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Morphological characters, geographic distribution and ecology of neophytic *Amaranthus blitum* L. subsp. *emarginatus* in Austria

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Abstract

Amaranthus blitum L. subsp. *emarginatus* (MOQ. ex ULINE & BRAY) CARRETERO, MUÑOZ GARMENDIA & PEDROL. has been recently introduced to Austria. This neophyte occurs on banks of the rivers Thaya and March along the north-eastern border of Austria where it has been established. All further locations encountered were restricted to ruderal habitats. A revision based on herbarium material and the authors' collections as well as a geographic distribution map of subsp. *blitum* and subsp. *emarginatus* including morphologically problematic specimens are given. A first chromosomal record for latter subspecies from Austria is cited. The morphological characters are discussed in detail. Data on phytosociology of subsp. *emarginatus* from both natural and anthropogenic habitats are presented, and according to indigenous vegetation, the ecology of this neophyte is discussed.

Keywords: alien species, *Amaranthus*, *Amaranthaceae*, Austria, chromosome number, ecology, geographic distribution, taxonomy, phytosociology

Zusammenfassung

Amaranthus blitum L. subsp. *emarginatus* (MOQ. ex ULINE & BRAY) CARRETERO, MUÑOZ GARMENDIA & PEDROL. ist eine erst spät in Österreich eingeschleppte Art. Neben den zumeist noch sporadischen adventiven Vorkommen dieses Neophyten existieren an den Flussufern der Thaya und March etablierte Populationen. Erstmals wird seine Verbreitung in Österreich aufgrund von Herbarauswertungen und Aufsammlungen dargestellt. Eine für Österreich neue Chromosomenzählung dieses Taxons wird angegeben. Die taxonomische Bewertung dieser adventiven Sippe wird durch morphometrische Analyse diagnostischer morphologischer Merkmale überprüft. Die Einnischung in die Flussufer-Annuellenfluren wird pflanzensoziologisch belegt und seine Ökologie an diesem Standort diskutiert sowie eine ökologische Beurteilung dieses Neophyten angeführt.

Introduction

Amaranthus blitum L. subsp. *emarginatus* is a neophyte of Europe and North America. It is native to the Tropics of both hemispheres and was first noted for Austria by FISCHER (1995). The first documented specimen for Austria was collected in 1986 whereas first records in Europe date back to the end of the 19th and beginning of the 20th

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century: Germany 1889, France 1904, Poland 1930, Switzerland 1920 (THELLUNG 1914, PROBST 1949), England 1822 (BRENAN 1961). In contrast WALTER & al. (2002) mentioned that its neophytic status is questionable. We state the occurrence of this alien subspecies in Europe not before the 19th and 20th centuries. However, past floristic surveys of several European countries did not recognize this taxon. It might have been overseen and for this reason it is underrepresented in current scientific collections and records.

THELLUNG (1914) stated two wild "races", subsp. *emarginatus* (proles "*polygonoides*") and subsp. *blitum* (proles "*ascendens*"), beside the cultivated varieties *oleraceus* and *lividus* (Table 1). He considered subsp. *emarginatus* to be the most distinctive form of *A. blitum.* Within subsp. *emarginatus* he distinguished a var. *pseudogracilis* ("f. *pseudogracilis*") collected in the botanical garden of Straßburg (1904). He further suggested two aberrant forms "*axillaris*" and "*integrifolius*", the first one was assigned to var. *blitum* but the other one he thought to be a taxon of problematic relationship due to its acute, hardly emarginated leaves. The taxa var. *oleraceus* and var. *lividus* are old useful plants cultivated for a long time which have evolved from the wild var. *blitum*. The whole plant of var. *lividus* is of purplish to reddish colour while var. *oleraceus,* which he considered to be an ancient Mediterranean useful cultivar, lacks the red colour and is distinguishable by its larger leaves. The latter one was actually cultivated in India, Java, Africa and southern Europe (JANCHEN 1956-60). Var. *blitum* is stated to be an archaeophyte for the Austrian flora and at least for some regions of Central Europe while subsp. *emarginatus* is a more recently introduced neophyte of tropical origin.

Although subsp. *blitum* and subsp. *emarginatus* are morphologically clearly distinguishable taxa in the countries where they have been introduced, there is an area in the (sub-)tropical regions of India and China where transitional forms frequently occur. However, subsp. *emarginatus* seems to be uniform in South America (TOWNSEND 1980). According to latter author subsp. *emarginatus* is not restricted to cultivated lands and disturbed areas as subsp. *blitum* is, which occurs predominantly in areas of old civilisations. He concludes further, that subsp. *emarginatus* may be the presumed wild progenitor, because it is the only one found in natural and undisturbed areas. Polymorphic taxa usually show only a fraction of their total morphological and biological variation in recently colonized areas, for only a limited number of forms took part in the invasions. For this reasons but also for the fact that so far only morphological and ecological investigations of geographically restricted concern exist, we agree to the taxonomic rank of subspecies as recently suggested by WISSKIRCHEN & HAEUPLER (1998). This view is supported by LAMBIGNON & WORMS 1993 who analysed both taxa in different areas (France, Gran Canaria and Rwanda). In contrast, COSTEA & al. (2001a, b) emphasised anatomical characters of the pericarp which was found to provide considerable differences between the cultivated and wild grain amaranths but also between subsp. *blitum* and subsp. *emarginatus*. Latter has a three-layered, thin (18 - 25 µm) pericarp while it is four-layered and thicker (50 - 70 µm) in subsp. *blitum*. Furthermore pores of pollen grains of subsp. *blitum* are significantly larger than in subsp. *emarginatus*.

Material and methods

Plant material was obtained from the herbaria GZU, KL, LI, SZU, W, WNLM, WU (HOLMGREN et al. 1990) and from the private collections H. Vondrowsky and J. Walter. Most of the material refers to Austrian locations but comprised also some accessions from abroad. The biometric analysis was based on a subset of 108 vouchers. Per individual 3 - 5 leaves, respectively, 10 - 20 seeds were measured. Canonical discriminant analyses were carried out using SPSS version 11.0. The program was also used to generate scatter plots of the two first discriminant functions as well as to compute the descriptive statistic estimates provided.

Following the phytosociological method of BRAUN-BLANQUET (1964) 17 localities were analysed along the rivers March and Danube as well as populations from clarifiers of the sugar refinery in Hohenau close to the March river in 1994. The ecology of the populations respectively the zonation of their short-lived habitats on the banks of the river March, was investigated in 1994.

Chromosome counts were carried out on root tips of seedlings applying the HCl/Giemsa method (GUERRA 1983). Fruits of var. *pseudogracilis* collected at Markthof were sown and the plants were cultivated in the Botanical Garden of Vienna (HBV) to test for plasticity of morphological characters.

Results and Discussion

Morphological analysis

According to HÜGIN (1986, 1987) *A. blitum* and *A. emarginatus* are two well separated taxa (for the habit of both taxa see Fig. 11, 12). He encountered only few morphologically transitional specimens among the clearly separated specimens and populations of these two taxa in Europe. We likewise observed only few critical specimens in Austria among the investigated material. The morphological characters estimated by our own investigations as well as by third parties are summarised in Table 2. The most important diagnostic characters are seed size, shape and depth of the apical emargination of the leaf blade (at least for var. *pseudogracilis*), further the green colour or (partially) discoloration of the plant, colour of fruits and of the inflorescence (infructescence) as well as thickness of the midrib, size and the number of the tepals. The additional characters as size of pores of pollen grains and thickness of pericarp were emphasized by COSTEA & al. 2001a.

The seed size is confirmed to be one of the most important morphological characters, while, in contrast, the hitherto stressed broadly ovate to circular shape varies much according to our findings (Fig. 6). According to COSTEA & al. (2001a) the marginal zone of the seed coat is more evidently sculptured in subsp. *emarginatus*. But we did not get a strict separation due to the high variation in testa texture. Both taxa can be strictly distinguished by the means of seed length and width (calculated on 10-20 seeds measured per specimen) (Fig. 1). But also size ranges of individual seeds of the two taxa overlap to a small extent only (Fig. 2). The transitional forms cluster with subsp. *emarginatus* but had in average clearly larger seeds than that taxon making them in this respect intermediate to subsp. *blitum*.

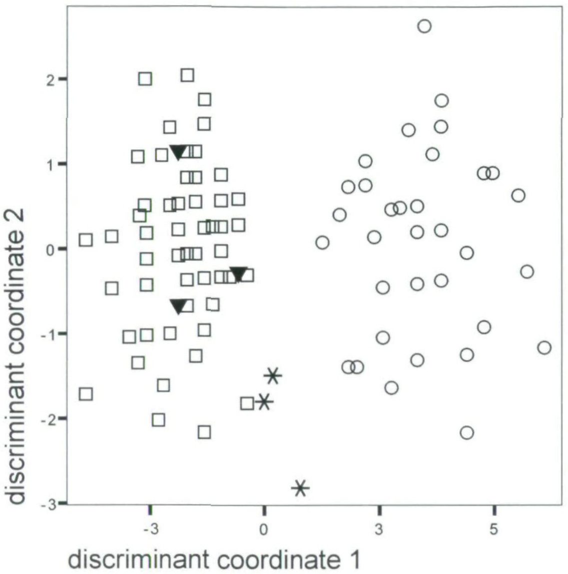

Fig. 1: Canonical discriminant analysis on means of seed length and width (means are calculated on 10-20 seeds each).
□ – *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis*
▼ – subsp. *emarginatus* var. *emarginatus*
○ – subsp. *blitum*
✱ – transitional forms between subsp. *blitum* and *emarginatus*.

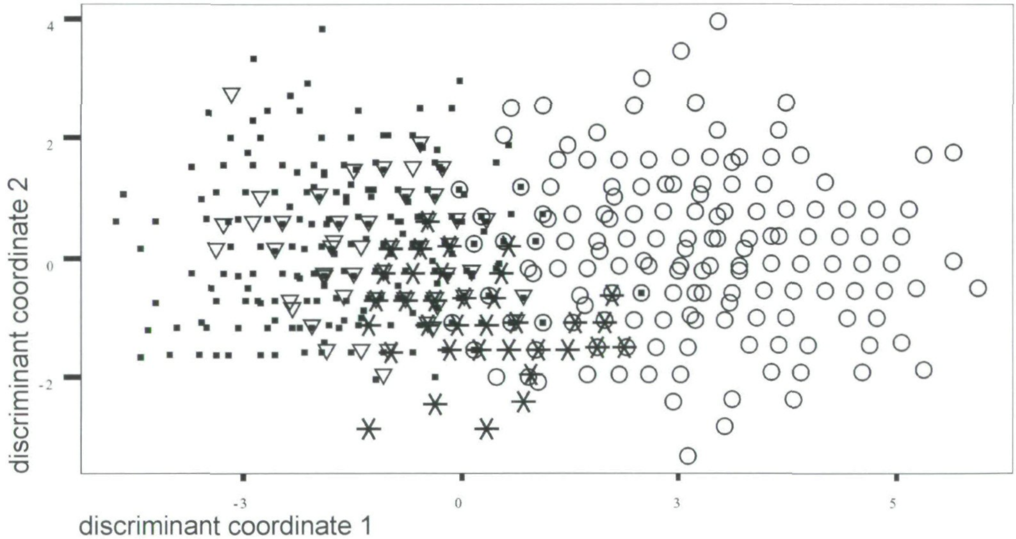

Fig. 2.: Canonical discriminant analysis on seed length and width; legend see Fig. 1, except ▪ – *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis*

The fruits of both taxa are often bullate to wrinkled or smooth. However, some specimens of var. *pseudogracilis* have stronger verrucously wrinkled fruits than those of subsp. *blitum* but the total extent of variation did not allow to discriminate the subspecies based on this feature. Even intraindividual variation is extremely high, and the whole morphological spectrum can be sometimes observed in one specimen (Fig. 5). The fruit size correlates with seed size but shows higher variation. Accordingly the fruit size is of less power to discriminate between the taxa (Hügin 1986, but see also Costea & al. 2001a, Tab. 2). Ripe fruits of var. *pseudogracilis* show a slight tendency to form more strongly verrucous, bullate to wrinkled pericarp structures. The reason for that might be the thinner pericarp, figured out by Costea & al. (2001b), making it more prone to deformation.

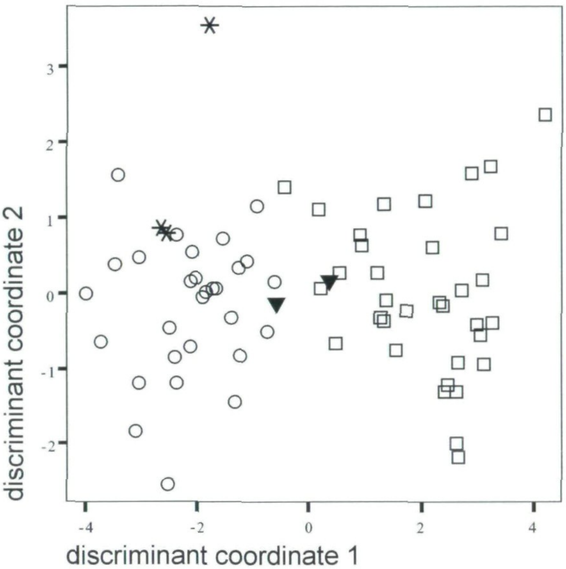

Fig. 3.: Canonical discriminant analysis on means of 5 leaf characters: length of leaf stalk, length and width of leaf blade, depth and width of apical leaf emargination (means are calculated on 3-5 leaves each); legend see Fig. 1.

The leaf blade of var. *pseudogracilis* is usually of larger size than in var. *blitum* but there is a broad overlapping range. Luxuriant specimens of var. *blitum* (f. *major*) have large leaf blades and these forms can be mixed with var. *oleraceus*. The shape of the leaf blade is elliptic or rhombic to obtrullate in var. *pseudogracilis* but broadly elliptic to ovate or nearly round in subsp. *blitum*. Furthermore leaf blades differ in respect to the shape of its bases, which are narrowly cuneate and shortly angustate in former taxon and broadly (rarely narrowly) cuneate to nearly truncate in latter one, as well as in shape and deepness of its apical emargination (Fig. 7, 8; Tab. 2). Combining these characters allows for a sharp distinction of the two taxa as could be shown performing a canonical discriminant analysis (Fig. 3). However, all transitional forms were assigned to the *blitum* cluster by this analysis.

The shape of the cotyledons and primary foliage leaves were compared between one population each (Fig. 9, 10). The difference of the shape of cotyledons between both taxa is more distinct in seedlings (Fig. 9, 10, no. (5) 6 - 7) compared with the larger cotyledons of juvenile plants (Fig. 9, 10, no. 1 - 5). Particularily the tip of the cotyledons is somewhat acute in subsp. *emarginatus* while it is obtuse in subsp. *blitum*. Similarily the base of the cotyledons are different, being narrowly cuneate to shortly angustate in subsp. *emarginatus* and (broadly) cuneate in subsp. *blitum*. The primary foliage leaves (Fig. 9, 10, no. 1c-5c) represent already the morphological characters which were described in the leaf blades of adult specimens (compare Fig. 7, 8). The measurements of the cotyledonal blades are listed in Tab. 2 (n = 9 for *blitum* and n = 14 for *emarginatus*).

Therefore, the biometric results of both generative and vegetative characters confirm the intermediate position of the critical specimens. They are most likely hybrids or introgressive forms between subsp. *blitum* and *emarginatus*.

The subspecies are further distinguishable by the colour of the leaves (strongly effected by the fleshiness of the blades), a character which correlates with differences in the eco-

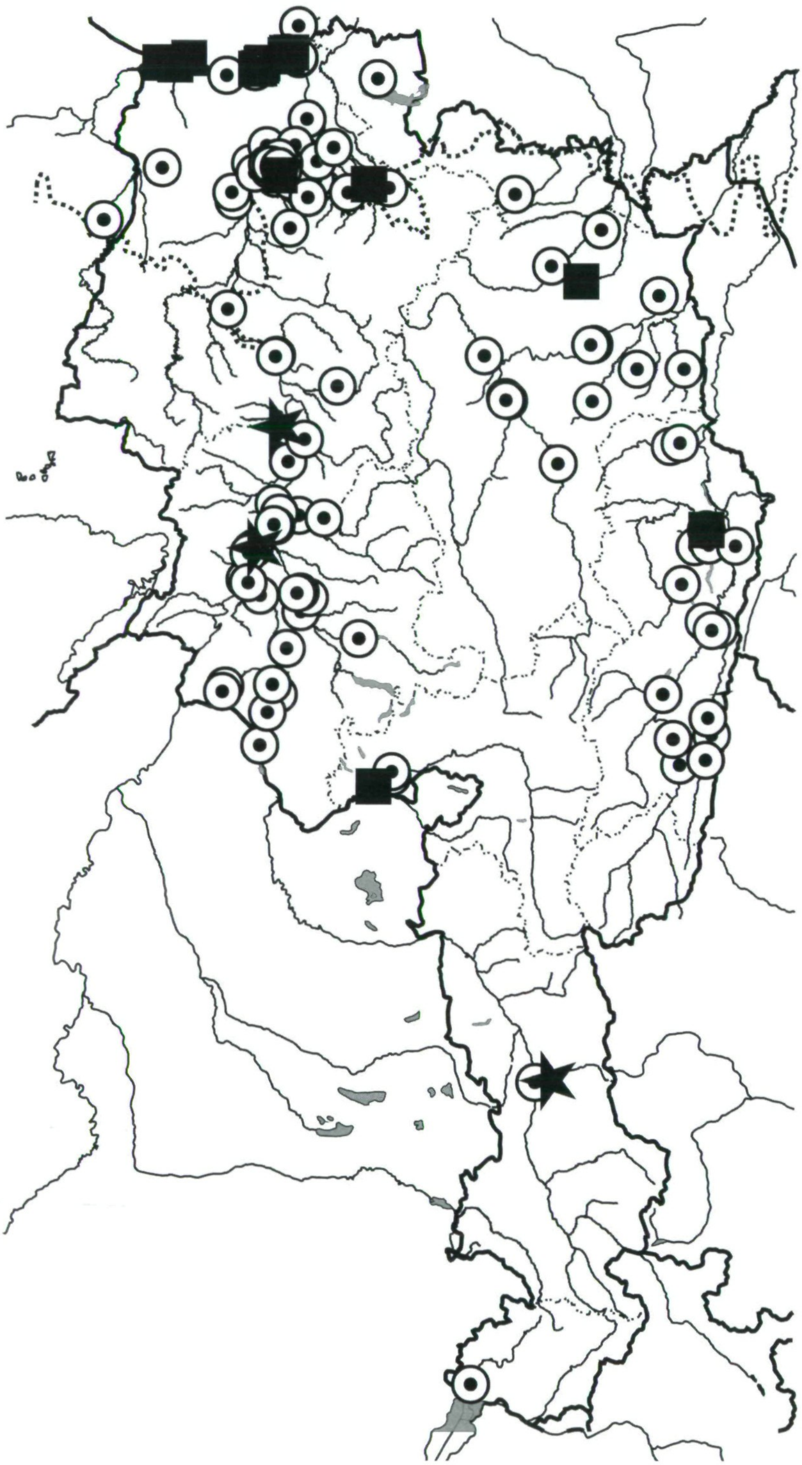

Fig. 4: Geographic distribution of *Amaranthus* subsp. *blitum* (◉), subsp. *emarginatus* var. *pseudogracilis* (■), and transitional forms (★) in Austria.

Fig. 5: A) *Amaranthus blitum* subsp. *blitum*, variation of dried diaspores with persisting tepals from one specimen (cult. HBV, J. Walter 4592). – B) *A. b.* subsp. *emarginatus* var. *pseudogracilis*, variation of dried diaspores with persisting tepals from one specimen (Vienna, Odoakergasse, J.Walter 4246); scale 1 mm.

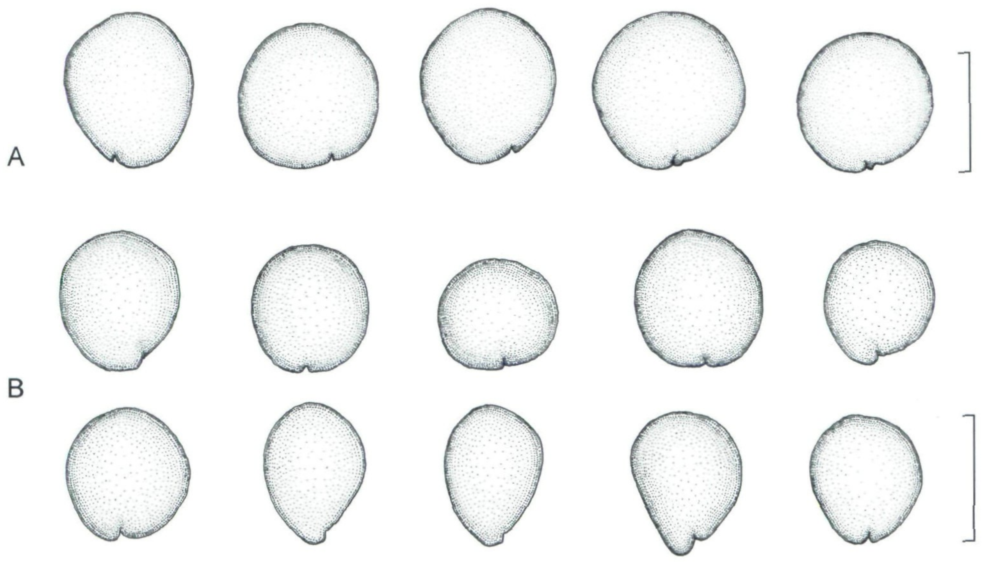

Fig. 6: A) *Amaranthus blitum* subsp. *blitum*, variation of seeds from one specimen (HBV, J. Walter 4592). – B). *A. b.* subsp. *emarginatus* var. *pseudogracilis*, variation of seeds from one specimen (Vienna, Odoakergasse, J.Walter 4246); scale 1 mm.

Table 1: *Amaranthus lividus*: infraspecific classification after THELLUNG 1914, AELLEN 1959.

***A. blitum* subsp.** (actual) ***A. lividus* var.**	***emarginatus*** ***polygonoides***	***blitum* var. *blitum*** ***ascendens***	***blitum* var. *oleraceus*** ***oleraceus***	***blitum* var. *lividus*** ***lividus***
Characters				
stem	prostrate to ascending	prostrate to ascending	ascending to erect	erect
– thickness	thin to moderately thick	thin to moderately thick	robust/thick (often hollow)	robust/thick (often hollow)
– surface:	faintly striated	faintly striated	crenate or striated	crenate or striated
discoloration:	stem wine-coloured to dark purple	stem green or wine-coloured to dark purple; leaves green or somewhat reddish discoloured	stem and nerves pale to whitish; leaves pale green (green to purple[1]), nerves whitish	whole plant dark reddish to black to dark purple; leaves purple to green, nerves purple
(female) tepals	broadly spatulate, obtuse	narrowly spatulate, often acute		
– length (mm)	shortly more than 1	1,5-1,75		
seed size (mm)	0,9-1,2	1,1-1,5	1,3-1,5	ca. 1,7

[1] referring to COSTEA & al. (2001a)

morphological capabilities of these taxa to adapt to drought (similar to *Chenopodium suecicum* -light green or glaucous- and *C. album* -dark to greyish green). Regarding the coloration of the plants the reddish colour is restricted to the axis of the stem and of the branches in subsp. *emarginatus* but old leaves can sometimes also become somewhat discoloured. In contrast, leaves and the whole plant of subsp. *blitum* are sometimes strongly discoloured (as it is also characteristic for other species e. g. *A. retroflexus, A. powellii, A. albus, A. graecizans*). This conspicuous feature is induced by short-day conditions and lower temperatures in late summer and autumn. However, some genotypes show a strict discoloration independent of these ecological triggers. Subsp. *blitum* often displays dark spots on the leaf blade, a character which is constantly missing in subsp. *emarginatus*. The nuts and consequently the infructescence of latter one are grey to yellowish brown when ripe and those of subsp. *blitum* are reddish brown to purplish but both have green fruits when immature.

The inflorescence of var. *pseudogracilis* is relatively long, slender and curved, the uppermost apical part being flexuous (Table 2). It is occasionally completely missing in subsp. *blitum* (var. *blitum*, f. *repens*, THELLUNG 1914) and even in var. *pseudogracilis* it sometimes starts late to lengthen. The colour of the inflorescence is also of high diagnostic value and allows, together with its shape, to distinguish flowering plants even from distance. Var. *emarginatus* is characterised by a shortened apical inflorescence, which can be almost completely reduced (HÜGIN 1987). However, the two varieties are not strictly distinguishable by the length of the apical inflorescence (WISSKIRCHEN 1995, HÜGIN 1986). ULINE & BRAY 1894, for instance, mentioned for the North American Flora specimens bearing long inflorescences but small leaves.

Cultivated juvenile plants of subsp. *emarginatus* var. *pseudogracilis* were found to grow initially prostrately but switched soon to an orthotropic growth. Both cultivated and wild plants show this behaviour. The extent of ascending depends on various ecological factors. However, plants growing very close to each other or occurring in dense vegetation usually have more strictly ascending stems and branches, while vice versa, in open, competition-poor habitats, they tend to take over the space and to have merely slightly ascending branches or they grow even procumbent. The growth-form of var. *emarginatus* was mentioned to be strictly prostrate and to be genetically controlled (HÜGIN 1986, 1987). The other taxa var. *lividus* and var. *oleraceus* are of erect habit (the latter one can ascend too).

Chromosome counts

Chromosome numbers vary only little in the genus *Amaranthus*. The two dysploid numbers 2n = 32 and 2n = 34 were reported repeatedly (GOLDBLATT 1981, 1984, 1985, 1988, GOLDBLATT & JOHNSON 1990, 1991, 1994, 1996, 1998). In several cases both exist within single taxa (e.g. *A. albus, A. graecizans)*. HÜGIN 1986 found 2n = 34 for both *A. blitum* subsp. *blitum* and subsp. *emarginatus*. For latter taxon this result is here confirmed for Austria, and for subsp. *blitum* 2n = 34 was reported for Austria (DOBEŠ & VITEK 2000).

Fig. 4 provides an overview of the geographic distribution of *Amaranthus* subsp. *blitum* and subsp. *emarginatus* in Austria. The map was exclusively based on herbarium material reviewed by the authors. Although only a fairly restricted number of accessions of *Amaranthus* were available from the herbaria, subsp. *blitum* seems to be especially abundant in the southern part of Carinthia, in south-eastern Styria, in southern Burgenland, in Vienna and its surroundings in Lower Austria. These areas are characterised by comparably warm and mild climate on an Austrian scale. Many other records refer further to the Danube basin and tributary streams in Lower and Upper Austria. However, from personal observation it can be concluded, that this subspecies should be much more frequent in the whole Pannonian region of Austria (Weinviertel of Lower Austria and northern Burgenland). OBERDORFER (2001) considered subsp. *blitum* to be a East-Sub Mediterranean element.

For subsp. *emarginatus* only its var. *pseudogracilis* has been recognized for Austria so far. It thrives in the basins of the rivers Thaya and March (Danube), along the north-eastern border of Austria. Since at least 15 years its seems to be established in these riparian habitats. One population was formerly richly developed at the confluence of the rivers March and Danube, but finally has not been established since the last years.

All further records of subsp. *emarginatus* refer to anthropogenic ruderal habitats, as waste deposits like rubbish tips, compost and effluent sludge heaps as well as other places stamped by birdseed, where it occurs occasionally. A floristic summary of the subspecies's occurrence, predominantly in Europe, can be given as follows: Germany:

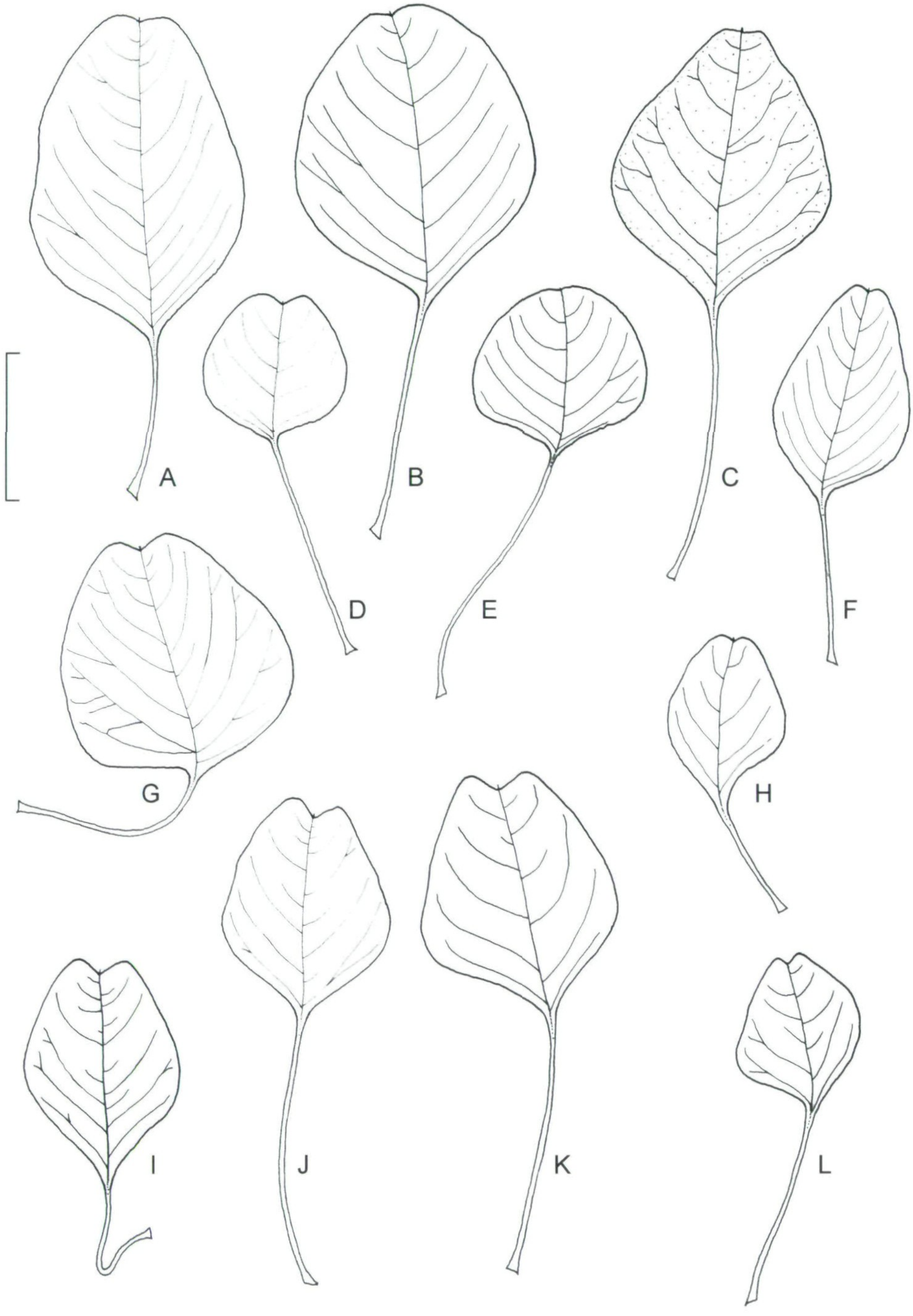

Fig. 7: *Amaranthus blitum* subsp. *blitum*, variation of leaves from 4 specimens: A, B, F (HBV, J.Walter 2185), E, D, G (HBV, J.Walter 2319); H, L (Upper Austria, Goldwörth, LI); I, J, K (Carinthia, Villach, LI); scale 3 cm.

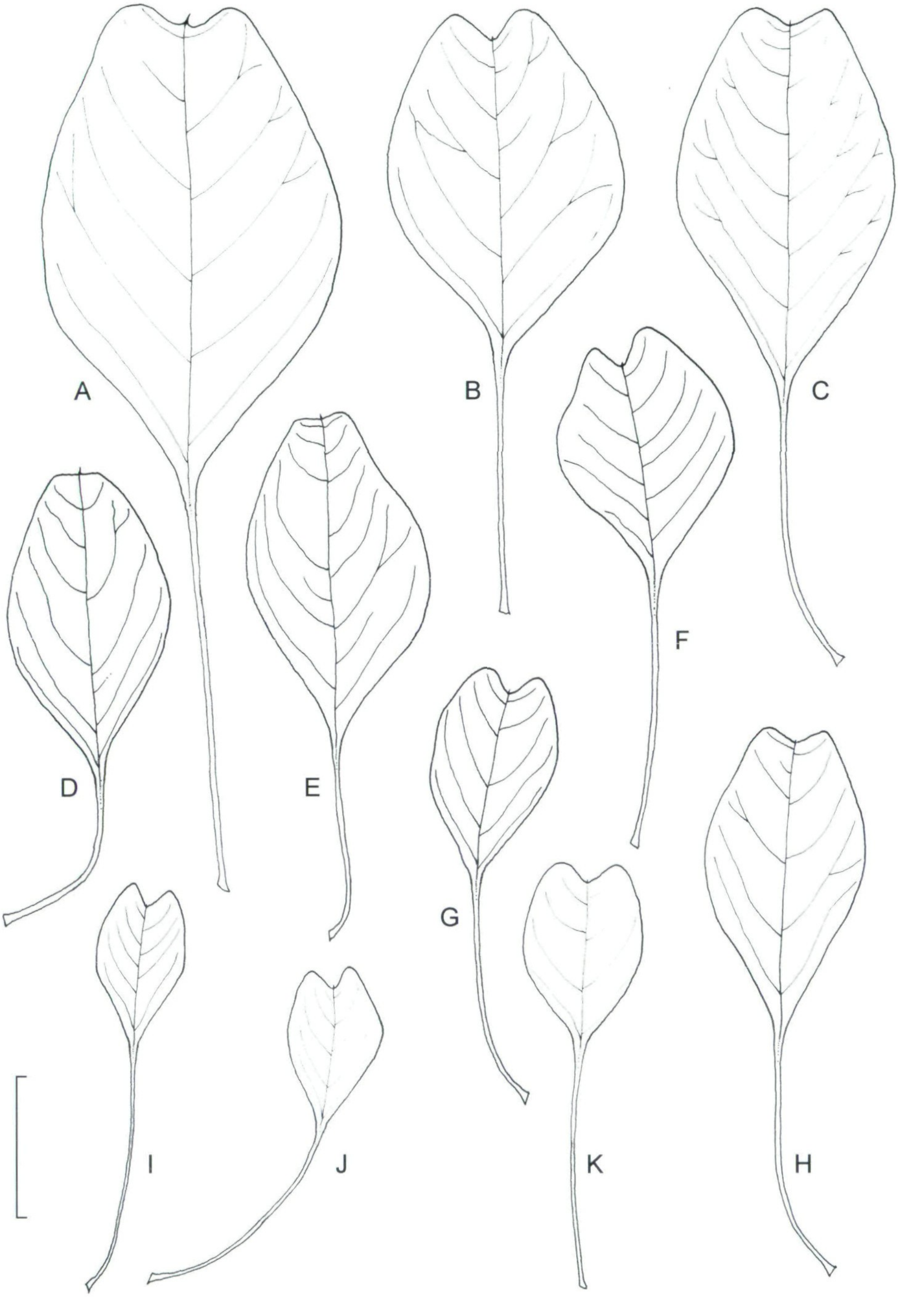

Fig. 8: *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis*, variation of leaves from 6 specimens: A, D, E (Lower Austria, river March at Marchegg, J.Walter 2239); B (J.Walter 2247), C, H, K (J.Walter 2528 29), F, G (river March at Markthof, J.Walter 2244); I, J (Salzburg, Siggerwiesen, W); scale 3 cm.

Table 2 – Morphological characters of Austrian specimens of *Amaranthus blitum* subsp. *blitum* var. *blitum* and subsp. *emarginatus* (only var. *pseudogracilis* was recorded so far). All characters have been verified by our revisions except * (based on HÜGIN 1986); bold script is used to highlight most important characters.

Characters	**subsp. *blitum* var. *blitum***	**subsp. *emarginatus* var. *pseudogracilis***
growth-form	ascending or prostrate	ascending, rarely prostrate
plant height (cm)	5–80(150)	[5]–100(150)
plant colour	**dark green**	**light green**
red discoloration	**frequently** leaves to whole plant, especially in autumn	**missing** or restricted to stem axis (old leaves)
cotyledonal leaf		
- shape of apex	ovate; obtuse /	narrowly ovate; acute /
- shape of basis	(broadly) cuneate	narrowly cuneate and shortly narrowed
- length (mm)	10-13	6-9
- width (mm)	3-5	2-3
leaf blade		
- shape	broadly elliptic to ovate, nearly circular	elliptic/rhombic to obtrullate
- length (mm)	(10-) 20-60 (-80)[1]	(20-) 30-100 (-120)
- width (mm)	(10-) 15-50[1]	15-60 (-70)
- shape of basis	broadly (rarely narrowly) cuneate to nearly truncate	narrowly cuneate and shortly angustate
- coloration	**often** dark spots, often discoloured	spots **missing**, no discoloration
- thickness	thick/robust (some drought-tolerant)	thin/delicate (sensitive to drought)
apex (of leaf blade)		
- shape	**mostly faintly (rarely distinctly) emarginated, sometimes not**	**distinctly (rarely faintly) emarginated, hence often nearly 2-lobed**
- emargination:		
- width (mm)	**(0,1-) 2-9 (-11)**	**(2,5-) 5-18 (-22)**
- depth (mm)	**0,2-3,5**	**(1-) 1,5-6 (-7)**
- width /- depth	**(2) 2,5-12 (-50)**	**(0,4-) 2-5 (-6)**
inflorescence	terminal to (rarely just) axillar; not flexuous	terminal (rarely nearly axillar); flexuous
- thickness of terminal pseudospikelet	**thick/rotund, erect and straight to curved**	**thin/slender, flexuous**
fruit (ripe!)		
- surface	verrucous/bullate-wrinkled to flat	mostly verrucous/bullate-wrinkled (rarely flat)
- colour	**reddish brown**	**grey- to yellowish brown**
- size (mm)	1,7-2,1 *	1,5-2,1 *
- pericarp[2]	4-layered	3-layered
tepal		
- shape	narrowly elliptic to obovate to narrowly spathulate	narrowly elliptic to obovate

- quantity	(2-) 3	2 (-3)
seed:		
- colour	dark reddish to black	dark reddish to black
- length (mm)	**(1,1-) 1,2-1,5 (-1,6)**	**[0,8-] 1,0-1,2 (-1,3)**
- width (mm)	**(1,0-) 1,1-1,4 (-1,5)**	**[0,8-] 0,9-1,1 (-1,2)**
- shape	broadly ovate to circular	(broadly) ovate (to circular)
- surface	dull or fine, shallowly reticulate, conspicuously glossy	mostly fine, shallowly reticulate or dull, conspicuously glossy
pollen grain:		
- pores: (μm)[2]	2,4-3,3	1,6-1,9
somatic chromosome number (2n)	34	34
introduction period	archaeophyte or indigenous? *	neophytic *

[1] The high values of the leaf blades refer to luxuriant specimens of compost heaps (HBV).
[2] Data according to COSTEA et al. (2001a), referring to subsp. *blitum* and subsp. *emarginatus*.

OBERDORFER (1990), STOHR (2002); Switzerland: HÜGIN (1987), LANDOLT (2001); Hungary: HÜGIN (1987), Romania: COSTEA (1998a, b); Slovakia: MARHOLD & FRANTIŠEK (1998); France: THELLUNG (1914), "Index synonymique France" (homepage), LAMBINON & WORMS (1993), WISSKIRCHEN (1995); Turkey: GÜNER & al. (2000); Greece: RAUS (1997); Italy: ZÁNGHERI (1976: 106), FIORI (1923); Spain: CARRETERO (1990); Madeira: PRESS & SHORT (1994), HÜGIN (1987), Teneriffa: HÜGIN (1987), Gran Canaria: LAMBINON & WORMS (1993); Egypt: HADIDI & HADIDY (1980); Rwanda: LAMBINON & WORMS (1993); Great Britain: BRENAN (1961); North Europe: KARLSSON (2001); Europe: AELLEN (1964), AKEROYD (1993), JALAS & SUOMINEN (1980). GREUTER & al. (1984) and HEJNÝ (1948) included this taxon in a polymorphic *A. blitum* in their treatments of the Mediterranean and Slovak floras, respectively. According to TOWNSEND (1980) subsp. *emarginatus* is distributed from the Caucasus through India to Malaysia, Java and New Guinea, East Africa, Australia and in South America from Guyana south to Argentina.

Ecology

Due to its tropical origin subsp. *emarginatus* depends on even higher temperatures than subsp. *blitum* does. Within the warmer regions of the temperate zone of Europe and North America subsp. *emarginatus* has been introduced for a long time but has just recently become an established alien. It is characterised by its Sub-Mediterranean (-Sub-Atlantic) distribution (WISSKIRCHEN 1995, Table 2). However, varieties within subsp. *emarginatus* behave ecologically slightly different. The var. *pseudogracilis* prefers warmest areas at least in Germany and France. The differences in the geographic distribution of the varieties may also reflect their unequal capabilities to endure water stress. The larger leaved and habitually ascending var. *pseudogracilis* may suffer more seriously from drought than the prostrate and small-leaved var. *emarginatus*. In particular the latter one may be better adapted to the summer-dry Mediterranean climate, since most of the records from the Mediterranean belong to this variety (CARRETERO

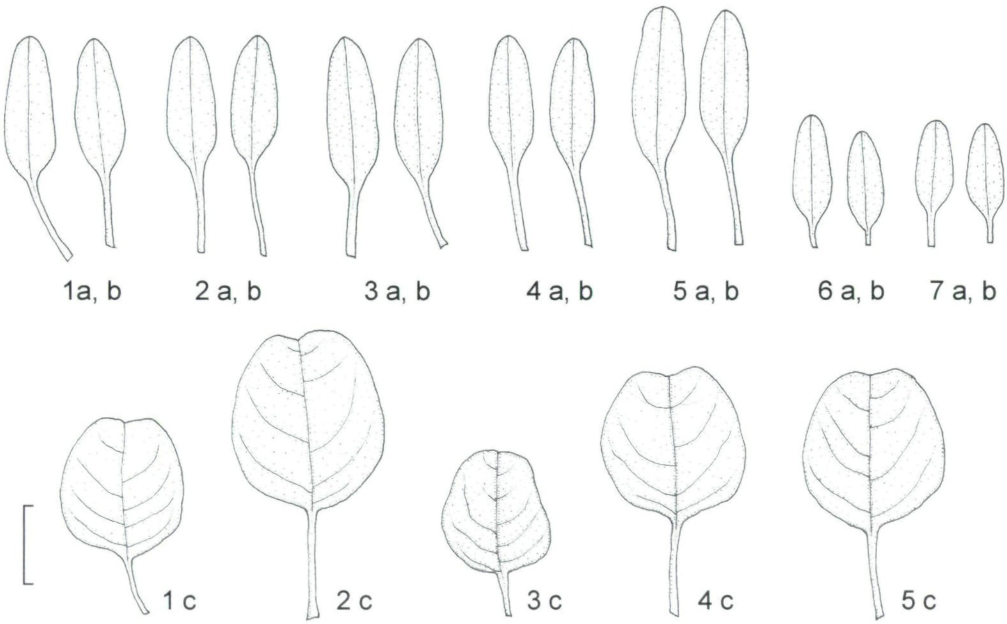

Fig. 9: *Amaranthus blitum* subsp. *blitum*, variation of cotyledons: (a - b) and primary foliage leaves (c) from 5 juvenile specimens (1 - 5) and cotyledons from 2 specimes of seedlings (6 - 7) (J.Walter 5315); scale 1 cm.

1990, RAUS 1997 and presumably GÜNER & al. 2000). HÜGIN (1986) suggested slight ecological difference (ELLENBERG 1998). Nitrogen and light indication value were both estimated as 7 - 8 for subsp. *blitum* and 8 - 9 for subsp. *emarginatus*, respectively.

The size of the Austrian populations at the river March varies significantly between years in response to the inundation dynamics of the river. Subsp. *emarginatus* is associated in these riparian sites with other neophytic summer annuals, such as *Xanthium saccharatum*, *Bidens frondosa* and *Echinocystis lobata*, all of them being characteristic species of flood plains. The habitats are further characterized by gritty, sandy to silty, periodically dry soils building up riverbanks which are themselves frequently eroded.

All species of the genus *Amaranthus* are C_4 plants of often high drought-tolerance. In this respect subsp. *emarginatus* is exceptional as it needs a permanent water supply which is usually realized in these riparian habitats. The cultivated specimens in the botanical garden often suffered in case of insufficient irrigation. In contrast, subsp. *blitum* tolerated some drought.

Neophytic species often disperse preferably via river valleys or anthropogenic pathways like railways or roads. The ability to germinate under subaquatic conditions has been thought to be an important factor for the effective spread of these species. However, according to BRANDES & EVERS (1999) subsp. *emarginatus* has a relatively low germination capacity when submerged in water (30 %) as compared to *Rumex stenophyllus* (100 %) and even *Portulaca oleracea* (65 %). Low germination rates were found by

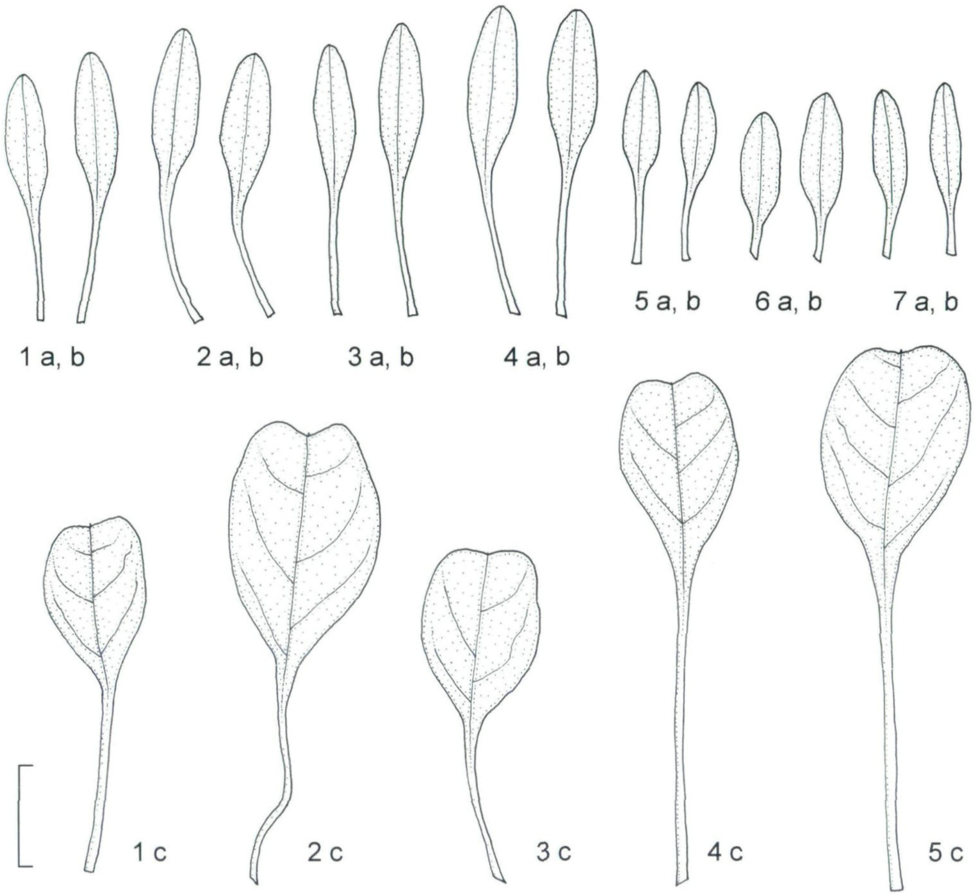

Fig. 10: *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis*, variation of cotyledons (a - b) and primary foliage leaves (c) from 5 juvenile specimens (1 - 5), and cotyledons from 2 specimens of seedlings (6 - 7) (J.Walter 5316, 5317); scale 1 cm.

these authors also for other species such as *Leonurus marrubiastrum* (30 %) of similar habitats. In contrast, submersed seeds of species from even semi-dry habitats like *Bromus tectorum, Hordeum murinum* and others showed 100 % germination. Anyway the aquatic dispersal of floatable diaspores of subsp. *pseudogracilis* consisting of tepals and bracteoles, which enclose the fruit, is a much more important feature to be considered here. Although the nut is not inflated like in *A. deflexus,* the shrivelled, mostly verrucous and bullate to wrinkled nut of subsp. *emarginatus* enables the buoyancy of the diaspore. Seeds of this subspecies kept alive and were able to germinate even after having been submersed in water for a period of 31 or more days. This is a considerable long period compared to other species of riparian vegetation, e.g. *R. stenophyllus* (4 days) or *Leonurus marrubiastrum* (14 days).

SCHMITZ (2002) did not find subsp. *blitum* along the river banks at the lower parts of the Rhein River, but exclusively subsp. *emarginatus* var. *emarginatus*, whereas var. *pseudogracilis* was only recorded by him from localities in the city of Düsseldorf. Subsp.

Fig. 11: Habit of *A. blitum* subsp. *blitum* (LI 805/73).

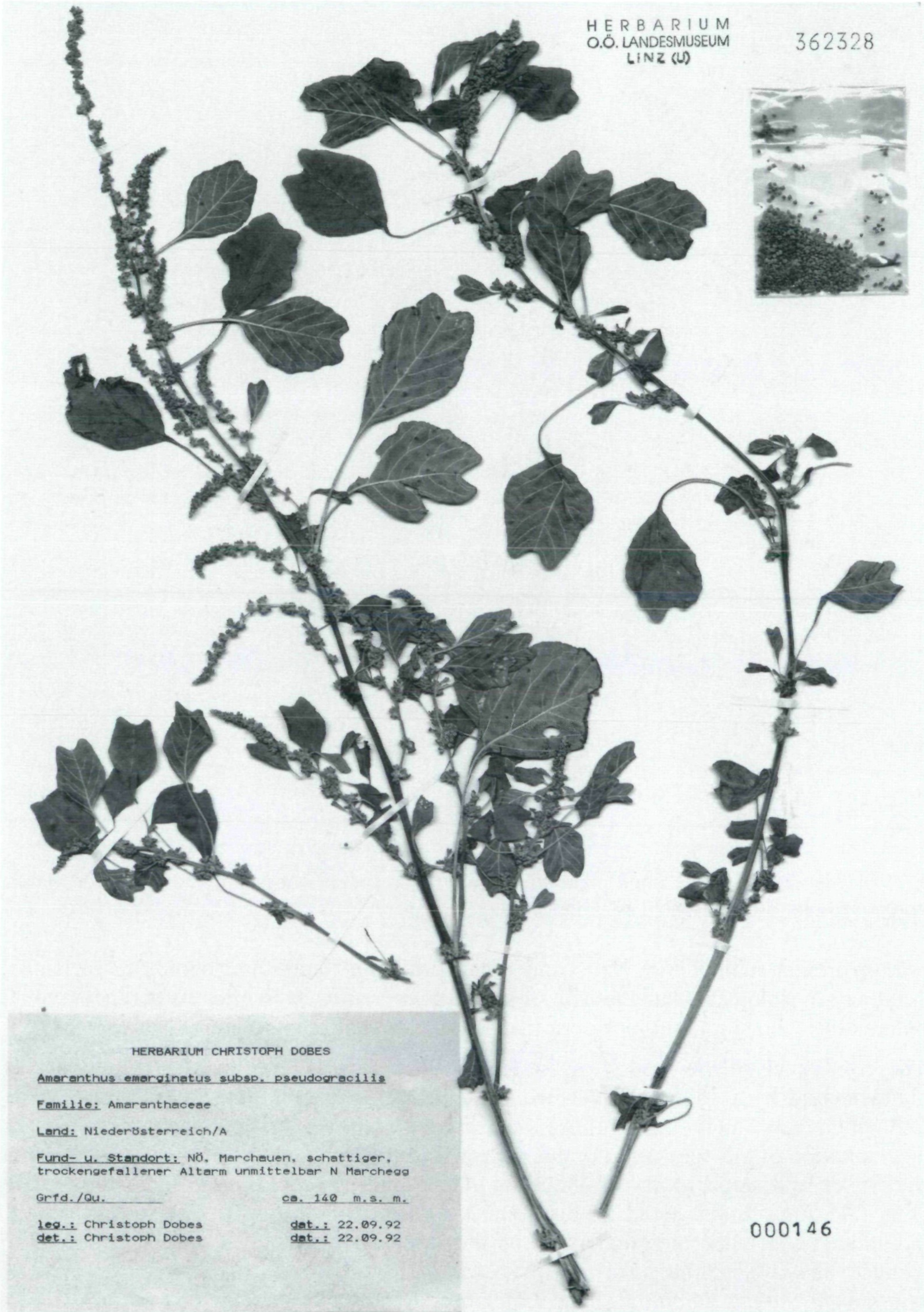

Fig. 12: Habit of *A. blitum* subsp. *emarginatus* var. (LI 362328).

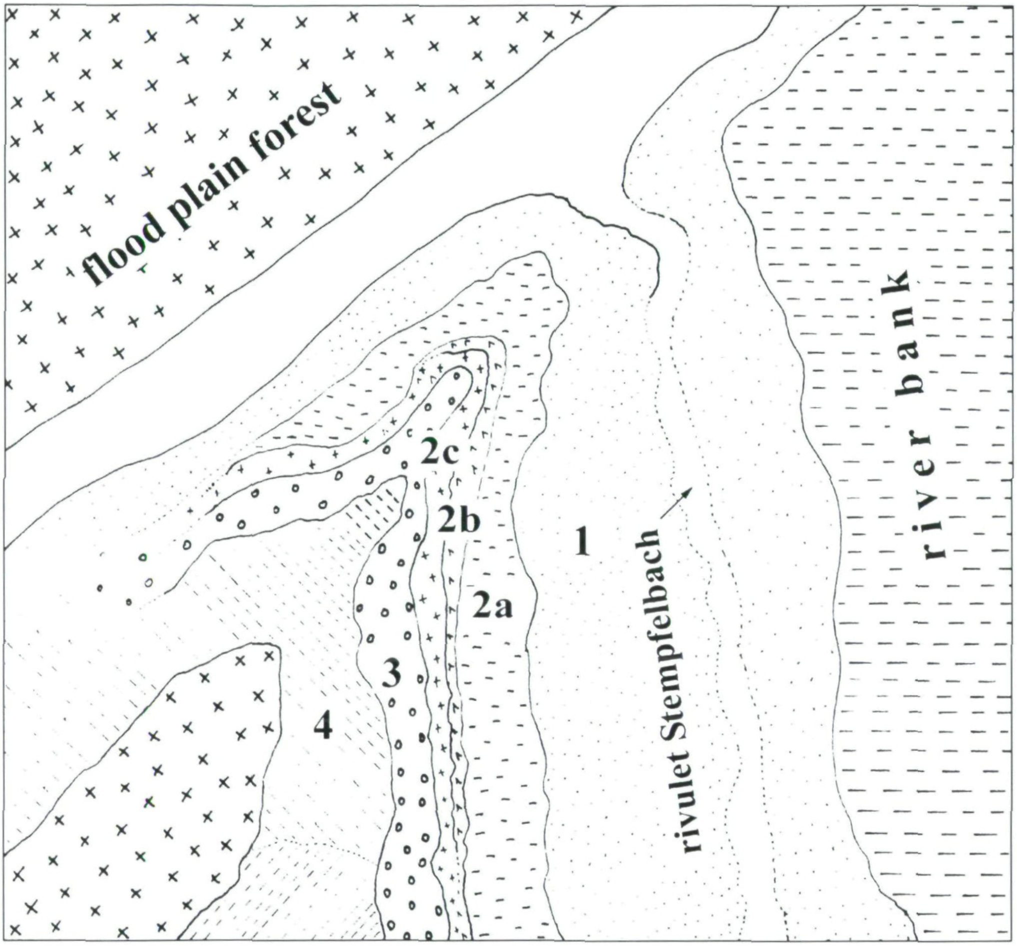

Fig. 13: Vegetation of the flood plain after water had receded at the branch of the river March and the rivulet Stempfelbach, zonation 1 - 4.

blitum prefers mainly vineyards and other cultivated lands and avoids river banks. Another physiological characteristic of subsp. *emarginatus* explaining its eco-geographic behaviour is the stimulation of germination rates by high temperatures (at least 30° C).

The confluence of the branch of the river March and the rivulet of Stempfelbach is characterized by a wide flat river bed which often dries up in late summer or autumn and which then usually bears pioneers and colonizers covering the muddy soil (Fig. 13). The zonation of the vegetation in this area was investigated along a transect comprising the lower and upper parts of the river banks and an enclosed insular flood plain (Fig. 14). Four zones could be distinguished along this gradient: The lowest zone 1 occupied wide outer marginal parts of the dried-up branch bed with species belon -ging to the Cyperetalia fusci (e.g. *Cyperus fuscus, Limosella aquatica, Gnaphalium uliginosum, Juncus bufonius*). Zone 2 includes all more elevated habitats, forming a belt which follows the river bank. 3 sub-zones, covered by luxuriant annual species, could

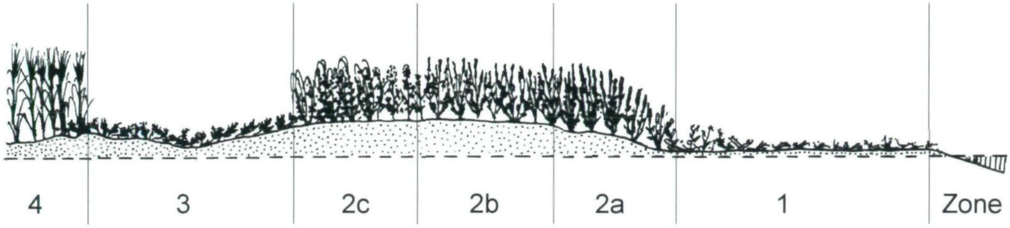

Fig. 14: Vegetation profile along a transect at the confluence of the branch of the river March and the rivulet Stempfelbach, zonation 1 - 4.

be distinguished: subzone 2a is mainly dominated by *Chenopodium rubrum* which is associated with *C. ficifolium* subsp. *ficifolium,* followed by subzone 2b which is characterised by the dominance of *Bidens frondosa*, and finally by subzone 2c in which *A. blitum* subsp. *emarginatus* var. *pseudogracilis* prevails. Zone 3, again of moist conditions at low-lying places, is mainly covered by *Rorippa amphibia*, and gradually shifts into dense stands of *Phalaris arundinacea* and *Phragmites australis* (zone 4).

The syntaxonomical classification of subsp. *emarginatus* in riparian habitats of the alliance Chenopodion glauco-rubri in Germany and France is discussed by WISSKIRCHEN (1995). The highest constancy (V) was found for the Echinochloo muricatae-Amaranthetum pseudogracilis association respectively for the sub-associations bidentetosum frondosae, cyperetosum fusci and typicum, consisting mainly of neophytic character species and differential species. Subsp. *emarginatus* also occurs in the Xanthio albini-Chenopodietum rubri community and further in the *Xanthium italicum* community, the *Xanthium albinum* community, the Chenopodietum glauco-rubri association, the *Brassica nigra* community, and the *Xanthium orientale* s. l. community. Within the association Polygono brittingeri-Chenopodietum rubri typicum it is stated only in the variant of warmer, climatically advantageous areas while it is missing within the "typical" Central European variant.

In Austria subsp. *emarginatus* var. *pseudogracilis* is frequently associated with several other annual neophytes, e.g. *Bidens frondosa, Xanthium saccharatum, Echinocystis lobata* and it occurs in the two alliances Chenopodion glauci and Bidention tripartiti. The phytosociology of var. *pseudogracilis* based on 17 relevés is presented in Table 3 The relevés 10 - 11 from the natural banks at the confluence of the March and Danube have a similar floristic composition as those of the anthropogenic habitats of the clarifiers of the sugar mill Hohenau (relevés 12 - 17). Eight relevés are (sub-)dominated by *C. rubrum* (to a lesser extent also by *C. ficifolium* subsp. *ficifolium*) and var. *pseudogracilis* and refer to the alliance Chenopodion glauci. These habitats are covered by thermophilous, high and dense stands. WISSKIRCHEN (1986) described such vegetation types also from clarifiers, but stated that they actually might be species-poor stands ("fazies") actually belonging to the Chenopodietum glauco-rubri or the *C. rubrum* community. These habitats (sugar-beet sludge ponds and other clarifiers, septic tanks, dunghills) are extremely rich in nutrients, especially in ammonia but also nitrates and occasionally other salts (GEISSELBRECHT-TAFERNER & MUCINA (1993). In contrast, relevés 1-9 are characterized by the sub-dominance of *Bidens frondosa* and by the occurrance of further taxa, such as *Persicaria lapathifolia* subsp. *lapathifolia*, *P. hydropiper, Rorippa palustris, Rumex maritimus*, which refer to the *Bidention tripartiti*. *Xanthium italicum*, which is closely related to *X. saccharatum*, is mentioned to be a floristic element of Chenopodion glauci (GEISSELBRECHT-TAFERNER & MUCINA 1993). In the relevés 1-5 X. *saccharatum* is associated with the sub-dominating *Bidens frondosa* and refers to Bidention tripartiti. The dynamics of this annual-rich vegetation might cause problems in establishing syntaxonomical units especially between the above-mentioned alliances. LAZOWSKI (unpub./in litt.) investigated the riparian habitats of the Thaya River and reported the occurrence of subsp. *emarginatus* in the Leersietum oryzoides.

Impacts on the natural vegetation

River valleys generally serve as dispersal routes for neophytes like railways and roads do. The habitats of riparian ecosystems (banks of rivers, shores of lakes and rims of ponds) are often stamped by eutrophication and water management (MÜLLER 1995; KOWARIK 1992, 1999, SUKOPP 1962, 1976). Riverbanks are extraordinarily rich in neophytes in Central Europe. They harbor highest numbers of neophytes and archaeophytes compared with all other natural and near-natural vegetation types of Central Europe (LOHMEYER & SUKOPP 1992). *Aster lanceolatus*, *Solidago canadensis*, *Fallopia japonica*, *Helianthus tuberosus* and *Impatiens glandulifera* for instance are known to be definitely invasive species forming clustered monodominant stands in these ecosystems and therefore they change species composition (HARTMANN & KONOLD 1995, KONOLD et al. 1995, BÖCKER & al. 1995, SUKOPP & SUKOPP 1994).

BRANDES (2000) investigated the river Elbe for a distance of 600 km between the Bohemian Massif and Lauenburg and stated 86 neophytes. He demonstrated that the dynamics in these habitats are very high and as a result in the last years one species per year was found to spread into this area. BRANDES (2000) classified subsp. *emarginatus* ("*A. emarginatus*") as an invasive species (presumably in the sense of rapidly spreading and producing large populations; compare also IUCN 2001). Although riparian habitats are highly dynamic ecosystems, environmental alterations and fluctuations need not necessarily involve changes in the physical structure of the vegetation units, but usually manifest in an increase in the number of neophytes (e.g. the Xanthio albini-Chenopodietum rubri or Rumicetum maritimae of the class Bidentetea communities, BRANDES 2000).

One third (= 7) of the species encountered in the 17 relevés are neophytes. However, in Austria the impact of the neophytes on the vegetation of the banks of rivers March and Thaya is not as serious as it is at the major streams of Germany and France. Although the abundance of subsp. *emarginatus* varies highly owing to the yearly fluctuating water regime, it cannot be considered yet an invasive subspecies in the sense of being "transformative". Hence this taxon does not really compete with indigenous species, and therefore it has not displaced the native flora so far (IUCN 2001, ESSL & RABITSCH 2002, compare RICHARDSON & al. 2000). One reason for that situation might be that associated pioneers, such as *Bidens spp., Echinochloa crus-galli, Persicaria lapathifolia* subsp. *lapathifolia*, are likewise successful competitors (WISSKIRCHEN 1995). The scarceness of open areas, such as recently eroded, exposed muddy to gravel-rich habitats, necessary for those therophytes might also be an important reason for the subspecies's limited establishment.

Appendix: plant material examined

The following vouchers have been used to compile the distribution map and some of them for biometric analysis marked with one asterisk "*" at the beginning of each voucher. The voucher regarding to the chromosome count is marked with two asterisks "**".

***Amaranthus blitum* subsp. *blitum*:**

Austria: Burgenland: Podersdorf am Neusiedler See; 9.9.1952 H. Schaeftlein [GZU 150048]. – Oberschützen, Internatsgarten; Gartenerde; 4.10.1935 W. Möschl [GZU 75H79]. – **Kärnten:** bei Klagenfurt. 1825 s. coll. [KL 22575]. – Etwa N des Bahnhofs St. Andrä bei Siebending; in einem Maisfeld, mehrfach; 22.8.1996 H. Melzer [LI 282641]. – *Feldkirchen; 30.8.1929 J. Schneider [W 1947-116]. – ibidem; 24.6.1931 J. Schneider [W 1947-113]. – Ferlach; Straßenrand; 12.8.1932 s. coll. [W 1947-119]. – Gailtal, Talboden d. Gail, NW bis NW Goderschach; segetal, Maisacker; 14.9.1998 P. Schönswetter [WU 20767]. – Hermagor;. 8.1963 s. coll. [LI 842949]. – Villach; 7.1904 Benz [KL 11032]. – Klagenfurt-Ost, W v. Hörtendorf; planierter Teil d. Deponie; zahlreich in unterschiedlichen Formen; 24.8.1987 H. Melzer [KL 83770]. – s. coll. 1992 [GZU 11-92] – Klagenfurter Becken, in Wrießnitz SW Karnburg; in einem Garten; 21.6.1973 G.H. Leute [KL 21301]. – Lavanttal, S von Mühldorf; auf einem Rain; 8.9.1983 H. Melzer [KL 71779]. – Oberdrautal, Unterfrallach bei Dellach; zwischen Haferfeld und Misthaufen bei einem Bauernhof; 17.7.1979 S. Wagner [KL 43058]. – Obervellach. 7.1979 s. coll. [KL 17564]. – S Villach; auf einem aufgelassenen Müllplatz (früher Schottergrube), auf Sandboden; 1.10.1988, H. Melzer [LI 23315]. – Spittal an der Drau, östliche Vorstadt; Bauerngarten; 26.9.1977 S. Wagner [KL 37307]. – St. Andrä bei Villach; Unkrautgesellschaft; 10.1950 Bach [GZU 100]. – Steinfeld im Vw; Gartenunkraut, Glimmerschiefer; 630 m s.m; 9.1928 Th. Glantschnig [KL 15251]. – Tröpolach; 1859 s. coll. [KL 17781]. – **Niederösterreich:** Weinviertel, 9 km SSW Laa a. d. Thaya, 1 km SE Oberschoderlee, knapp S Kote 284, SE des "Blauen Berges" (Naturdenkmal); Bauschuttdeponie, ausgedehnte, üppige Annuellenfluren; 1.9.1998 J. Walter [WNLM] – Amstetten; in den Straßen; 5.8.1904 E. Korb [W 1951-6643]. – Bei [Bad] Vöslau; in Weingärten; 9.1877 H. Braun [W 1887-5328]. – Bei Achau; im Schlamm eines ausgetrockneten Tümpels; 27.9.1917 E. Korb [W 1951-6641]. – *Bei Baumgarten [a. d. March]; an Gartenzäunen; 2.10.1908 J. Vetter [W 1947-16897]. – *Bei Fischamend an der Donau; im Gemüsegarten; 26.9.1911 E. Korb [W 1951-6647] – Bei Stillfried a. d. March, Marchufer; Flußbett; E. Korb 20.9.1911 [W 1951-6646] – Bisamberg; 18.8.1930 Hasl [LI 874028]. – *Ca. 1 km E Markthof, Stempfelbacheinmündung in March; üppige Schlammfluren, Pioniervegetation, Altarmufer; 22.9.1992 J. Walter [J. Walter 2183a b]. – *Marchfeld, in Gänserndorf; an Häusern; E. Korb 19.9.1920 [W 1951-6645]. – In Scheibbs; in hortis; 9.1879 s. coll. [GZU 155]. – Klosterneuburg; 2.10.1924 J. Schneider? [W 1947-115]. – Mödling, Stadtgarten; 18.9.1878 E. Witting [WNLM s.n.]. – Moosbrunn; an Häusern; 26.9.1916 E. Korb [W 1951-6640]. – St. Andrä; an der Strasse; 19.9.1897 K. Fritsch [GZU 140]. – *Stein bei Krems; an Wegen; 20.7.1906 E. Korb [W 1951-6644]. – *Stockerau; 2.9.1922 s. coll. [W 1947-117]. – SW v. Vienna, Kaltenleutgeben, gegenüber v. Castello; auf Schuttplatz; niederliegend; 24.8.1987W. Adler [W. Adler s.n.]. – Um Hainburg a. d. Donau; in Gärten. 7.1889 C. Aust [W 1959-8186, 1959-8189]. – Vom Markt Melk zum Schiffe (Donau); 29.9.1872 F. Vierhapper [WU Acq. 2100]. – Wiener Neustadt; in Gärten; 9.1897 Lonklar [WU Acq. 771]. – *Wienerwald, in Rekawinkel; im Gemüsegarten; 15.9.1917 E. Korb [W 1951-6642]. Niederösterreich/Wien, Kalksburg, (genau Landesgrenze); Park; 29.9.1973 s. coll. [W 1966-15869]. – Niederösterreich/Wien, Kaltenleutgeben. 8.9.1922 J. Schneider? [W 1947-122]. – **Oberösterreich:** *SE Linz, 4,7 km NW Enns, 2 km N Asten, Hausmülldeponie; auf Hausmüll; 12.8.1990 J. Walter [J. Walter 2189]. – Beim Posthofe in Linz; Schutt; 22.8.1885 s. coll. [GZU s.n]. – Pöstlingberg bei Linz, Dürrnberg; 8.1860 s. coll [LI s.n]. – SE Linz, 4,7 km NW Enns, 2 km N Asten, Hausmülldeponie; auf Hausmüll; 17.7.1987 J. Walter [J. Walter 2194]. – *ibidem; 11.9.1988 W. Forstner [W 1991-2034]. – Enns; 1963 A. Lonsing [LI 805/73]. – Enns Au, gegen Mauthausen, Überschwemmungsgebiet Auwald, Lichtung in der Au; Feld; 8.8.1964 F. Sorger [LI 313239]. – Steyr, Aichet; Garten; 8.9.1952 F. Hasl [LI 874025]. – N Pösting bei Goldwörth; Feldrand; 5.9.1989 F. Grims [LI 33394]. – Traunsee, E.Ufer; 19.8.1931 K. Ronninger [W 1963-15833]. – Gmunden, Linzerstraße; Straßenrand; 18.8.1936 K. Ronninger [W 1963-15836]– *Taufkirchen a. d. Pram, Wagholming; Zuckerrübenfeld; im Gebiet s. slt.; 1.10.1982 F. Grims [LI 830104]. – *Goldwörth; 17.8.1994 A. Rechberger [LI 164389]. – Aistersheim; s. dat. K. Keck [WU/Keck s.n.]. – Aistersheim; Pflasterritzen; 8.1889 K. Keck [WU Acq. 1076]. – Innviertel, Ried im Innkreis, Riedauerstrasse, Häuserblocks; im Kies vor den Häusern; 435 m s.m.; 12.10.2001 M. Hohla [LI s.n]. – Peterskirchen; Pfarrhofgarten; 19.9.1877 M. Haselberger [LI s.n]. – Thalbachmühle bei Wels; 16.8.1867 F. Vielguth [LI s.n]. – Taufkirchen an der Pram; Verladefläche des Bahnhofes; 320 m s.m.; 11.9.1989 F. Grims [LI 33423]. – Mühlheim; Schottergrube; 5.8.1999 M. Hohla [LI 389397]. – Grieskirchen; Pfarrhofgarten. 23.9.1872 J. Wiesbauer [LI 80628]. – Harter Wald S Steinhaus bei Wels; Ödland; 15.9.1979 F. Grims [LI s.n]. – Fraham bei Eferding; Unkrautflur eines Gemüseackers; 25.9.1975 F. Grims [LI s.n]. – S.Saxen, Naarn.Au; ca. 230 m s.m.; 27.9.1964 F. Sorger [LI 313238]. – Stallbach Nr. 7/Kronsdorf; 21.8.1989 F. Essl [LI 33541]. – **Salzburg:** (?); Eisenbahnbrücke; 1874 K. Fritsch [GZU 140]. – Parsch;auf einem Misthaufen; 1.10.1929 K. Fritsch [GZU 140]. – **Steiermark:** Söchau;Kulturboden, halbwild; 7.1908 J. Schneider [WU Acq. 2479] – bei Hochenegg; wüste Plätze; 7.8.1899 Hayek [WU Acq. 1912]. – um Gratz (=Graz); s. dat E. Witting [WNLM s.n.] – Leoben; an Wegrändern; 8.10.1934 Fest & Wagner [WU Acq. 3115]. – Windische Bühel, Wies, Landesversuchsanlage f. Sonderkulturen, N v. Schloß Burgstall; 2.9.1995W. Till [WU s.n.]. – Eggenberg bei Graz; 27.8.1927 J. Eggler 5782 [GZU 84354]. – Graz, Wetzelsdorf, Peter Rosegger Straße; Müllsturz; 15.8.1959 H. Melzer & Hachtmann [GZU 193]. – In Stainz; 1923 P. Trogen [GZU s.n]. – Leoben; an Wegrändern, Schotter; 8.10.1934 Fest & Wagner [GZU 104899]. – St. Nikolai ob Draßling; Gartenunkraut; 1927 Strohmayer [GZU 112989]. – Bei Köflach; s. dat. R. Wagner [GZU 26919]. – OstStyria (= Oststeiermark), bei St. Johann bei Herberstein; in einem Maisfeld; 26.9.1971 W. Maurer [GZU 100]. – Leoben; an Wegrändern, Schotter; 550 m s.m.; 8.10.1934 Fest & Wagner [GZU 162]. – Oberes Murtal, in Zeltweg in der Hauptstraße; in einer Gartenanlage; 9.1999 H. Melzer [GZU 225525]. – Leoben, Zentralfriedhof; 30.10.1986 H. Melzer [LI 876108]. – Mürztal, bei Kapfenberg, in Schirmitzbühel; auf Aufschüttungen der aufgelassenen Müllverbrennungsanlage; 5.10.1979 H. Melzer [LI 36945]. – **Tirol:** Innsbruck, Büchsenhausen; 22.9.1886 Evers [GZU 18]. – **Vorarlberg:** *Bregenz, Friedhof; auf einem Grab; 14.9.1990 W. Forstner [W 1991-2002]. – **Wien:** *01. Bezirk, hinter dem Gebäude der Akademie der bildenden Künste (=Schillerplatz 3); an Hecken; 23.8.1920 H. Zerny [W 1957-11347]. – Karlsplatz; 8.1946 Rechinger fil. [W 1950.11561]. – *02. Bezirk, Ausstellungsstraße, zw. Haupt. u. Nebenfahrbahn; Grünstreifen 18.10.1988 J. Walter [J. Walter 2195, *2196]. – Heinestraße/Stadtgutstraße, neben dem Radweg entlang der Heinestraße; Grünstreifen, hundekotbeeinträchtigt; 18.7.1994 J. Walter [LI 171005, *J. Walter 2649a b]. – *Obermüllnerstraße; am Rand einer Baumscheibe; 26.6.1990 J. Walter [J. Walter 2188]. – *Praterstern, bei der Straßenbahnlinie 21; bei den Straßenbahnschienen; 19.7.1990 J. Walter [*J. Walter 2191, *2192]. – 03. Bezirk, Botanischer Garten d. Univ. Vienna (HBV), Rennweg 14; spontan auf dem Komposthaufen [J. Walter 4593, *2319]. – *Ibidem; 8.7.1992 J. Walter [J. Walter 2185a b]. – *Ibidem; 28.7.1992 J. Walter [J. Walter 2184a c]. – Ibidem; 17.8.1994 J. Walter [J. Walter 3812, 3813]. – Ibidem; 19.7.1994 J. Walter [J. Walter 3811, 3788]. – Ibidem; 15.10.1984 B. Wallnöfer [B. Wallnöfer 196]. – *Jagdschloßgasse in Lainz; Unkraut im Gemüsegarten; 10.10.1909 E. Korb [W 1951.6639]. – Ibidem; 7.10.1909 E. Korb [W 1951.6635]. – Viehmarkt St. Marx; M. 6.10.1942 Effenberger [WHB 204]. – Höhe des Fürst Schwarzenberg'schen Palastes im 3. Bezirke; Pflasterritzen; 11.8.1897 F. Vierhapper [WU Acq. 2100]. – 04. Bezirk, in den Anlagen vor der R. im 4. Bezirk; Unkraut; 28.8.1918 V. Bittermann [W 1966.17850]. –*Neubaugürtel zw. Sorbaitgasse u. Hütteldorfer Straße; Rand einer kl. Grünfläche; 26.8.1993 J. Walter [J. Walter 2648]. – 04. Bezirk; 8.10.1942 M. Effenberger [WHB 208]. – 06. Bezirk; 11.8.1942M. Effenberger. [WHB 203]. – 09. Bezirk, Franz Josefs.Bahnhof; Gehsteigrinne; 12.10.1987 J. Walter [J. Walter 2193]. – Van Swieten.Gasse; Mauer, Gehsteinfuge; 18.9.1991 J. Walter [WU Acq. 3731]. – *Ibidem; [J. Walter 2186, *2187)]. – 10. Bezirk, Wienerberg; Planierung; 9.10.1969 W. Holzner [WHB 196]. – Ibidem; 19.10.1991 *W. Forstner [W 1992-15327]. – 10. Bezirk; 3.8.1942 M. Effenberger [WHB 206]. – *11. Bezirk, Simmering, Zentralfriedhof; auf einem Komposthaufen; 11.9.1988 W. Forstner [W 1991-2031]. – W Zinnergasse, N Kaiser Ebersdorfer.Straße, zw. Kleingartenareal u. Hausneubau; auf Erdaufschüttungen 9.9.1992 J. Walter [J. Walter 3687]. – Zentralfriedhof in Simmering; Komposthaufen. 11.9.1988 W. Forstner [W 1991-2030]. – 16. Bezirk, Hasnerstraße, knapp bei Sulmgasse;. [J. Walter 5315]. – *19. Bezirk, Grinzing; 8.1881 Halácsy [W 1887-5327]. – Grinzing; in einer Handelsgärtnerei; 13.9.1917 E. Korb [W 1951-6636]. – *Hackhofergasse in Nußdorf; 7.9.1920 E. Korb [W 1951-6637]. – 18. Bezirk; Hochschulgarten der Hochschule für Bodenkultur; 7.1971 Wittholz; [WHB 193]. – Neuwaldegg; 6.1904 Gerald Rosner [GZU 54]. – *22. Bezirk; Mülldeponie Rautenweg, auf einem Komposthaufen; 22.9.1990 W. Forstner [W 1991-2029]. – 23. Bezirk, Erlaa; 13.8.1970 W. Holzner [WHB 195]. – *Vienna, Abbruch Rampe; an Wegen; s. dat E. Korb [W 1967-17859]. – Vienna. 7.1863 J. B. [WU Acq. 1278].

Croatia: *Istrien, Gebiet des Monte Maggiore (= U?ka gora), in Volosca; wüste Plätze; 12.9.1906 A. Ginzberger [WU Acq. 3089].

Croatia/Slovenia: *Istrien; an einem Fahrwege; 10.09.1929 E. Korb [W 1951-6633].

***Amaranthus* cf. *blitum*:**

Austria: Niederösterreich: Persenbeug; frische, gesäte Wiese; 7.1977 Leopoldinger [SZU 28837].

***Amaranthus emarginatus* subsp. *emarginatus*:**

*s. loc.; 1887 A. Heimerl [WU Acq. 2198].

Brazil: *S Brasilia, Est. Paraná, Jaguariaíva; waste place; 17.10.1966 J. C. Lindeman & J. H. de Haas [W 1972-15302].

Germany: *Schleswig Holstein, bei Blankensee; auf Schutthaufen; 8. 1892 Justus Schmidt [LI s. n.].

***Amaranthus emarginatus* subsp. *pseudogracilis*:**

Austria: Kärnten: *Klagenfurt-Ost, W von Hörtendorf; zahlreich in unterschiedlichen Formen, z.T. sehr mastig, auf dem planierten Teil der Mülldeponie; 12.9.1992 H. Melzer [GZU 11.92]. – *Ibidem; 18.9.1988 H. Melzer [GZU 9.88], [LI 23901]. – **Niederösterreich:** Unteres Thayatal, 1,2 km SE Rabensburg, S.Teil der Müllgraben, E Rabensburg bis zum Damm; Wiesen; 25.9.1987 B. Wallnöfer [B. Wallnöfer 1907]. – Unteres Thayatal, ca. 2 km ESE Rabensburg, Durchstich v. Altarm, Ufer; Kies, Schlickanschwemmungen, Pionierstandort; 4.9.1994 W. Lazowski. [no herbarium, collected fresh plant seen!]. – *Marchau, 3,7 km E Drösing, ESE v. Krummer See, E.Ende d. Altarmbucht; Schlammufer, kleine, lichtreiche Stelle; 10.10.1992 J. Walter [J. Walter 2236a b, *2237a b, *2238]. – **Marchau, N Ende v. Marchegg, ca. 0,3 km E v. Jagdschloß, bei Brücke, neben dem Damm; ausgetrockneter Altarm; 22.9.1992 J. Walter [J. Walter 2240, *2239a c, *2241a b, *2242a b, *2243]. – Marchegg, E des Dammes; 143 m s.m; 25.9.1993 J. Walter [LI 209135, 209136, 209137]. – NE.Rand von Marchegg, beim Zusammenfluß d. March u. Altarm ostwärts bis zum Denkmal; Uferbereich des Altarmes; 7.9.1998 J. Walter [WNLM s.n]. – Marchegg, ca. 0,2 km WNW v. Schloß, Aubereich, Altarm; schlammiger Uferbereich; 16.10.1994 E. Hörandl no herbarium, collected fresh plant seen!]. – Marchegg, E d. Dammes; üppige Schlammfluren, Pioniervegetation, Altarmufer; 25.9.1993 J. Walter [J. Walter 2324a b, 2323a c, 2322a b, 2321a d]. – Unmittelbar N Marchegg; schattiger, trockengefallener Altarm; 140 m s.m.; 22.9.1992 C. Dobes 146 [LI 362328]. – *S Ortsrand v. Hohenau, Zuckerfabrik, Bereich der Großen Herrschaftswiese; schlammige, hypertrophierte Ufer der Klärbecken; 15.9.1998 J. Walter [WNLM 2074,*2075, *2073, *2064, *2065, *2066, *2067,*2068, *2069; the two vouchers *2070; *2071 see: Cuscuta campestris (with Amaranthus!)]. – 1,5.2,5 km S Hohenau: Areal der Zuckerrüben.Klärteiche; schlammige, hypertrophierte Ufer der Klärbecken, Kanalrand; 12.10.1996 J. Walter [*J. Walter 2325a b, *2326a d, 3035a f]. – *Ca. 1 km E Markthof, Stempfelbacheinmündung in March; üppige Schlammfluren, Pioniervegetation, Altarmufer; 140 m s.m.; 22.9.1992 J. Walter [J. Walter 2244, *2245,*2246,*2247,*2248]. – Ibidem; 20.8.1994 J. Walter [J. Walter *2528a i, *2529, *2530, *2531, *2532, *2533, *2534, *2535, *2536]. – Ibidem; 19.9.1992 C. Dobes 145) [LI 362327]. – Ex cult. Botanical Garden of Inst. of Botany, Univ. of Vienna (HBV) (original: Stempfelbacheinmündung in einen Marchaltarm; 23.8.1995 J. Walter) [LI 227013]. – NE Markthof; 27.8.1994E. Sinn [E. Sinn 940007]. – *N.Ende v. Marchegg, zw. Jagdschloß u. Einmündung d. Altarmes in die March, beim Damm; üppige Schlammfluren, Pionierveg., Altarmufer; 20.8.1994 J. Walter [J. Walter 2525a, *2526]. – *Einmündung d. March i. d. Donau; feinsandreiches aulehmiges Schotterufer; 20.8.1994 J. Walter [J. Walter 2537]. – *Zwischen Marchegg u. Baumgarten; bei Niedrigwasser trockenfallende Flachufer von Ausstichen, (IV, VI), Kies und Sand mit einer Auflage von feinkörnigem Sediment; 12./19.10.1986 A. Drescher & R. Drescher [GZU 85.88]. – E Baumgarten a. d. March, Mäander bei der Holzwiese; Niederwasser, freigelegte Schlammflur; 11.10.1999M. Mann [M. Mann s. n.]. – Wiener Becken, Steinfeld, 2,7 km SE Sollenau, Firmengelände; auf Klärschlamm; 19.9.1998 J. Walter [J. Walter 4174a g]. – **Salzburg:** *N von Stadt Salzburg, Deponie bei Siggerwiesen; Mülldeponie; 11.9.1990 W. Forstner [W 1991-2015]. – **Steiermark:** 2 km E Gleisdorf, an der Straße nach Fürstenfeld (B 65), W der Autobahnbrücke, bei Kote 410; Kompostwerk, auf Kompost; 21.8.1996 J. Walter [J. Walter 2982]. – **Wien:** *16. Bezirk, Odoakergasse zw. Wilhelminenstraße u. Seeböckgasse, Lebensmittelfiliale Hofer; Cotoneaster-, Berberis-Grünfläche; 14.10.2001 J. Walter [J. Walter 4251, *4244, *4246, *4247a, b, *4248a c, *4249b c, *4245a b, *4250] – 3. Bezirk, Botanischer Garten, Inst. f. Botanik d. Univ. Vienna (HBV), Rennweg 14; spontan in dem Kulturbeet; (from cultivated plants of

1993); 4.9.1995 J. Walter [J. Walter 4589, 4590, 4591]. – Ibidem; 12.7.1994 J. Walter [J. WALTER 3809]. – Ibidem; spontan auf Kompost; 17.8.1994 J. Walter [J. Walter 3808a b, 3786a c]. – Ibidem; 23.8.1994 J. Walter [J. Walter 3807, 3785]. – Ibidem; 12.7.1994 J. Walter [J. Walter 3787, 3810]. – 7. Bezirk, Neustiftgasse, knapp unterhalb Myrtengasse, direkt bei Busstation 48A (Neubaugasse); in gr. Beton Blumentrog vor Fenster; 2. 6. 2003 J. Walter [J. Walter 5316, 5317]. – Ibidem; 18.07.2002 J. Walter [J. Walter 4263, 4264, 4265, 4266, 4267, 4268].

Brazil: *Batria (=NW v. Salvador); in ruderatis; s. dat Salzmann? [W 1889-260205].

Germany: Niedersachsen: *Hamburg, am Reitersteig, bei der Wollkämmerei; auf dem planierten Teil der Mülldeponie; 1897 J. Schmidt [W s. n.].

Italy: Südtirol: *6 km ESE Bruneck (Brunico), unmittelbar W v. Nasen; Straßenrand, Misthaufen; 6.8.1994 A. Tribsch [J. Walter 2539]. – *Meran, Straße v. Vellau nach Tschars; Straßenrand; 23.7.1982 H. Vondrowsky [H. Vondrowsky 1606/82]. – **Umbrie:** *Lago Trasimeno, Isola Polvese, 7 km E Castiglione del Lago; lake shore, stoney; 13.9.2001 J. Walter (only seeds collected! [*J. Walter 4242, *4243, *4240, *4241; only seed collection: AMAR-075, *AMAR.076, *AMAR.081, *AMAR.082!].

Romania: *Oltenia, distr. Oltenia, prope pagum Orlea, loco Lacul Potelu, dicto; in arenosis locis; Amarantho Chenopodietum; s. dat D. & M. Cîrtu [WU Acq. 3240].

Surinam: *Paramaribo; in cultis; s. dat Wullschlägel [W 1889-140346].

***Amaranthus blitum/emarginatus* (transitional forms):**

Austria: Oberösterreich: *Strudengau, Sarmingstein, Bahnhof; Blumenrabatte; 260 m s.m.; 17.10.1999G. Kleesadl 2701 [LI 380317]. – *Linz-Stadt; 16.9.1964 s. coll. [LI 842951]. – **Tirol:** *Ahrental bei Innsbruck; Müllplatz, Mülldeponie; 19.9.1990 W. Forstner [W 1991-2019].

Tab. 3: Phytosociology of *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis* based on 17 relevés.

Relevé No.:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Surface (m^2):	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Species total:	15	10	11	12	15	4	7	7	6	6	8	9	3	5	4	6	6
Covering (%):	90	100	100	85	90	100	100	100	100	100	100	100	100	100	100	100	100
Bidentalia tripartiti:																	
Amaranthus blitum subsp. *emarginatus* var. *pseudogracilis*	+	r	+	r	r	3	4	3	1	1	1	3	4	2	4	2	4
Echinochloa crus-gallii	r	+	1	+	+		+	r		+	+	2	2	1	1	2	1
Atriplex prostrata	+		+	3	+				r			r					
Bidention tripartiti:																	
Xanthium saccharatum	3	5	5	1	1		+		r	+	+						
Bidens frondosa	2	2	1	3	4	4	4	3	1								
Persicaria lapathifolia subsp. *lap.*			1	1	1	1		1		1	1						
Persicaria hydropiper	+				r												
Rorippa amphibia	r					1	+	1	1								
Rorippa palustris	+							+									
Rumex maritimus	r				r							+					
Echinocystis lobata		1															
Chenopodion glauci:																	
Chenopodium rubrum							+	+	1	5	5	4	3	5	4	5	4
Chenopodium ficifolium (subsp. *ficifolium*)		+	+				+			r	r	r		+	r	+	+
Chenopodium glaucum											+						
Others:																	

Amaranthus powellii											r	r					
Amaranthus retroflexus		r	+	+	+							r					
Chenopodium album s. str.												r				r	+
Atriplex sagittata														+			
Cuscuta campestris																r	
Tripleurospermum inodorum				+	1												r
Artemisia vulgaris	+	r	r	+	1												
Calystegia sepia		1	+	+	+												
Urtica dioica	+			1	+												
Aster lanceolatus				+	1												
Plantago intermedia					r												
Solanum dulcamara		+	r														
Populus nigra (× *canadensis*?)	+																
Salix cf. *fragilis* /× *rubens* K!	2																
Gnaphalium uliginosum	r																
Lycopus europaeus	1																

Aufn. 1 = Marchegg, close to the old castle, old coarse, 20. 8. 1994.
Aufn. 2 - 5 = SE of Marchegg, riverbank of the March, 20. 8. 1994.
Aufn. 6 - 9 = Markthof at the confluence of the branch of the March an the rivulet Stempfelbach, riverbank, zonation, 20. 8. 1994.
Aufn. 10, 11 = Riverbank of the Danube at the confluence of March and Danube, 20. 8. 1994.
Aufn. 12 - 17 = Hohenau, sugar beet sludge ponds of the sugar mill, 15. 9. 1998.

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