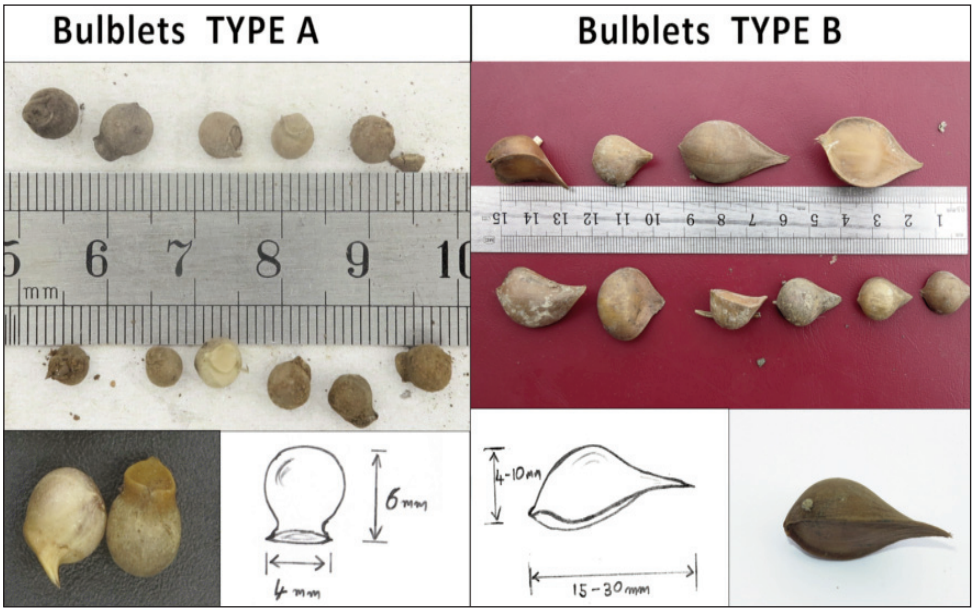

Fig. 9. Two of the three types of bulblet morphology found in the studied specimens. Type A subglobose with a short flat base forming the what so called "helmet" shaped bulblets, 4–9 mm wide (*Allium polyanthum*: specimen AS601a); and Type B with hemispherical to hemi elliptical-fusiform shapes with one end distinctly acuminate, the other shortly acuminate, caudate or obtuse, always longer than high, 15–30(–40) mm long (*Allium commutatum*: specimen CS625b).

Discussion

Identity of group P

Found in exposed rocky patches in garigue, degrded garigue, steppe, abandoned fields, less often in vegetated coastal areas and wasteground, 5–250 m asl. The characters of group P corresponds with *A. polyanthum*. This species is related to *A. ampeloprasum*, but it is a smaller plant, with smooth margins in mature plants due to the quick weathering (or absence) of papillae, have less papillae on the external tepals, and more importantly possess very few or usually complete absence of papillae on the internal tepals.

The classification of *A. polyanthum* is a rather debatable and subjective. Aedo Pérez (2014) followed the classification of De Wilde-Duyfjes (1976); observing plants with intermediate character-states between *A. polyanthum* and *A. ampeloprasum* to co-occur in Spain, their taxonomic treatment was a single, broad *A. ampeloprasum*. Jauzein & Tison (2005) and Tison & al. (2015), consider such intermediates as a hybrid swarm of two distinct subspecies. Jeanmonod & Gamisans (2007), Dobignard & Chatelain (2010) and Floc'H & al. (2010) also followed this classification. Mathew (1996) considered the distinction wide enough to treat *A. polyanthum, A. ampeloprasum* and *A. porrum* L. as distinct species and later they were clearly separated on moleculer bases by Hirschbegger & al.

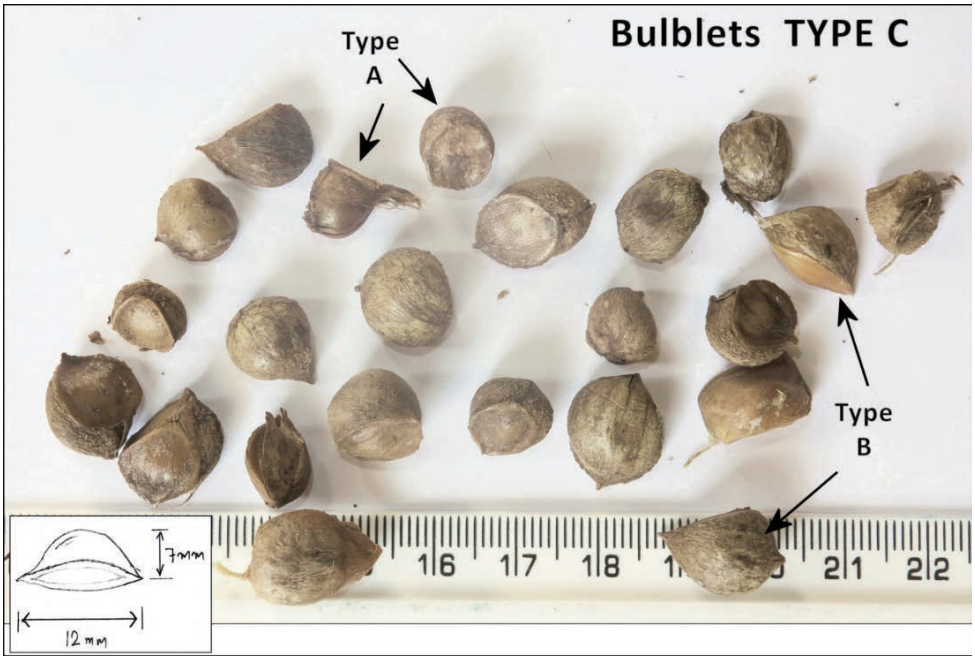

Fig. 10. Type C bulblets composed of mixed Type A and Type B bulblets, and numerous irregular or somewhat intermediate shapes measuring between 7–20 mm long (*A. commutatum* × *A. polyanthum*: specimen AS601e).

(2009). Since our plants are well distinct from the cultivated *A. porrum* s. str. and since specimens showing the characters of *A. ampeloprasum* have not been found, the species rank for *A. polyanthum* is preferred in this work.

The presence of *A. polyanthum* in Malta extends the western distribution of the species, currently occurring in Algeria, Balearic islands, Corsica, France, Italy, Morocco, Sardinia, Spain and Tunisia (GBIF 2017, Euro+Med 2006-2017). However unpublished records from Greece and Crete have been confirmed (pers. comm J-M. Tison).

Identity of group C

Found in littoral habitats, 5-20m asl up to 300m inland. According to the keys and descriptions of Stearn (1980), Mathew (1996), Aedo Pérez (2014), Tison & al. (2015) and Pignatti (2017), group C corresponds perfectly with *A. commutatum*. This species has been confirmed only from Xgħajra at the south east coast of mainland Malta and is to a new record for the Maltese islands. All records of *A. commutatum* for the Maltese Islands in past literature (Lanfranco 1995, Lanfranco & Lanfranco 2003, Mifsud 2002-2014, Bonett & Attard 2005, Weber & Kendzior 2006, Lanfranco 2007, Casha 2013 and Lanfranco & Bonett, 2015) refer to *A. polyanthum* or to groups Z and G for the reported ‘giant forms’ at Filfla and Fungus Rock and nearby mainland shores. The large population at Cava D’Aliga

and the few individuals at Arizzo in Ragusa, Sicily are also *A. commutatum* and were used to compare their characters with the Maltese material. The Maltese population comprises of plants that are distinctly larger from those in Cava D'Aliga but within the variation range of the species and they might be a result of ecotypism or more likely polyploidy. Moreover, all specimens have white tepals instead of pink or purple as it was found at Ragusa, however it is well known that the flower colour of *A. commutatum* vary, and is found either white or deep purple in France and Corsica (sometimes intermixed within the same population) or pink in Greece. The Maltese population exhibit a homogenous morphology.

Identity of groups Z and G and their relationship with A. commutatum

Groups Z and G are found in littoral habitats or abandoned fields near the coast, 5-80 m a.s.l. and are clearly related to *A. commutatum*, but they do not match in a number of characters, the most important being that the internal stamens are never tricuspidate: simple and monocuspidate in group Z, bicuspidate sometimes tricuspidate but with the third cusp partial in group G. Other important differences from *A. commutatum* were observed in the morphology of the papillae of the leaf margin and tepals, the spathe has a shorter beak, the corolla is deep purple, flowering earlier by 3-4 weeks and the bulblets are heterogenous including helmet-shaped and irregular forms as described in detail below and summarised in Table 1.

On evaluating these diagnostic characters, group Z appears to have an array of intermediate characters between *A. polyanthum* (group P) and *A. commutatum* (group C). The type C floral papillae (Fig. 6) of group Z superficially seems to be a direct superimposition of Type A papillae (of *A. polyanthum*) and Type B papillae (of *A. commutatum*). The foliar papillae also seems to be a combined morphology or patter of mixed *A. commutatum* and *A. polyanthum* either in their simple form, hence both papillar forms are found separately on the leaf margin or in a compound or complex form as if having shapes of both papillar types merged together, typically forming broad-based papillae abruptly narrowing to a teat-shaped tip or into capitate heads (Fig. 1f). Bulblets shapes typical of the two species mentioned above were found together in specimens of groups G and Z together with irregularly shaped bulblets judged as intermediate forms. The flowering period (end May to beginning of June) occurs after that of *A. polyanthum* (May) and before *A. commutatum* (end June). The monocuspidate shape of the internal stamens in group Z is a strong character of *A. polyanthum*, while some tricuspidate internal stamens found in group G are typical in *A. commutatum*. The number of bicuspidate internal stamens found in group G (Type C stamens, Fig. 3c) or tiny secondary lateral cusps (tiny appandage) ocassionally found in group Z (Type B stamens, Fig. 3b) are considered as an intermediate form between monocuspidate and tricuspidate stamens of *A. polyanthum* and *A. commutatum* respectively. The length of the beak of group G and Z of 6-13 cm is also perfectly intermediate between 2-4 cm in *A. polyanthum* and 12-30 cm in *A. commutatum.*

This morphological study strongly suggest that group Z and group G represent a hybridogeneous population between *A. commutatum* and *A. polyanthum.* As discussed above, both groups either share character states of both parents resulting in an overall heterogenous picture of both states, or have intermediate morphological states between the putative parents or have characters which superficially appears to be a superimposition of character states of the parents. As a result, it is concluded that groups Z and G are likely hybrids: *A. commutatum* × *A. polyanthum.*

Group Z (Żurrieq, southern coast of Malta) show a more balanced character set between the putative parents, while group G (Gozo populations) approaches more to the parent *A. commutatum,* with a later flowering period, smaller papillae on the tepals and 2–3 cusps on the internal stamens. Interestingly, group Z produces fully fertile seeds, but plants of group G in majority are sterile, where the seeds are shrivelled, empty and crumble easily when pressed.

Some individuals within these taxon groups reach up to 180 cm in height, form an umbel the size of a tennis ball, with huge leaves up 4 cm wide and generally very robust plants. These large leeks have also been observed from the islets of Filfla and Fungus rock (Lanfranco 1989; M. Briffa & J. Sultana pers. comm. 2014) and referred to giant forms of *A. commutatum*. Likely, they also represent a well-established hybridogeneous community of *A. commutatum* × *A. polyanthum* as found in the closest shores in mainland Malta and Gozo respectively. Photos of these large leeks growing in Filfla taken by Edwin lanfranco and Joe Sultana are in general identical to groups Z or C, although their details could not be assessed.

Nevertheless, it is safely assumed that Filfla and Fungus Rock harbour an *Allium* population showing features of group Z and group G respectively. Further karyological studies are currently being carried out to confirm the *A. commutatum ´ polyanthum* hybrid, also detected in south France and North Africa (pers. comm. Errol Vela).

Identity of group K

The cultivated leeks collected from fields in Żurrieq, Xewkija and Mġarr ix-Xini shared the same morphology and were identified as *A. porrum* L. s.l. According to two interviewed farmers their crops correspond to *A. porrum var. kurrat* (K. Krause) Seregin. This taxon, forms vigorous plants with thick stems and wide leaves (up to 35 mm broad) with characteristic elongated papillae between 300 and 400 µm long at the margin and keel forming a subpilose fringe (Fig. 1g). The tepals have a particular distribution of small and large papillae throughout the external tepals, where the large papillae are not restricted on the keel but occupying most of the face except at the border (Figs 7 & 8: type D). On examing material of *A. ampeloprasum* submitted to us from France, the same type of distribution was observed concluding that these cultivars maintained these diagnostic characters from *A. ampeloprasum* from which they originate. *A. porrum* and *A. porrum var. kurrat* have not been found naturalising rocky habitats away from their source of cultivation or known to form any populations except some casual escapees close to field margins. As a result they should be treated as agricultural crops and not to be included in flora of the Maltese Islands.

What is *Allium melitense*?

A. melitense (Sommier & Caruana) Cif. & Giacom. was described as a small variety of *A. ampeloprasum*. According to this revision they correspond to the lower small-sized individuals within group P with all diagnostic characters identical to the larger plants of this group. Therefore, no taxonomic distinction could be found plausible as has already been suspected by Mifsud (2011).

In the early 20th century, *A. ampeloprason* was thought to occur in steppic and garigue communities in Malta. Being by description a rather large species (80-180 cm high), the

small-sized *Allium* individuals may have contrasted with *A. ampeloprason* and merited to be described as a distinct small variety (*A. ampeloprasum* var. *melitense)*. But since now it is established that the Maltese plants are *A. polyanthum* - a species with a height of 15–100 cm, these small plants fall within the lower range of *A. polyanthum,* hence resulting that *A. melitense* has no particular distinction. Individuals with a very small habit, flowerheads (2 cm across), bulblets (4-5 mm) and bulbs (8-12 mm) are considered to be small ecotypes of *A. polyanthum* occurring in very degrarded areas or in restricted volume of soil in pockets of karst rock.

The fact that the size of the plant and flower head have no taxonomic importance was demonstrated in situ in several occassions. A clump of twelve plants found at Wied Diegu, Żurrieq (Fig. 11) were composed both of normal sized plants ('*A. ampeloprasum*') and small-sized plants ('*A. melitense'*). The May-flowering Maltese population contributes to a continuous range of sizes within the species concept of *A. polyanthum*. Such small plants have also been observed in France intermixed with *A. polyanthum* (pers. comm. Errol Vela, 2014). As a result, *A. melitense* and *A. ampeloprasum* subsp. *melitense* should be treated as synonyms of *A. polyanthum*.

Allium ampeloprasum and its status in Malta

A. ampeloprasum had been recorded from the Maltese islands in historical literature, until it was gradually substituted by *A. commutatum* (Lanfranco 1989). To verify that none of our studied material correspond to *A. ampeloprasum* and since the distinction in literture (eg. Stearn 1980; Mathew 1996, etc) is based on an unclear character of stamen exsertness, a voucher specimen of *A. ampeloprasum* kindly submitted by Errol Vela was studied and compared with the collected material. The diagnostic characters differed from those found in all Maltese collections but related to specimens from or close to cultivated areas which in this study corresponded to *A. porrum* var. *kurrat*. This taxon is often found in synonym with *A. ampeloprasum* or as its infraspecific rank (ThePlantList 2013), although it is considered distinct by some authors for being a cultivated leek with wider leaves and larger bulbets (Mathew 1996). The shape, distriburion and morphology of the floral papillae of *A. ampeloprasum* was for example similar to *A. porrum* var. *kurrat*, but slightly smaller and longer than it is wide, hence more conical in shape. Therefore, since *A. ampeloprasum* was not collected from natural habitats it is suggested to be removed from the current flora of the Maltese Islands and historical records likely refered to *A. polyanthum* or its hybrid with *A. commutatum.*

Specimens from the southeast coast of Sicily

On June 2015, a sizeable population of *A. commutatum* was found east of Cava' d'Aliga beach on vegetated coastal rock, a few metres away from the sea. This population was composed of several hundreds of individuals in three seperate clumps very close to each other. On comparing with the Maltese population (Fig. 12), the Sicilian plants were in general smaller and had pinkish tepals. A higher frequency of slightly larger papillae on the

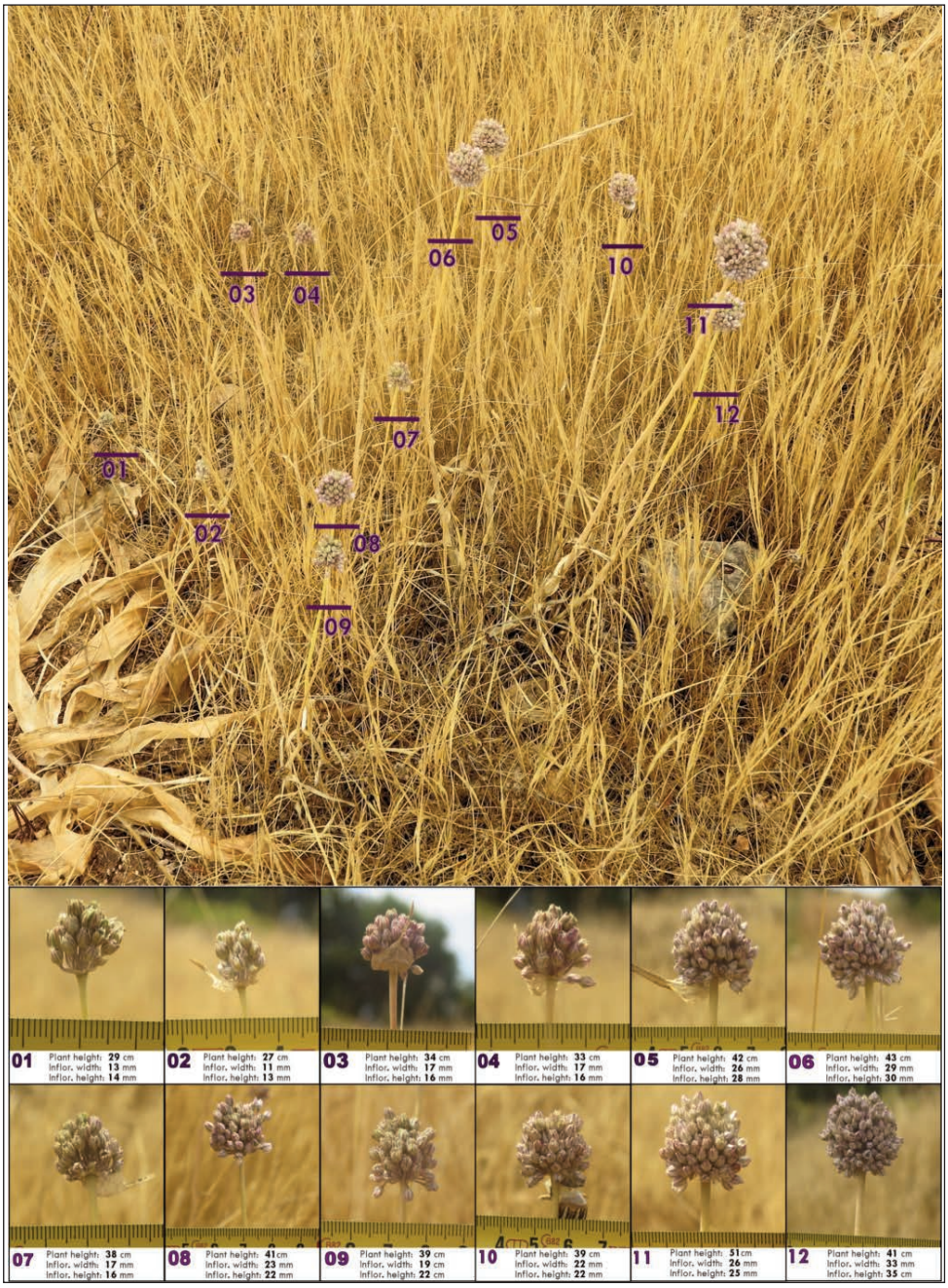

Fig. 11. Clump of twelve individuals of *Allium polyanthum* at Wied Diegu, Żurrieq (1 June 2014) and their plant height and inflorescence size clearly showing that some measurements are within the species concept of the presumed endemic *A. melitense*, distinct and described for its small stature and hemispherical inflorescences less than 3 cm wide.

keel of the external tepals was observed, but then not as numerous or large as in the hybrid taxa (groups G and Z).

Five individuals of *A. polyanthum* were found at Spiaggia Bruca, close to Arizza beach, in their developed but still closed fruit. It is assumed that their flowering period was several weeks prior to this observation, hence in mid May. Despite the fact that these examples were quite dry, they had leaves with a smooth leaf margin, Type A floral papillae and small helmet-shaped bulblets. Previous notes to the name *A. polyanthum* in Sicily, as synonym of *A. ampeloprasum,* can be found in Giardina & al. (2007). The record of this species for Sicily is included in the recent checklist of the Flora of Italy (Bartolucci & al. 2018).

Three individuals *Allium* sp. were found close to Marina di Modica, in a degraded vegetated littoral ground. They had very young pale green fruits and few old, shrivelled flowers indicating that the flowering period occurred a few weeks before, more or less in mid June. The leaf margin had half-weathered but distinct papillae; the outer stamens tricuspidate, inner stamens simple and monocuspidate; floral papillae Type C but with some large papillae spread away from the keel in few tepals and numerous heterogeneous bulblets with helmet-like, hemispherical and irregular (angular) shapes as in Type C bulblets (Fig. 10) This character set approaches that of *A. commutatum ´ polyanthum*. This is the first record for Sicily and Italy according to Giardina & al. (2007) and Brullo & Guarino (2017). Bartolucci & al. (2018) does not includes hybrids. Further investigations are needed to clarify its distribution in Sicily.

Allium section *Allium* subsect. *Scoroprasum* on the Maltese Islands

A. polyanthum Schult. & Schult. f. Syst. Veg. 7: 1016 (1830)

= *A. ampeloprasum* var. *melitense* Sommier & Caruana Gatto; = *A. melitense*. (Sommier & Caruana Gatto) Ciferri & Giacomini

Common in Malta, Gozo, Comino and other islets (Mifsud 2011; Mifsud & al. 2016), probably also present in the islets of Filfla and General's rock (Fungus rock). Habitat: steppe and degraded garigue, but sometimes also in wasteground, abandoned clayey fields (usually forming larger plants), and rarely in littoral areas. Native.

A. commutatum Guss. Enum. Pl. Inarim. 339 (1855)

Very rare and confirmed from the location at Xgħajra, Malta, and very recenlty found at Saint Paul's Bay. Habitat: disturbed coastal rocky ground. Native, threatened by human disturbance, future or illegal development, alien species, massive collection of waste dumping and recreational activities close to the sea. It is suggested to include this species in the future edition or the Red List for the Maltese Islands.

A. commutatum* × *A. polyanthum

Rare but locally frequent in established populations at the coast of Wied iz-Żurrieq, Wied Babu and Blue Grotto, Żurrieq in mainland Malta and at Dwejra, Xlendi and San Dimitri in Gozo. Large individuals recorded from the islets of Filfla and General's rock (Fungus rock), (Lanfranco 1989; pers. comm. Michael Briffa and Joe Sultana) are likely other established hybridigenous populations. Habitat: coastal rocky ground and steppe. Native.

Fig. 12. Photos comparing the umbel, corolla and floral papillae of the external tepals of: 1. *A. polyanthum* (Mġarr ix-Xini, Ta' Sannat, Gozo, 23 May 2014); 2. *A. commuatum* (Xgħajra, 25 June 2016); 3. *A. commutatum* × *A. polyanthum* (Wied iż-Żurrieq, 6 June 2015) from the Maltese Islands and 4. *A. commutatum* (Cava d'Aliga, 27 June 2015) from the southeast coast of Sicily.

Identification key to species of Allium *subsect.* Allium *in Malta*

1. Leaf margin subpillose with long digitate papillae more than 400 µm long. Only cultivated .....***A. porrum* var. *kurrat***

1. Leaf margin smooth or with shorter conical papillae reaching up to 300 µm long. Wild, native or naturalised. **2**

2. Stamens included, same level of corolla mouth or slightly exserted by 1 mm; leaf margins smooth (papillae absent) or rarely crenulate with weathered flattened papillae <100 µm long; inner tepals without or with very few papillae.....***A. polyanthum***

2. Stamens fully exserted by 2 mm or more above the corolla mouth; leaf margins scabrid by persistent papillae, usually visible by naked eye (>150 µm long) even in mature individuals; inner tepals densely papillose and punctate. **3**

3. Outer tepals with numerous large papillae (>80 µm) distributed throughout most of the tepal except at the border and small papillae (20–40 µm) spread throughout the entire surface. Inner stamens always simple and monocuspidate. .....***A. ampeloprasum***

3. Outer tepals without of with few large papillae (>80 µm) present only on the keel and small papillae (20–40 µm) spread throughout the entire surface. Inner stamens tricuspidate or bicuspidate (very rarely monocuspidate.) **4**

4. Inner stamens mostly tricuspidate; outer tepals without large (>80 µm) papillae, or if present occupying less then third of the keel; bulblets homogenous all fusiform-elleipsoid, with a long tapering end; spathe beak >15 cm long.....***A. commutatum***

4. Inner stamens either simple, or mixed biscuspidate and tricuspidate but never all tricuspidate; tepals with large distinct papillae (>80um) on at least one third of the length of the keel; bulblets heterogenous; spathe beak usually < 15 cm long. .... ***A. commutatum* × *A. polyanthum***

Conclusion

This study on *Allium* subsection *Allium* has brought important changes for the flora of Malta, which so far relied on historical flora (e.g. Sommier & Caruana Gatto 1915; Borg 1927; Haslam & al. 1977). The study on 165 specimens from 59 populations resulted in the occurrence of three reckognised taxa in the Maltese Islands: *A. polyanthum* (very common), *A. commutatum* (very rare) and their hybrid *A. commutatum* x *A. polyanthum* (rare). *A. melitense* is now treated as synonym of *A. polyanthum* while *A. ampeloprasum* was not found in the examined material and most probably is not present in natural habitats in Malta.

Despite these novelities, more karyological work is required to establish the chromosome numbers of these population especially for the two hybrid populations in the Maltese islands, where the Gozitan population was found to be sterile while that from Żurrieq in mainland Malta produced many sterile seeds.

Acknowledegments

Our special thanks must go to Errol Vela, and Daniel Pavon for the comments pertaining to the taxonomy and treatment of *Allium* Sect. *Allium* in France and to Edwin Lanfranco, Michael Briffa and

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