

A STUDY OF THE GENUS *PERSICARIA* MILLER (POLYGONACEAE) IN THE MALTESE ISLANDS

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ABSTRACT

A detailed study on the taxonomy, distribution and populations of *Persicaria* spp. occurring on the Maltese Islands is carried out based on field surveys between 2008 and 2011. Four taxa are recognised in this study: two forms of *Persicaria senegalensis*, *P. lanigera* and *P. salicifolia*, of which only the latter is native. A taxonomical overview of these species and a detailed account of the distribution and size of the populations of each species (including new records) is given. Habitat preference of the species and their significance in Maltese wetland ecosystems are discussed.

KEYWORDS: *Persicaria*, *Polygonum*, Taxonomy, Distribution, Wetland flora, Malta.

1. Introduction

Persicaria, commonly known as smartweeds, is a genus debatably segregated from the parent genus of *Polygonum* by Miller back in 1754. Currently, it comprises about 150 mostly cosmopolitan species. Most species are found in temperate regions, few others in tropical and sub-tropical regions from sea level to a range of different altitudes. (Heywood *et al.*, 2007).

While some authors do not recognize *Persicaria* as a genus but only as a section of *Polygonum* s.l. – for example Webb (1993), Watson & Dallwitz (1992) and Alvarez (2001); systematic research based on pollen studies and anatomical data commencing from that of Hedberg (1946) together with recent phylogenetic analysis such as that by Lamb Frye & Kron (2003) gives evidence that the segregated genus of *Persicaria* as proposed by Ronse De Craene & Akeroyd (1988) is valid. *Persicaria* is currently an accepted genus by several authorities such as Wilson (1990), Henwood *et al.* (2007), Morris (2009), Kantachot *et al.*, (2010), TPL, FNA and FZB.

According to the keys provided by Webb (1993) species of Sect. *Persicaria* (and *Bistorta*) differ from Sect. *Polygonum* as follows:

"ochreae entire or fimbriate but scarcely lacerate; flowers usually in dense spikes, rarely in lax, leafless spikes (Sect. *Bistorta* & *Persicaria*)

ochreae usually becoming deeply lacerate; flowers in small, sessile axillary clusters, or in lax, slender, often leafy spikes (Sect. *Polygonum*)“

Additionally, flowers of *Persicaria* have 2 styles (rarely 3) while *Polygonum* have 3 styles, rarely 2. (Webb, 1993)

Species of *Persicaria* are herbaceous plants or climbing shrubs with swollen nodes. The ochrea is a tubular sheath with an entire or ciliate margin but not lacerate. Leaves are simple, large, alternate or spiral, glabrous or pubescent often long elliptic, lanceolate to ovate. Flowers are arranged in singular spikes, less often a spicate panicle or capitate panicle, rarely a singular capitulum. Bracts either absent or few and inconspicuous. Perianth is petaloid, 3-5-merous, tepals united at the base. Corolla is often pink, but also white or rarely yellow, with the tepals often persistent in fruit. Stamens 5-9. Styles 2 or rarely 3, cleft-like, united below. Nut shape is lenticular, trigonous or slightly circular. (Kantachot *et al.*, 2010)

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2. Historical literature and recent records of *Persicaria* spp. in Malta.

In historical Maltese floras, *Persicaria* species were, as expected, given under the genus *Polygonum*. In the flora of Borg (1927), 8 taxa under five *Polygonum* species are given:

- 3 varieties of *P. aviculare* - found in fields and roadsides:
 - var. *aviculare* (common);
 - var. *depressum* (frequent)
 - var. *bellardi* (rare at Mara, San Anton and Ghajn Tuffieha);
- *P. maritimum* - a sand dune and salt marsh species, at that time rather frequent.
- *P. convolvulus* - found on irrigated land and gardens, frequently in mainland Malta, rare on the island of Gozo.
- 2 varieties of *P. lapathifolium* - found on irrigated land and gardens
 - var. *lapathifolium* (rare at Ġnien Ingraw, Ghajn Zejtuna, Ġnien Fieres, Burmarrad and Attard)
 - var. *persicaria* [syn = *P. persicaria*] (rare at Ġnien Ingraw, Bahrija and Imtahleb)
- *P. minus* var. *serrulatum*- found in streamlets, ditches and moist places at Ġnien il-Kbir, Imtahleb, Ġnien Ingraw and Bahrija

Only the last three taxa from the list above are now assigned to *Persicaria* that is:- *Persicaria lapathifolia* (L.) Delarbre, *P. maculosa* Gray and *P. salicifolia* (Brouss. ex Willd.) Assenov respectively.

Persicaria salicifolia (basiosyn. *Polygonum salicifolium* Brouss. ex Willd.) is recorded from Mtahleb (Grech Delicata, 1853), Ġnien il-Kbir (Sommier & Carauna Gatto, 1915) Ġnien Ingraw and Bahrija (Borg, 1927) but in this study based on man ysurveys, the species was only found at Wied il-Bahrija ('wied' = valley). Its occurrence at the other three stations is also questioned by Lanfranco (1989), where he states that it is "restricted to just two stations" of which one is Wied il-Bahrija and the other is an unpublished record at Rdum Hurrieqa at Dingli Cliffs found some 2 decades ago (pers. comm., Edwin Lanfranco). On surveying the latter location on the 27th November 2011, no population of *Persicaria* spp. was observed, instead, the area was disturbed and overcrowded by strands of *Arundo donax*, L., while the spring of water was found to be in short supply.

Persicaria lapathifolia s.l. was not confirmed in surveys at the stations reported in past literature. Haslam (1977) cites the same historical records of Borg (1927), while no records have appeared in recent publications (Lanfranco, 1989; Weber, 2006; Tabone, 2008). The last appearance of *P. lapathifolia* on Malta was a casual occurrence that persisted for few years about 30 years ago. It was spotted by Mr. E. Lanfranco on the granaries at St.Elmo, Valletta and believed to have become extinct a few years later (pers. comm., Edwin Lanfranco). Similarly, *Persicaria maculosa* has never been confirmed or reported in recent work.

Finally, Lanfranco (1971) reports *Polygonum equisetiforme* from Manoel Island, Ta' Xbiex, but he states that this population was destroyed by development. Some specimens were transplanted to the Argotti Botanical Gardens, Floriana (Lanfranco, 1989) where it still survives.

On the 16th April 1987, Michael Briffa had found a population of a white-flowering *Persicaria* at Ghajn il-Kbira and Wied il-Girgenti, located at the limits of Siggiewi, Malta (pers. comm., Michael Briffa). This was first identified as *Polygonum mite* Schrank and published under that name in the Red Data Book for the Maltese Islands (Lanfranco, 1989). Later, it was determined to be a different species - *Persicaria senegalensis* (Meisn.) Soják (basiosyn. *Polygonum senegalense* Meisn.). The same population was observed in 1992 by Tabone (2008) and was observed by the author of this work on (May 2010) at Wied ta' Brija, a segment of the valley system following Ghajn il-Kbira and Wied il-Girgenti. Tabone (2008) recorded a new population of *P. senegalensis* at Wied tal-iSperanza, Mosta, Malta. Moreover, a new population was found scattered along the valley bed of Wied il-Ghasel on the 14th Feb 2010, by the author of this work. Both populations were observed again on September 2011

On the 18th June 1990, Michael Briffa, discovered another *Persicaria* population with rose-pink flowers at wied tal-Hzejjen, located at the limits of Mgarr, Malta. This was identified to him as *Persicaria glabra* (Willd.) M.Gómez (pers. comm. Michael Briffa). The discovery of clustered populations with similar rose-flowered specimens is attributed to the author of this work, located at Wied tal-Grazzja, Victoria, Gozo (30th Jan 2008), Wied l-Ort, Ghasri, Gozo (23rd Apr 2008) and Wied Sara, Victoria, Gozo (23rd, Apr 2008). These are valley segments of a 7km-long valley system running from the village of Ghasri eastwards to Victoria and then southwards to Wied Marsalforn where finally it flushes in the shore of Marsalforn bay. These populations were observed again in October 2011. Tabone (2008) recorded *P. glabra* from Wied Sara on the 10th of June 2008.

Persicaria lanigera (R.Br.) Soják - another species that was new for the Maltese flora - was discovered from Wied Sara and Wied tal-Grazzja, Gozo on October 1992 by Tabone (2008). Later, on the 12th of April 1993, Mr. Anthony Bonnici and Mr. Michael Briffa found another population at Wied tas-Seqer, Ghasri, Gozo (pers. comm., Michael Briffa), while another population was spotted at Wied il-Ghajj (l/o Bidni), Marsascula, Malta by Stevens & Tanti (1997) on the 15th July 1997. Tabone (2008) recorded another population at Wied Ghasri, Ghasri, Gozo on the 30th of September 2000. With the exception of Wied tas-Seqer, the author confirmed these populations in the beginning of October 2011.

3. Materials & Methods.

Fifteen different morphological characters were studied from twelve *Persicaria* spp. populations (table 1). The resulting character states are summarised in table 2a and 2b. Taxonomy of these populations has been studied at different periods between 2008 and 2011, but in order to study these characters in the same period of time, a fresh study on all material was conducted between 15 September and 18 October 2011. The exceptions are population **PSN1** (refer to Table 1) because this population was destroyed and the results are hence based on previous studies and **PSN5** which was studied in Nov 2013 after it was reported to the present author later in 2012 (pers. comm., E. Lanfranco & D. Stevens). The size and distance between adjacent meta-populations of each population were recorded. The first metapopulation given in the list below is that located most upstream along the valley, where the subsequent metapopulations downstream are then given serially till the last metapopulations met along the water course.

A 10x magnifying glass and a 20x – 40x stereo light microscope were used to study the structure of the glands on the leaves and peduncles. The ochreae studied were those located at the upper part (terminal third) of the stem; normally being well developed and not destroyed or damaged by weathering as those at the lower parts of the stem. Ochreae at this part of the stem had the best representation of their indumentum and apical margin. With regards to the measurement of leaves, 10 to 12 leaves were randomly selected from the upper foliar rosette of the stem, each from a different specimen and an average was calculated. The length includes the petiole, while the width was measured at the widest part of the leaf. The measurement of the nuts includes the tiny beak.

4. Taxonomy

4.1 *Persicaria salicifolia* (Brouss. ex Willd.) Assenov

Persicaria salicifolia (= *Polygonum salicifolium* Brouss. ex Willd., *P. serrulatum* Lag., *P. serrulatoides* H. Lindb.) is a perennial plant with rooting, procumbent or decumbent stout stems reaching up to 70cm in height. The 7-15cm long, linear-lanceolate leaves are glabrous except for some stiff hairs on the margins and the veins beneath. It produces pink flowers, in long, lax, very slender spikes. Nuts 2-2.5 mm, black, glossy, usually trigonous. It is native to the South of Europe dwelling in wet places and river-banks (Webb, 1993). It is distinct from the other *Persicaria* species in Malta mainly from its lax flowers in narrow spikes, trigonous nuts, and smaller linear-lanceolate leaves.

This species is quite variable, with a history of numerous synonyms and several subspecies and varieties described, of which now, they are all treated as synonyms (FZB, TPL). It seems that there is no consensus which taxon is accepted; for instance, according to FZB and GRIN, *P. salicifolia* is a synonym of *P. decipiens* (R. Br.) K.L. Wilson while, according to TPL, it is a synonym of *P. serrulata* (Lag.) Webb & Moq. It is beyond the scope of this account to discuss which taxon must be applied, but the conventional *Persicaria salicifolia* is used in this paper, in line with that used in the Red data book (Lanfranco, 1989) under the basionym of *Polygonum salicifolium* Brouss. Ex Willd. and by the Malta Environment Planning Authority, such as in their recent educational article in local media (TOM, 2011).

4.2 *Persicaria lanigera* (R.Br.) Soják

Persicaria lanigera (= *Polygonum lanigerum* R. Br.) is an erect, villous, perennial plant reaching up to 200cm in height. It forms shortly petiolated, lanceolate to ovate-lanceolate leaves (10-25 × 2-6 cm in size), with a cuneate base and acuminate tip, densely covered with white lanate hair especially beneath. It produces dense spikes of pink flowers. It is rather easy to distinguish owing to its characteristic eglandular lanate leaves making them appear greyish and hoary, the shortly villous ochreae with a line of woolly cilia over 5mm long on its apical margin and the presence of white woolly hair on the eglandular peduncles (Thiselton-Dyer, 1913; Webb, 1993).

Table 1: List of populations of *Persicaria* spp. in Malta from which material has been studied.

Popl. Code	Site, locality, island	First record	Reported or identified as	Date of study
PSL1	Wied il-Bahrija, Rabat, Malta.	1853 by Grech Delicata	<i>Polygonum minus</i>	Oct 2011
PSN1	Wied il-Girgenti / Wied ta Brija, Siġġiewi, Malta	1987 by M. Briffa (pers. comm.)	<i>Persicaria senegalensis</i> (s.l.)	May 2010
PSN2	Wied l-iSperanza, Mosta, Malta.	1992 by Tabone (2008)	<i>Persicaria senegalensis</i> (s.l.)	Sep 2011
PSN3	Wied il-Għasel, Mosta, Malta.	2010, in this work (new record)	n/a	Sep 2011
PSN4	Tar-Rummien Quarry, Kirkop, Malta	2000 by Lanfranco (2000)	Not identified (<i>Persicaria</i> spp.)	Nov 2013
PGL1	Wied il-Hzejjen, Mgarr, Malta.	1990 by M. Briffa (pers. comm.)	<i>Persicaria glabra</i>	Sep 2011
PGL2	Wied l-Ortolan, Għasri, Gozo.	2008, in this work (new record)	n/a	Oct 2011
PGL3	Wied Sara, Victoria, Gozo.	2008 (by Tabone, 2008)	<i>Persicaria glabra</i>	Oct 2011
PGL4	Wied tal-Grazzja, Victoria, Gozo.	2008, in this work (new record)	n/a	Oct 2011
PLA1	Wied il-Għajn (tal-Bidni), M'Scala, Malta.	1997, by A. Bonello and A. Falzon in Stevens & Tanti (1997)	<i>Persicaria lanigera</i>	Sep 2011
PLA2	Wied il-Għasri, Għasri, Gozo.	2000 by Tabone (2008)	<i>Persicaria lanigera</i>	Oct 2011
PLA3	Wied Sara, Victoria, Gozo.	1992 by Tabone (2008)	<i>Persicaria lanigera</i>	Oct 2011

4.3 *Persicaria senegalensis* (Meisn.) Soják and *Persicaria glabra* (Willd.) M.Gómez

The following debate concerns the other two *Persicaria* species reported from Malta as *P. senegalensis* (= *Polygonum senegalense* Meisn.) and *P. glabra* (= *Polygonum glabrum* Willd.). It does not seem a coincidence that from such local accounts and personal communications, there is a misconception that the pink- or rose-flowering *Persicaria* (**PGL1-4**) are attributed to *Persicaria glabra*; while the white flowering populations (**PSN1-3**) to *Persicaria senegalensis*. Since both taxa are described as forming flowers ranging from white to pale pink to rose-pink (Graham, 1958; FIN; FNA; FOC; FZB), flower colour is not a distinguishing character. Both *P. senegalensis* and *P. glabra* are large, perennial plants similar in habit and inflorescence to *P. lanigera*. From the various floras researched (FCN; FNA; FZB; Thistleton-dyer, 1913; Graham, 1958; Maire, 1961; Miller *et al.*, 1996; and Jansen, 2004) the main distinguishing differences between *Persicaria glabra*, *P. senegalensis* and *P. lanigera* are chiefly based on the following characters:

- (i) the pilosity of leaves and flower peduncles,
- (ii) yellowish sessile glands on the abaxial leaf surfaces and flower peduncles
- (iii) the indumentum and apical margin of the stem's ochreae and
- (iv) the shape of the nuts.

Other taxonomical differences of minor importance include plant size and robustness, redness of stems, and width of leaves. One must early point out that these two species are rather variable with marginally overlapping distinguishing character states (Wilson, 1990) that makes their identification not a straight forward process.

Jansen (2004) describes *P. senegalensis* to be, “variable in its indumentum, from glabrous to densely white woolly tomentose. This has resulted in the distinction of several subspecies, varieties and forms, but numerous intermediate types exist, sometimes even on the same plant”. The same author also states that that *P. senegalensis* much resembles *P. glabra* (Willd.) M.Gómez, but it is usually larger with wider leaves longer perianth and fruit never triangular.

The flora of Thiselton-Dyer (1913) covers 20 keyed and described *Polygonum* species which comprises *Polygonum lapathifolium*, *P. lanigerum*, *P. glabrum*, *P. senegalense* and *P. sambesiacum*. Here, *P. lanigerum* is distinguished from other species by having leaves with white dense lanate hair. *P. senegalense* and *P. sambesiacum* are distinguished from *P. glabrum* by having leaves moderately hairy below compared to *P. glabrum* which is glabrous. *P. sambesiacum* differs from *P. senegalense* by having yellow glands at the underside of the leaves, but *P. sambesiacum* is now treated as a synonym of *P. senegalense* (APD, TPL).

Reference to the pilosity and yellow glands at the lower side of leaves of *Persicaria senegalensis* is made by Graham (1958), Maire (1961) and FZB the latter stating “glabrous apart from hairs on the midrib and margins to densely white-woolly on both surfaces, often more densely so on the lower surface, covered with small yellowish glands on the lower surface”. These three authors also mention the presence of amber glands on the flowering peduncles. For example “peduncles up to 7 cm long, with orange glands, glabrous or with adpressed hairs” (FZB) and “peduncles covered with orange glands, puberulent varying to white-tomentose.” (Graham, 1958). The ochreae are generally glabrous or glabrescent, without cilia or with up to 3 mm long slender cilia according FZM; with few short, sparse cilia according Maire (1963) and eciliate according Thiselton-Dyer (1913). Finally one should mention that this species exudes a yellow substance from its glands onto herbarium papers when pressed (Graham, 1958).

According to FZW, APL and TPL there are two accepted forms of *Persicaria senegalensis*: forma *senegalensis* and forma *albotomentosa* (R.A. Graham) K.L. Wilson, where, as the epithet suggests, the latter differs from the nominal form by having a white tomentum. FZM further states that forma *senegalensis* is glabrous with green leaves whereas forma *albotomentosa* has whitish leaves due its tomentose hairs.

Persicaria glabra is characterised to be a glabrous plant throughout (Thiselton-Dyer,1913; FCN; FPK; FIN) though FNA states that rarely, it could be pubescent distally. The leaves are normally glabrous but some authors make reference to the presence of scabrous hairs only on the midrib and main nerves (Thiselton-Dyer , 1913; FNA; FIN) - such varieties were even described as *P. glabra* var. *scabrinervis* (Hook.f.) H. Hara. Thiselton-Dyer (1913), Miller et al.(1996), FNA, FCN, FPK or FIN, give no indication that *P. glabra* has pubescent or tomentose hair at the abaxial surface of the lamina. With regards to the foliar glands, there are mixed descriptions. Thiselton-Dyer (1913) and FCN does not mention presence of any foliar glands; FPK and FZB states completely glabrous, sometimes red-gland dotted; FIN states “minutely pustulate, otherwise usually smooth” ; FNA’s description is “sometimes glandular-punctate” while Miller et al., (1996) writes “minutely yellow glandular”.

Thiselton-Dyer (1913), FCN, FPK, and FZB do not mention the presence of glands on the peduncles of *P. glabra* - for example “[peduncles are] glabrous, not glandular” (Thiselton-Dyer (1913) but FNA and FIN states peduncles can rarely be glandular-punctate. The ochreae of *P. glabra* is described by Thiselton-Dyer (1913), FPK, and FNA to be glabrous and completely eciliate except FIN which states “apex not ciliate, sometimes with a few bristles ca. 0.5mm long”. Finally, Miller et al., (1996) make emphasis on the nuts which, in their key, apart the yellow glands on the peduncle coherent with the above account, they differentiate *P. senegalensis* from *P. glabra* by (the former) having nuts with dimpled faces against nuts without dimples in *P. glabra*. Apart that, they also state that the nuts of *P. senegalensis* are 3mm and seldom trigonous in shape, while those of *P. glabra* can be either lenticular or trigonous and 2.5mm diameter.

4.4 Taxonomic key for the *Persicaria* spp. in Malta

To simplify the identification of the Maltese material, a key was adapted from the information given above.

- 1a. Spikes lax and slender; larger leaves up to 18cm long, finely serrulate; nuts trigonous*P. salicifolia*
- 1b. Spikes dense and stout, with the flowers crowded and overlapping; larger leaves much over 18cm long; nuts lenticular**2**
- 2a. Both sides of leaves greyish due to a covering of lanose white hairs, peduncles densely lanate, ochreae shortly lanate with a row of cilia (>5mm long) on the margin*P. lanigera*

- 2b. Upper surface of leaves green, glabrous to glabrescent, peduncles without dense hair, at most scantily strigose; ochreae glabrous, eciliate or with a row of short cilia (<4mm long) on the margin..... **3**
- 3a. Peduncles glabrous without or with a few punctate glands, apical margin of most ochreae eciliate, nuts lenticular or trigonous *P. glabra*
- 3b. Peduncles with several sessile (bulging) yellow glands, apical margin of ochreae with 2-3mm long cilia, nuts always lenticular**4** (*P. senegalensis* s.l.)
- 4a. Abaxial side of lamina glabrous apart from strigose midrib, veins and margin.....*P. senegalensis* forma *senegalensis*
- 4b. Abaxial side of lamina with short white hair to densely tomentose *P. senegalensis* forma *albotomentosa*

5. Identity of the *Persicaria* spp. and notes on the corresponding populations.

A comparison of morphological features of all Maltese populations are given in Table 2a & 2b, and the most distinguishing ones are further illustrated in Figures 1, 2, 3 and 4

5.1.1 Material: **PSL1** - Wied il-Bahrija (Bahrija, Malta) ; Examined: 18 October 2011, October 2013)

A population of *Persicaria* present at Wied il- Bahrija has been known since Borg (1927). Concurring with previous work (Haslam, 1977; Lanfranco 1989, 2002) the species corresponds to *Persicaria salicifolia*, distinguished from its relatively small habit, long stiff bristles lining the apical margin of the ochreae, linear-lanceolate, (willow-like) leaves, lax inflorescence on 1cm thick spikes and trigonous nuts.

During a survey at Wied il-Bahrija on 18-Oct-2011, three metapopulations were observed in this valley bed. Although not anymore a “dominant component of its [Wied Bahrija] vegetation” as reported more than 20 years ago by Lanfranco (1989), the population is still well-defined. The dense stands of *Arundo donax* L. engulfing the wetland habitat of this valley bed is the main natural threat for *Persicaria salicifolia*. The metapopulations observed at Wied il-Bahrija are given below of which the largest one was found in one of the very few exposed parts of the valley where *Arundo donax* is not present. 20 to 30 years ago, Edwin Lanfranco (pers. comm.) and Michael Briffa (pers. comm.) recall much larger populations of *P. salicifolia* in parts of this valley which was not overrun by *Arundo donax* L. as is at present

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|-------------------------|--------------|--|
| 1) First metapopulation | | Size: 4m x 2m (hindered by sparse stands of <i>Arundo donax</i>) |
| 2) Next metapopulation | 280m away | Size: 5m x 2m (beside a footpath) |
| 3) Next metapopulation | 60m away | Size: 25m x 3m (in an exposed clearing) |
| 4) Next metapopulation | 500m c. away | Size: 3m x 2m (in a depression of the valley bed amongst <i>A. donax</i>) |

5.2. 1 Material: **PLA1** - Wied il-Ghajj (M’Scala Malta) ; examined: 18-Sep-2011

The examined material had eglandular, lanate leaves and flowering peduncles. ochreae tomentose with a line of shaggy cilia more than 5mm long on its apical margin. According to the taxonomical discussion above (section 4.2 and 4.4) the material is identified as *Persicaria lanigera*, consistent with the identity given by Stevens & Tanti (1997); Tabone (2008), Edwin Lanfranco and Michael Briffa (pers. comm.)

The population at Wied il-Ghajj was first observed by the author back on the 31-Aug-2006 as a large and dominating population of about 60m x 10m. It was visited again on April 2008, and the population was found to have decreased by half. A few specimens were at that time parasitized by *Cuscuta campestris* Yunck; a recent introduction to the Maltese Islands (pers. comm. Edwin Lanfranco). On the 18-Sep-2011, the area that 5 years before was dominated by *P. lanigera*, now exhibited only a clump of about 15 plants occupying an area of merely 4 x 2m in size. They were found surrounded by ruderal species chiefly *Aster squamatus* (Sprengel) Hieronymus, *Amaranthus viridis* L., and few specimens of *Mirabilis jalapa* L., *Datura innoxia* Mill, *Rumex conglomeratus* Murray and *Rumex cristatus* L. The later species is a rare and strictly protected species which was not previously recorded from this site.

Further areas were explored during the survey in Sep 2011, and two other metapopulations composed of few individuals or small clumps were found dispersed downstream. The metapopulations observed at Wied il-Ghajj are as follows:

- | | | |
|-------------------------|-----------|---|
| 1) First metapopulation | | Size: 4m x 2m (beneath a small bridge) |
| 2) Next metapopulation | 50m away | Size: 5m x 5m (individual specimens scattered here and there) |
| 3) Next metapopulation | 180m away | Size: 5m x 3m (near a dam built across the valley) |

5.2.2 Material: **PLA2** - Wied tal-Sara (Victoria, Gozo) ; examined: 3-Oct-2011

The only site in Malta which comprises two different *Persicaria* spp. growing together is that at Wied Sara, where two small clumps of a *Persicaria* sp. with grayish leaves (**PLA2**) were found intermixed with a larger population of another *Persicaria* sp. with bright green leaves (**PGL2**, discussed below). **PLA2** had the same characters of **PLA1** and identified as *Persicaria lanigera*. This concurs with the species reported from here by Tabone (2008). Only 2 small clumps of about 2-3m diameter and 5-8m apart were observed on a survey carried out on 3-Oct-2011.

5.2.3 Material: **PLA3** - Wied il-Ghasri (Ghasri, Gozo) ; examined: 11-Oct-2011

Another population of *Persicaria* was observed colonising an area of 30m x 5m of at the valley bed of Wied Ghasri, Gozo. No other metapopulations were found during a survey of this valley on 11-Oct-2011. The examined specimens had the same morphological characters as the material in **PLA1** and **PLA2**, that is, leaves and peduncles covered with the characteristic white, lanose indumentum and with tomentose ochreae with long-ciliated wool-like cilia. The population was hence identified as *Persicaria lanigera*, coherent with the record of Tabone (2008) from this site.

5.3.1 Material: **PSN1** - Wied il-Girgenti / Wied ta' Brija (Siggiewi, Malta) ; examined: May-2010

Specimens of this white-flowering smartweed had leaves with conspicuous sessile yellow glands mostly located at the lower surface. Leaves were hairless at both surfaces except scabrous hairs at their margins, midrib and main branching veins. The peduncles were mostly glabrous, covered with similar yellow glands as on the leaves. The ocheae were glabrous and had a line of 3mm long cilia on their apical margin. Nuts were not studied because the population was not anymore extant when this character was being studied for. Nevertheless, with reference to section 4.3 and 4.4 of this account, the characters are those of *P. senegalensis* forma *senegalensis*. Populations from neighbouring sites of Ghajn il-Kbira and Wied il-Girgenti had been already identified as *P. senegalensis* by Tabone (2008) and Michael Briffa (pers. comm.)

During a survey in May 2010, this population was about 15m x 5m in size and found in a shallow pond along the valley bed. In summer 2010, the population was missing by dredging of the valley bed. Despite the species produces large amounts of seeds, none had regenerated the population after more than within 3 years. Fortunately, few specimens of this population regenerated and observed in January 2014.

5.3.2 Material: **PSN2** – Wied l-isperanza (Mosta, Malta) ; examined: 19-Sep-2011

Specimens at Wied l-isperanza exhibited the same morphological characters as in **PSN1**, with the characteristic yellow sessile glands at the abaxial side of the lamina and flower inflorescences. The nuts were all lenticular, 3mm in diameter, many with dimpled faces. This population also corresponds to *P. senegalensis* forma *senegalensis*. The identification concurs with that given by Tabone (2008) from this site.

Wied l-isperanza is part of a large valley system starting from Dingli and Rabat at the North West of Malta and it ends up at Salini, a coastal area located at the East of Malta. The part of Wied Speranza sampled is in the limits of Mosta. The population was found to be scattered in several metapopulations along the valley bed during a survey carried out on 18-Sep-2011. No water was found flowing during this site visit but parts of the valley bed were damp. A series of 8 metapopulations were found along the valley bed for about 500m as follows:

- | | | |
|-------------------------|-----------|---|
| 1) First metapopulation | | Size: 15m x 5m (In a water pond at the bottom of a bridge) |
| 2) Next metapopulation | 200m away | Size: 100m x 5m (close to the <i>San Pawl tal-Qliegha</i> chapel) |
| 3) Next metapopulation | 20m away | Size: 25m x 3m |
| 4) Next metapopulation | 50m away | Size: 5m x 2m |
| 5) Next metapopulation | 40m away | Size: 15m x 2m |
| 6) Next metapopulation | 65m away | Size: 3m x 2m |
| 7) Next metapopulation | 20m away | Size: 5m x 2m |

8) Last metapopulation 40m away Size: 10m x 10m (in a rock cavity flooded with water)

All these meta-populations were present in small localised areas where water is retained and flooded for a long time, forming long-lasting temporary ponds. In Summer, such areas dry out, but the ground remains damp and seems to be enough for the rootstock to survive.

5.3.3 Material: PSN3 – Wied il-Ghasel (Mosta, Malta); examined 20-Sep 2011

A population of *Persicaria* sp. with white flowers was found by the author at Wied il-Ghasel (Mosta) on 2-Dec-2009 during a wetland survey for MEPA. Similar to **PSN1** and **PSN2**, examined material consisted of glabrous leaves with strigose margins and midveins and numerous yellow glands mostly located at the abaxial surface. The peduncles bore similar glands but lacked hair, while the apical margin of the ochreae had a line of cilia about 2mm long. The species was identified as *Persicaria senegalensis* forma *senegalensis* and is a new record from this valley, which belongs to the same valley system from which **PSN2** was recorded, about 1.5km upstream. There is no evidence to confirm whether this rather remote population originated by a dispersal event by water streams from population **PSN2** or if it is a new introduction, but the former seems to be more plausible.

Three metapopulations were found along the valley bed during a survey on 20-Sep-2011:

- | | | |
|-------------------------|-----------|----------------|
| 1) First metapopulation | | Size: 15m x 2m |
| 2) Next metapopulation | 150m away | Size: 40m x 3m |
| 3) Next metapopulation | 220m away | Size: 5m x 2m |

5.3.4 Material: PSN4 – Quarry at ta'Rummien, Kirkop, Malta; examined 2-Nov-2013

A population of *Persicaria* was spotted by Timothy Tabone from an unused quarry flooded with water at Kirkop and tentatively identified and reported as *Persicaria cf lanigera* (Lanfranco, 2000). It was not possible for the cited persons to reach and identify the population to species level (pers. comm. Edwin Lanfranco). The present author was informed about this population in May 2013 (pers.comm Darrin Stevens) and visited the quarry on 1-Nov-2013. Two large clumps at the west and northeast side of the quarry together with two smaller clumps at the south side were observed. Access was gained from the south side and voucher specimens were collected and examined.

The plants formed pink flowers with elongate slender lance-shaped leaves giving an instinctive indication that, as in the other pink-flowering populations from Malta, this population corresponds to *P. senegalensis* f. *albotomentosa* or *P. lanigera*. The latter was easily discarded due to the absence of long silky hair on the leaves, ochreae and peduncles. The leaves were generally glabrous, but microscopic examination revealed very short, scabrid hairs only on the veins of the abaxial side. Moreover, the abaxial surface was densely covered by yellow glands that gave the leaf a yellowish tinge. The margin was shallowly undulate and strigose, with stiff, short, appressed bristles. The margin of young ochreae had a row of bristles about 2mm long, although numerous mature ochreae had lost their bristles and appeared glabrous. The peduncles were densely covered with yellow glands but without any hair, hence having the same indumentum as at the abaxial surface of the leaves. The seeds were 3mm in size, black, all lenticular and some (less than half) with a dimpled face. The lack of hair at the lamina and peduncles led the identity to *Persicaria senegalensis* f. *senegalensis* and **PSN4** corresponds to the first population of this subordinate taxon in Malta with pink flowers (PSN1-3 have white flowers).

5.4.1 Material: PGL1 - Wied tal-Hzejjen (Mgarr, Malta) ; examined: 21-Sep-2011

Wied tal-Hzejjen is part of a large valley system running from limits of Mgarr (West of Malta) and joins the valley system of Wied il-Ghasel at Burmarrad (l/o St.Paul's Bay) where it finally meets open sea at Salini, at the North East of Malta. The area where *Persicaria* was found consisted of a large clearing flooded with water during the rainy period with scarce amounts persisting throughout summer. During a site visit on 21-Sep-2011 the valley bed was damp and muddy and a small pond of water was still present close to the population. The main population was about 25m x 10m in size, and there were few smaller satellite clumps of plants close-by. No other metapopulations were found along this valley.

Examined specimens were quite variable in a few important characters. Most notably the indumentum of the leaves, which varied from very hairy (almost tomentose in a few examples) to scantily and shortly hairy (puberulous). Moreover the lamina had a mixture of punctate green glands and yellow sub-sessile glands. The density of glands appeared to be inversely proportional to the pilosity of the lamina, that is, leaves with dense hair were almost eglandular. Confusingly, some specimens had leaves with a different density of pilosity, while others had a patchy distribution of hairiness on the same leaf. The ochreae were glabrous with a line of cilia, 2-3mm long on the apical margin, similar to that in **PSN1-3**.

The studied peduncles possessed sessile yellow glands, also in different densities between specimens. In general glands were abundant in young inflorescences and on the flattened surface of the lower part of the petiole. Some specimens had glabrescent peduncles with short hair only visible by a x10 magnification glass, while others had obvious white hair visible to the naked eye. Several specimens had numerous yellow glands on the hyaline bracteoles when observed under a light microscope at x40 magnification. The colour of the flowers varied from pink to rose-pink grouped in long, often nodding spikes. All seeds examined were lenticular, black, polished, 3mm in diameter and many (c. two thirds) had dimpled faces.

Based on the detailed taxonomy given above (sect 4.3 and 4.4), the material was identified as *Persicaria senegalensis* forma *albotomentosa*, not *Persicaria glabra* as previously identified. The ciliated ochreae, yellow glands on the leaves and peduncles and the white hair on the leaves were the distinguishing characters for this identification.

5.4.2 Material: **PGL2** - Wied tal-Ort (Ghasri, Gozo) ; examined: 3-Oct-2011
PGL3 – Wied Sara, (Victoria, Gozo) ; examined: 3-Oct-2011
PGL4 – Wied tal-Grazzja, (Victoria, Gozo) ; examined: 3-Oct-2011

Several large-sized clumps of *Persicaria* sp. dwell along the Wied Sara valley system, precisely in valley segments called Wied tal-Ort, followed by Wied Sara and then Wied tal-Grazzja, together making a stretch of little more than 2km.

Wied tal-Ort consists of a series of dams built across the valley to form seven water catchment areas, all deep and narrow (5-10m across), except the last one which is about 120m x 20m in size and flooded with relatively shallower water all year round. It is exposed to sunlight and lined by clayey soil or open fields, instead of being shaded and cut into limestone rock as in the previous catchment areas.

The largest metapopulation of Wied l-Ort was found dominating the South side of the water catchment area while a smaller one was present along the inner side of the dam. Unlike other populations which tend to grow at the valley bed, this population was offset to the clayey side, likely because the water is too deep at the central part to support its life.

Wied Sara is the subsequent valley segment following Wied l-Ort. Several small-sized metapopulation (**PGL3**) were noted along the valley bed in April 2008, dominated by *Bolboschoenus maritimus* (L.) Palla, *Schedonorus phoenix* (Scop.) Holub. and *Dactylis glomerata* s.l. L. The largest population was located in a pond of water along the valley bed.

Following Wied Sara is the valley segment called Wied tal-Grazzja in which 2 metapopulations of *Persicaria* sp. were found (**PGL4**), one at each ends of this valley and both located at the foot of small bridges crossing the valley. The largest metapopulation was that in a shallowly flooded area behind a dam close to the Cappuchine's convent and church. No further metapopulations of *Persicaria* were observed in the consecutive valley segments of Wied tal-Kappucini and Wied Marsalforn.

The metapopulations recorded along this valley system on the 3rd October 2011 are:

- | | | |
|------------------------------------|-----------|---|
| 1) First population (Wied tal-Ort) | | Size: 5m x 2m |
| 2) Next population (Wied tal-Ort) | 20m away | Size:35m x 5m (on clayey soil aside the pond) |
| 3) Next population (Wied tal-Ort) | 220m away | Size:25m x 4m (L-shaped, in front of the dam and aside) |
| 2) Next population Wied Sara | 20m away | Size:80m x 4m (fragmented metapopulation just behind the dam under large Eucalyptus trees,) |
| 3) Next population Wied Sara | 70m away | Size: 8m x 2m (narrow valley bed, weedy sides) |
| 4) Next population Wied Sara | 100m away | Size:25m x 3-8m (in a pond of water) |
| 5) Next population Wied Sara | 80m away | Size:15m x 3m (beside tunnel under Triq Wied Sara) |

- 6) Next population Wied tal-Grazzja 280m away Size: 10m x 3m (beside tunnel under Triq l-imghallem)
 7) Next population Wied tal-Grazzja 950m away Size: 15m x 10m (beside tunnel under Triq Marsalforn)
 8) Next population Wied tal-Grazzja 30m away Size: 10m x 3m (last metapopulation)

The morphology of the material at **PGL2**, **PGL3** and **PGL4** were identical in all important characters, and hence belong to the same species. The perennial plants were between 80 to 180cm high, and had swollen stem nodes that varied in colour from green to reddish-wine to brown. They formed bright green leaves that at a glance appeared to be glabrous but under magnification the abaxial side of the lamina had very short, white hair, rather dispersed but constant throughout or somewhat denser towards the edges and tip of the leaf. Moreover, the lamina had punctate dark-green lucid glands and yellow glands. The proportion of the two varied between specimens, but in general there were more punctate glands. The midrib, many of the main lateral veins and the margin of the leaf had short stiff bristles (=strigose). The adaxial surface possessed much less hairs, best described as glabrescent.

Young peduncles holding buds and blossoming flowers were covered by sessile yellow glands, but old peduncles holding last flowers and unripe fruit had much less glands and these were sometimes observed as glabrous to the naked eye. Some specimens had peduncles with white hair ranging from scanty to numerous, especially on the lowermost flowering branch of the inflorescence ramification, but such pilosity never extended to a pilose or lanate one. Under magnification, it could be clearly seen that many peduncles, had white hairs. Few yellow glands were present on the petals of the flowers too.

The ochreae were glabrous, mucilaginous and with a truncate apical margin lined with cilia between 1-3mm long. The cilia were present in more or less the upper 6-8 ochreae, and gradually, they were lost further down the thickening and weathered stem. About a total of 80 nuts were examined from different specimens and all were black with a lenticular shape, never trigonous. A few were measured and examined carefully and had a diameter of 3mm across and around half of the seeds examined had dimpled faces.

According to the detailed taxonomy given in section 4.3 and 4.4, it has been concluded that the combination of characters falls within the variable range of *Persicaria senegalensis* f. *albotomentosa*. The examination of **PGL2-4** concurs with Wilson (1990) that *P. glabra* and *P. senegalensis* are rather variable species with marginally overlapping distinguishing features. Distinct characters that led to this determination include the presence of yellow glands on the leaves and more predominantly on young peduncles, leaves that are hairy (although minutely and scanty so), ochreae with a line of 1-3mm long cilia and all seeds are lenticular (none trigonous) some having dimpled faces.

6. Origin of the *Persicaria* species recorded from Malta and notes on their introduction.

Persicaria salicifolia is native in our islands owing to the fact that part of its distributional range is the South of Europe and North Africa (FZB, GRIN). *P. lanigera* is native to the Old World Tropics (Webb, 1993). It is specifically recorded from Benin, Gabon (GBIF), Israel (FIS) Egypt (APD; Webb, 1993) and first recorded from Europe in Crete in 1983 (Akeroyd, 1987). *P. senegalensis* is native to South and tropical Africa and reported from the following African countries: Benin, Burkina Faso, Ethiopia, Gabon, Kenya, Ivory Coast, Malawi, Mayotte, (GBIF), Botswana, Mali, Tanzania (GBIF, GRIN), Algeria, Egypt, Somalia, Uganda, Gambia, Ghana, Niger, Senegal, Swaziland, Madagascar, Yemen, Israel (GRIN), Mozambique, Zambia and Zimbabwe (FZ), Palestine, Tropical Asia and Tropical Africa (Maire, 1961). Ethiopia is the country with most occurrences from the countries listed by GBIF. It has also been introduced in the USA and UK (GBIF). Algeria and Egypt are the closest African countries to Malta.

In contrast, *Persicaria glabra* is distributed further away; native in South America, Tropical Asia, Temperate Asia, and Madagascar, located at Western Indian Ocean. (GRIN). The biota of Madagascar has a different origin from that of continental Africa and indeed includes a very large number of endemic taxa, even at the level of higher taxonomic groups.

As stated above *P. lanigera* is first recorded in Europe from Crete in 1983 (Akeroyd, 1987) while the Maltese stations of *P. senegalensis* s.l. reported few years later could be the first European records, however with a doubt because of a single record from the UK (GBIF, BSBI) dating back between 1939-1969 (BSBI). One must mention that this British record was not considered by Webb (1993) in the Flora Europaea, or currently listed by GRIN. Both species are not recorded from Italy, where *Persicaria nepalensis* (Meisn.) H. Gross. and *P. orientalis* (L.) Spach are the only introduced species listed by Conti *et al.* (2005).

According to Akeroyd (1987), *P. lanigera* was introduced into Crete from neighbouring countries like Egypt as a weed of irrigated cultivation. For the Maltese islands, the vector of recent introduction of *P. senegalensis* s.l. and *P. lanigera* is not by human intervention. One possible method of introduction is by seeds via migratory birds from North African or Middle East regions, namely Algeria and Egypt. Evidence that birds consume seeds of *P. senegalensis* is given by Ita (1994) where he states that over 300 species of game birds, waders and other avian migrants in Kainji Reservoir, Nigeria make use of *Polygonum senegalensis*. Although seeds are evacuated after ingestion, they can adhere to birds' feathers or muddy feet, to be liberated when the migrant birds land in Maltese valleys; an observation first reported by Darwin (1859: p859).

7. Notes on Habitat and growth.

In its native territories, *P. senegalensis* is found growing in damp places near or in shallow water bodies, such as dam sides, lakes and rivers, as well as in sandy soils of recently dried out channels at altitudes of between 50 to 1700m. (FZB). In Crete, *P. lanigera* is recorded on muddy soil along the river bank of River Yeros (Akeroyd, 1987)

Based on observations during this study, *Persicaria salicifolia*, *P. lanigera*, and *P. senegalensis* s.l. have a similar habitat on the Maltese islands, that is, wetland areas in valley beds where water has accumulated and remains for a long period of time. Such localised sites tend to remain damp, muddy or flooded even throughout summer and favouring the growth of these semi-hydrophyte species. Examples include water catchment areas formed by dams, natural ponds found along rocky valley beds, and sheltered ponds formed in rock depression immediately downstream from dams. Several metapopulations were located at the foot of bridges passing over valleys, and instead of a coincidence, these structures provide shade, minimize the effects of drought, and leave the area beneath them damp.

Populations in wide valleys such as Wied tal-Hżejjen, Wied tal-Ort, and, to some extent, Wied il-Ghajjn, [PGL1, PGL2, PLA1] respectively, were found on the muddy areas at the sides of the water catchment areas, but not in the deeper parts of the ponds. Nevertheless, they can withstand or perhaps prefer to be immersed in shallow water rather than in aerial soil. Eutrophication and *Lemnaceae* species were often observed in the waters where *Persicaria* spp. grew. This indicated that the water is nitrogen/phosphate enriched, as expected in valleys that run through agricultural areas where organic farming is seldom practiced. The four metapopulations of *Persicaria salicifolia* [PSL1] seem to prefer shallow flooded sites or ponds along the valley bed.

There seem to be no particular association between the *Persicaria* populations and the accompanying flora. Populations [PGL1], [PGL2] and [PGL4] were found rather isolated from any plant communities, while populations [PLN1] and [PSN1] were found among ruderal species and *Arundo donax*. Despite that, one can find certain species like *Holoschoenus vulgaris* Link, *Cyperus longus* s.l. L., *Alsima plantago-aquatica* L. and *Rumex conglomeratus* close to the other *Persicaria* metapopulations, namely [PSN3], [PGL3/PLA2] and [PSL1]. In other words, one cannot tell the wetland habitat-type for *Persicaria* spp. from the accompanying flora, since this was inconsistent amongst the various populations studied.

Persicaria lanigera and *P. senegalensis* s.l. tend to dominate these shallow ponds rather quickly, but they do not colonise drier parts. [PGL4] was monitored for three years, and was first observed in January 2008 as a group of five specimens situated in a partially flooded area that measured 10m x 15m. In Feb 2009 there was a clump filling a bit less than half this area, while in Jan 2010 the entire area was occupied by hundreds of specimens of this species. On the other hand, it was demonstrated by some populations that they are not highly resilient. A dense population at [PLA1] was for some reason reduced by 95% while the plants at [PSN1] regenerated only after three years following a temporary eradication from valley bed dredging in 2010. For sure, *Persicaria* species have a good spreading potential, colonising water pockets by their fast-spreading, subterranean stolons and forming new populations along valley systems by long distance dispersion of seeds through water currents. At the submission of this manuscript (Nov. 2013) three plants of *Persicaria* sp. were observed at the mouth of Marsalforn valley, possibly disseminated from [PSG4], about 4km upstream the valley system.

8. Discussion

The introduced *Persicaria* species have successfully naturalised wetland ecosystems in the Maltese islands, and are now becoming an integral part of the Maltese wetland flora. The sites they dominate consist of localised shallow ponds along valley systems and hence they cannot be classified to be invasive or to be of a particular threat to Maltese habitats. As exemplified below, this study did not provide any clear evidence that introduced *Persicaria* species have replaced any native species. However this conclusion might be too hasty and this work

may at least serve, as the first step to monitor the behaviour of *Persicaria* spp, introduced in Malta in the last 25 years.

At Wied Sara and Wied tal-Grazzja [PGL3-4] *Persicaria senegalensis* did not replace any considerable patch of the native *Bolboschoenus maritimus* L., *Schedonorus phoenix* (Scop.) Holub, or *Dactylis glomerata* L.; at Wied Ghasri [PLA3], the only population of *Persicaria lanigera* remained singular for almost 25 years; while the populations of Wied il-Ghasel [PSN3] and Wied Speranza [PSN2] was not widespread over a large area but localised in small patches where ponds formed along the rocky valley bed. On a different note, one can mention the benefits that these *Persicaria* species have to nectar-seeking pollinators in summer, owing to the fact that they produce numerous flowers all year round. Bees and wasps have been observed visiting the flowers of *Persicaria* spp. in Malta. Munched leaves have been also observed in some populations, but the responsible herbivore was not observed in order to determine whether it is a native species. The dense populations that *Persicaria* spp. form are in fact very likely to offer shelter to a number of animals and their seeds may provide food to some birds

9. Conclusion

Following taxonomical studies, the species of *Persicaria* present in the Maltese island are *P. salicifolia* (native), *P. lanigera* and *P. senegalensis* (both introduced). Two forms of the latter species exist, of which one - forma *senegalensis* has been found in a new site (Wied il-Ghasel, Mosta) and the other - forma *albotomentosa* is a new taxon for the Maltese islands; previously misidentified as *P. glabra*. This form is present at Wied tal-Hżejjen (Malta), Wied l-Ort, Wied Sara and Wied tal-Grazzja (Gozo). The introduced *Persicaria* spp. naturalised flooded wetland habitats, specifically at banks of water catchment areas or ponds along valley beds. Populations have not shown to be particularly resilient or invasive, though they tend to become dominant in small ponds and shallow parts of flooded areas they occupy. Moreover, as a result of a number of benefits they give to wetland ecosystems (until new studies show otherwise), it is suggested that alien *Persicaria* spp should not be eradicated by competent authorities.

Table 2: Comparison of characters from different populations of *Persicaria* spp. found on the Maltese islands

Morphological character	Bahrija, Malta [PSL1]	Marsascala, Malta [PLA1]	Wied Sara, Gozo [PLA2]
Height of plant	50-100cm	150-200cm	80-100cm
Stem posture	Ascending to erect, thin (4-6mm) stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems
Stem nodes	Not conspicuously swollen, not rooting.	Swollen, not rooting.	Swollen, not rooting.
Cross Section of stem nodes	Solid (unhollowed) with a spongy white tissue at the core	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed
Leaf shape	Linear lanceolate or linear-elliptic	Narrow lanceolate	Lanceolate
Leaf base	Obtuse, rounded.	Cuneate	Cuneate
Leaf apex	Acute	Long acuminate	Acuminate to acute
<u>Leaf pilosity</u>	Glabrous	Lanate, densely so at the abaxial surface	Lanate, densely so at the abaxial surface
<u>Leaf margin</u>	Strigose	Entire, lined by tomentose hair of lamina surfaces	Entire, lined by tomentose hair of lamina surfaces
Patches on lamina	Not present	Not present	Not present
<u>Leaf glands at abaxial surface of lamina</u>	Not present	None observed under light microscope (X20)	None observed
Leaf ribs	Numerous, arched or straight with curved endings, not swollen but sunken	Numerous, conspicuous, bulging, slightly arched with swell towards leaf base	Numerous, conspicuous, bulging, shallowly arched
Leaf size L x W (cm)	11-16 x 1.2-2.5	25-34 x 5.0-9.0	26-33 x 6.3 x 8.0
L : W ratio of leaves	8.3	4	4
<u>Ochreae texture</u>	Glabrous	Tomentose, rather sparse giving ochreae a silver-green colour	Sparsely tomentose, becoming denser at the apex
<u>Ochreae margin</u>	Long, well-spaced cilia, 10mm long	Long pilose cilia, 3-7mm long, abundant and conspicuous	Long pilose cilia, 5-6mm long, abundant and conspicuous
Inflorescences	Erect, thin	Erect or more often nodding, stout	Erect or more often nodding, stout
<u>Petioles</u>	Glabrous, polished	Shortly tomentose, eglandular	Shortly tomentose, eglandular
Colour of flowers	Pale pink	Pink and pale pink (some specimens almost white)	Pale pink
<u>Nuts</u>	Trigonous, lanceolate, black, shiny, 2mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)

Morphological character	Wied il-Ghasri, Gozo [PLA3]	Wied l-iSperanza, Malta [PSN2]	Wied il-Ghasel, Malta [PSN3]
Height of plant	80-160cm	100-180cm	70-120cm
Stem posture	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems
Stem nodes	Swollen, not rooting.	Swollen, rooting at lower nodes in touch or immersed in water	Swollen, rooting at lower nodes in touch or immersed in water
Cross Section of stem nodes	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed
Leaf shape	Lanceolate	Lanceolate	Lanceolate
Leaf base	Cuneate	Cuneate	Cuneate
Leaf apex	Acuminate to acute	Acuminate to acute	Acuminate
Leaf pilosity	Lanate, densely so at the abaxial surface	Glabrous	Glabrous, scantily puberulent in few specimens.
Leaf margin	Entire, lined by tomentose hair of lamina surfaces	Entire, strigose, often sinuated	Entire, strigose, sometimes slightly sinuated
Patches on lamina	Not present	Not present	Not present
Leaf glands at abaxial surface of lamina	None observed	Yellow Sessile glands, dense, most abundant at the leaf borders of the abaxial side	Yellow-green sessile glands present at irregular distribution
Leaf ribs	Numerous, conspicuous, bulging, shallowly arched	Numerous, conspicuous, bulging, slightly arched with swell towards leaf base	Numerous, conspicuous, bulging, slightly arched with swell towards leaf base
Leaf size L x W (cm)	27-32 x 6.5 x 7.7	20-30 x 5.5-7.0	20-32 x 4.0-7.0
L : W ratio of leaves	3.8	4.5	4.4
ochreae texture	Sparsely tomentose, becoming denser at the apex	Glabrous, hyaline with a pale rusty brown apical border	Glabrous, hyaline with a pale rusty brown border (3mm long).
ochreae margin	Long pilose cilia, 5-8mm long, abundant and conspicuous	A line of sparse cilia about, 2-4mm long	A line of sparse cilia about, 1-3mm long
Inflorescences	Erect or more often nodding, stout	Erect or more often nodding, stout	Erect or more often nodding, stout
Petioles	Shortly tomentose, eglandular	Sessile yellow glands, especially in young petioles or unexposed part of petiole.	Glabrous or slightly hairy; sessile glands present in all peduncles studied
Colour of flowers	Pale pink	White	White
Nuts	Circular, lenticular, black, shiny, 3mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)

Morphological character	Wied tal-Hzejjen, Malta [PGL1]	Wied l-Ort, Gozo [PGL2]	Wied tal-Grazzja, Gozo [PGL4]
Height of plant	100-150cm	70-180 cm	100-150 cm
Stem posture	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems	Mesh network of prostrate, thick (>0mm) stems forming ascending or erect branched vegetative stems
Stem nodes	Swollen, rooting at lower nodes in touch or immersed in water	Swollen, rooting at lower nodes in touch or immersed in water	Swollen, rooting at lower nodes in touch or immersed in water
Cross Section of stem nodes	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed	Solid (unhollowed) with a thick reddish-purple border and a white spongy core. In old stems, this spongy tissue becomes hollowed
Leaf shape	Narrow lanceolate	Lanceolate	Lanceolate
Leaf base	Cuneate, gradually tapering to petiole	Cuneate, gradually tapering to petiole	Cuneate, gradually tapering to petiole
Leaf apex	Acuminate	Acuminate	Acuminate
<u>Leaf pilosity</u>	Variably pubescent, from sparingly hairy to tomentose. More so at the lower surface.	Variable, Shortly pubescent to puberulent to glabrous, strigose on midrib and veins at abaxial surface.	Variable, Shortly pubescent to puberulent to glabrous, strigose on midrib and veins at abaxial surface.
<u>Leaf margin</u>	Entire and strigose. A sub-glabrous border of about 1mm thickness is present between margin and lamina's tomentum	Entire, strigose, sometimes slightly sinuated	Entire, strigose, sometimes slightly sinuated
Patches on lamina	Not present	Not present	Not present
<u>Leaf glands at abaxial surface of lamina</u>	Yellow-green Sessile glands which are often replaced by tomentose hairs.	Variable, colourless or yellowish-green glands half embedded in leaf tissue (pustulate). Glands exudate a slightly sticky substance	Yellowish-green glands (sometimes green) half embedded in leaf tissue (punctate). Glands exudate a slightly sticky substance
Leaf ribs	Numerous, bulging, straight and becoming curved at their ends.	Numerous, conspicuous, bulging, slightly arched with swell towards leaf base	Numerous, conspicuous, bulging, slightly arched with swell towards leaf base
Leaf size L x W (cm)	22-32 x 4.5-6.5	20-36 x 4.0 - 6.2	20-32 x 3.8 - 6.0
L : W ratio of leaves	5.0	5.2	5.1
<u>ochreae texture</u>	Glabrous becoming puberulent towards the top	Glabrous, hyaline with a pale rusty brown apical border	Glabrous, hyaline with a pale rusty brown apical border
<u>ochreae margin</u>	A line of sparse cilia about 2-3mm	A line of sparse cilia about, 1-2mm long	A line of sparse cilia about, 1-2mm long
Inflorescences	Erect or more often nodding, stout	Erect or more often nodding, stout	Erect or more often nodding, stout
<u>Petioles</u>	Sessile yellow glands at various densities often accompanied by sparse hairs.	Yellow sessile glands in distal parts or young petioles.	Yellow sessile glands in distal parts or young petioles.
Colour of flowers	Pale pink to rose-pink	Pale pink to rose-pink	Pale pink to rose-pink
<u>Nuts</u>	Circular, lenticular, black, shiny, 3mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)	Circular, lenticular, black, shiny, 3mm long (incl. beak)



Figure 1: Morphological characters of *Persicaria salicifolia* found in specimens on the Maltese Islands [PSL1]. Top left: Narrow spike-form inflorescence with lax flowers; Top right: Margin of ochreae with long stiff bristles; Bottom left: Linear-lanceolate leaves; Bottom right: Trigonous, black seeds, c. 2.0-2.5mm long.



Figure 2: Morphological characters of *Persicaria lanigera* found in specimens on the Maltese Islands. Top left: Abaxial (left) and adaxial surface of leaves from Wied Sara [PLA2], Victoria, Gozo. Lower surface is more densely hairy and has a white appearance (3-Oct-2011); Top right: Close up of woolly indumentums at the abaxial surface of lamina from Wied il-Ghajj [PLA1], M'Scala, Malta (18-Sep-2011); Bottom left: ochreae lined with long shaggy cilia, about 5-6mm long from Wied Ghasri [PLA3] (11-Oct-2011); Bottom right: Peduncles covered with greyish-white short tomentose hair from Wied il-Ghajj [PLA1] (18-Sep-2011)

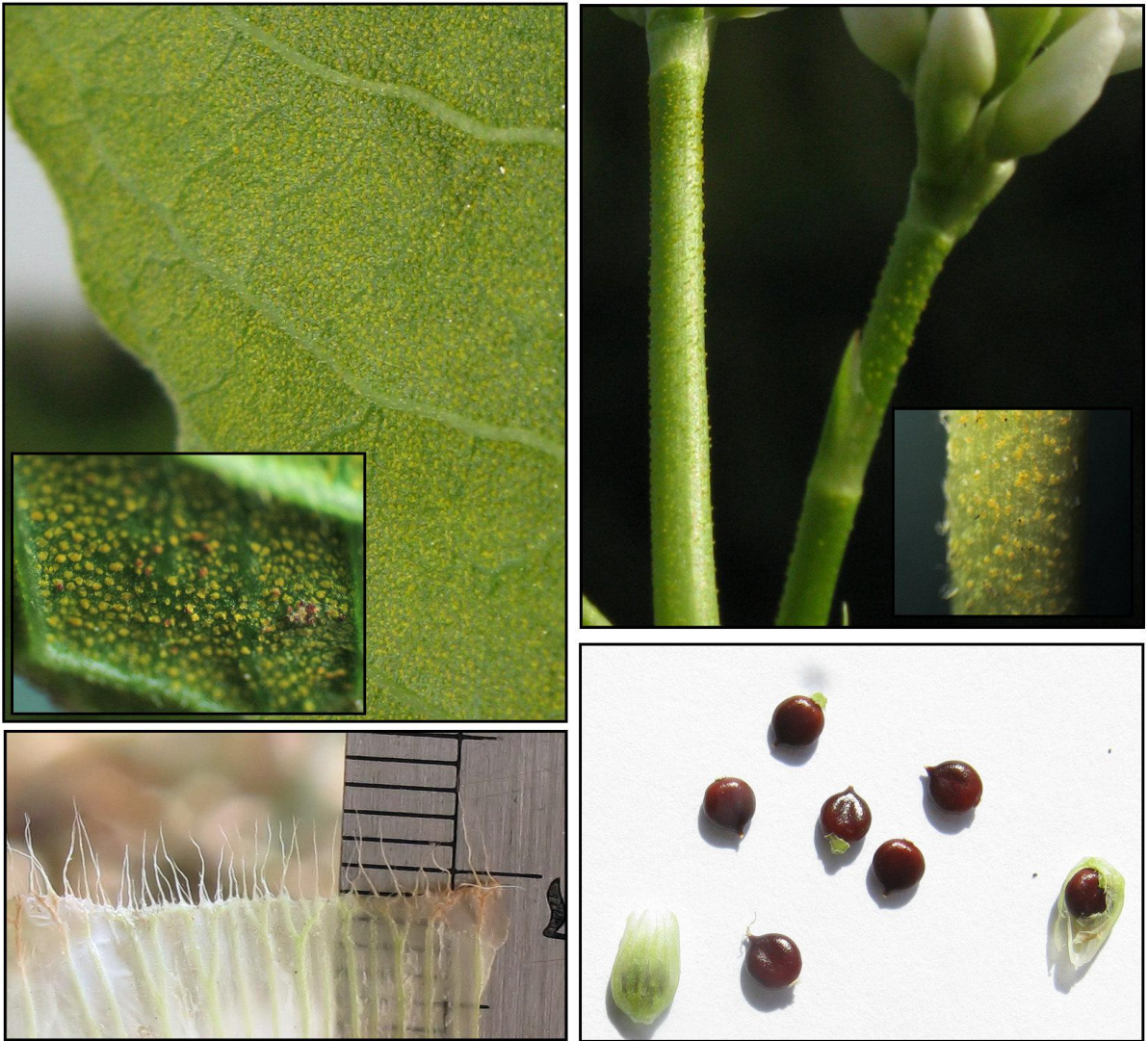


Figure 3: Morphological characters of *Persicaria senegalensis* forma *senegalensis* found in specimens on the Maltese Islands. Top left: Abaxial surface of leaf lamina from [PSN2] which is glabrous and covered with many sessile yellow glands, magnified at x40 in the inset. Top right: Peduncles from [PSN1] showing numerous yellow glands, magnified at x40 in the inset. Bottom left: ochreae from [PSN3] having 2mm long cilia at the apical margin; Bottom right: Nuts from [PSN2] some with dimpled faces.



Figure 4: Morphological characters of *Persicaria senegalensis* forma *albotomentosa* found in specimens from the Maltese Islands. Top left: Abaxial surface of lamina from [PGL1] having a shortly tomentose indumentum with a close up of the margin in the inset; Top right: Abaxial surface of lamina from [PGL1] having a sparse short hair and yellow glands, better seen in the close up shown in the inset; Centre left: ochreae from [PGL1] with a line of cilia 2mm long; Bottom left: Close up of peduncle from [PGL1] showing sessile, bulging, yellow glands. Bottom right: peduncle from [PGL1] with sessile yellow glands;



Figure 5: Morphological characters of *Persicaria senegalensis* forma *albotomentosa* found in specimens present on the Maltese Islands. Top left: Abaxial surface of lamina from [PGL2] having short white hair; Centre left: Magnified image (x40) of abaxial surface of lamina from [PGL1] showing scattered white hair, some yellow glands, and numerous translucent glands; Bottom left: same as above but material from [PGL4]; Top right: Peduncles from [PGL3] covered with sessile yellow glands; Centre right: ochreae from [PGL2] with a line of cilia 2-3mm long; Bottom right: Seeds from [PGL1] where some have dimpled faces.



Figure 6: Populations of *Persicaria lanigera* in the Maltese islands. Top left: Wied il-Ghajj [PLA1] Marsascala, Malta (31-Aug-2006); Top right: Same population in 18-Sep 2011 to show its degradation down to 20-30 specimens; Centre: Wied Sara [PLA2]; Victoria, Gozo (3-Oct-2011); Bottom left: *P. senegalensis*, Wied Sara [PLA2] (3-Oct-2011); Bottom right: Whitish perianth of a metapopulation present at Wied il-Ghajj [PLA1] (18-Sep-2011). Flowers of another metapopulation (1A/1B) were pink.



Figure 7: Populations of *Persicaria senegalensis* forma *senegalensis* in the Maltese islands. Top left: Wied Speranza [PSN2], Mosta, Malta (12-Dec-2009); Top right: Inflorescence from specimens at Wied Speranza [PSN2] (4-Nov-2009); Center: Wied ta' Brija [PSN1], Girgenti area, Siġġiewi, Malta (12-Nov-2008); Bottom left: Wied il-Ghasel [PSN3], Mosta, Malta (22-Sep-2011); Bottom right: Basal stem submerged in water with red roots at the base of the nodes taken from Wied Speranza [PSN2] (4-Nov-2009) .



Figure 8: Populations of *Persicaria senegalensis* forma *albotomentosa* in the Maltese islands. Top Left: Wied il-Hżejjen [PGL1], l/o Mgarr, Malta (13-Dec-2009); Top right: Close up of inflorescence from Wied tal-Hżejjen [PGL1] (13-Dec-2009); Centre left: The only three specimens present at Wied tal-Grazzja [PGL4], Victoria Gozo (20-Jan-2008); Centre right: Same metapopulation observed almost two years later on (8-12-2009) showing the rapid colonisation of the species in shallowly flooded wetlands; Bottom: Wied l-Ort [PGL2], Ghasri, Gozo (3-Oct-2011)

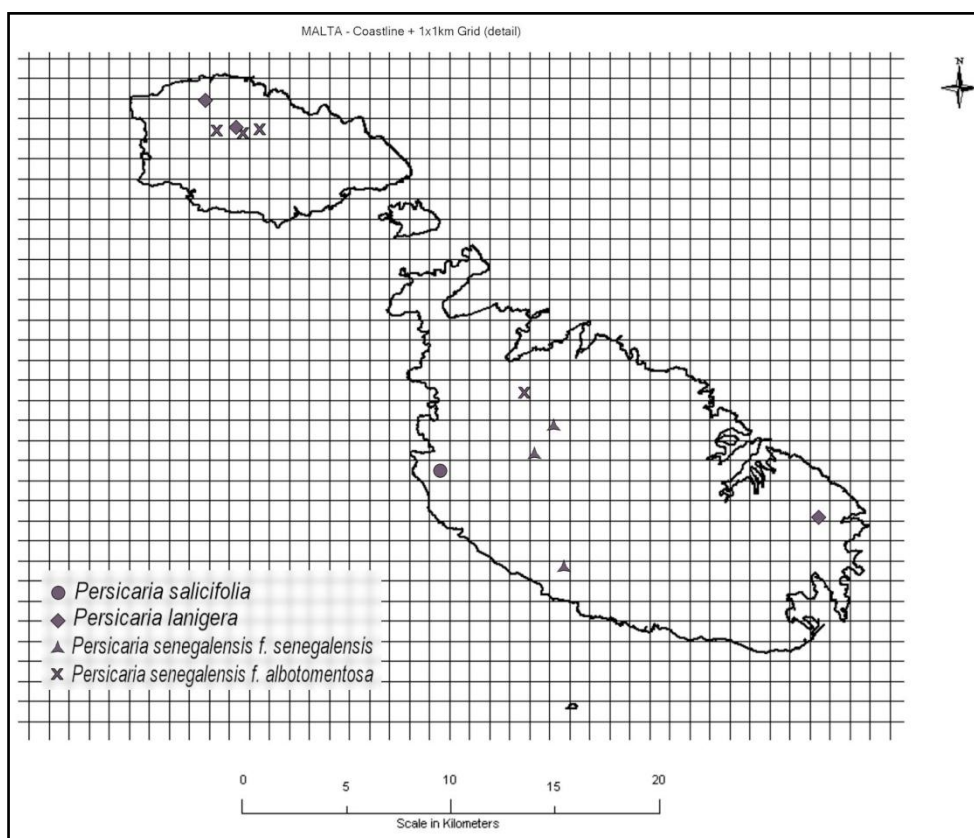


Figure 9: Distribution of *Persicaria* species in the Maltese Islands.

All photographs in this article were taken by the author (Stephen Mifsud).

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