CHARLES UNIVERSITY IN PRAGUE
FACULTY OF SCIENCE • DEPARTMENT OF BOTANY

A thesis submitted in partial fulfilment of the requirements
for the degree of Master of Science.

The *Juncus bufonius* polyploid complex in central Europe.

by

Frederick Rooks

1st September 2008

Supervisor: Doc. Jan Kirschner

Diplomová práce **Fredericka Rookse** byla obhájena na katedře botaniky PřF UK v Praze dne 23.9.2008 a ohodnocena klasifikačním stupněm **výborně**.

Diplomová práce
Polyploidní komplex *Juncus bufonius* ve střední Evropě

Charles University in Prague
Faculty of Science
Department of Botany
Benátská 2
Prague
Czechia
`http://botany.natur.cuni.cz`

For further information, please contact the author.
E-mail: `fredrooks@gmail.com`.

Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

Prague, 1st September 2008

Frederick Rooks

Abstract

CYTOMETRIC ploidy level screening was done in 120 populations of the *Juncus bufonius* group, mainly in central Europe. Two polyploid cytotypes, which are sometimes treated separately as *J. minutulus* and *J. bufonius* s. str., were detected and considered to be DNA tetraploids and hexaploids with 2C values of 1.18 ± 2.8% pg 2C DNA and 1.84 ± 1.6% pg 2C DNA, respectively. The correspondence between nuclear DNA content and the number of chromosomes was verified by chromosome counting, establishing that true polyploidy, as opposed to agmatoploidy, is behind the karyological variation. To asses the utility of supposedly diagnostic quantitative morphological characters, measurements of 6 floral and 3 vegetative quantitative characters (no less than 10 measurements per flower, 30 per plant) were obtained for 358 mature plants of known ploidy level from 49 localities. Principal component analysis did not show any separation of the ploidy levels. Canonical discriminant analysis indicated inner tepal length followed by mean capsule width and mean capsule length to be the most useful characters for identifying the ploidy levels; however, the estimated 10-fold cross-validation error rate of a simple k nearest neighbour classification analysis is 0.45. No novel distinction between the cytotypes was discovered. It is thus concluded that it is not possible to reliably tell apart *J. minutulus* and *J. bufonius* s. str. in both mixed or pure populations. Thus, *J. bufonius* in Europe is best treated as a variable species with two cytotypes that are almost inseparable using the quantitative morphological traits suggested by extant literature.

Key words: Juncus, bufonius, minutulus, taxonomy, cytometry, chromosomes, genome size, isozymes, discriminant analysis...

Abstrakt

BYL proveden cytometrický průzkum 120 populací skupiny *Juncus bufonius* převážně ve střední Evropě. Byly nalezeny dva polyploidní cytotypy, které jsou v literatuře někdy odlišovány jako *J. minutulus* a *J. bufonius* s. str., odpovídající tetra- a hexaploidnímu ploidnímu stupni s obsahem jaderné 2C DNA 1.18 ± 2.8% pg a 1.84 ± 1.6% pg. Bylo ověřeno, že obsah jaderné DNA odpovídá počtu chromosomů, takže karyologické rozdíly lze připsat pravé polyploidii a nikoli uvažované agmatoploidii. Za účelem ověření užitečnosti domnělých diagnostických znaků bylo měřeno 6 květních znaků a 3 vegetativní (ne méně než 10 měření na květ a 30 na rostlinu) u 358 rostlin se zralými tobolkami a známým ploidním stupněm ze 49 lokalit. Analýza hlavních komponent neukázala žádné oddělení mezi oběma ploidními stupni. Kanonická diskriminační analýza sice ukázala jako znaky nejužitečnější při určování délku vnitřních okvětních lístků a následně šířku a délku toboky, ale provedené klasifikační analýzy určily při cross-validaci chybně 45% jedinců. Žádná nová odlišnost, která by umožnila od sebe určit obě ploidie, nebyla nalezena. Závěr tedy zní, že není možné spolehlivě určit *J. minutulus* pomocí doposud publikovaných kvantitativních morfologických znaků jak ve smíšených tak čistých populacích. Předkládám hypotézu, že *J. bufonius* v Evropě je nejlépe hodnotit jako variabilní polyploidní druh se dvěma cytotypy, které od sebe téměř nelze morfologicky odlišit podle znaků uvedených v současné literatuře.

Klíčová slova: Juncus, bufonius, minutulus, taxonomie, cytometrie, isozymy, diskriminační analysa...

Acknowledgements

FIRST and foremost I would like to thank Jan Kirschner for his ideological leadership. My cordial thanks also go to Vlasta Jarolímová whom without I would be totally helpless at chromosome counting. I also wish to thank Pavel Trávníček, Tomáš Urfus, Petr Vít and Magdalena Kubešová for their assistance in the cytometric laboratory and Jan Suda and Lenka Záveská Drábková for their insights and valuable suggestions. I feel deeply indebted to Zita Červenková, Jan Štěpánek, Lucie Drhovská, Pavel Špryňar, Michal Ducháček, Tereza Klinerová, Jana Rauchová, Jarda Zahradníček, Hanka Chudáčková and others who have endowed me with some exciting plant material, Ivana Plačková, Eliška Záveská and Soňa Píšová who kindly did the isozyme work, and Daniel Chicouène, Karol Marhold, Jan Suda, Anežka Eliášová, Jiří Soják, Zdeňka Navrátilová, and Lubomír Hrouda for their valuable advice, recommendations and comments. I also feel obliged to thank all those anonymous drivers who kindly gave me a lift while hitching during field-trips. Last but not least, my thanks go developers of Free Software whose tools I used to complete this thesis.

Contents

List of Figures

List of Tables

1

Introduction

THIS thesis deals specifically with the two morphologically most similar species of the *Juncus bufonius* group: *J. minutulus* and *J. bufonius* s. str. Toad rushes are a group with a very broad distribution range (see subsection 1.2.1), a fascinating scientific history (see subsection 1.2.2), a peculiar reproductive strategy (see subsection 1.2.3), distinctive ecological requirements (see subsection 1.2.4) and one very special use (see subsection 1.2.5). To put the subject of this study into some biosystematic perspective, I present a short summary of the taxonomic treatment of the *Juncaceae*.

1.1 Biosystematics of the *Juncaceae* Juss. and *Juncus* L.

The family *Juncaceae* Jussieu, nom. cons. is one of the world's most widely distributed families of vascular plants. It is probably paraphyletic (see Drábková *et al.*, 2006, 2003, 2004). The APG website lists the following six genera within the family: *Distichia* Nees & Meyen, *Juncus* L., *Luzula* DC., *Marsippospermum* Desv., *Rostkovia* Desv. and *Oxychloe* Phil., of which *Juncus* and *Luzula* are distributed widely, while the remaining genera are confined to South America and New Zealand.

The age of stem-group *Juncaceae* has been estimated to be *ca* 88 million years before present, and the divergence of the crown group *ca* 74 million years before present (Bremer and Janssen, 2006).

Based on results of superimposing nuclear genome size data on a parsimonious molecular cladogram in Leitch *et al.* (2005), the commelinid clade is mainly composed of very small-genome clades ($\leq$ 1.4 pg 1C DNA), which include the *Juncaceae*, accompanied by two small-genome clades

($> 1.4, \leq 3.5$ pg 1C DNA), the *Arecaceae* and *Poaceae*, and the *Commelinaceae*, which is a clade of intermediate genome sizes ($< 3.5, \leq 14.0$ pg 1C DNA).

Juncus L. is a cosmopolitan genus of *ca* 315 species in two subgenera (*Juncus* and *Agathryon* Raf.) divided into 12 sections (Kirschner, 2002*c*). In a molecular phylogenetic analysis based on rbcL sequences (Drábková *et al.*, 2006), *J. bufonius* (ploidy level unknown) clustered within a well supported clade together with members of sect. *Juncotypus (e. g., J. effusus)* and sect. *Steirochloa (e. g., J. compressus*; see Figure 1.1).

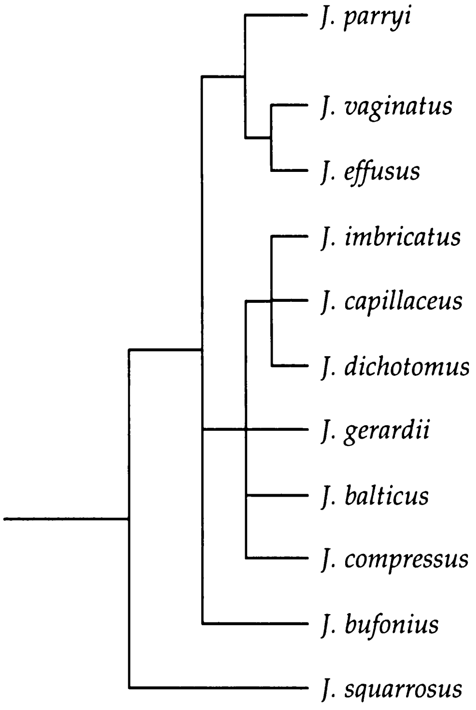

Figure 1.1: Phylogeny of subgenus *Agathryon* taken from the strict consensus tree of the entire *Juncaceae* based on rbcL data (Drábková *et al.*, 2006).

According to Kirschner (2002*c*), the basic chromosome number in the genus is possibly $1n = 10$ while saying that there are many other, secondary basic numbers, 'ranging from $1n = 9$ to $1n = 25$ at least'. Aneuploidy is obviously not uncommon, and paleopolyploidy surely plays its part. (Löve and Löve, 1961) gives the basic chromosome number of

$1n = 5$, but the lowest chromosome number of a member of the *Juncaceae* published so far is $2n = 18$, and reliable chromosome counts are still missing for some less widely distributed genera.

1.2 The *Juncus bufonius* polyploid complex

The polyploid complex of *J. bufonius* belongs to the section *Tenageia* Dumort. of the subgenus *Agathryon* Raf. of the genus *Juncus* L. It comprises at least six species that are currently accepted (in alphabetic order): *J. bufonius* L. s. str., *J. hybridus* Brot., *J. minutulus* (Albert *et* Jahand.) Prain, *J. ranarius* Songeon *et* Perrier, *J. sorrentini* Parl. and *J. turkestanicus* Krecz. *et* Gontsch. (Kirschner, 2002*d*).

In central Europe, only three species *(i. e., J. minutulus, J. ranarius* and *J. bufonius* s. str.) are present (Kirschner, 2002*a*), which, according to two groups of authors (Mičieta and Mucina, 1983; van Loenhoud and Sterk, 1976) represent three ploidy levels that can be more or less easily identified morphologically: (1) *J. ranarius*, a diploid with $2n = 34$ chromosomes; (2) *J. minutulus*, a tetraploid with $2n = ca\ 72$ chromosomes; and (3) *J. bufonius* s. str., a hexaploid (according to Cope and Stace, 1985) with $2n = ca\ 108$ chromosomes.

In this thesis I follow the taxonomic classification of Kirschner (2002*d*). It needs to be pointed out that, unless noted otherwise, by '*J. minutulus*' I refer to the name *J. minutulus* (Albert *et* Jahand.) Prain., that is, a taxon described by Albert and Jahandiez (1908) and brought up to the species rank by *et* al Prain (1921).

I use the term '*J. bufonius* aggregate' (or 'group') in the same sense as Cope and Stace (1985; *i. e.*, a group of morphologically similar annual rushes from the kinship of *J. bufonius* L.), but I opted for a slightly different terminology for the taxonomic structure of the group—one that is more compatible with the treatment of Kirschner (2002*d*) as well as the ideas of, for example, Mičieta and Mucina (1983); Snogerup (1985); van Loenhoud and Sterk (1976). Compared to the terminology of Cope and Stace (1985), mine is shifted one step higher. In other words, *J. bufonius* s. l. in my concept is equal to *J. bufonius* s. str. in the sense of Cope and Stace (1985). *J. bufonius* s. str. in the meaning of Cope and Stace (1985) with *J. minutulus* (Albert *et* Jahand.) Prain *(i. e.,* tetraploids) excluded is analogous to *J. bufonius* s. str. as understood herein (see Table 1.1).

Table 1.1: Nomenclatural conventions

Convention	Explanation
J. bufonius sensu lato (s. l.)	*J. bufonius* group excluding diploids *(e. g., J. ranarius)* but including tetraploids *(i. e., J. minutulus)*
J. bufonius sensu stricto (s. str.)	*J. bufonius* s. l. excluding *J. minutulus*

1.2.1 Distribution

The centre of diversity of *Juncus* subgen. *Agathryon* lies in the western Mediterranean. *J. bufonius* s. str. and *J. minutulus* are the two most widely distributed species of the group, occurring almost throughout the world. Their current distribution range owes much to human activity (Kirschner, 2002*d*; Snogerup, 1980).

1.2.2 Taxonomic history

The entire *J. bufonius* group is highly variable in overall appearance and both quantitative and, to a lesser extent, qualitative traits. This has led authors to regard it as taxonomically complex. As in other groups labelled 'taxonomically complex', there are authors who favour distinguishing narrowly defined species (*e. g.,* Holub, 1976; Mičieta, 1980; van Loenhoud and Sterk, 1976) and those inclined more towards accepting a wider delimitation of species (*e. g.,* Cope and Stace, 1973; Foerster, 1969; Novikov, 1978; Stasiak, 1978*b*). Let me summarize the history of scientific interest in the group as it unfolded.

Linnaeus gave *J. bufonius* L. its name in Species Plantarum 328 (1753). A century later in 1858 the name *J. bufonius* L. var. *parvulus* Hartm. got published (Hartman, 1858). This was probably the first attempt to describe a species related to *J. bufonius* L.' that differs in being minute, but no type locality is indicated (Kirschner, 2002*d*). Today the name is a synonym of *J. minutulus* (Albert *et* Jahand.) Prain (Kirschner, 2002*d*), though according to Holub (1976) this name was published validly.

In 1908 Albert and Jahandiez described a new taxon from the south of

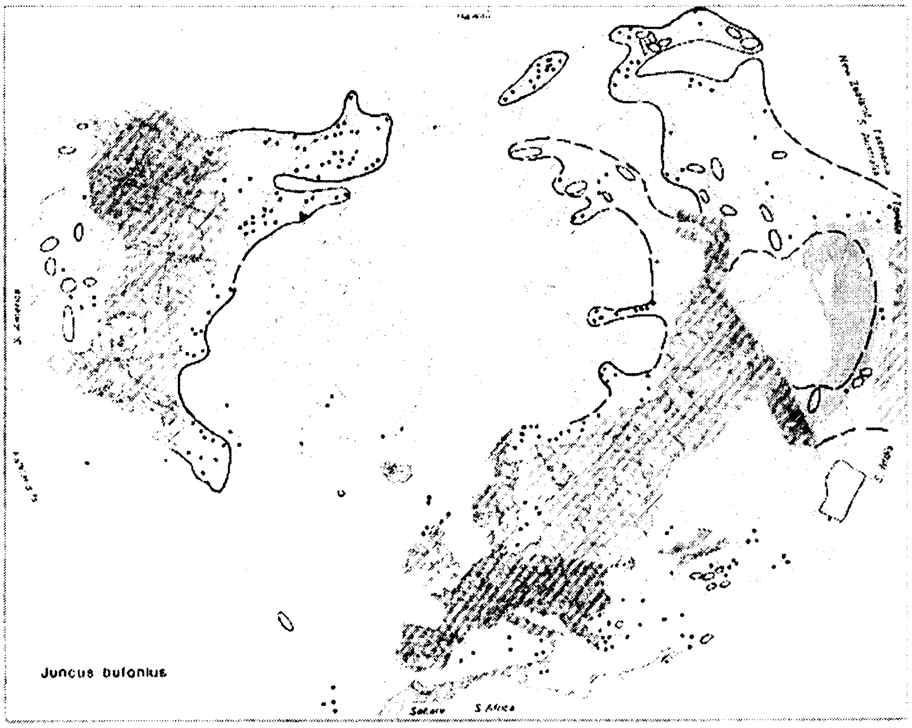

Figure 1.2: Distribution of *Juncus bufonius* s. l. in the Northern hemisphere. Reproduced from Hultén (1971) and converted to monochrome.

France, which is similar to *J. bufonius* L. but has smaller features: *J.* f.[1] *minutulus* Albert *et* Jahandiez. The combination *J. minutulus* Albert *et* Jahand. was first used at the species rank by *et* al Prain (1921), though, which has been pointed out by Holub (1976). In the same year, the name *J. minutus* Litard was also published (validly, according to Holub, 1976).

To my knowledge, the first chromosome count of a plant from the *J. bufonius* group ($2n = ca\ 60$) published in Wulff (1937; for list of chromosome counts published see Table 1.3).

Apparently unaware of the existence of a previous use of the epithet, Kreczetovich and Gontscharov (1935) also described a species similar to *J. bufonius* L. but smaller from Russia, part. this time with a much narrower circumscription. This extraordinary coincidence has been a source of confusion ever since (see below). They state that their *J. minutulus* differs from *J. bufonius* in having smaller dimensions, a uniflorous inflorescence and smaller flowers (see Table 1.4). The original designation of the type says that the type specimen bears the name '*J. bufonio* f. *dimera*', which suggests that the plant has dimerous flowers.

Segal (1962*a,b*) expressed doubts that *J. ranarius* and *J. bufonius* belong to the same polyploid complex, stating that 'Their morphological similarity is a case of convergence rather than divergence.' He bases this claim on chromosome counts of $2n = 30$ or 32 and $2n = 80$ for *J. ranarius* and *J. bufonius*, respectively.

In 1969 *et* al Hitchcock reported minute plants of the *J. bufonius* group with short anthers and cleistogamous flowers from North America.

Snogerup (1971) included the species *J. minutulus* Albert *et* Jahand. as described by Albert and Jahandiez (1908) in the Flora Iranica and cites *J. minutulus* Krecz. *et* Gontsch. as a synonym. Flora Iranica is often cited as the source of the first reliable chromosome count of *J. minutulus* (*e. g.*, Holub, 1976; see also Table 1.3). Snogerup (1971) also used stomatal length to predict the chromosome count of *J. turkestanicus*, which eventually proved successful.

Cherepanov (1973) saw *J. minutulus* Albert *et* Jahand. and *J. minutulus* Krecz. *et* Gontsch. as different taxa, but he remains the only author who holds this view.

In a short article informing about the occurrence of *J. minutulus* in Czechoslovakia, Holub (1976) maintains that it is possible to differen-

---

[1] Also referred to as 'proles'.

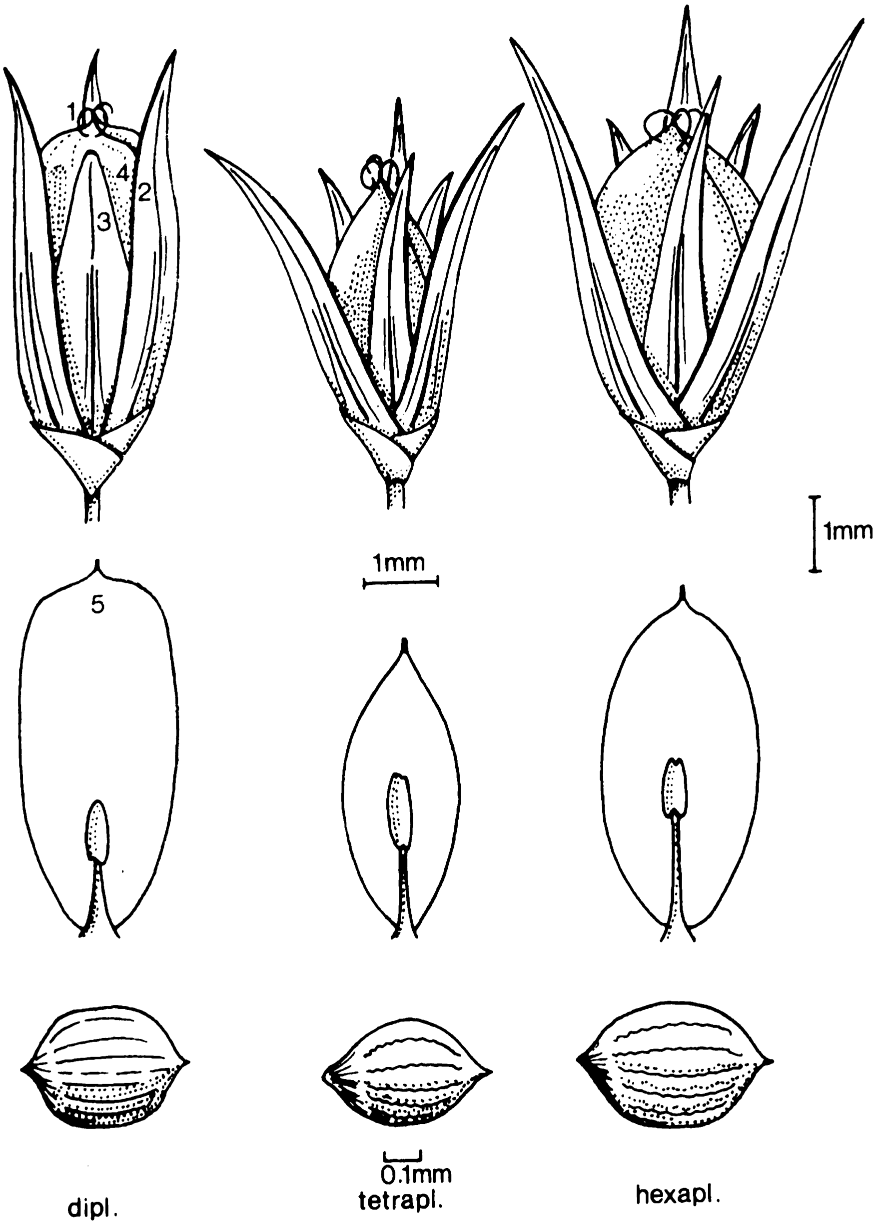

Figure 1.3: Reproduced from van Loenhoud and Sterk (1976): Morphology of flowers, fruit valves with stamens and seeds of diploid *(J. ranarius)*, tetraploid *(J. minutulus)* and hexaploid *(J. bufonius)* plants'. (1) stigma; (2) outer tepals; (3) inner tepals; (4) capsule; and (5) fruit valve.

tiate between individuals of *J. minutulus* and *J. bufonius* s. str. when they grow sympatrically or even when they form mixed clumps, claiming that the two species can be reliably told apart by measuring quantitative traits. Holub (1976) claims that the smaller size of some flowering and fruiting organs, by which *J. minutulus* supposedly differs from *J. bufonius*, 'seems completely constant' and that the two species can be distinguished relatively easily with a certain amount of experience. I have taken this as a hypothesis and made an attempt to test it (see section 1.3).

Holub (1976) specifically speaks of three morphotypes of *J. minutulus* of the many which he thinks are probably induced ecologically. One concerns clumped plants with erect or ascending stems bearing three or more 3.5–4.5 mm long flowers and 3 mm long capsules containing 0.4 mm long seeds. The second morphotype, which according to Holub is caused by seeds germinating at high densities and partly a deficit of light, comprises pale-green single-stemmed plants with erect, usually unbranched straight, slender stems 2–7 cm in length that bear 1–4 remote flowers. The third, 'rare', morphotype Holub had seen consists of plant only 1–3 cm high, usually unbranched, with one to three 2.5–3.5 mm long flowers bearing 2–2.5 mm long capsules contaning *ca* 0.3 mm long seeds. This last morphotype Holub considers to conform with the description of *J. minutulus* by Kreczetovich and Gontscharov (1935), which he considers to fall within the circumscription of *J. minutulus* Albert *et* Jahand. Holub (1976) opines that if *J. minutulus* is found to be conspecific with the North-American taxon named *J. congdonii* Watson, Proceed. Amer. Acad. 22: 48, 1887 (n. v.), which is a species with short stems, three stamens, clustered flowers and smoother seeds, the name *J. congdonii* would have to be used due to priority.

Dutch authors van Loenhoud and Sterk (1976) found three discrete ploidy levels, which they call 'cytodemes', within the *J. bufonius* group in the Netherlands: (1) $2n = 27$–37; (2) $2n = 58$–78; and (3) $2n = 81$–115. They confirmed reports of previous authors that obtaining chromosome counts in this group is very difficult because of the small size of the chromosomes and their sheer number. Moreover, they state that it is nearly impossible to ascertain the number of chromosomes with absolute precision. To compare the three ploidy levels, they sampled two flowers from a comparable part of the inflorescence of ten plants per ploidy level *(i. e.,* altogether sixty flowers of thirty plants of three ploidy levels). They then used a series of Wilcoxon tests to assess the differences among the three groups and used their results to determine a set of supposedly differentiating characters (see Figure 1.3 and Table 1.4). They then used these characters to identify 584 sheets of the *J. bufonius* group in order to ascertain the geographic distribution and ecological preferences of the three cytotypes.

Merely mentioning the existence of the name *J. minutulus*, Novikov (1978) cites Holub (1976) but dismisses the justification for accepting *J. minutulus* (and also '*J. erythropodus*') as species. He indicates that these what he calls 'minute taxa' are caused by soil conditions.

Stasiak (1978*b*) investigated in detail the morphology of *J. bufonius* and *J. ranarius*[2] in Poland using biometric methods described in Stasiak (1978*a*). She sampled 50 or 30 individuals from 21 localities in Poland and collected data on 22 characters. Interestingly, although she cites Novikov (1978), Stasiak (1978*b*) does not cite van Loenhoud and Sterk (1976) nor Holub (1976). She cites the name *J. minutulus* as described by Kreczetovich and Gontscharov (1935) without mentioning that there is an earlier homonym [*J. minutulus* (Albert *et Jahand.*) Prain], which is the valid name, as pointed out by Holub (1976). Her conclusion is that the average number of flowers clustered together, the ratio of the length of inner tepals to the length of the capsule and the 'the vertical angle of the inner tepals' are statistically significant ('on the 99.9% and 99.0% levels') for discrimination between *J. bufonius* and *J. ranarius*. Regarding *J. minutulus (i. e., J. minutulus* Krecz. *et* Gontsch.), she completely rejects this taxon, saying that this form is entirely conditioned by the soil properties and that both *J. bufonius* and *J. ranarius* produce such phenotypes. She does not address the karyologic difference between *J. minutulus* and both these species, considering *J. minutulus* to be based merely on habitual traits. This has been later criticised by Mičieta and Mucina (1983; see below). Stasiak recommends accepting the following taxa within the *J. bufonius* complex: (1) '*J. bufonius* var. *bufonius*'; (2) '*J. bufonius* var. *mutabilis* A. *et* G. (= *J. nasthanthus* Krecz. *et* Gontsch.)'; and '*J. ambiguus* Guss.' (= *J. ranarius* Song. *et* Perrier)'. To the variety *J. bufonius* var. *mutabilis* A. *et* G. she ascribes plants with flowers in groups of two, three or five. A drawing in Schubert *et al.* (1987; see Figure 1.2.2) depicts a plant with clustered flowers under the name 'var. *mutabilis* Savi (var. *fasciculatus* Koch)'. Note the inconsistency in the authorship; for details, see below.

Cope and Stace (1983) studied the *J. bufonius* complex biometrically and

---

[2] 'Using the name *J. ambiguus*' *Guss.*

also conducted some germination and growth experiments. They support the recognition of five species in the group, four of which are diploid (*J. foliosus, J. ranarius, J. hybridus* and *J. sorrentini),* the fifth comprising all polyploid derivatives *(i. e., J. minutulus* and *J. bufonius* s. str.). Cope and Stace hold the view that, while the diploid species are readily identifiable, polyploids represent either '. . . a single, highly polymorphic species' or 'several taxa whose distinctions are partially obscured by intermediates'. Cope and Stace (1983) acknowledge that Snogerup (1971, 1980); van Loenhoud and Sterk (1976) accept *J. minutulus* on account of cytological and supposed morphological differences, but claim that these differences are 'far from clear, at least at the level of the individual'. The authors also suggest that the variation in polyploids, great as it is, is even higher in areas where they co-occur with diploids.

Cope and Stace (1983) did not consider absolute seed size to be of 'much taxonomic importance' with the sole exception of *J. foliosus*, which, they reckon, has marginally but constantly larger seeds than the other species. They did, however, report distinct values of the mean seed length/breadth ratio for the five species they accept. Regarding leaf anatomy, the authors found no significant difference among the taxa, besides a proportionate relationship between leaf width and the number of vascular strands and air canals.

Mičieta and Mucina (1983) criticised Stasiak (1978*b*) for dismissing *J. minutulus* as a taxon without considering karyological data and basing her claim that plants ascribed to this species are in fact mere 'rachitic' forms on a single sample. They also directed some criticism towards Cope and Stace (1983) for not accepting *J. minutulus* as a species, saying that Cope and Stace base their assertions on an erroneous understanding of the species' description. Mičieta and Mucina (1983) carried out their own numerical taxonomic study of 34 Slovak populations (15–25 specimens from each) of the *J. bufonius* complex, measuring 11 characters (50 measurements per character) and performed principal components analysis, reciprocal averaging, single linkage clustering, average linking clustering, McQuitty's similarity analysis, Ward's method, Lance-Williams beta-flexible method, one-way ANOVA and F-tests. They concluded, in agreement with van Loenhoud and Sterk (1976), that the following characters are statistically significant for the separation of *J. ranarius* ($2n = 34$), *J. minutulus* ($2n =$ *ca* 72) and *J. bufonius* (diploid*ca* 100–110): length of capsules, length of seeds, length of inner tepals, length of anthers and the anther to filament length ratio. All clustering techniques they used, with the sole exception of single linkage clustering, always separated *J. minutulus* in their data well. But this was still not enough to persuade authors such as (Cope and Stace, 1973, 1983, 1985; Ertter, 2000) to accept *J. minutulus* as a species (see below).

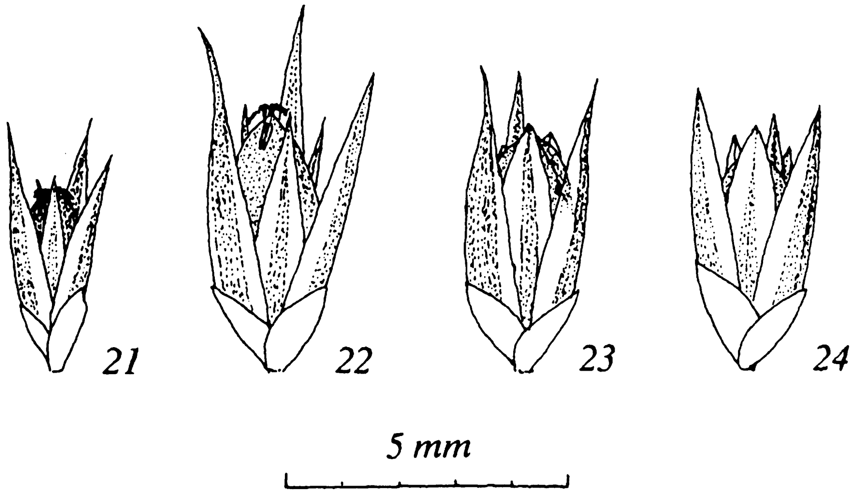

Figure 1.4: Fruit-bearing flowers of the *Juncus bufonius* complex as portrayed in Flora Iranica (Snogerup, 1985), (21) *Juncus minutulus*; (22) *J. bufonius*; (23) *J. hybridus*; and (24) *J. turkestanicus*. Only the species of interest were cut from the original figure with their original numbering, and the scale was moved.

Snogerup (1985) accepts the species *J. minutulus* Krecz. *et* Gontsch. in the Flora of Turkey and not *J. minutulus* Albert *et* Jahand., as in Snogerup (1971). He also states that among the records of the occurrence of *J. bufonius* that he cites, some 'probably include forms resulting from hybridisation with *J. minutulus* and *J. turkestanicus*'. He also says about *J. bufonius* that it is 'very variable' and that 'even cytologically or morphologically abnormal specimens are usually quite seed fertile'. A drawing of capsules within flowers in Snogerup (1985) illustrates Snogerup's understanding of the complex (see Figure 1.4). For example, the capsule of *J. minutulus* is depicted as the smallest, and also both its inner and outer tepals are the shortest.

The only nuclear DNA content value published so far is that of 2.60 pg

Table 1.2: Accessions of *J. minutulus* and *J. bufonius s. str.* in sympatry (Mičieta and Mucina, 1983)

No.	Locality	Date	Chromosome count
3.	Záhorská nížina Lowland Šajdíkove Humence, a sand pit	31/07/1978	2n = *ca* 72
4.	Záhorská nížina Lowland Šajdíkove Humence, a sand pit	11/09/1979	2n = *ca* 72
5.	Cultivated material from locality no. 3		2n = *ca* 72
6.	Záhorská nížina Lowland Šajdíkove Humence, a sand pit	7/09/1978	2n = 100–110
7.	Záhorská nížina Lowland Šajdíkove Humence, a sand pit	11/09/1979	2n = 100–110
8.	Cultivated material from locality no. 6		2n = 100–110
9.	Oravská kotlina basin, Oravská priehrada, Slanický ostrov	28/07/1977	2n = *ca* 72
10.	Oravská kotlina basin, Oravská priehrada, Slanický ostrov	28/07/1977	2n = 100–110
11.	Oravská kotlina basin, Suchá hora, along a road to the peat bog	27/06/1974	2n = *ca* 72
12.	Oravská kotlina basin, Suchá hora, along a road to the peat bog	27/06/1974	2n = 100–110
22.	Bukovské vrchy mountains, Ruský Kazimír	11/08/1974	2n = *ca* 72
23.	Bukovské vrchy mountains, Ulič-Krivé, locality Zboj, at the alluvium of the Ulička brook	20/06/1971	2n = *ca* 72
24.	Malé Karpaty mountains, Jahodník near Smolenice	21/06/1978	2n = *ca* 72

2C DNA for *J. bufonius* (ploidy level not indicated) which was determined by Feulgen staining (citing Band, 1984 pers. comm. Leitch *et al.*, 2005).

In their study focused on the cytology of the *J. bufonius* group, Cope and Stace (1985) counted chromosomes of the five species recognized in their previous study (Cope and Stace, 1983). They did not reveal any within-species variation in chromosome numbers and the only polyploid chromosome number they report is $2n = 108$ (in fact $1n = 54$). Cope and Stace (1985) describe in detail their method of obtaining chromosome counts and how difficult a task it presents. They attribute the problems posed by this material to the nature of the chromosomes themselves, which they describe as 'poorly resolved circular bodies averaging 0.5–0.8 µm'. Their hybridization experiments yielded only 26 tentatively hybrid seeds out of 490 cases of cross-pollination. *J. ranarius* was the maternal plant in every case, and *J. bufonius* ($2n = 108$), *J. foliosus* and *J. hybridus* were the successful pollen donors. No more than two of the 26 seeds germinated, both results of a cross between *J. ranarius* and *J. foliosus*. Morphologically they were intermediate between the parents in some traits and 'quite different' in others. What is remarkable is that they were very similar to *J. bufonius* s. str., only highly sterile. The expected chromosome count of $2n = 30$ was verified in the hybrid plants. Cope and Stace (1985) theorize that polyploids within the *J. bufonius* complex have therefore possibly arisen by hybridization of diploids, allotetraploidization, and subsequent backcrossing with diploids and tetraploids, which produced hexaploids, possibly in a polytopic manner, a process which may be still continuing. *J. minutulus* might therefore be the result of such hybridization of two diploid species followed by tetraploidization. The authors view the *J. bufonius* aggregate as an example of 'pillar complex' as conceived by Babock and Stebbins (1938; see below).

Cope and Stace (1985) discuss the basic chromosome number for the group. They propose that each taxonomic group in the genus *Juncus* be considered separately due to aneuploidy and the distinct chromosomal evolution within individual subgenera of the genus. Hence, species of the *J. bufonius* complex with chromosome numbers of $2n = 26$ and $2n = 34$ are considered to be diploid or near-diploid. Cope and Stace (1985) talk of considerable aneuploidy at each ploidy level within the aggregate, though they admit that the precise extent of aneuploidy cannot be ascertained because of the challenges posed by the extremely small and numerous chromosomes. They also discuss the possibility of agmatoploidy in the group, such as there is in the genus *Luzula* (see section 1.1), Cope and Stace (1985) state that their chromosome counts and measurements are not accurate enough to answer this question and call for estimations of nuclear DNA content.

Cope and Stace (1985) studied stomatal length in the *J. bufonius* polyploid complex and concluded that there are three groups of species with different levels of mean stomatal length: (1) *J. bufonius* s. l.[3] together with *J. foliosus*—mean stomatal length 38 µm; (2) *J. ranarius* and *J. hybridus*—30 and 32 µm, respectively; and (3) *J. sorrentini*—29–42 µm, 35 µm overall mean. *J. bufonius* s. l. and *J. foliosus* are considered to be mesophytic species, whereas *J. hybridus, J. sorrentini* and *J. ranarius* can be regarded as xerophytes because they either grow in dry places or are subjected to physiological drought, being halophilous (Cope and Stace, 1985). Stomatal length therefore seems to correlate more with ecological specialization than with the level of ploidy. Earlier, Cope and Stace (1983) reported that the values of this character for the most part responded to controlled conditions of their growth experiments.

One particularly interesting figure can be found in Schubert *et al.* (1987; Fig 38) which depicts eight different morphological types of *J. bufonius* (see Figure 1.2.2).

Figure 1.5: Figure (on the next page) reproduced from Schubert *et al.* (1987). (1) The typical form of moist overgrown places; (2) open spaces; and (3) drying habitats; (4) a dwarf form var. *parvulus* Hartm.' *(i. e, J. minutulus)*; (5) 'var. *capillaris* Rchb.', a very slender form of shady places; (6) 'var. *grandiflorus* Schult.' with long pointed tepals; (7) 'var. *mutabilis* Savi (var. *fasciculatus* Koch)' with clustered flowers; (8) 'var. *viviparus*; (9) unequally long tepals; (10) tepals of nearly equal length; and a ripe capsule (11) with seeds (12).

---

[3] *J. bufonius* s. str. in their concept

Fig. 57. *Juncus bufonius.*

1. Typische Form an feuchten, bewachsenen Orten; 2. an offenen Stellen; 3. an trocknen Stellen; 4. Zwergform var. parvulus Hartm.; 5. sehr zierliche Form schattiger Orte (var. capillaris Rchb.); 6. var. grandiflorus Schult. mit lang zugespitzten Perigonblättern; 7. var. mutabilis (Savi; var. fasciculatus Koch) mit gedrängten Blüten; 8. var. viviparus A. u. G. mit in Laubsprosse auswachsenden, z. T. nur halb vergrünten Blüten; 9. Blüten mit ungleich langen, 10. mit fast gleichlangen Perigonblättern; 11. reife Kapsel; 12. Samen. 1—8 nat. Gr., 9—12 vergr. (1—3, 9, 11, 12 nach Reichenbach, das übrige Original.)

Caption on previous page.

In his textbook Stace (1992) quotes the *J. bufonius* group as an example of a so-called polyploid pillar complex in which a series of distinct diploid species have hybridized and produced tetraploid, hexaploid or even higher levels of ploidy, making it difficult to recognize distinct taxa among the polyploids. This is a paraphrase of the theory published in 1985.

J. minutulus is a species that is not accepted in many recent floras (*e. g.*, Sell and Murrell, 2006; Stace and Thompson, 1997). The New Flora of the British Isles (Stace and Thompson, 1997), strangely, does not even mention a tetraploid chromosome count although it lists *J. minutulus* Krecz. *et* Gontsch. as a synonym of *J. bufonius*, giving a single chromosome count of $2n = 108$. The Flora of Great Britain and Ireland (Sell and Murrell, 2006) does list chromosome counts ranging from $2n = 54$ to 110, though.

Kirschner (2002*d*) mentions two hybrid combinations: (1) *J. bufonius* × *J. ranarius* supposedly known from Norway; and (2) *J. bufonius* × *J. minutulus*, possibly identified from Siberia '[Irkutsk, V. Vašák (PR)]' and reportedly in 'local hybrid swarms' in Sweden' (Snogerup, unpubl.).

Kirschner lists the name *J. congdonii* Watson in the synonymy of *J. hybridus*, but according to him, the holotype of the name 'may represent an extreme form of *J. sorrentini*.' The isotype (in LD) of *J. nastanthus* Krecz. *et* Gontsch. is, according to Kirschner (2002*d*), ascribable to *J. ranarius* and the name, which is widely used in Russian literature, has probably been mistakenly used in part also for *J. turkestanicus* and *J. hybridus*.

Kirschner (2002*d*) suggests that agmatoploidy may have played an important role in the evolution of this group, as, for example, in the genus *Luzula*. If indeed the variation in chromosome counts—relied upon by all previous authors as the main argument for the separation of *J. mintulus*, among others—does not reflect shifts in nuclear DNA content *(i. e.*, true polyploidy) but mere fissions or fusions of holokinetic chromosomes *(i. e.*, agmatoploidy), then flow cytometry would most probably be completely useless in distinguishing among individuals with differing chromosome counts. On the contrary, if the chromosomal variation is a product of true polyploidization (as hypothesized, for example, by Cope and Stace, 1985), flow cytometry could serve as a high-throughput tool for rapid and reliable identification of cytotypes.

Harmaja (2003) has created a very interesting web page about his observations of *J. bufonius* s. l. in Finland. He discusses the supposed differences between *J. minutulus* and *J. bufonius* and proposes a few additional distinctions (see Table 1.4).

Table 1.3: Chromosome counts reported for *J. bufonius* s. l. (*i. e.*, polyploids). To set aside diploids, only counts of 40 and more are listed.

Chromosome count	Reference
$2n = ca\ 54$	Hämet-Ahti and Virrankoski (1970)
$2n = ca\ 60$	Delay (1947*a*), Delay (1947*b*), Rohweder (1937), Wulff (1937), Podlech and Dieterle (1937)
$2n = ca\ 70$	van Loenhoud and Sterk (1976)
$2n = 72$	Snogerup (1971)
$2n = 80$	Jørgenson *et al.* (1958), Segal (1962*a*), Segal (1962*b*), Uhriková (1974)
$2n = 100$–110	Snogerup (1971); van Loenhoud and Sterk (1976)
$2n = 104$–106	Snogerup (1959)
$2n = 106$	Löve (1980), Löve (1981); Weimarck (1963)
$2n = ca\ 108$	Harriman and Redmond (1976)
$2n = 108$	Cope and Stace (1978)
$2n = ca\ 108$–120	Wulff (1937)
$2n = ca\ 120$	Löve and Löve (1948)

Table 1.4: Morphological differences between *Juncus minutulus* and *J. bufonius* s. str. reported in the literature.

Character	*J. minutulus*	*J. bufonius* s. str.	Reference
Mode of pollination	cleistogamy	chasmogamy and cleistogamy	Kirschner (2002*d*)
	usually cleistogamy	cleistogamy or chasmogamy	Snogerup (1985)
	cleistogamy	chasmogamy and cleistogamy	Snogerup (1971)
Plant height	3–15(–25) cm	1–5(–50)	Snogerup (1985)
	0.8–5 cm	10–50 cm	Kreczetovich and Gontscharov (1935)
	< 10 cm	—	Chicouène (1996)
Capsule length	2.5–3.0 mm	3.5–5.0 mm	Kirschner (2002*d*)
	2.5–3.0 mm	(3.0–)3.5–5.0 mm	Snogerup (1971, 1985)
	2.5–3.0 mm	3.0–4.0 mm	van Loenhoud and Sterk (1976)
	2.2–3.2 mm	3.5–4.5 mm	Harmaja (2003)
	1.5–2.5 mm	4–4.5 mm	Kreczetovich and Gontscharov (1935)
	2–3 mm	—	Chicouène (1996)
Tepal to capsule length ratio	slightly longer	clearly longer	Harmaja (2003)

Table 1.4: (continued)

Character	*J. minutulus*	*J. bufonius* s. str.	Reference
Capsule shape	obtuse	ovoid to almost ellipsoid	Snogerup (1985)
Outer tepal length	4.0–6.5 mm	(4.5–)6.0–8.0 mm	Snogerup (1971)
	2.5–4.5 mm	4.5–6.5 mm	Harmaja (2003)
	2.5–3.5 mm	6.5–7.5 mm	Kreczetovich and Gontscharov (1935)
Inner tepal length	3.0–4.5 mm	4.5–6.5 mm	Snogerup (1971)
	2–3 mm	5–6 mm	Kreczetovich and Gontscharov (1935)
Number of stamens	2 or 3, rarely 6	6, rarely 3	Kirschner (2002*d*)
	3 or 6	6	Snogerup (1985)
	generally 3	6	Chicouène (1996)
Stamen length	1–1.2 mm	2 mm	Kreczetovich and Gontscharov (1935)
Stamem to tepal length ratio	1/3–1/2	1/3–1/2	Snogerup (1971)
Anther length	0.2–0.6	0.5–1.0 mm	Snogerup (1985)
	0.2–0.6	0.5–1.0 mm or more	Chicouène (1996)

Table 1.4: (continued)

Character	*J. minutulus*	*J. bufonius* s. str.	Reference
Anther to filament length ratio	1/4–1/3	1/3–1	Snogerup (1985)
	1/4–1/3	2/5	Chicouène (1996)
Style length	0.1–0.4 mm	0.4–0.5 mm	Kirschner (2002*d*)
	0.1–0.4 mm	*ca* 0.5 mm	Snogerup (1971)
Stigma length	1–1.5 mm	*ca* 1 mm	Snogerup (1971)
Stigma shape	recurved divergent or almost contorted	±patent deflected	Kirschner (2002*d*)
Seed length	0.3–0.45 mm	0.4–0.55 mm	Kirschner (2002*a*)
	0.36–0.42 mm	0.41–0.49 mm	van Loenhoud and Sterk (1976)
	0.35–0.40(–0.50) mm	0.40–0.55 mm	Snogerup (1971)
	0,3–0,4(–0,5) mm	—	Chicouène (1996)
Seed width	0.23–0.27 mm	0.24–0.30 mm	van Loenhoud and Sterk (1976)
Seed shape	ovoid to ellipsoid	ellipsoid, sometimes suboblique	Snogerup (1971)
	ovate, with 0.3 mm long dark mucro	0.3 ovate-elliptical	Kreczetovich and Gontscharov (1935)

Table 1.4: (continued)

Character	*J. minutulus*	*J. bufonius* s. str.	Reference
Overall colour of plant	paler, partly yellowish green	fairly dark greyish green	Harmaja (2003)
Colour of mature capsule	pale to dark red (at apex, at least)	green or pale brown	Harmaja (2003)
Colour of mature capsule	mostly present	mostly absent	Harmaja (2003)
Leaf width	< 1 mm	0.5–2 mm	Snogerup (1985)
Leaf shape	short, usually subterate	flat, but margins often convolute	Snogerup (1985)
Bract length	< 1 mm	< 2.5 mm	Kreczetovich and Gontscharov (1935)
Stem	very thin, with usually only 1 small leaf below inflorescence	—	Snogerup (1985)
Maturation of plants (capsules)	fast	slow	Harmaja (2003)

Table 1.4: (continued)

Character	*J. minutulus*	*J. bufonius* s. str.	Reference
Inflorescence	short, pauciflorous (2 or 4 flowers)	—	Chicouène (1996)

1.2.3 Reproduction

J. bufonius had received considerable attention in literature around 1871 after Batalin (1871) published his account of observing the selfing behaviour of *J. bufonius* in Russia (see subsection 1.2.3), arousing reactions from German botanists, whose observations were somewhat different.

Batalin describes the floral morphology of *J. bufonius* in detail, stating that Russian plants usually have three stamens behind outer tepals, although some plants may have 'six to five' stamens, three of which are behind inner tepals, giving a reference to Buchenau (1870), who also writes about this 'deviation'. Ascherson (1871) reacts to Batalin's article in the same journal shortly after. He confirms Batalin's observations of cleistogamous fertilization to be correct but adds that triandrous and cleistogamous flowers were mostly on terminal branches of the inflorescence. Unlike Batalin, Ascherson observed chasmogamous hexandrous flowers on the same plants that bore triandrous cleistogamous flowers but on different, lower branches of the inflorescence, also noting that he saw as little as two anthers in one flower. He later confirmed this in wild plants (Ascherson, 1872), reporting three stamens in top, cleitogamous flowers and four, five or six of them in lower branches of the inflorescence. Buchenau's specimens have many flowers with three stamens and another many with six. Another specimen, collected by Schrenk in the Altai (No. 62), also has six stamens.Buchenau (1871) essentially agrees with Ascherson (1871) and states that, in Germany at least, an overwhelming majority of flowers have six stamens. Also, he says that cleistogramy correlated with triandry and occurs mainly in terminal flowers. Bucheneau also wrote two essays about the *Juncaceae* in which he specifically talks of *J. bufonius*; the first one concerning dimerous flowers (Buchenau, 1871) and the other vivipary.

Cleistogamy

Batalin (1871) studied the process of self-pollination in *J. bufonius* and gives the first account of it in the literature. According to him, self-fertilization in *J. bufonius* is successful in nearly all cases. Ascherson (1872) describes his encounter with a single open flower of *J. bufonius* with erect stamens. He says that although in many cases of cleistogamous pollination the anthers adhere to the stigma and are subsequently torn of, still many anthers remain on their filaments even after cleistogamous pollination.

According to Cope and Stace (1985), *J. bufonius* s. l. in their material was almost exclusively clestogamous, and only occasionally do its flowers open for two to three hours.

1.2.4 Ecology

In the Netherlands van Loenhoud and Sterk (1976) demonstrate that hexaploids have the widest ecological amplitude of the three 'cytodemes' and are also the most common. On the contrary, the tetraploid cytotypes is (according to van Loenhoud and Sterk, 1976) the rarest, being 'almost restricted in its occurrence to Pleistocene sands in the interior', being 'more restricted to relatively little disturbed oligotrophic and not extreme habitats', unlike the hexaploids, which are 'especially encountered in anthropogenic, strongly disturbed places which tend to be ruderal'.

J. bufonius s. l. seemingly takes advantage of any disturbance to the soil, and if seeds are present, it will sprout almost anywhere on bare soil if it is moist enough. For example, it was found to be abundant in shell-holes in the Somme battleground as one of a few species to have colonized the area seven month after the offensive ended (Hill, 1917). Bernhardt (1993) studied the dynamics of *J. bufonius* during succession and found that it is a rapid colonizer of open habitats, reaching its highest population densities in the first two years.

Holub (1976) as well as Kirschner (2002*a*) claim that *J. minutulus* exhibits a preference for sandy soil. Chicouène (1996) describes *J. minutulus* as relatively heliophilous, growing in lawns and trampled sites that dry in spring, sometimes together with the typical *J. bufonius* and *J. capitatus*.

Phenology

It has been reported repeatedly that *J. minutulus* and *J. bufonius* s. str. differ in their phenology (Harmaja, 2003; Holub, 1976; Kirschner, 2002*d*; Ovchinnikova and Chukavina, 1963). A putative difference in flowering time may act as reproductive isolation mechanism (Holub, 1976). *J. minutulus* supposedly flowers earlier, and its capsules mature more rapidly. Harmaja (2003) theorizes that the difference in the speed of maturation of capsules might be associated with the species' pollination strategies.

1.2.5 Importance

It had taken me a very long time to locate a literary record of the utility of *J. bufonius* to mankind. Indeed, *J. bufonius* is not a mere weed of wet wasteland or a greenhouse nuisance, but, according to Moerman (1998), it had found its use with native American people, especially runners and other athletes, who used a toad rush decoction as an emetic infusion to induce vomiting and to wash the skin (about three times) during the week-long run-up to a race in order to strengthen the body. A modern-day clinical study is probably still yet to be conducted.

1.3 Questions and objectives

Extant literature (*e. g.,* Holub, 1976; Kirschner, 2002*d*; see subsection 1.2.2) suggests that at least two karyologically distinct taxa, differing in overlapping quantitative morphological traits, are recognizable with a certain degree of difficulty within the widely delimited *Juncus bufonius* s. l. My main objective is to test this hypothesis. The principal questions to be answered by this study are:

1. What is the cytotype composition of populations of *J. bufonius* s. l.?
2. What is the nature of the cytotypes; are differences in chromosome numbers reflected in nuclear DNA content; are chromosomal differences attributable to agmatoploidy or true polyploidy?
3. Can cytotypes of *J. bufonius* s. l. be distinguished using known morphological characters (and are there any other possible diagnostic characters)?
4. To what extent do known quantitative morphological characters overlap in natural populations of *J. bufonius* s. l. cytotypes?

My answers to these questions are presented in chapter 5.

2

Materials and Methods

2.1 Sampling

The plant material used in the analyses comes can be divided according to their origin. (1) Most of it was collected by myself (occasionally with the help of others) in various parts of Europe (mainly Czechia, Slovakia, Romania and the Ukraine, and, to a lesser degree, Montenegro, Italy, France, and Britain); (2) Some material was collected during an expedition to the Caucasus, namely Georgia, on which I had the opportunity to accompany Jan Kirschner; (3) A collection of specimens and seeds gathered by Jan Kirschner and Lenka Drábková comprising samples from north Africa, the centre of diversity of annual rushes, (Morocco, Tunisia), Europe (Czechia, Germany, Denmark, Sweden, Austria), Central Asia (Ladakh) and North America; and (4) any specimen from anywhere that I could get my hands on. The co-ordinates of each locality were obtained using a Garmin e-Trex Global Positioning System device.

The sampling strategy was decided upon on the basis of several considerations. Firstly, with agmatoploidy thought to be taking place, it is necessary to collect specimens in geographically remote areas to maximize the genetic diversity of plants under study. Secondly, plants of different species or cytotypes are known to be growing in close contact at the same localities, so it is necessary to sample variation occurring at small scales. Thirdly, annual rushes possess extraordinary phenotypic plasticity, so it is necessary to pick plants growing in different (micro-)habitats.

With the huge quantities of seeds each toad rush individual can produce, there is a great risk of seed contamination, which can happen naturally without any methodological mishap. It would be technically difficult to isolate individual plants from each other in the field. Furthermore, with the high densities of toad rush populations, there is a real danger that seeds of some plants are scattered over other individuals. To ensure that seeds collected are not a mixture of seeds from multiple plants, loose seeds were discarded, and new ones were taken directly out of the capsules of the given plant under a dissection microscope, usually by opening further a capsule that was only partially open. Sample seeds are stored in paper envelopes together with the plants they were collected from.

2.2 Cultivation

Seeds could be easily germinated in Petri dishes filled with water which were inside a growth chamber with temperatures of 25 and 10 °C in 12-hour day/night cycle. After successful germination, seedlings could be analysed cytometrically and those intended for further cultivation were transferred to gardening pots.

2.3 Morphology

Morphometric measurements were done on dry material under a stereo zoom microscope (models SZX12 and SZ51; Olympus Corp., Tokyo, Japan) equipped with an eyepiece micrometer. Plant height (PH), which was measured using a ruler. The following quantitative morphological characters were studied: plant height (PH), stem thickness at base (STB), capsule length (CL), capsule width (CW), outer tepal length (OTL), inner tepal length (ITL), filament length (FL) and anther length (AL); besides, the stamens in each flower (NoS) and the flowers on each plant (NoF) were counted (see Table 2.1). In addition, it was recorded whether a plant has clustered flowers (CLUST) or whether a capsule is bilocular (BILOC). Measurements were recorded in a form.

From these values, the following additional characteristics were calculated: mean capsule length on plant (CLAVG), mean capsule width on plant (CLAVG), mean outer tepal length per flower ($\mathrm{OTLAVG_O}$), mean outer tepal length on plant (OTLAVG), mean inner tepal length per flower ($\mathrm{ITLAVG_O}$), mean inner tepal length on plant (ITLAVG), mean filament length per flower ($\mathrm{FLAVG_O}$), mean filament length on plant (FLAVG), mean anther length per flower ($\mathrm{ALAVG_O}$), mean anther length on plant (ALAVG; see Table 2.2).

Table 2.1: Measured morphological characters.

Character	Abbreviation	Unit	Measurements per flower
Plant height	PH	mm	—
Number of flowers	NoF	—	—
Stem thickness at base	STB	mm	—
Bilocular capsule	BILOC	yes/no	1
Capsule length	CL	mm	1
Capsule width	CW	mm	1
Outer tepal length	OTL	mm	(2–)3
Inner tepal length	ITL	mm	(2–)3
Number of stamens	NoS	—	1
Filament length	FL	mm	2–4
Anther length	AL	mm	(0)–1–4

Table 2.2: Calculated morphological variables.

Character	Abbreviation
mean capsule length on plant	CLAVG
mean capsule width on plant	CLAVG
mean outer tepal length per flower	OTLAVG$_0$
mean outer tepal length on plant	OTLAVG
mean inner tepal length per flower	ITLAVG$_0$
mean inner tepal length on plant	ITLAVG
mean filament length per flower	FLAVG$_0$
mean filament length on plant	FLAVG
mean anther length per flower	ALAVG$_0$
mean anther length on plant	ALAVG

The position of a flower in the inflorescence influences the size and shape of its organs in that the smallest flowers and least mature capsules are usually found at the ends of the stem or its branches; however, in the bottom and central part of the inflorescence, the spatial distribution of quantitative values seems random. For this reason, I measured all or no less than three well developed flowers on each plant, excluding those at the extremities of the inflorescence.

Regarding capsule colouration, I have not made any attempt to record the colour of capsules even though previous authors have expressed opinions that capsule colouration may be a useful character (see, *e. g.*, Harmaja, 2003) because I could observe the whole range of colouring *(i. e.,* from green to dark red or brown) in both ploidy levels. I think the colour of capsules as well as entire plants is mostly conditioned by the environment. Let my collections serve as evidence of this.

Plant height was measured using a ruler with the precision of 5 mm. Tepal, capsule lobe, anther and filament length were measured using the eyepiece micrometer calibrated using a 10 mm gauge block at 20-fold magnification with the precision of 0.05 mm.

Occasionally, when an anther adheres to the stigma during cleistogamous pollination it does not detach from its filament but tears it, leaving only a short stump. Often a markedly short filament is present among longer ones. For this reason, the maximum filament length (FLMAX) in each flower is calculated and not the mean, as it is likely influenced by uneven tearing of the filament.

Seed dimensions were recorded by computer image analysis with the help of ImageJ[1] (Abramoff *et al.*, 2004; Rasband, 1997–2007; Image Processing and Analysis in Java). Images were acquired using a flatbed scanner Prior to image analysis the scale of each image was set (Analyze > Set Scale), and each image image was converted to an 8-bit bitmap (Image > Type > 8-bit) and then binarized by setting a threshold value that separated the objects from the background (Image > Adjust > Threshold). Particles touching the image edges were excluded (Exclude on Edges). Although I struggled to prevent it, seeds occasionally touched each other. This problem was ameliorated by using the watershed algorithm (Process > Binary > Watershed). Finally, particle analysis (Analyze > Analyze particles) extracted the needed properties of each particle. Particle length

---

[1] Public domain.

Table 2.3: Internal standards used in flow-cytometric analyses.

Species	Cultivar	2C value[2]
Lycopersicon esculentum	cv. Stupické polní tyčkové rané	1.96 pg DNA
Glycine max	cv. Polanka	2.50 pg DNA

was determined as maximum calliper length, also called maximum Feret's diameter, which is the measured distance between theoretical parallel lines that are drawn tangent to the particle profile and perpendicular to the ocular scale.

2.4 Flow cytometry

Tissue of varying ontogenetic stages from different parts of the plant was used. Precisely, whole seedlings as young as a few days raised in an incubator as well as leaves, stems, bracts and parts of the inflorescence except flowers from mature plants were analysed to test for the presence of ontogenetic variation and endopolyploidy. Same samples were analysed repeatedly to tell if any temporal variation occurs.

As an internal standard, *Glycine max* cv. Polanka (2C = 2.50 pg DNA) was used in most analyses; a minority of analyses, when soybean was unavailable, were carried out with *Lycopersicon esculentum* cv. Stupické polní tyčkové rané (2C = 1.96 pg DNA). However, based on direct comparison with *Glycine max* cv. Polanka (2C = 2.50 pg DNA), the 2C value of the *Lycopersicon esculentum* standard used was found to be 2.07 pg of DNA (see Table 2.4 and Figure 2.1). Analyses conducted with *Lycopersicon esculentum* where not included in calculations of 2C values of samples, and were only used for ploidy estimation.

Soybean was the internal standard of choice because, firstly, the peak of tomato is located too close to the peak of hexaploid *J. bufonius* and, secondly, the position of the tomato peak overlaps with the G2 peak of hexaploid *J. bufonius*.

Propidium iodide (PI hereafter), with its absorption maxima of 488 nm when unbound and 535 nm when bound to DNA, and emission maxima

Table 2.4: FCM analysis of *Lycopersicon esculentum* cv. Stupické polní tyčkové rané (1.96 pg 2C DNA) together with *Glycine max* cv. Polanka (2.50 pg 2C DNA).

	Index	Mean	Area	Area	CV (%)	ChiSqu.
Lycopersicon	1.000	205.63	2585	64.70	1.81	0.46
Glycine	1.209	248.56	1233	30.87	1.73	0.46

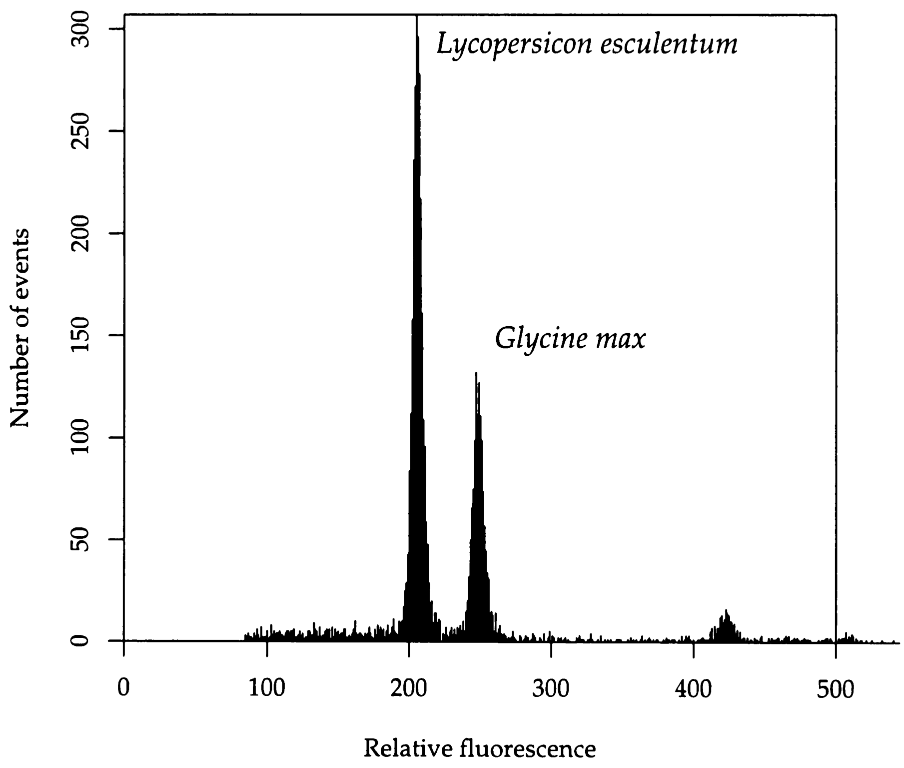

Figure 2.1: FCM analysis of *Lycopersicon esculentum* cv. Stupické polní tyčkové rané (1.96 pg 2C DNA) together with *Glycine max* cv. Polanka (2.50 pg 2C DNA).

at 590 nm when unbound and 617 nm when bound to DNA, was the fluorochrome used in most analyses. As an intercalating dye, it bounds with DNA quantitatively, allowing for measuring the amount of nuclear DNA in absolute units. 4′,6-diamidino-2-phenylindole (DAPI), with its absorption maximum of 358 nm when bound to double-stranded DNA, excited with ultraviolet light of a UV mercury arc lamp was employed in a small minority of analyses.

Preparation of nuclei suspension and fluorescent staining of nuclei

Nuclei were prepared for flow cytometry by a two-step procedure using Otto I+II buffers (Otto, 1990). Centrifuging proved to be unnecessary, and was therefore omitted. (1) Propidium iodide and RNase, both 50 $\mu g/cm^3$, was added to the Otto II buffer. β-mercaptoethanol (0.002 cm^3/cm^3) was added to avoid oxidation of polyphenolic compounds. (2) Propidium iodide-staining: 20 cm^3 Otto II buffer + 1 cm^3 PI stock solution + 1 cm^3 RNase stock solution + 40 cm^3 β-mercaptoethanol). (3) Intact leaf or stem tissues (typically 1 cm) were chopped with a new razor blade in a petri dish containing 500 cm^3 of ice-cold Otto I buffer. (4) The resulting suspension was filtered through a 42 µm nylon mesh into a test tube. (5) Samples were incubated at room temperature for 5–120 min. (6) 1 cm^3 of Otto II buffer with PI was supplemented just prior to analysis.

Cytometer set-up

A Partec CyFlow cytometer (Partec GmbH, Münster, Germany) equipped with a green (532 nm) solid state laser was employed. The gain of the cytometer was adjusted to position the peak of the internal standard on channel 200 (400 in the first batch of analyses). The Partec Ploidy Analyser PA-II was used for analyses of DAPI-stained nuclei. The gain was set to place the peak of the internal standard on channel 400.

Data analysis

Data were acquired using the cytometer's default Partec Flomax version 2.4d software (Partec GmbH, Münster, Germany) and saved in Flow Cytometry Standard version 2.0 format[3] (Dean *et al.*, 1990) of the Society

---

[3] FCS 2.0.

for Analytical Cytology. Peak detection was performed using the proprietary software's inbuilt functions. Histograms were exported with the 'Export histogram' option.

Although only CVs below 3% are perfectly acceptable (Galbraith *et al.*, 1998; Marie and Brown, 1993), this requirement may be relaxed a bit, and CVs up to 5% can be considered acceptable if better precision cannot be achieved (Doležel and Bartoš, 2005). The former requirement is too strict for the material used in this study, so I have arbitrarily chosen the threshold value of 3.5%. Any analysis in which the CV of either the peak of the samples or the internal standard exceeds this limit is discounted from nuclear genome size calculations. The difference between the lowest and highest 2C value within a group was expressed as the percentage of the mean ($\frac{2C_{max}-2C_{min}}{2C_{mean}} \times 100$).

2.5 Chromosome counting

Germinating seeds were pre-treated in saturated p-DCB[4] for two hours, placed in freshly prepared Carnoy's I solution[5], left at room temperature for 24 hours, and stored in a refrigerator for up to one month.

Wet mounts were prepared for viewing. A sprout was dipped in a solution of 1 EtOH : 1 HCl[6] and placed in water for a few minutes. The root tip was then cut off on the mount, water was drained, and a drop of stain was added. A cover slip was then placed over the specimen which was squashed with a needle. The cover slip was lifted with a razor blade so that the stain reached the whole specimen and the squash was completed. Chromosomes were then counted under a light microscope with a 100× immersion lens.

2.6 Protein electrophoresis

Whole plants of known ploidy level were taken from pots in the greenhouse and analysed immediately. An extraction buffer that was successfully used for the genus *Luzula* turned out to work acceptably with annual *Juncus*. Tris-glycine was used as the standard. Samples were then subjected

---

[4] 1,4-Dichlorobenzene

[5] 3 : 1 95% ethanol to glacial acetic acid

[6] 1:1 95% ethanol to 38% hydrochloric acid

to polyacrlylamide gel electrophoresis following standard procedures at the Isozyme laboratory of the Botanical Institute of the Czech Academy of Sciences in Průhonice. The following enzymatic systems were tested: 6-phosphogluconate dehydrogenase (6-PGDH), aspartate amino transferase (AAT), alcohol dehydrogenase (ADH), diaphorase (DIA), esterase (EST), glucose-6-phosphate dehydrogenase (G-6-PDH), leucine aminopeptidase (LAP), malic enzyme (ME), nicotinamide adenine dinucleotide dehydrogenase (NADH-DH), phosphoglucomutase and phosphoglucose isomerase (PGM + PGI), and shikimate dehydrogenase (ShDH).

2.7 Statistical analyses

Most statistical procedures were carried out using R version 2.7.1. svn revision 45970 (R Development Core Team, 2008), which is Free Software[7]. All scripts used for the actual analyses mentioned in this thesis are included in the supplement.

Univariate normality was tested by the procedure `shapiro.test` (Shapiro-Wilk normality test) from the `stats` library.

The Kruskal-Wallis rank sum test (function `kruskal.test` of package `stats`) was used as a non-parametric method for comparing distributions of variables between two groups.

Correlation Spearman's correlation coefficient was computed using the `cor` function of the `stats` library.

Multivariate normality and outliers Multivariate normality was tested using the function `mshapiro.test` from the library `mvnormtest`.

Multivariate outliers were detected by use of the function `aq.plot` from `mvoutlier`.

Homogeneity of variances Homogeneity of variances was tested using the non-parametric routine `fligner.test` for the Fligner-Killeen test from the `stats` library and the `hov` procedure from the library `HH` (Brown and Forsyth, 1974).

---

[7] GNU General Public License version 2 or later

Principal components analysis PCA was done using `prcomp` (`stats`) with centering and scaling enabled.

Generalized canonical discriminant analysis was performed with the procedure (candisc) from the library of the same name.

Classification discriminant analysis was then done with the non-parametric method `sknn` (simple k nearest neighbours) from the `klaR` package. Prediction error rates were estimated using `errorest` from the `ipred` library.

3

Results

3.1 Flow cytometry

3.1.1 Ploidy levels

Three basic DNA ploidy levels.

I have found three levels of nuclear DNA content in the *Juncus bufonius* complex: (1) with *ca* 0.65 (diploid species *J. hybridus*, *J. ranarius* and *J. sorrentini*); (2) with 1.18 ± 2.8%; and (3) 1.84 ± 1.6% pg 2C DNA (see subsection 3.1.3).

Setting aside diploids, which were all ascribable to one of the diploid species on morphological arguments alone, I encountered tetraploid and hexaploid plants in either apparently pure or, abundantly, intermixed populations. In populations consisting of both tetraploids and hexaploids, there were numerous assays showing variability within single compact tufts. In many cases, a single tetraploid stem grew attached by the roots a cluster of diploid stems, ofter intertwining with them. Not less often in predominantly tetraploid populations it was the other way round. When retrospectively examining samples that yielded mixed assays, the source of the secondary peak was usually identified easily.

3.1.2 Localities

Over the course of this study, plants were collected at over 120 localities in Czechia, Slovakia, the Ukraine, Romania, Montenegro, Italy, Corsica and Georgia, 49 of which were selected for morphometric evaluation. Some donated material was also available from Sweden, Denmark, Cyprus, Montenegro, Morocco and the United States of America.

Many localities harboured mixed-ploidy populations of *J. bufonius* s. l., mainly comprising tetraploids and hexaploids (see section 3.1). In Corsica

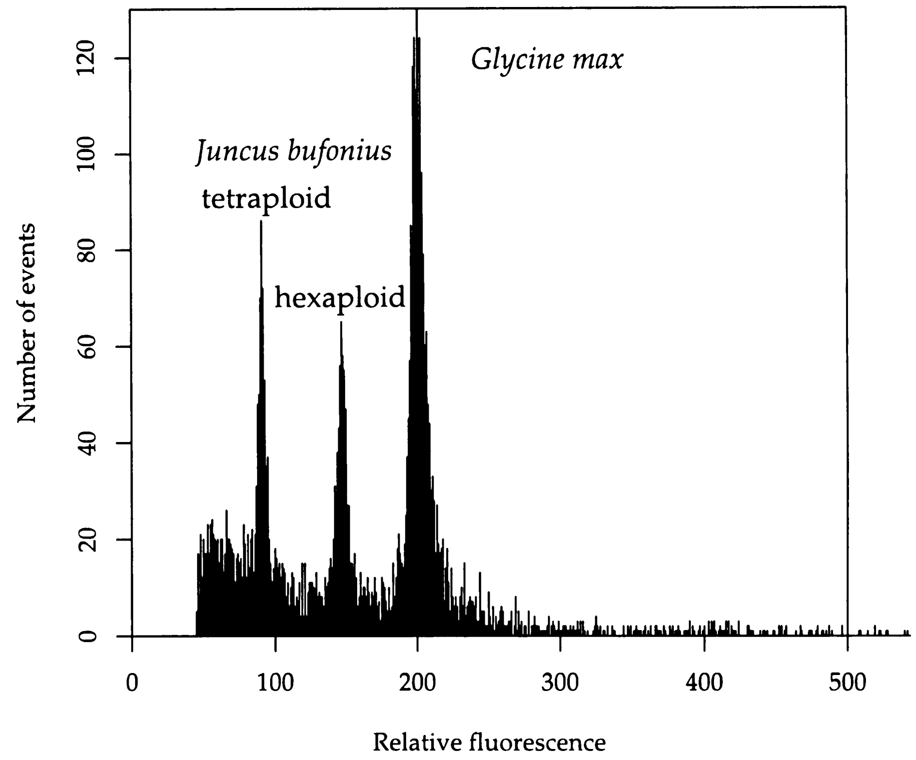

Figure 3.1: Flow-cytometric histogram showing a mixed sample containing tissue from one tetraploid and one hexaploid plant together with the internal standard. The morphological similarity between tetraploids and hexaploids caused the number of mixed samples to be vast.

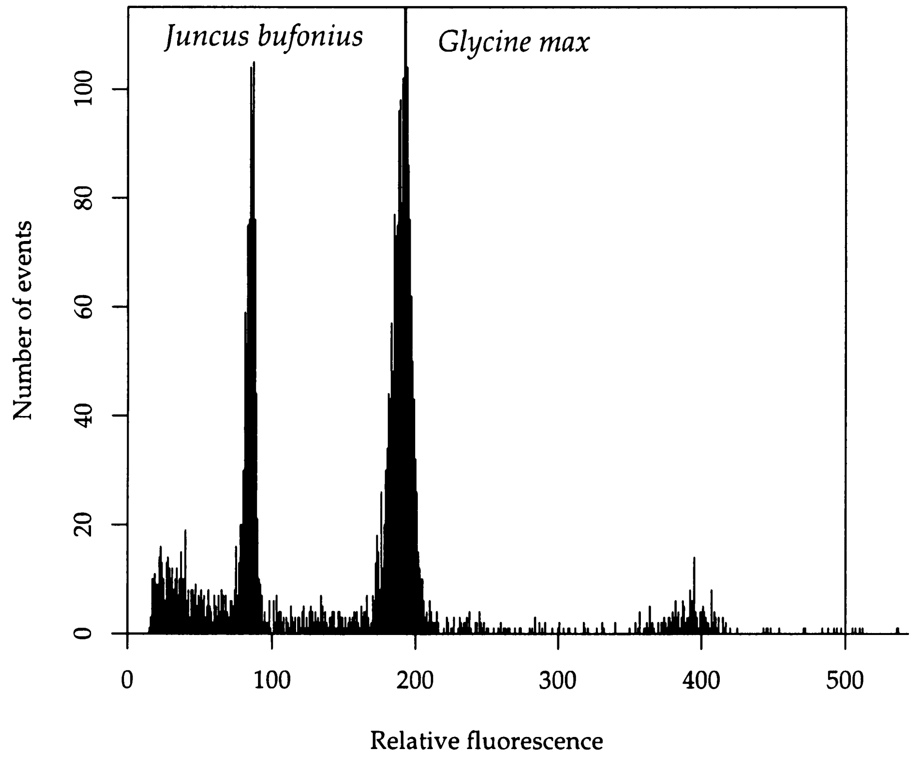

Figure 3.2: Nuclear DNA content estimation of tetraploid *Juncus bufonius*.

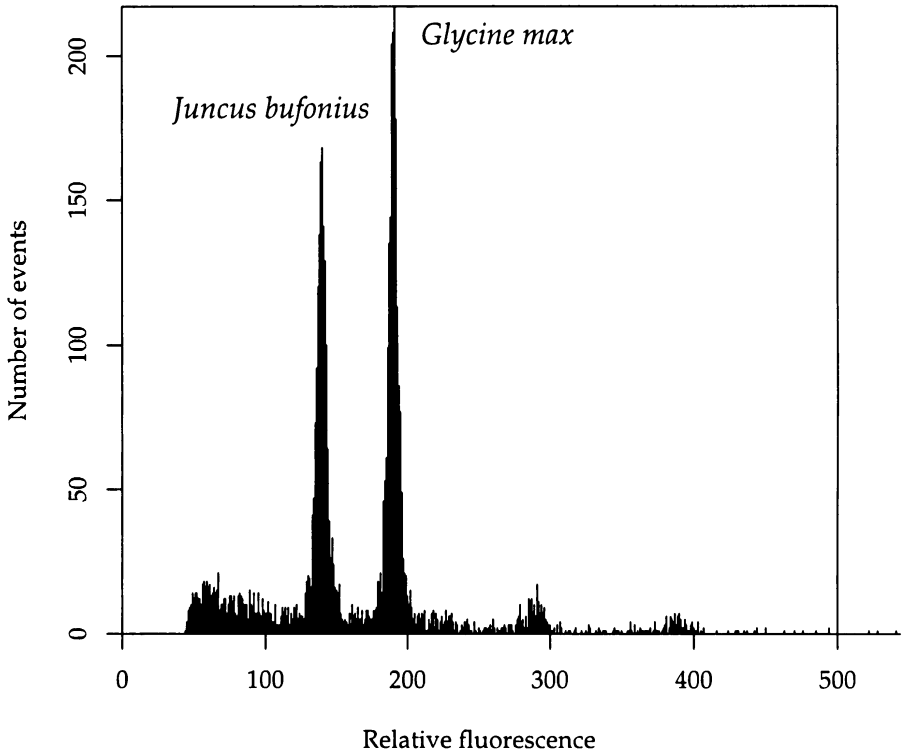

Figure 3.3: Nuclear DNA content estimation of hexaploid *Juncus bufonius*.

(locality number 222), I have found diploid, tetraploid and hexaploid plants growing together. The diploids have been identified as *J. sorrentini* and *J. hybridus* and were easily separable from the two polyploid cytotypes using characters found to be differential by Cope and Stace (1983).

More often I encountered mixed tetraploid and hexaploid populations in which identification of cytotypes proved difficult. Misidentification of other taxa as the *J. bufonius* group also happened. I will admit to collecting chopping up *J. bulbosus* for FCM (in Czechia), unknowingly collecting *J. pygmaeus* (in Corsica) and, shamefully, even juvenile plants of *Carex remota* (in Slovakia).

Table 3.1: Localities at which plant material was collected for the purposes of this study. Vouchers are deposited in the Herbarium of Charles University in Prague (PRC).

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
1	6×	Czechia	Kvilda	49.01050	13.5797	river bank
13	6×	Czechia	Obořiště	49.74169	14.1514	muddy bank of fish pond
14	6×	Czechia	Praha	50.15939	14.4013	river bank
15	6×	Czechia	Praha	49.99581	14.4004	river bank
16	6×	Czechia	Praha	50.01864	14.3951	river bank
17	4×	Czechia	Veselí nad Lužnicí	49.90724	14.3208	tramped forest clearing
19	6×	Czechia	Vysoká u Příbramě	49.63552	13.9344	forest path
20	6×	Czechia	Dubno	49.69440	14.0533	margin of field
21	6×	Czechia	Dubno	49.68930	14.0555	sediment from uranium mine
22	6×	Czechia	Dubno	49.68813	14.0559	sediment from uranium mine
25	6×	Czechia	Starý Hrozenkov	48.96900	17.8734	forest path
26	6×	Czechia	Žítková	48.98404	17.8953	forest path
28	6×	Czechia	Doublovičky	49.60317	14.4828	bottom of empty fish pond
29	6×	Czechia	Veselí nad Lužnicí	49.18657	14.7024	muddy river bank
30	6×	Czechia	Vlkov	49.15925	14.7124	sandy bank of lake
31	6×	Czechia	Vlkov	49.15711	14.7125	sandy bank of lake
32	6×	Czechia	Vlkov	49.15578	14.7102	sandy bank of lake
33	6×	Czechia	Vlkov	49.15452	14.7096	sandy bank of lake

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
39	4× 6×	Czechia	Malá Víska	49.76365	13.8820	forest path
55	2×	Italy	Foggiamare	41.49631	15.9161	salt marsh
59	6×	Czechia	Veselí nad Lužnicí	49.17078	14.7153	sandy bank of lake
60	6×	Czechia	Veselí nad Lužnicí	49.16617	14.7156	sandy bank of lake
61	6×	Czechia	Vlkov	49.16431	14.7156	sandy bank of lake
62	6×	Czechia	Vlkov	49.16136	14.7153	sandy bank of lake
63	6×	Czechia	Vlkov	49.16050	14.7140	sandy bank of lake
64	6×	Czechia	Vlkov	49.16044	14.7127	sandy bank of lake
65	6×	Czechia	Vlkov	49.16022	14.7088	sandy bank of lake
66	6×	Czechia	Brdy	49.69411	13.9296	forest path
67	6×	Czechia	Brdy	49.69003	13.9005	forest path
68	6×	Czechia	Brdy	49.68900	13.8996	forest path
69	4×	Czechia	Tok	49.69200	13.8847	forest road
81	4×	Romania	Muntele Mare	46.52033	23.3178	mountain road
87	6×	Czechia	Dobříš	49.78837	14.1754	bank of pond
88	6×	Czechia	Hořovice	49.84217	13.9015	concrete bank of fish pond
89	6×	Slovakia	Chočské vrchy	49.13626	19.3534	edge of forest road
102	4×	Czechia	Louka	50.06617	12.7885	forest path
123	6×	Czechia	Žítková	48.99180	17.9016	forest path
124	6×	Czechia	Žítková	48.96832	17.8910	pasture
130	4× 6×	Czechia	Voznice	49.82382	14.2264	edge of forest road

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
131	6×	Czechia	Prague	50.06779	14.4114	river bank
132	6×	Slovakia	Malá Bara	48.41408	21.7258	
133	6×	Slovakia	Malá Bara	48.41042	21.7252	
134	6×	Slovakia	Strážne	48.38233	21.8576	
135	6×	Slovakia	Veľký Kamenec	48.34511	21.8349	
137	6×	Slovakia	Vinné	48.81850	21.9568	
138	6×	Slovakia	Slanská Huta	48.59904	21.4575	
139	6×	Slovakia	Latorica	48.50053	22.0533	most
140	6×	Slovakia	Latorica	48.49865	22.0558	most
141	6×	Slovakia	Soľnička	48.49344	21.9387	muddy track
142	6×	Slovakia	Soľnička	48.49165	21.9377	muddy track
143	6×	Slovakia	Veľký Kamenec	48.35869	21.8082	
146	4× 6×	Czechia	Voznice	49.83076	14.1649	edge of forest road
147	6×	Romania	Zarnesti	45.54106	25.2944	
148	6×	Romania	Casa de Vanatoare Piatra Craiului	45.49506	25.1736	puddle on forest road
149	6×	Romania	Dâmboviţa valley	45.49964	25.1465	puddle on forest road
150	6×	Romania	Dâmboviţa valley	45.51863	25.0748	forest path
151	6×	Romania	Near Cabana Voina (Iezer Păpuşa mountains)	45.44239	25.0449	forest path

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
154	6×	Czechia	Pec pod Sněžkou	50.70163	15.7055	forest path
162	6×	Czechia	Řitka	49.89904	14.2746	forest path
165	6×	Czechia	Mníšek pod Brdy	49.88470	14.2538	rocky bank of fish pond
166	6×	Czechia	Padrťské rybníky	49.64794	13.7569	forest path
170	6×	Czechia	Skryje	49.96474	13.7638	muddy bank of fish pond
171	6×	Czechia	Klínec	49.89848	14.3504	edge of forest road
172	4× 6×	Czechia	Voznice	49.82299	14.1879	edge of forest road
173	4× 6×	Czechia	Voznice	49.82383	14.1860	outlet of fish pond
174	4× 6×	Czechia	Mukařov (Louňovice)	49.98696	14.7670	edge of forest road
175	6×	Czechia	Mukařov (Louňovice)	49.98500	14.7681	edge of forest road
177	4× 6×	Czechia	Vyžlovka	49.97674	14.7880	forest path
180	4× 6×	Czechia	Benátky	49.90790	14.9315	forest path
181	4×	Czechia	Horní Kruty	49.93414	14.9937	river bank
182	6×	Czechia	Praha	50.11481	14.4167	forest path
184	4× 6×	Czechia	Jíloviště	49.91702	14.3335	muddy bank of lake
185	4×	Czechia	Chomutov	50.46988	13.4282	forest path
187	4× 6×	Czechia	Boleboř	50.55464	13.3920	forest path
188	4×	Czechia	Boleboř	50.55631	13.4018	forest path
189	4×	Czechia	Hora svaté Kateřiny	50.59117	13.4269	muddy bank of fish pond

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
190	6×	Czechia	Mšeno	50.44182	14.6341	forest path
191	6×	Czechia	Lobeč	50.46068	14.6600	ditch
192	6×	Czechia	Lobeč	50.46331	14.6735	ditch
193	6×	Ukraine	Kvasy	48.18693	24.3100	Black Tisza river valley
194	6×	Ukraine	Chornohora massif	48.18237	24.3394	edge of forest road
195	6×	Ukraine	Chornohora massif	48.16474	24.3435	forest path
196	6×	Ukraine	Mount Petros (Chornohora massif)	48.16842	24.4145	mountain trail
197	6×	Ukraine	Chornohora massif	48.03081	24.5927	forest path
198	6×	Ukraine	Chornohora massif	47.99781	24.5701	forest path
199	6×	Ukraine	Chornohora massif	48.00997	24.5279	forest path
200	4× 6×	Czechia	Jince	49.75758	13.9384	forest path
201	6×	Czechia	Černolice	49.90457	14.2859	forest path
202	4× 6×	Czechia	Maxičky	50.82459	14.1723	forest path
203	4×	Czechia	Maxičky	50.82885	14.1653	forest path
204	4× 6×	Czechia	Maxičky	50.82939	14.1645	forest path
205	4×	Czechia	Jince	49.76038	13.9486	forest path
207	4× 6×	Czechia	Obecnice	49.71679	13.9229	forest path
209	4× 6×	Czechia	Radostín	49.65608	15.8963	forest path
212	4× 6×	Czechia	Vlkančice	49.91457	14.8871	forest path

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
217		Corsica	Macinaggio	42.96293	9.4486	edge of forest road
218		Corsica	Agriates Desert	42.65852	9.1588	puddle on mountain path
219	4×	Corsica	Foret de Bonifatu	42.44163	8.8434	muddy puddle at camp site
220		Corsica	Forêt d'Aïtone	42.28269	8.8709	edge of road leading to the beach
221		Corsica	Corte	42.29801	9.1490	
222	2× 4× 6×	Corsica	Santa Manza Plage	41.40642	9.2111	
227	6×	Czechia				
228	6×	Czechia				
229	4× 6×	Czechia				
230	4×	Czechia				
231	6×	Czechia				
232	6×	Czechia				
g37	6×	Georgia	Bakuriani	41.68142	43.573611	muddy bank of stream
LD107	6×	Sweden	Ystad			
LD372	6×	Germany	Berlin			
LD405a	6×	Sweden	Saltefjel			
LD419	6×	Morocco				

Table 3.1: (continued)

ID	Ploidy	Country	Place	Latitude	Longitude	Habitat
LD151	6×	Canada	Presqu'ile Provincial Park in Northumberland county (Ontario)			
LD248	6×	Czechia	Chlumy			
LD322	4×	Denmark	Jytland			
LD323	4×	Denmark	Jytland			
LD428	4×	Czechia	Chlumy			
LD439	4× 6×	Cyprus	Lemesos (Akrotiri)			
LD438	4× 6×	Cyprus	Lemesos (Akrotiri)			
LD437	4× 6×	Cyprus	Lemesos (Akrotiri)			
Hybridus	2×	Montenegro	Hybridus+G.FCS			
LD244	6×	Czechia	Střeleč u Libuně			

Table 3.2: Flow-cytometric data used to compute the nuclear DNA content of species and cytotypes under study. Only those analyses were included which were not spoiled by a mixed sample and which exhibited CVs smaller than 3.5% for both the study material and the internal standard.

	Mean	CV	St.Mean	CV0	Ploidy	2C
130-1A+G	135.62	3.45	293.43	2.60	4×	1.16
146-7C+G	90.93	3.21	199.45	2.62	4×	1.14
17-1+G	99.79	2.81	203.03	3.35	4×	1.23
17-10+G	155.03	2.90	322.20	2.17	4×	1.20
17-1B+G	136.20	3.25	278.29	2.81	4×	1.22
17-2+G	148.79	2.51	308.01	2.90	4×	1.21
17-3+G	145.05	2.56	300.53	2.71	4×	1.21
17-4+G	154.49	2.95	323.93	3.23	4×	1.19
17-5+G	145.03	2.49	297.23	2.26	4×	1.22
17-6+G	143.64	2.78	304.35	3.34	4×	1.18
17-7+G	136.06	2.72	278.11	3.29	4×	1.22
17-8+G	147.87	3.18	312.11	2.79	4×	1.18
17-9+G	158.75	3.01	325.95	2.44	4×	1.22
173-1+G	94.84	3.39	210.59	2.67	4×	1.13
180-1A+G	93.77	3.42	207.26	2.60	4×	1.13
184-2+G	92.52	3.28	205.25	2.45	4×	1.13
184-5+G	93.27	3.33	207.12	3.07	4×	1.13
189-11+G	102.72	3.28	214.17	2.48	4×	1.20
209-3+G	131.37	3.05	278.46	2.76	4×	1.18
212-1+G	145.27	3.18	302.85	2.75	4×	1.20
220+G	124.24	3.24	272.01	3.14	4×	1.14
226-1B+G	143.51	3.07	309.16	3.40	4×	1.16
226-1C+G	144.40	2.89	309.16	3.15	4×	1.17
230+G	146.33	3.29	308.27	2.92	4×	1.19
69B+G	190.75	3.11	395.89	2.17	4×	1.20
130-1B+G	148.08	3.14	201.27	3.18	6×	1.84
130-2B+G	151.27	2.66	203.18	2.81	6×	1.86
130-2C+G	303.90	2.37	402.72	2.05	6×	1.89
130-4+G	148.15	2.76	200.73	2.98	6×	1.85
130-6+G	147.43	2.57	201.75	2.95	6×	1.83
130-7+G	222.29	3.49	295.32	2.32	6×	1.88
130-8+G	228.17	3.38	301.79	2.76	6×	1.89
142+G	147.53	3.36	198.82	2.88	6×	1.86
146-13+G	141.72	2.90	196.51	2.89	6×	1.80
146-4+G	155.82	2.88	214.63	3.01	6×	1.81

Table 3.2: *(continued)*

	Mean	CV	St.Mean	CV0	Ploidy	2C
146-5+G	154.58	2.42	210.56	3.30	6×	1.84
146-6+G	156.10	2.58	213.06	3.01	6×	1.83
146-7+G	144.69	2.45	200.18	2.42	6×	1.81
146-9+G	151.79	2.81	206.20	3.43	6×	1.84
147-1+G	151.37	2.49	206.17	2.79	6×	1.84
148-1+G	148.35	2.76	197.47	3.34	6×	1.88
149-1+G	155.53	2.43	212.73	2.38	6×	1.83
150-1+G	149.37	2.24	202.56	1.99	6×	1.84
151-1+G	146.16	2.40	195.12	2.21	6×	1.87
152-1+G	153.89	3.07	209.57	2.09	6×	1.84
154-2+G	145.24	2.69	203.98	2.04	6×	1.78
162+G	152.79	2.41	203.40	2.68	6×	1.88
166-1+G	145.03	2.90	199.96	3.20	6×	1.81
171-5+G	152.61	3.37	210.26	2.50	6×	1.81
173-2B+G	151.92	2.66	208.21	2.49	6×	1.82
174-1B+G	136.34	2.68	185.75	2.96	6×	1.83
174-2B+G	143.46	3.31	193.19	3.09	6×	1.86
177-2+G	146.24	2.03	201.36	2.35	6×	1.82
177-4+G	147.60	2.57	202.62	2.38	6×	1.82
177-7+G	143.62	2.26	199.56	3.31	6×	1.80
184-6+G	153.29	2.45	212.16	3.15	6×	1.81
192-1+G	152.96	2.85	207.99	3.06	6×	1.84
192-2+G	143.34	3.46	197.71	3.21	6×	1.81
196+G	148.02	3.38	204.83	2.69	6×	1.81
200-10+G	158.76	2.90	218.81	3.23	6×	1.81
200-12+G	150.72	2.95	212.95	3.26	6×	1.77
200-23+G	151.01	3.33	206.61	2.65	6×	1.83
200-6+G	153.54	2.89	213.95	2.93	6×	1.79
200-7+G	156.87	3.18	214.08	3.00	6×	1.83
212-7A+G	221.42	2.83	299.72	2.56	6×	1.85
212-7B+G	222.59	2.46	301.10	2.36	6×	1.85
213-3+G	240.77	3.06	321.85	2.84	6×	1.87
217+G	235.11	2.86	305.65	2.78	6×	1.92
222-6+G	222.46	3.46	293.34	3.12	6×	1.90
223B+G	219.04	1.70	298.75	1.80	6×	1.83

Table 3.2: *(continued)*

	Mean	CV	St.Mean	CV0	Ploidy	2C
226-1A+G	234.60	2.25	320.62	3.09	6×	1.83
226-2A+G	215.32	2.97	289.05	3.26	6×	1.86
226-2B+G	223.72	2.54	300.78	2.33	6×	1.86
226-2E+G	222.51	3.18	299.87	3.28	6×	1.86
228-2+G	217.51	3.31	290.49	3.27	6×	1.87
232-1+G	223.67	3.49	304.49	2.87	6×	1.84
40+G	279.77	3.26	377.48	3.01	6×	1.85
89A+G	221.65	2.68	300.77	1.94	6×	1.84
89B+G	299.37	2.21	406.72	2.06	6×	1.84
LD105+G	150.37	2.91	204.34	2.24	6×	1.84
LD150+G	150.21	3.23	205.92	3.10	6×	1.82
LD151+G	146.16	2.40	195.12	2.21	6×	1.87
LD218	223.10	2.95	298.00	2.35	6×	1.87
LD371+G	144.25	3.41	200.56	3.22	6×	1.80
LD372+G	139.47	2.45	190.00	1.84	6×	1.84
LD405a+G	134.95	3.27	185.05	2.17	6×	1.82
LD405b+G	149.77	3.08	201.62	2.77	6×	1.86

3.1.3 Nuclear DNA content

The lowest, diploid DNA ploidy level was found in diploid species such as *J. ranarius*, *J. hybridus* or *J. sorrentini*, which were not the primary target of my study. The two remaining DNA ploidy levels—tetraploid and hexaploid—were found in *J. bufonius* s. l., correlated with tetra- and hexaploid chromosome counts (see Table 3.5), and seemed (at first) agree with the morphological diagnoses of *J. minutulus* and *J. bufonius* s. str., respectively. The tetraploid DNA content amounted to approximately double the diploid DNA content, proving true DNA tetraploidy. The third level, showing approximately triple the amount of that of DNA diploids, proves the occurrence of true DNA hexaploids. The three nuclear DNA content levels are well-defined without any overlap or intermediate values (see Figure 3.4). The mean nuclear DNA content is estimated at 1.18 ± 2.8% pg 2C DNA for tetraploids and 1.84 ± 1.6% pg 2C DNA for hexaploid plants. Other descriptive statistics are presented in Table 3.3 and Table 3.4. The p-values of the Shapiro-Wilk normality test on values of tetraploid and hexaploid 2C values are 0.0261 and 0.6569, respectively. We can thus reject the null hypothesis that the 2C values are normally distributed. For tetraploid plants, the difference between the minimum and maximum 2C value is 8.46% of the mean. For hexaploids it equals 8.15% of the mean value.

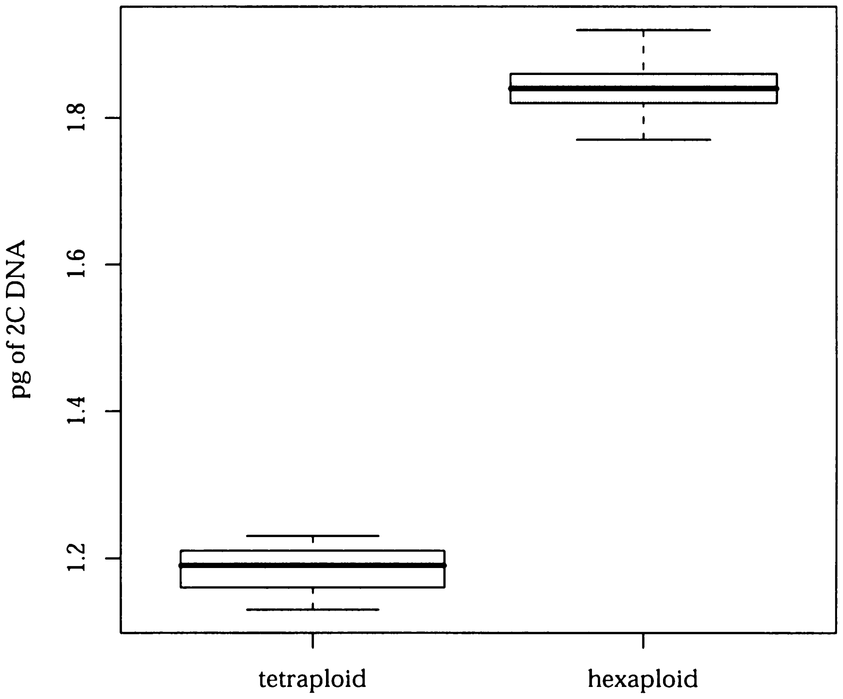

Figure 3.4: Boxplots of 2C values in pg DNA for tetraploid and hexaploid plants based on analyses in which the CV of the peaks was below 3.5%.

Table 3.3: Descriptive statistics of morphometric variables for tetraploid individuals based on analyses in which the CV of the peaks was below 3.5%.

	Min.	X1st.Qu.	Median	Mean	X3rd.Qu.	Max.
2C	1.13	1.16	1.19	1.182	1.21	1.23
CV	2.49	2.89	3.11	3.054	3.28	3.45
CV0	2.17	2.60	2.76	2.803	3.14	3.40

Table 3.4: Descriptive statistics of morphometric variables for hexaploid individuals based on analyses in which the CV of the peaks was below 3.5%.

	Min.	X1st.Qu.	Median	Mean	X3rd.Qu.	Max.
2C	1.77	1.820	1.840	1.840	1.860	1.92
CV	1.70	2.468	2.855	2.829	3.180	3.49
CV0	1.80	2.352	2.825	2.733	3.098	3.43

Not a single FCM analysis suggested the discovery of another cytotype, which could indicate possible hybridization. During tests for the occurrence of endopolyploidy, an FCM analysis of a single plant never yielded multiple peaks.

3.2 Chromosome counting

With massive help from Dr. Vlasta Jarolímová, three chromosome ploidy levels were ascertained using traditional chromosome counting in squash slides: (1) diploid with 2n > *ca* 30 and < *ca* 40; (2) tetraploid with 2n > *ca* 60 and < *ca* 80; and (3) hexaploid with 2n > 90 chromosomes counted. These limited results correlated with cytometric data (see Table 3.5).

3.3 Morphology

A total of 1371 flowers on 358 plants (166 tetraploid and 192 hexaploid) from 49 localities were included in the morphometric analyses. Measure-

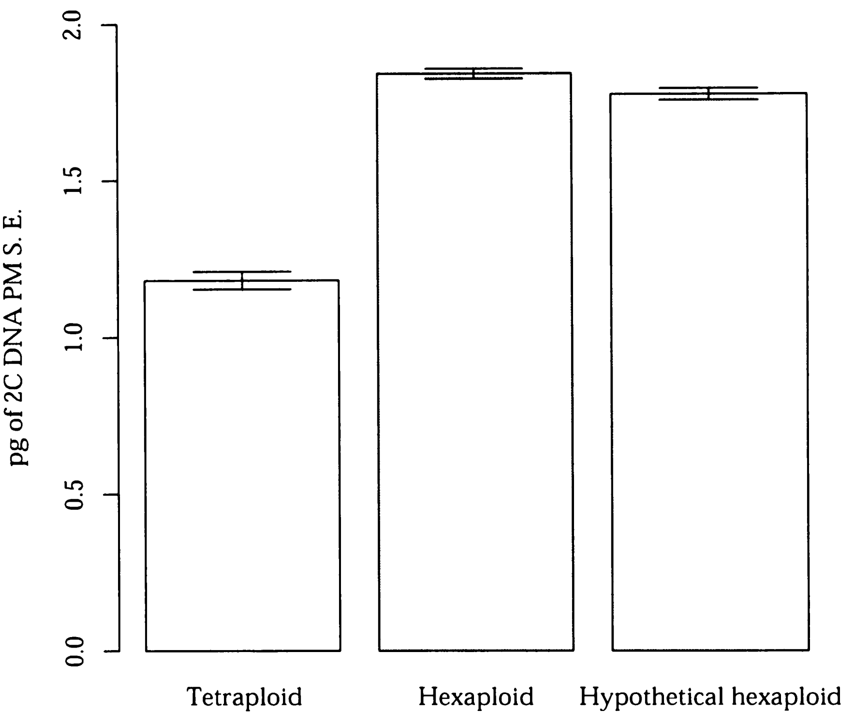

Figure 3.5: Barplots showing 2C values of tetraploids and hexaploids ± their standard error and a hypothetical hexaploid with 1.5-fold the mean tetraploid 2C value.

Table 3.5: Summary of chromosome counts obtained as part of this study.

Chromosome count	Nuclear DNA content	Ploidy level
2n > *ca* 30 and < *ca* 40	0.60 pg 2C DNA	diploid
2n > *ca* 60 and < *ca* 80	1.18 ± 2.8% pg 2C DNA	tetraploid
2n > *ca* 90	1.84 ± 1.6% pg 2C DNA	hexaploid

ments of 6 floral and 3 vegetative quantitative characters (mostly no less than 10 measurements per flower, 30 per plant). Primary data and the matrix used in multivariate analyses can be found in the appendix (Table A.1 and Table A.2). Cytometrically identified vouchers will be available in the herbaria of Charles University in Prague and the Botanical institute of the Czech Academy of Sciences in Průhonice.

3.3.1 Qualitative characters

I estimated the difference between the mean and the median of each of the variables *(i. e,* CL, CW, OTL, ITL, FL and AL) by directly comparing the distribution of their mean and median using a series of Kolmogorov-Smirnov tests, of which a single one allowed me to reject the null hypothesis that the results of the two computation methods *(i. e.,* mean and median) have different distribution (results not shown). By visually comparing boxplots (not shown), I established that there is virtually no difference in the shape of the distribution of each variable or in number of outliers when the mean or median is used.

Clustered flowers

With the exception of diploid plants (in my case *J. hybridus* and *J. ranarius*), only rarely did I find plants with clustered flowers. Most tetraploid or hexaploid plants under study have remote flowers although plants with clustered flowers were abundant in a few populations Smíchov). However, all these populations included plants with single, remote flowers as well as continuous transitions towards flower clusters. This applies to both ploidy levels. For these reasons, I have not included these data in the study.

Plant colouration

Some collections show conspicuously red colouring of the stem, sometimes at the base but often throughout the plant. I have observed this phenomenon at many localities in plants of both ploidy levels. During repeated visits to the same locality in different seasons and different years, the red colouration was not constant. I think that the red colour is caused by environmental conditions, probably the availability of water. I therefore have not considered the red tint to the plant as a character worth recording.

Table 3.6: Descriptive statistics of morphometric variables for tetraploid individuals.

	Min.	X1st.Qu.	Median	Mean	X3rd.Qu.	Max.
PH	1.7000	9.000	14.000	14.4500	19.000	30.000
NoF	2.0000	8.000	13.000	18.6200	20.000	91.000
CLAVG	2.1330	2.862	3.050	3.0470	3.240	3.900
CWAVG	0.6333	0.950	1.050	1.0640	1.163	1.500
OTLAVG	3.1120	4.356	4.688	4.7330	5.153	7.083
ITLAVG	2.0500	3.154	3.417	3.4520	3.745	5.025
FLAVG	0.8875	1.118	1.230	1.2350	1.321	1.917
FLMAX	0.9500	1.300	1.450	1.4630	1.550	3.600
ALAVG	0.2000	0.350	0.450	0.4792	0.525	1.700

The tint also seemed to be associated with proliferation, supporting my opinion that the plants were under drought stress.

Cleistogamy

I have observed signs of cleistogamy in all plants that I handled. It appears to be a universal phenomenon in the *J. bufonius* complex in all populations included in this study or ever visited by me. On a few occasions I was lucky to observe chasmogamous flowering in hexaploid plants but not in tetraploids, in congruence with observations of previous authors. However, there are clues which might suggest that chasmogamy takes place even in tetraploid plants (see chapter 4), though a direct observation is still missing.

3.3.2 Quantitative characters

For descriptive statistics of variables measured in tetraploid and hexaploid plants see Table 3.6 and Table 3.7, respectively. For p-values of the Shapiro test of normality see Table 3.8. Those variables which showed improved normality after a transformation were transformed accordingly (see Table 3.9 for p-values after transformation).

Table 3.7: Descriptive statistics of morphometric variables for hexaploid individuals.

	Min.	X1st.Qu.	Median	Mean	X3rd.Qu.	Max.
PH	2.0000	9.000	13.2500	13.9300	17.5000	34.000
NoF	2.0000	7.000	12.0000	18.1700	22.0000	91.000
CLAVG	2.4250	3.019	3.2620	3.2990	3.5170	5.025
CWAVG	0.7500	1.050	1.1650	1.1970	1.3380	2.000
OTLAVG	3.3380	4.460	4.8310	4.9250	5.2940	7.833
ITLAVG	2.6170	3.463	3.7800	3.8630	4.2740	5.138
FLAVG	0.8833	1.203	1.2950	1.3060	1.3800	2.338
FLMAX	1.0000	1.387	1.5000	1.5310	1.6000	3.600
ALAVG	0.2167	0.415	0.4914	0.5143	0.5794	1.250

Table 3.8: P-values of the Shapiro-Wilk normality for individual variables. P-values of the Shapiro-Wilk test for log-transformed variables (when beneficial) are summarized in Table 3.9.

	tetraploid	hexaploid
PH	0.0269	0.0044
NoF	0.0000	0.0000
CLAVG	0.2459	0.0000
CWAVG	0.4012	0.0071
OTLAVG	0.1853	0.0031
ITLAVG	0.6173	0.0512
FLMAX	0.0000	0.0000
ALAVG	0.0000	0.0000

Table 3.9: P-values of the Shapiro-Wilk normality test for individual log-transformed variables for which the transformation improved normality.

	tetraploid	hexaploid
log(NoF)	0.0130	0.0522
log(CLAVG)	0.0263	0.0010
log(CWAVG)	0.1895	0.8331
log(OTLAVG)	0.7483	0.5878
log(ALAVG)	0.0092	0.0998

Habit

The distribution of plant height (PH) and the number of flowers (NoF) appears to be very similar in tetraploid and hexaploid plants (see boxplots in Figure 3.6). In the number of flowers (NoF), both ploidy levels show a large number of outliers with high values of up to over eighty flowers per stem. Note that the notches on the boxplots of the two ploidy levels overlap noticeably. This suggests that their medians do not differ.

PH does not have a normal distribution in either tetraploids or hexaploids, even after transformation (see Table 3.8). NoF is a log-normal variable in tetraploids after a logarithmic transformation is applied (see Table 3.9).

Thickness of stem at base (STB) turned out to be a wildly variable character without any significance whatsoever (data not shown). It was therefore not pursued further.

Capsules length and width

Capsule length (CLAVG) in tetraploids has a normal distribution with or without log transformation; however, in hexaploids the distribution is neither normal nor log-normal (see Table 3.8 and Table 3.9), probably because of a larger number of outliers (see Figure 3.7).

Capsule width (CWAVG) exhibits normality in both ploidy levels after being log-transformed Table 3.9.

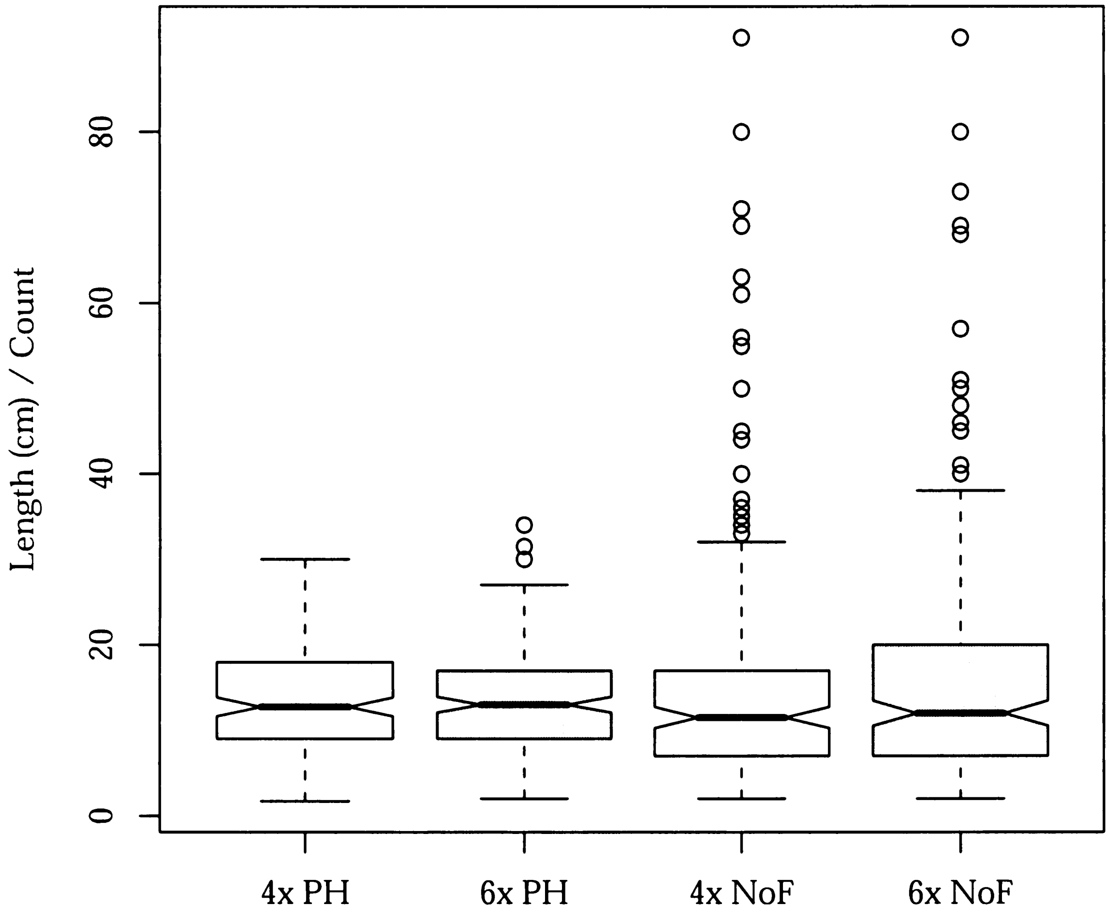

Figure 3.6: Boxplots of plant height (PH) and the number of flowers (NoF) in tetraploid and hexaploid plants.

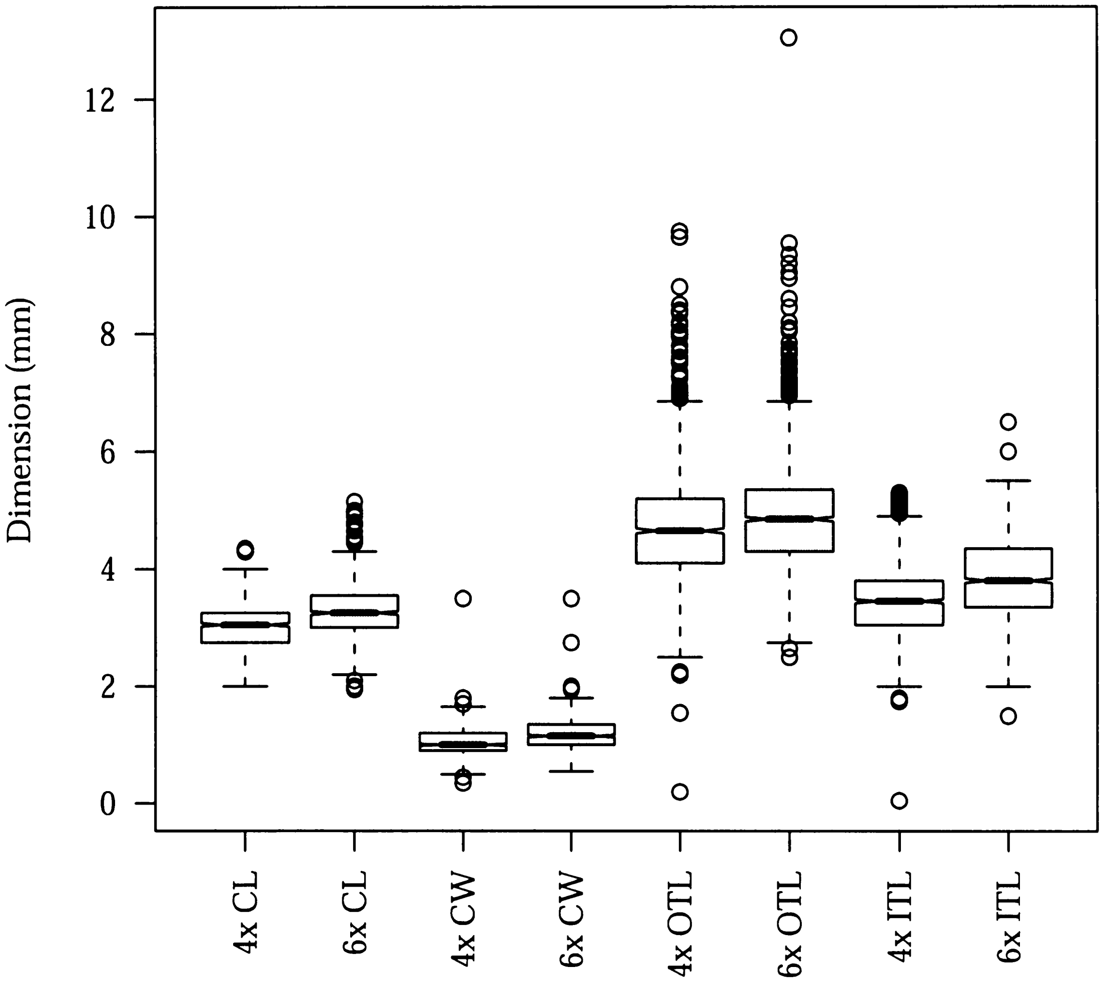

Figure 3.7: Boxplots of capsule length (CL), capsule width (CW), outer tepal length (OTL), inner tepal length (ITL) in tetraploid and hexaploid plants.

Tepal length

The boxplots of outer tepal length (OTL) shows an especially large number of outlier values (see Figure 3.7).

Mean outer tepal length (OTLAVG) has log-normal distribution in both tetra- and hexaploids (see Table 3.9). Mean inner tepal length (ITLAVG) shows normality without any transformation in both tetra- and hexaploids (see Table 3.8).

Number of stamens

Not surprisingly, NoS is a variable with two peaks: at 3 and 6 (see Figure 3.8). The number of stamens (or filaments) is not constant within ploidy levels, populations or even individual plants. Moreover, bilocular capsules tend to have two stamens (see Figure 3.3.2, Figure 3.10, Table 3.10 and Table 3.11). Only 14% of all the plants included in the morphometric study have a constant NoS of 3 or 6 (the real percentage is probably lower), and 9% have flowers with both 3 and 6 stamens. The remaining 3% have mostly 2 or 3 stamens. The real percentages are probably somewhat different because I did not examine every flower of each plant.

Length of anthers and filaments

Filament length presented a bit of a challenge. There is considerable variation even within individual flowers. Is could possibly be attributable to uneven shortening of the filament when the anther is torn off by the lengthening capsule. I have rarely seen anthers attached to the stigma or to the wall of the fruit valve which were still connected to a part of the filament. I have therefore decided to take the maximum filament length in each flower as the calculated variable and not the mean (as in other variables). FLMAX does not show normal distribution even after transformation. (see Table 3.8 and Table 3.9).

Unfortunately but understandably, measurements of ALAVG could not have been obtained for many plants because anthers were no longer present. This was the case in 69 plants. Even when log-transformed, ALAVG does have a normal distribution in tetraploids, but in hexaploids the p-value of its Shapiro-Wilk test marginally exceeds 0.05 (see Table 3.9).

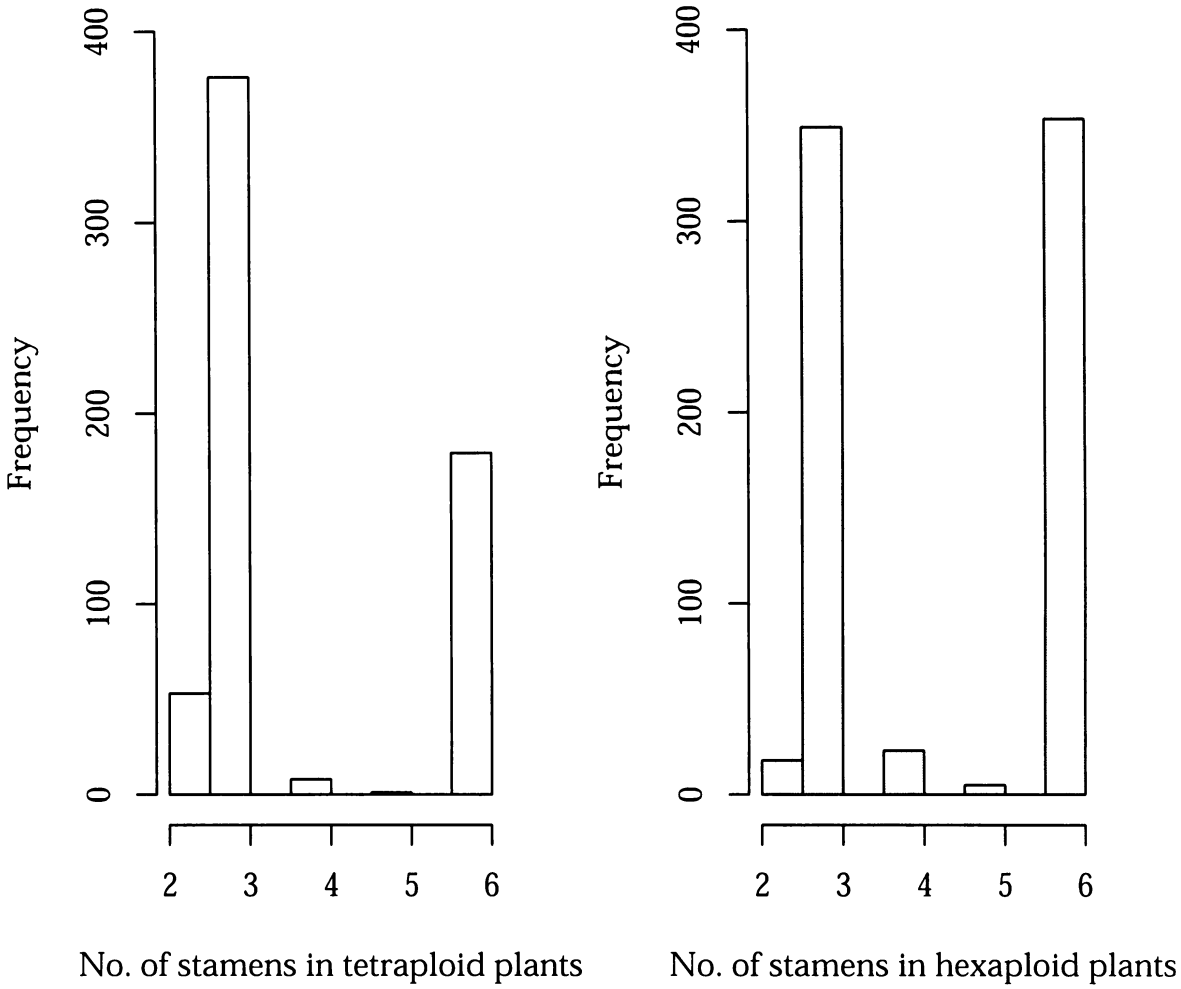

Figure 3.8: Histograms of the number of stamens (NoS) in tetraploid and hexaploid plants.

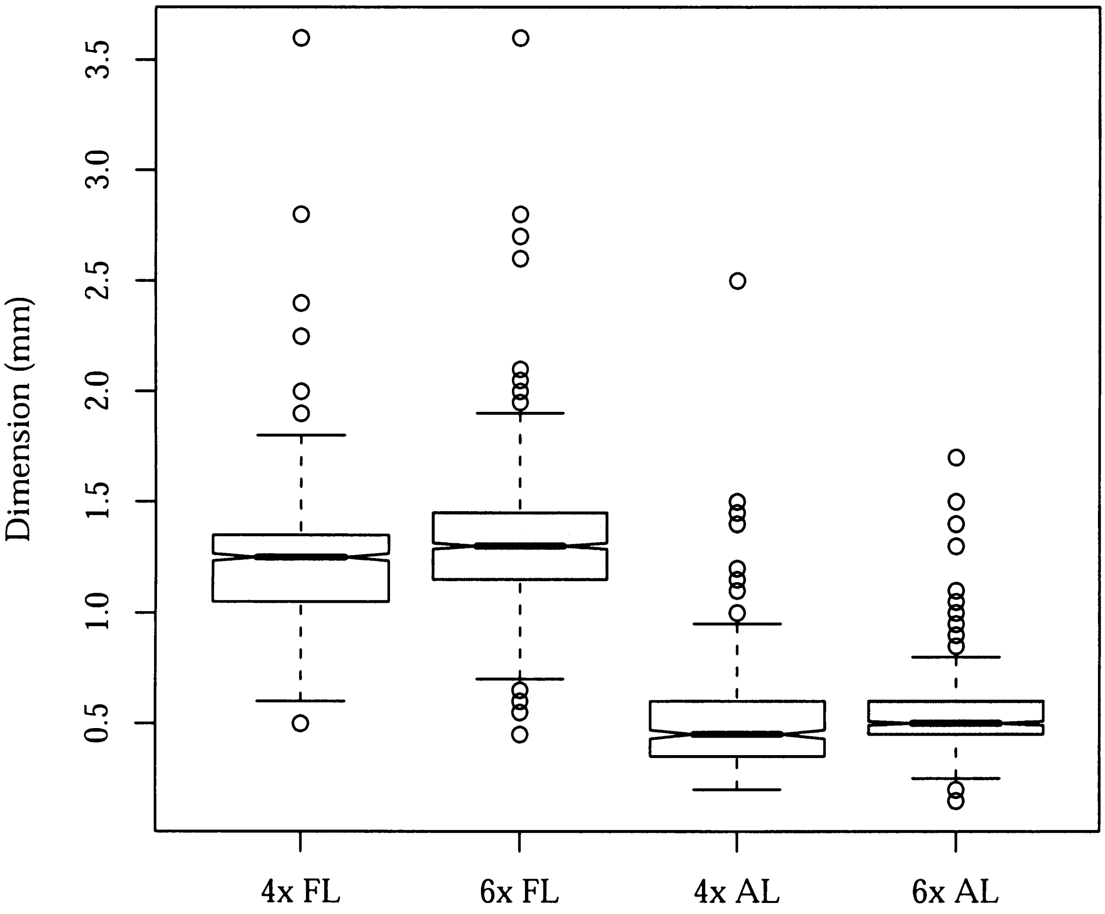

Figure 3.9: Boxplots of filament length (FL) and anther length (AL) in tetraploid and hexaploid plants.

Table 3.10: Kruskal-Wallis test to asses the effect of bilocular capsules on capsule length (CL), capsule width (CW), outer tepal length (OTL), inner tepal length (ITL), filament length (FL) and anther length (AL) in tetraploid plants.

	Kruskal-Wallis chi-squared	Df	p value
CL	44.9750	40	0.2714
CW	17.5971	27	0.9154
OTL	285.2797	257	0.1087
ITL	150.2748	189	0.9827
FL	58.9082	71	0.8466
AL	24.5136	53	0.9997
NoS	274.5614	4	0.0000

Dimerous flowers

Most individuals bear only regular trimerous flowers with three outer tepals, three inner tepals, a capsule with three lobes (*i. e.*, a trilocular capsule) and three or six stamens. However, a notable deviation from this rule is quite frequent. In many populations of both ploidy levels, at least some plants bear dimerous flowers with only two outer tepals, two inner tepals and a capsule with only two lobes (*i. e.*, bilocular capsules). A bilocular capsule can nonetheless occur in a flower with three outer and three inner tepals. Dimerous flowers often occur at the extremities of the inflorescence, but this is not a rule, as they can also be found in the lowermost flowers. Figure 3.10 contains boxplots of the measured morphological variables for dimerous and trimerous flowers in plants of both ploidy levels.

Performed separately for each ploidy level, a series of Kruskal-Wallis tests—the results of which are summarized in Table 3.10 and Table 3.11, respectively—indicate that dimerism significantly affects NoS, which is obvious. In the tetraploid group, dimerous flowers do not differ statistically at the 5% level from regular trimerous ones in any other of the variables, but in hexaploid plants, dimerism affects CL, CW and OTL (at the 5% level). But due to their low frequency of bilocular capsules in hexaploids they have little effect, and omitting them has no effect either.

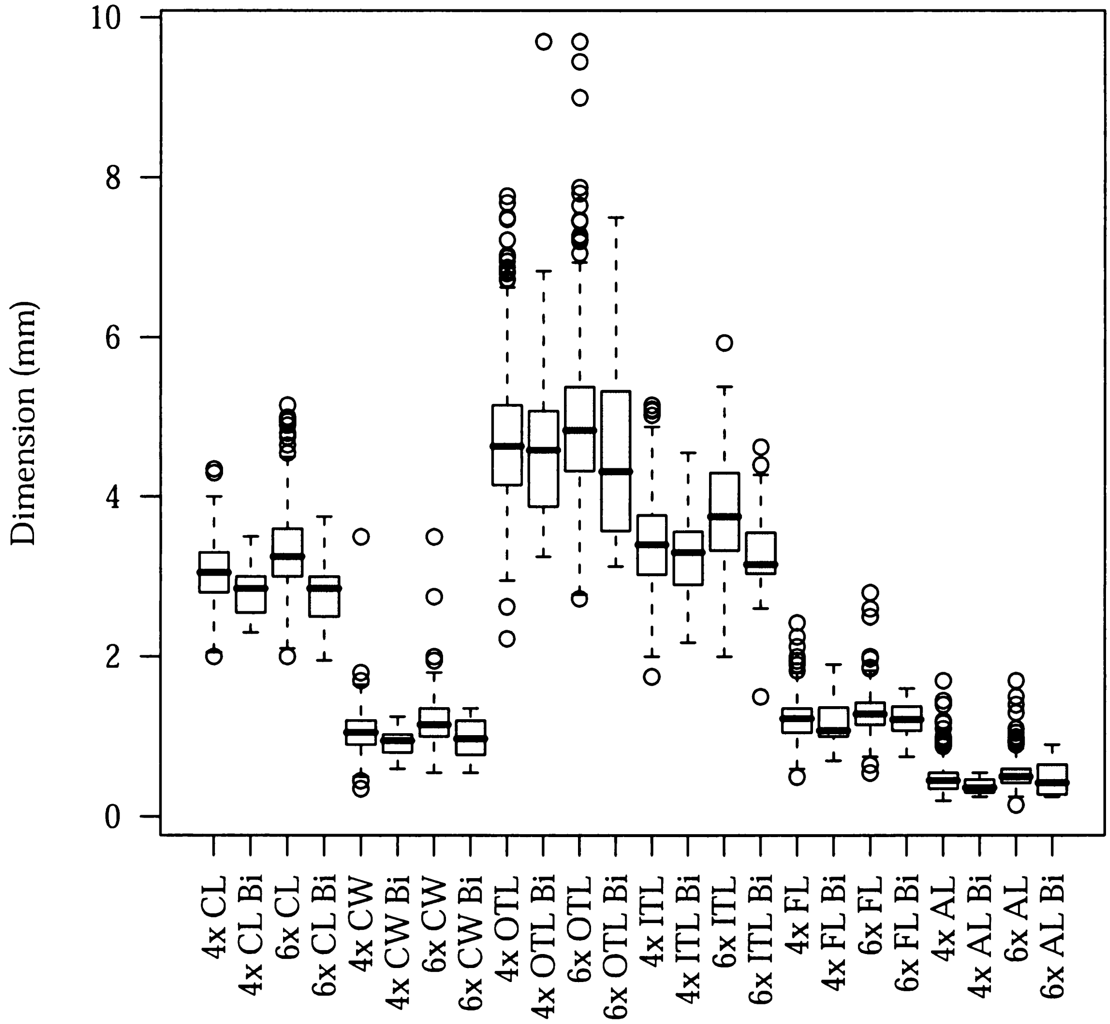

Figure 3.10: Boxplots of measured quantitative characters of flowers with bilocular and regular trilocular capsules in tetraploid and hexaploid plants.

Table 3.11: Kruskal-Wallis test to asses the effect of bilocular capsules on capsule length (CL), capsule width (CW), outer tepal length (OTL), inner tepal length (ITL), filament length (FL) and anther length (AL) in hexaploid plants.

	Kruskal-Wallis chi-squared	Df	p value
CL	128.0603	54	0.0000
CW	58.2851	29	0.0010
OTL	423.4073	292	0.0000
ITL	214.9742	230	0.7534
FL	57.2796	97	0.9996
AL	37.9909	66	0.9978
NoS	255.3763	4	0.0000

Seeds

Image analyses of seed dimensions failed to reveal any statistically significant difference between seeds of tetraploid or hexaploid individuals (results now shown).

Multivariate distribution

The Shapiro-Wilk multivariate normality test allowed me to safely reject the null hypothesis that the dataset has multivariate normal distribution (p-value = 5×10^{-19}). This p-value is returned when all variables except Ploidy and NoSMOD are included. Omitting variables with non-normal distributions (*i. e.*, PH, FLMAX, ALAVG) does not, however, make the data set normal (p-value of multivariate Shapiro-Wilk test = 2×10^{-6}). Omitting multivariate outliers (see subsubsection 3.3.3) does not give the data matrix a multivariate normal distribution either (p-value of multivariate Shapiro-Wilk test = 1×10^{-13}).

Multicollinearity

As the first step in assessing the relationships among the variables measured I produced two matrices of scatterplots: the first for values for each flower, the second for computed values for each plant. In the scatterplot matrix for variables measured in each flower (Figure 3.11), we can see that no combination of variables seems to separate the two groups in any way. Moreover, there does not seem to be any striking relationship between any pair of variables with the sole exception of OTL and ITL. The scatterplot matrix of values calculated for each plant *(i. e.,* the mean for CL, CW, OTL and ITL, maximum value for FL, and the mode for NoS; Figure 3.12) also shows the two groups without any apparent separation. There appears to be a certain linear relationship among CLAVG, CWAVG, OTLAVG and ITLAVG, less so for FLMAX, ALAVG and NoSMOD.

Because some of the variables used in the analyses do not have a normal distribution and the dataset does not have multivariate normal distribution in either group Table 3.3.2, the non-parametric Spearman's rank correlation coefficient will be used as a measure of correlation among the variables. Spearman's correlation coefficients among the variables in the dataset are not excessively high (Table 3.12). The highest correlation coefficient equals 0.81 (between OTLAVG and ITLAVG) and it exceeds 0.8 for no other pair, so there is no need to omit any of the variables. A graphical representation of the relationships among the variables based on variable clustering using Spearman correlation is presented in Figure 3.13. Note that Ploidy correlates least of all the variables. To compare the correlation coefficients of tetraploid and hexaploid observations, see Table 3.13 and Table 3.14; for an easier comparison, the values have been substituted by symbols. The values in the two groups seem to be reasonably similar.

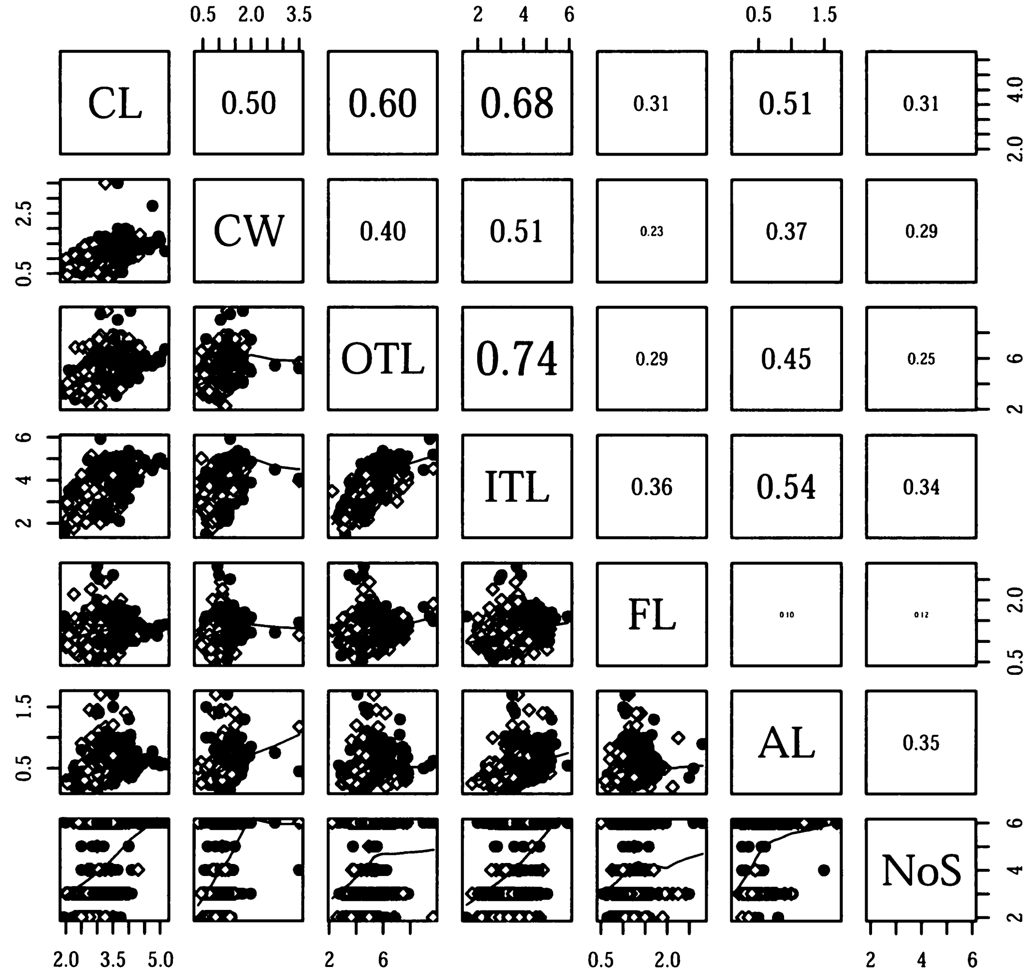

Figure 3.11: Scatterplot matrix of capsule length (CL), capsule width (CW), outer tepal length (OTL), inner tepal length (ITL), filament length (FL) and the number of stamens (NoS) in each flower measured. Tetraploids: ◇; hexaploids: •.

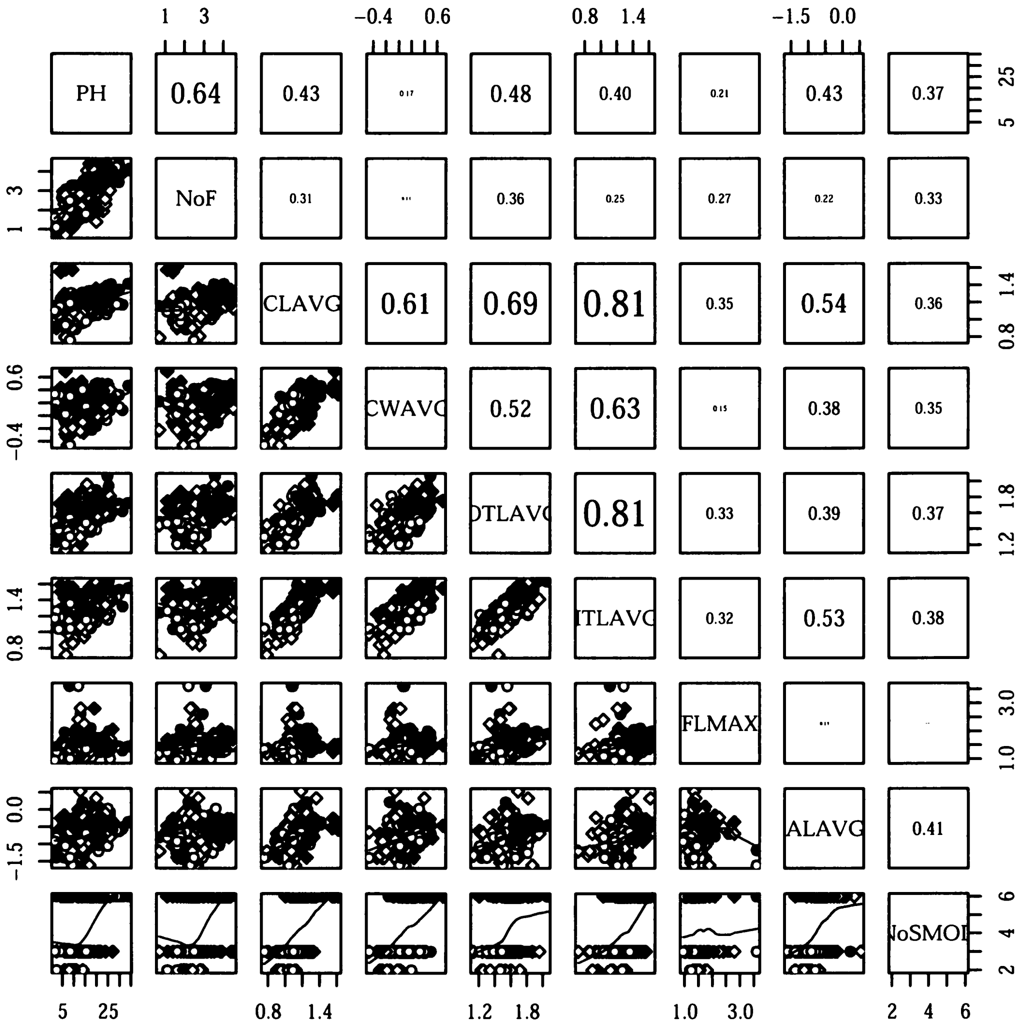

Figure 3.12: Scatterplot matrix of mean capsule length (CLAVG), mean capsule width (CWAVG), mean outer tepal length (OTLAVG), mean inner tepal length (ITLAVG), maximum filament length (FLAVG) and the number of stamens mode (NoSMOD) in each flower measured. Tetraploids: ◇; hexaploids: •.

Table 3.12: Spearman correlation coefficients for entire data set.

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLMAX	ALAVG	NoSMOD
PH	1.00	0.64	0.43	0.17	0.48	0.40	0.21	0.43	0.37
NoF	0.64	1.00	0.31	0.13	0.36	0.25	0.27	0.22	0.33
CLAVG	0.43	0.31	1.00	0.61	0.69	0.81	0.35	0.54	0.36
CWAVG	0.17	0.13	0.61	1.00	0.52	0.63	0.15	0.38	0.35
OTLAVG	0.48	0.36	0.69	0.52	1.00	0.81	0.33	0.39	0.37
ITLAVG	0.40	0.25	0.81	0.63	0.81	1.00	0.32	0.53	0.38
FLMAX	0.21	0.27	0.35	0.15	0.33	0.32	1.00	0.13	0.05
ALAVG	0.43	0.22	0.54	0.38	0.39	0.53	0.13	1.00	0.41
NoSMOD	0.37	0.33	0.36	0.35	0.37	0.38	0.05	0.41	1.00

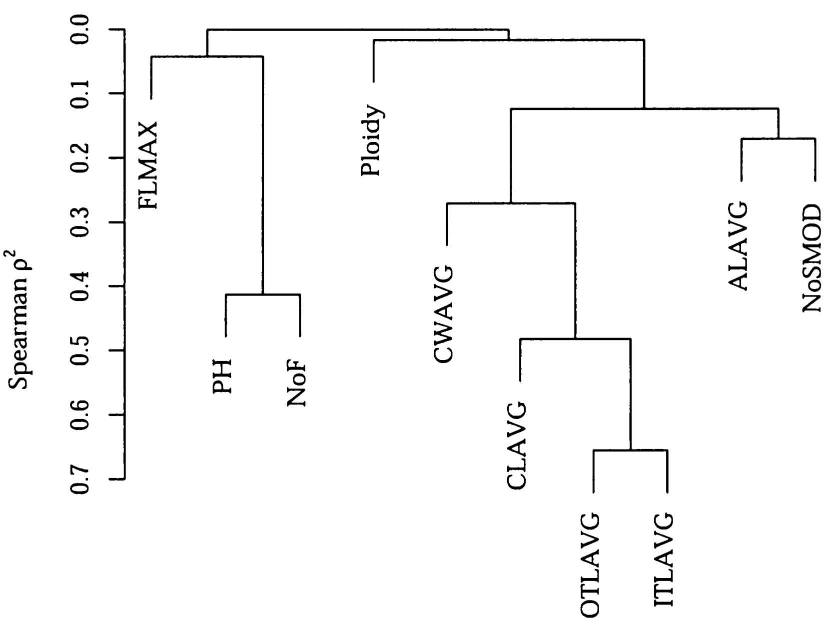

Figure 3.13: Hierarchical cluster analysis on variables using Spearman correlation.

Homogeneity of variance

To test the null that the variances in each of the two groups are the same, a Fligner-Killeen (median) test was used. This test was chosen because it is non-parametric, for my data set does not have a multivariate normal distribution. The Fligner-Killeen test of homogeneity of variances (p-value of 0.5156) did not let me reject the null hypothesis that the variances in the two groups differ; therefore, I consider the data matrix to be homoscedastic.

Table 3.13: Spearman correlation coefficients for tetraploid observations. Symbolic Number Coding. Values substituted by symbols: < 0.3: ' '; < 0.6: '.'; < 0.8: ','; < 0.8: '+'; < 0.9: '*'; < 0.95: 'B'; 1

	P	NF	CL	CW	O	I	F	A	NS
PH	1								
NoF	,	1							
CLAVG	.	.	1						
CWAVG			.	1					
OTLAVG	.	.	,	.	1				
ITLAVG	.		,	.	,	1			
FLMAX							1		
ALAVG	.		.	.		.		1	
NoSMOD	,	.	.	.	.	.		.	1

Table 3.14: Spearman correlation coefficients for hexaploid observations. Symbolic Number Coding. Values substituted by symbols: < 0.3: ' '; < 0.6: '.'; < 0.8: ','; < 0.8: '+'; < 0.9: '*'; < 0.95: 'B'; 1

	P	NF	CL	CW	O	I	F	A	NS
PH	1								
NoF	,	1							
CLAVG	.	.	1						
CWAVG			.	1					
OTLAVG	.	.	,	.	1				
ITLAVG	.		+	,	+	1			
FLMAX		.	.		.	.	1		
ALAVG	.		.	.	.	.		1	
NoSMOD									1

Table 3.15: Principal component analysis loadings for the first three principal components.

	PC1	PC2	PC3	PC4	PC5	PC6
PH	−0.325	0.524	−0.101	0.148	−0.230	0.059
NoF	−0.262	0.625	0.035	0.256	0.062	−0.387
CLAVG	−0.413	−0.268	0.060	0.004	−0.108	−0.047
CWAVG	−0.348	−0.385	−0.012	0.108	0.263	−0.677
OTLAVG	−0.400	−0.110	0.172	0.345	−0.032	0.524
ITLAVG	−0.430	−0.235	0.091	0.146	−0.066	0.180
FLMAX	−0.106	0.148	0.855	−0.470	0.051	−0.039
ALAVG	−0.303	−0.020	−0.337	−0.608	−0.558	−0.079
NoSMOD	−0.294	0.158	−0.319	−0.413	0.737	0.267

3.3.3 Ordination analyses

Principal components analysis (PCA)

Principal components analysis (PCA) was performed on the data set with individuals as OTUs. The resulting biplot (Figure 3.14) exhibits one large cloud of plants with increasing density towards the centre, a few isolated outlying individuals and a small group of observations. The plot does not suggest any hypothesis as to the separation of tetraploid and hexaploid groups. The first principal component explained only 46% of the variance, the second 15% (see Table 3.16). Separate PCAs were performed for tetraploid and hexaploid plants with similar results (see Figure 3.15 and Figure 3.16, respectively). The first principal component explained only 48% of the variance in tetraploids (see Table 3.18) and 45% in hexaploids (see Table 3.20). PCA ordination therefore does not indicate any appreciable difference between tetraploid and hexaploid observations in my data set, and the only hypothesis it would suggest is the null hypothesis that tetraploids and hexaploids are morphologically indistinguishable.

A detrended correspondence analysis (DCA) was performed on the same data set with no indication of any structure in the data whatsoever (results not shown).

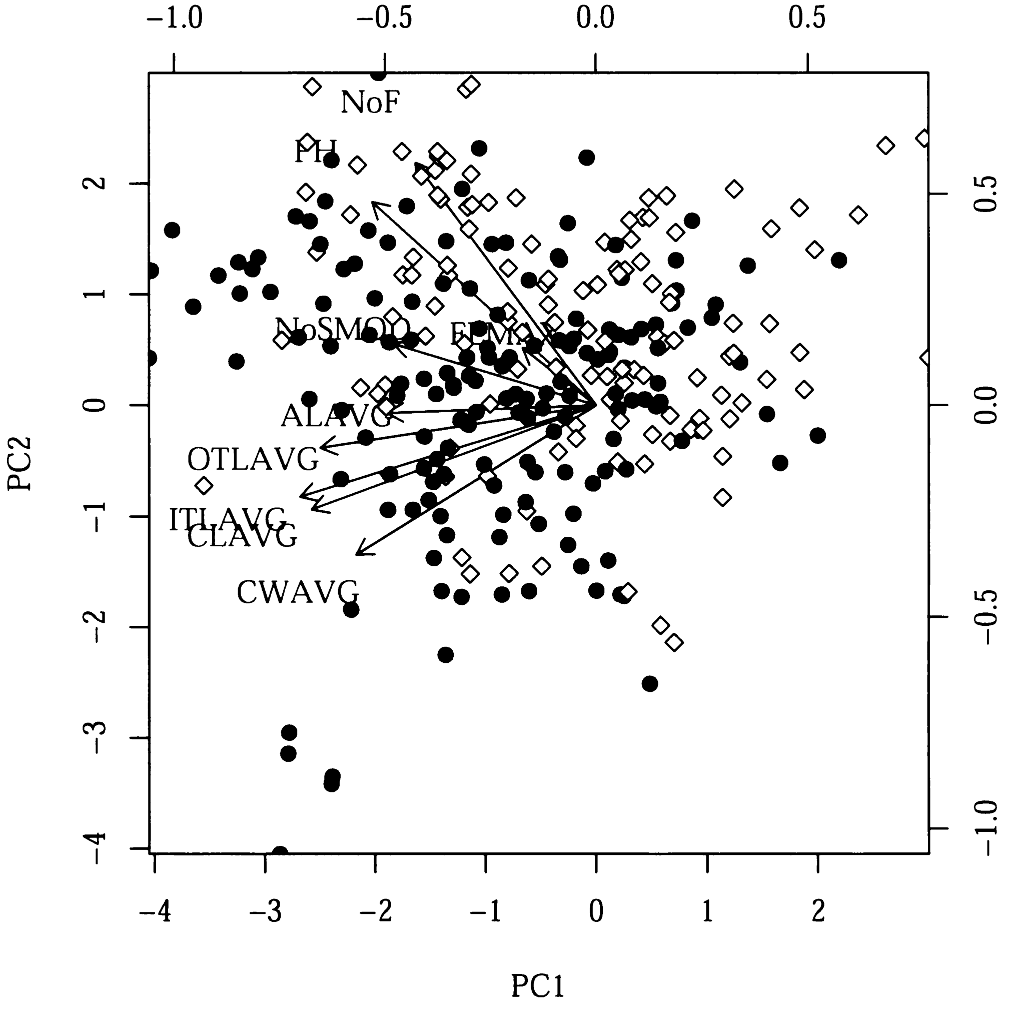

Figure 3.14: Principal components analysis for tetraploid and hexaploid plants.

Table 3.16: Principal component analysis importance for the first three principal components.

	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	2.042	1.146	1.016	0.860	0.797	0.652
Proportion of variance	0.463	0.146	0.115	0.082	0.071	0.047
Cumulative proportion	0.463	0.609	0.724	0.806	0.877	0.924

Table 3.17: Principal component analysis loadings for the first three principal components of tetraploid plants only.

	PC1	PC2	PC3	PC4	PC5	PC6
PH	0.375	−0.386	0.151	−0.036	0.234	−0.026
NoF	0.304	−0.460	0.311	0.234	−0.154	−0.573
CLAVG	0.396	0.319	−0.106	−0.107	0.092	−0.394
CWAVG	0.331	0.327	−0.217	0.006	−0.744	−0.071
OTLAVG	0.363	0.264	0.178	0.403	0.337	0.323
ITLAVG	0.396	0.325	−0.049	0.159	0.241	0.056
FLMAX	0.059	0.254	0.782	−0.541	−0.110	0.103
ALAVG	0.287	−0.155	−0.419	−0.673	0.261	−0.014
NoSMOD	0.355	−0.409	−0.025	−0.003	−0.329	0.626

Table 3.18: Principal component analysis importance for the first three principal components of tetraploid plants only.

	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	2.083	1.114	1.053	0.855	0.742	0.618
Proportion of variance	0.482	0.138	0.123	0.081	0.061	0.042
Cumulative proportion	0.482	0.620	0.743	0.824	0.886	0.928

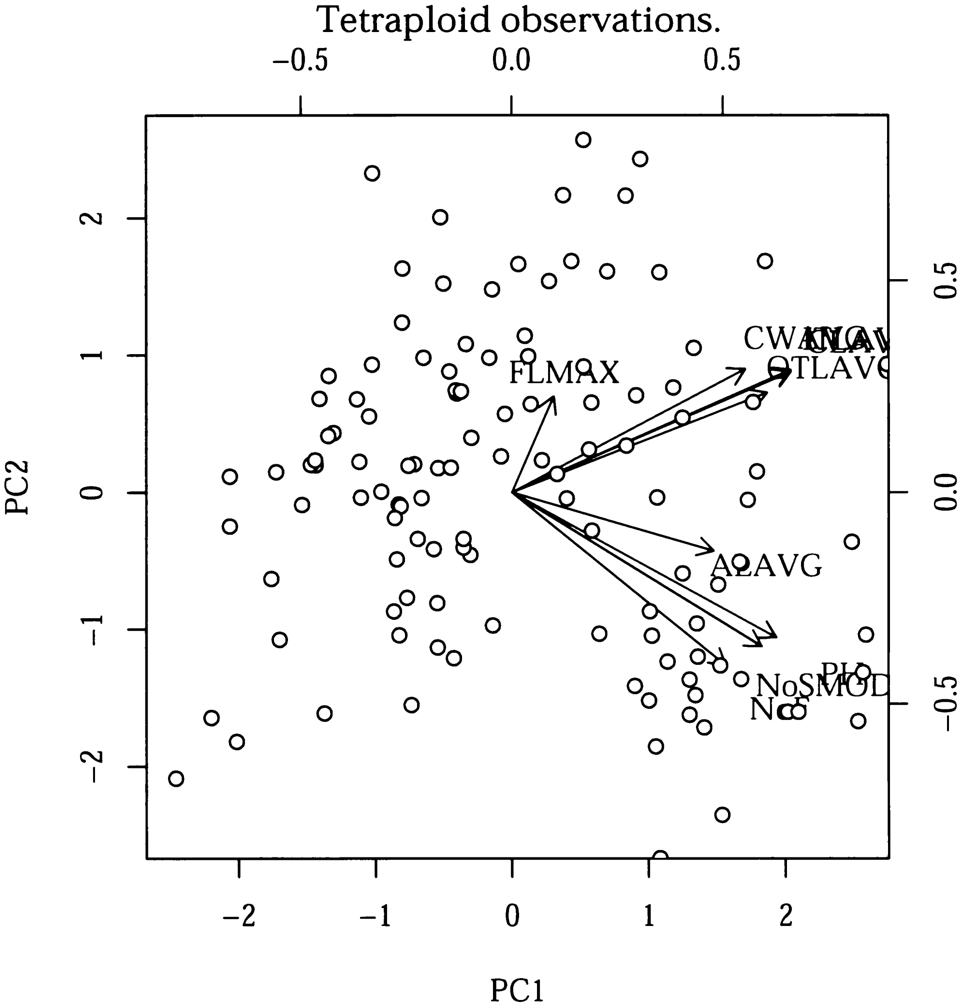

Figure 3.15: Principal components analysis for tetraploid plants.

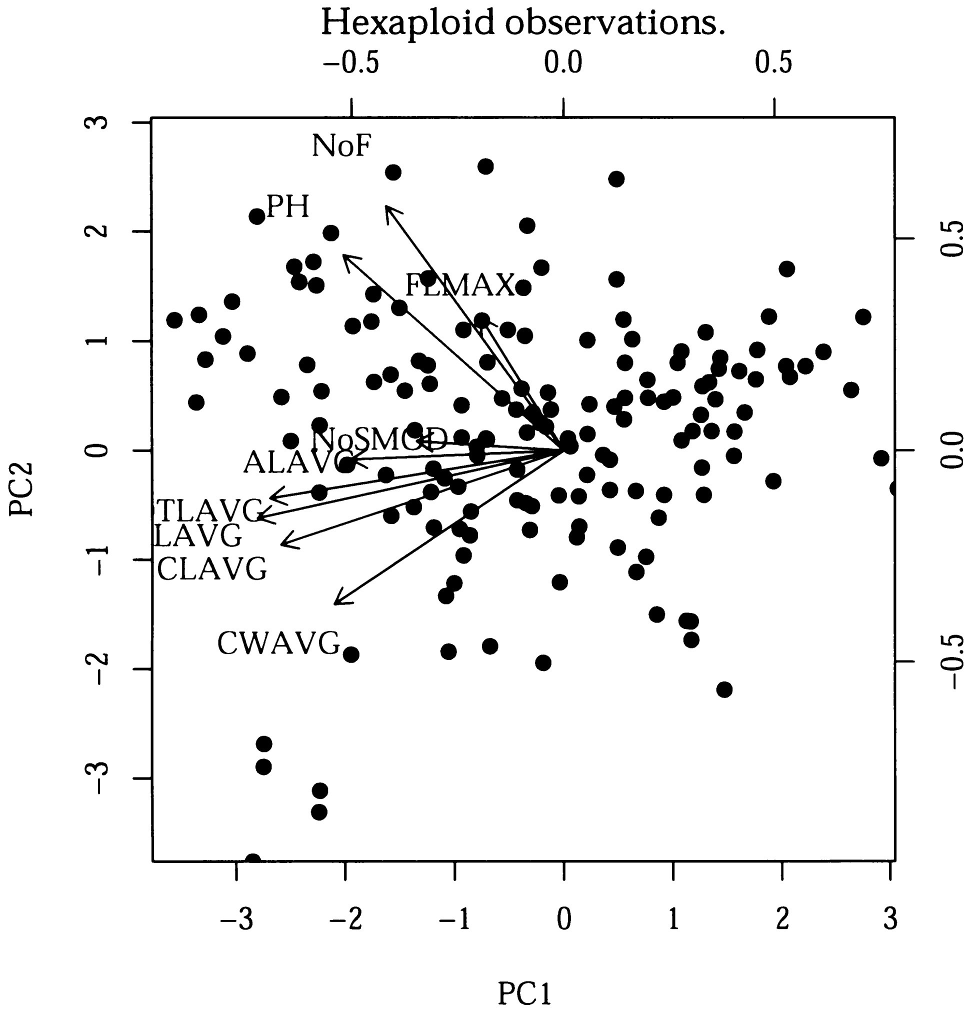

Figure 3.16: Principal components analysis for hexaploid plants.

Table 3.19: Principal component analysis loadings for the first three principal components of hexaploid plants only.

	PC1	PC2	PC3	PC4	PC5	PC6
PH	−0.322	0.496	−0.207	0.276	−0.106	0.021
NoF	−0.260	0.620	−0.101	0.215	0.206	−0.232
CLAVG	−0.414	−0.240	0.091	−0.030	−0.023	0.141
CWAVG	−0.336	−0.391	0.066	0.154	0.323	−0.738
OTLAVG	−0.430	−0.122	0.123	0.158	0.080	0.481
ITLAVG	−0.448	−0.172	0.118	0.113	0.008	0.246
FLMAX	−0.121	0.337	0.766	−0.500	0.084	−0.083
ALAVG	−0.312	−0.023	−0.154	−0.298	−0.814	−0.271
NoSMOD	−0.216	0.024	−0.544	−0.691	0.406	0.092

Table 3.20: Principal component analysis importance for the first three principal components of hexaploid plants only.

	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	2.015	1.163	0.977	0.924	0.837	0.638
Proportion of variance	0.451	0.150	0.106	0.095	0.078	0.045
Cumulative proportion	0.451	0.602	0.708	0.803	0.880	0.926

Multivariate outliers The PCAs indicate the presence of multivariate outliers. A comparison of ordered squared robust Mahalanobis distances of the observations against the empirical distribution function of the MD_i^2 facilitates their detection (see Figure 3.17). The analysis marked the following tetraploid plants as multivariate outliers: 146-15d, 173-1e, 174-1Af, 180-1e, 181-1a, 200-8b, 204-19d, 204-19e, 209-3b, 209-11b, 130b. Similarly, multivariate outliers among hexaploids are: 132a, 132b, 132c, 132d, 195a, 198-2c, 200-2c, 200-2d, 200-22a, 200-17a, 222-3a, 89a. As we can see, these are plants of both ploidy levels from various localities and are positioned in different parts of the ordination space (see Figure 3.17), so they have little in common.

3.3.4 Cluster analyses

Various different clustering algorithms (*e. g.*, k-means clustering, hierarchical clustering, partitioning around medoids) were tried on the data set, but none managed to separate tetraploid observations from hexaploid ones to any appreciable extent.

3.3.5 Discriminant analyses

The data set does not fulfil all the assumptions of linear discriminant analysis (LDA) on account of not having a multivariate normal distribution. Nonetheless, a parametric approach such as generalized canonical discriminant analysis is still useful for descriptive purposes. The data matrix is homoscedastic, and there is not a large difference between the Spearmann correlation matrices of tetraploid and hexaploid observations. For a classification analysis, a non-paramatric method must be preferred.

Canonical discriminant analysis

Figure 3.18 shows the output of generalized canonical discriminant analysis. The distributions of tetraploid and hexaploid observations along the canonical axis overlap considerably. Moreover, the means of the two groups are both positioned near the centre of the discriminant axis, and the box of the hexaploid boxplot crosses the zero point on the first canonical axis. Table 3.21 presents the values of the canonical coefficients. Canonical structure values of PH and NoF are negative. The rest are positive, the largest being the value for ITLAVG followed by CLAVG and CWAVG,

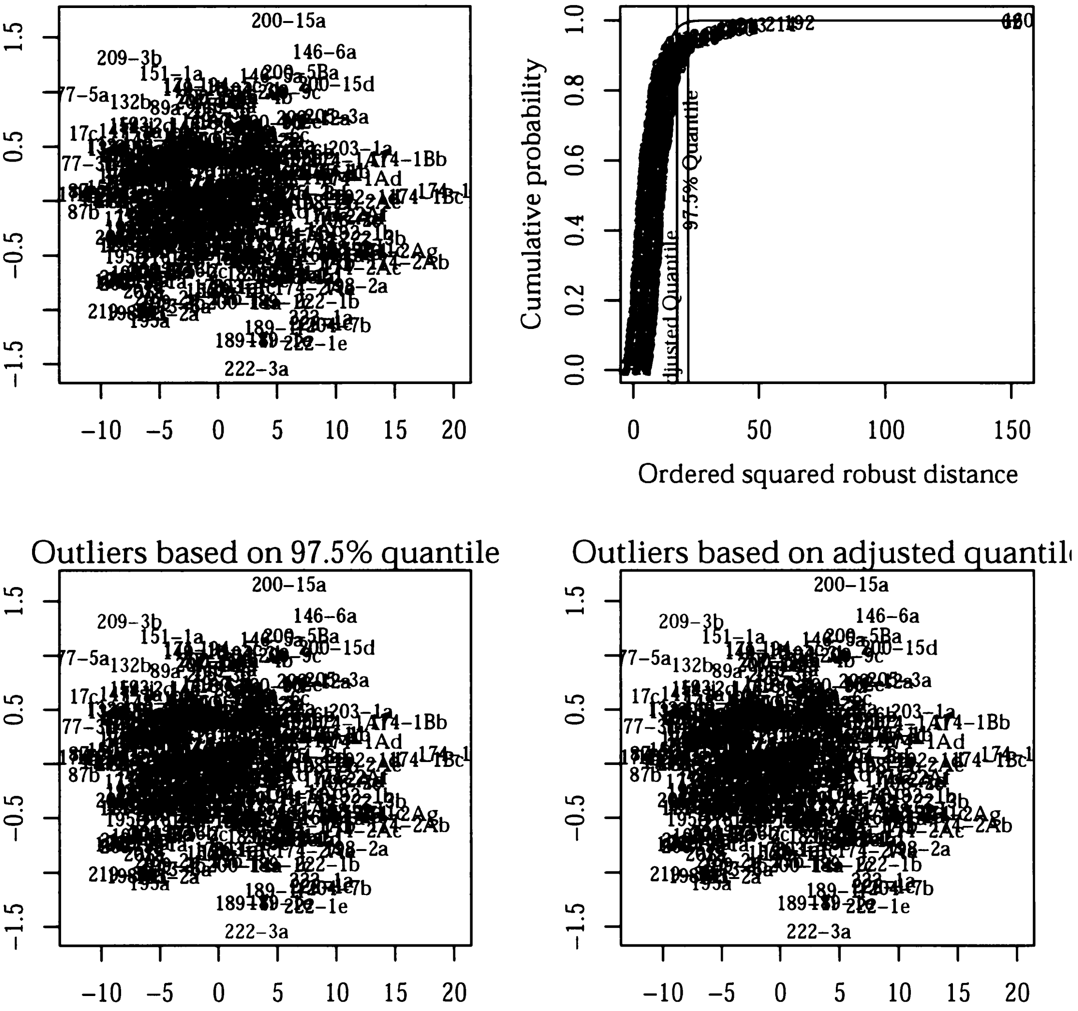

Figure 3.17: Multivariate outliers based on comparing ordered squared robust Mahalanobis distances of the observations against the empirical distribution function of the MD_i^2.

Table 3.21: Canonical coefficients.

	standard	raw	structure
PH	−0.3918	−0.0625	−0.0794
NoF	−0.1308	−0.1707	−0.0582
CLAVG	0.0906	0.7587	0.5937
CWAVG	0.1582	0.9004	0.6116
OTLAVG	−0.8280	−5.8587	0.2714
ITLAVG	1.2705	9.0867	0.7258
FLMAX	0.2005	0.6576	0.2144
ALAVG	−0.0885	−0.2629	0.3119
NoSMOD	0.3992	0.2724	0.4537

which are close to each other, FLMAX, and OTLAVG and ALAVG, which are similarly low.

Many ALAVG measurements are missing from the data set. Because the structure coefficient of ALAVG in the canonical discriminant analysis is only 0.3119, I can omit this variable from further analyses to increase the number of observations to 358.

Classification discriminant analysis

Because the data set violates the assumption of multivariate normality (see Table 3.3.2), a non-parametric method was chosen for classification discriminant analysis, namely the simple k nearest neighbours discriminant (SKNN) classifier. For this analysis, the number of tetraploid and hexaploid observations was the same. The SKNN procedure using 3 nearest neighbours misclassified 16% of individuals in the training set (see Table 3.22). A plot of SKNN predictions (Figure 3.19) illustrates this. This apparent error rate has an optimistic bias. Using the 10-fold cross-validation estimator, the misclassification error of the analysis is estimated at 0.45. This analysis was also tried on individual mixed populations (and groups of populations) with similar results.

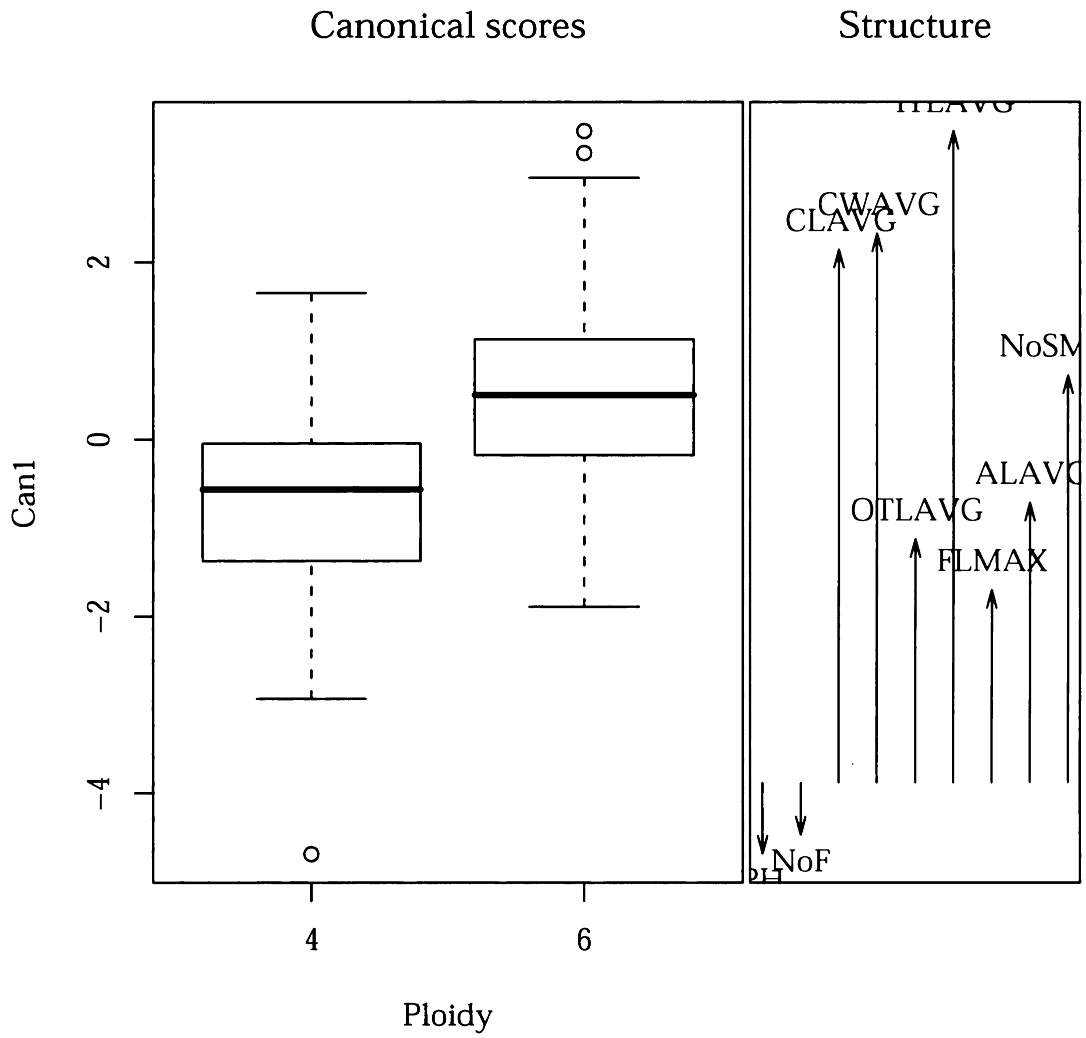

Figure 3.18: Output of generalized canonical discriminant analysis.

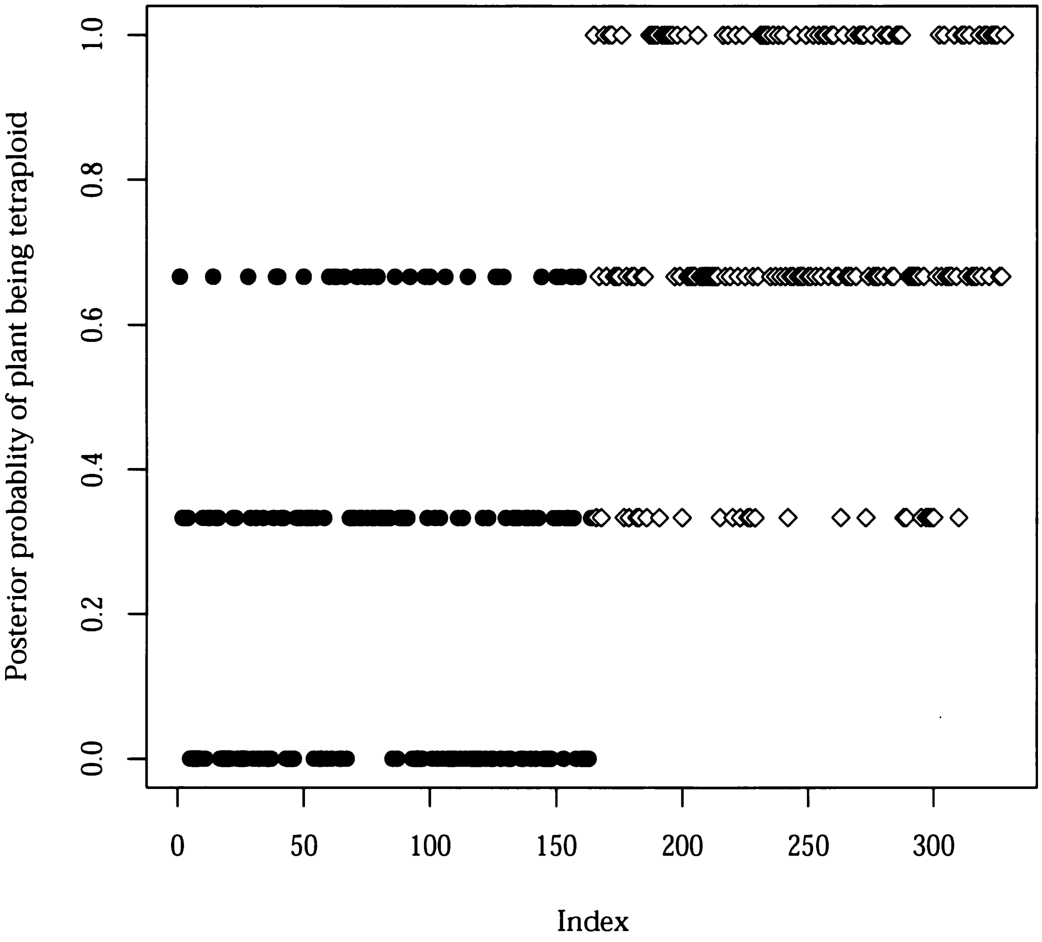

Figure 3.19: Prediction based on simple k nearest neighbours classification. Tetraploids: ◇; hexaploids: •. The apparent error rate of this classification analysis is 0.16. 10-fold crossvalidation increases the error rate to 0.45.

Table 3.22: SKNN confusion.

	tetraploid	hexaploid	$\sum$
tetraploid	84	16	16
hexaploid	17	83	17
$\sum$	52	48	16

Stepwise variable selection

Stepwise variable selection based on SKNN classification using the default performance measure (*i. e.*, correctness rate or 1− error rate) returned this formula: `'Ploidy ~ CWAVG + ITLAVG'`. However, the overall 10-fold cross-validated error rate was 0.36 (the apparent error rate was 0.23). Figure 3.20 shows a partition plot with the classification result of this analysis.

3.4 Protein electrophoresis

Twelve enzymatic systems were tested, of which 6-PGDH, PGI, PGM, DIA, AAT, LAP, ADH and exhibited interpretable diversity (see Table 3.24).

6-PGDH Four genotypes were detected in this dimeric isozyme system: *6-PGDH-aa*, *6-PGDH-ab*, *6-PGDH-ac*, *6-PGDH-aac* and *6-PGDH-bd*. Allelic composition was the same in tetraploids and hexaploids, but hexaploids have a higher proportion of the allele *6-PGDH-a*. Hexaploid accessions 244-1 and 244-2 possibly have the same dosage of alleles *6-PGDH-a* and *6-PGDH-b*. The 'Bakuriani' hexaploid accession is different from the rest, having a heterozygous allelic composition *6-PGDH-bd*.

PGI The slowest zone of activity of this enzyme cannot be interpreted. In its second zone of activity, tetraploid accessions 322-1, 322-2, 323-1 and 323-2 possess two alleles, being of the genotype *PGI-ab*. The allele of the *J. hybridus* accession *(PGI-dd)* is completely different from that of tetraploids. Hexaploid accessions 244-1 and 244-2 have a simpler allelic composition similar to that of tetraploids (322-1, 322-2, 323-1 and 323-2). Other hexaploids except the 'Bakuriani' accession probably have three

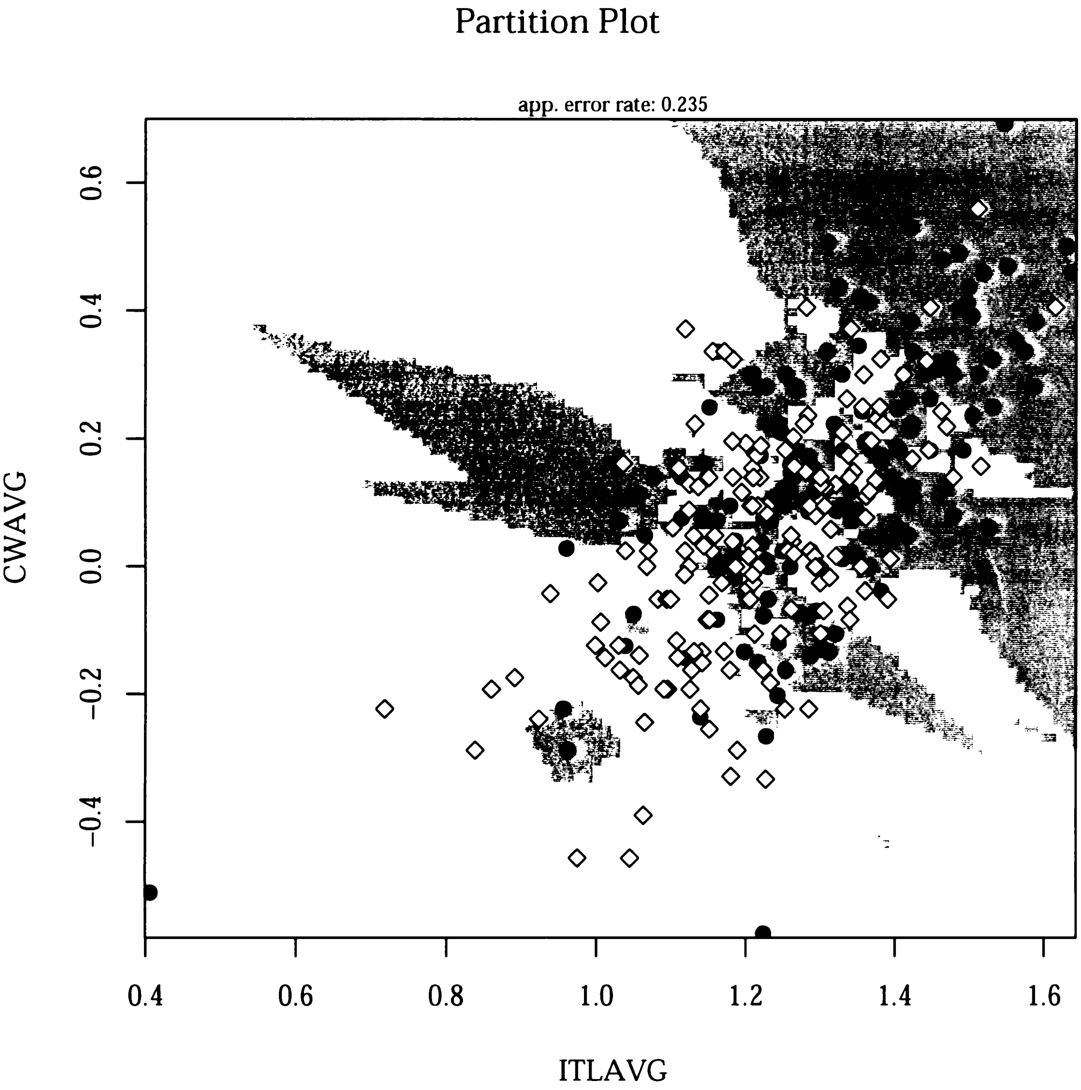

Figure 3.20: Partition plot showing the output of stepwise variable selection based on SKNN classification. Tetraploid group: white background; hexaploid group: grey background. Tetraploids: ◇; hexaploids: •. Incorrectly classified objects have a red outline. The apparent and 10-fold cross-validated error rate of this analysis is 0.23 and 0.36, respectively.

Table 3.23: Samples included in isozyme analysis.

Track	Sample	Ploidy
1	LD405-A	6×
2	LD405-B-1	6×
3	LD405-B-2	6×
4	LD322-1	4×
5	LD322-2	4×
5	LD323-1	4×
7	LD323-2	4×
8	LD244-1	6×
9	LD244-2	6×
10	LD218-1	6×
11	LD218-2	6×
12	LD372	6×
13	146-32	6×
14	LD151	6×
15	LD78	6×
16	173-2B	6×
17	173-6	6×
18	LD107	6×
19	Bakuriani	6×
20	Hybridus	2×

alleles instead of two, their genotype being designated PGI-abc. Hexaploid accessions 78 and 'Bakuriani' also have a simpler allelic composition than the rest of the hexaploids with one allele which is different from that of accessions 244-1 and 244-2., their fenotype being *PGI-ac*.

PGM PGM presented itself at two loci. The slower one, designated locus 2, shows six distinct heterozygous genotypes. Hexaploid accessions except 'Bakuriani' have a unique allele *PGM-a*. Tetraploid accessions 322-1, 322-2, 323-1 and 323-2 differ in having allele *PGM-b*, but accessions 405-A, 405-B-1 and 405-B-2 may have the same allele in their *PGM-bcd* genotype. The faster locus, designated locus 1, is illegible. However, accessions 151 and *J. hybridus* possess a rare, fast allele.

DIA In the fast zone of activity DIA, two homozygous and one heterozygous configurations were found: *DIA-aa*, $DIA\text{-}a_1a_1$ and *DIA-ab*. The neighbouring slower zone of activity possibly also shows two alleles *(a* and *b)*, but it cannot be fully evaluated because of insufficient density.

SHDH did not offer any well defined band pattern.

AAT This dimeric isozyme system exhibited weak bands in accessions 322-1, 322-2, 323-1 and 323-2. They might be homozygous with one allele designated *AAT-aa*. Most other accessions are heterozygous with one allele identical to *AAT-a*.

LAP The accession of *J. hybridus* bears the homozygous configuration *LAP-aa*. Tetraploid accessions 322-1 and 322-2 are homozygous with the allelic configuration *LAP-bb*, while tetraploid accessions 323-1 and 323-2 are heterozygous *(LAP-bc)*. Hexaploid accessions are either homozygous or heterozygous with one to three alleles. Hexaploid accession 'Bakuriani' is notably different from the rest.

ME This hexameric isozyme system exhibits complicated heterozygous configurations.

G-6-PDH could not be resolved.

EST did not provide meaningful patterns.

ADH Two loci of this dimeric enzymatic system, one faster and one slower, showed up: locus 1 and locus 2, respectively. The *J. hybridus* accession possesses a homozygous genotype *(ADH-aa)*, as do tetraploid accessions 322-1, 322-2, 323-1 and 323-2. Hexaploid accessions are heterozygous *(ADH-ab* or *ADH-aab*, possibly also *ADH-abb)*.

NADH could not be interpreted.

Table 3.24: Allelic configurations of interpreted isozymes systems.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6-PGDH	*aa*	*aa*	*aa*	*ac*	*ac*	*ac*	*ac*	*ab*	*ab*	*aac*	*aac*	*aac*	*aac*	*aac*	*aac*	*aac*	*aac*	*aac*	*bd*	*aa*
PGI	*abc*	*abc*	*abc*	*ab*	*ab*	*ab*	*ab*	*ab*	*ab*	*abc*	*abc*	*abc*	*abc*	*abc*	*ac*	*abc*	*abc*	*abc*	*ac*	*dd*
PGM	*bcd*	*bcd*	*bcd*	*bc*	*bc*	*bc*	*bc*	*ac*	*ac*	*ac*	*ac*	*ac*	*ac*	*ac*	*ac*	*ac*	*ac*	*acd*	*bc*	*cc*
DIA	*aa*	*aa*	*aa*	*ab*	*ab*	*ab*	*ab*	*aa*	*aa*	*aa*	*aa*	*aa*	*aa*	*ab*	*aa*	*aa*	*aa*	*ab*	a_1a_1	*aa*
LAP	*ad*	*ad*	*abc*	*bb*	*bb*	*bd*	*bd*			*bb*	*bb*		*bb*	*bb*	*bb*	*bb*	*bb*	*abc*	*ab*	*aa*
ADH	*ab*	*ab*	*ab*	*aa*	*aa*	*aa*	*aa*	*ab*	*ab*	*aab*	*aab*	*aab*	*ab*	*ab*	*ab*	*ab*	*ab*	*ab*	*aab*	*aa*

4

Discussion

Chromosome numbers, nuclear DNA content and ploidy in the *Juncus bufonius* complex

Initial chromosome counting showed that differences in the number of chromosome are reflected in the nuclear DNA content, allowing detection of three ploidy levels within the *Juncus bufonius* complex via flow cytometric analyses (see section 3.2). Looking at the results, I am confident that I have, using relative nuclear genome size as the primary marker, investigated similar morphological phenomena as previous authors who had distinguished between *Juncus bufonius* and *Juncus minutulus* on the basis of chromosome counts. My claim is that it is possible to explain the same amount of morphological variability employing relative nuclear DNA content, as previous authors did using chromosome numbers. Relative nuclear DNA content correlates with chromosome numbers.

Agmatoploidy.

Whether agmatoploidy occurs in the *J. bufonius* complex remains an open question. I have not found evidence of any chromosome fission of fusion, but given the limited number of chromosome spreads done as part of my study, I cannot rule it out. Either way, in the polyploid complex under study, true polyploidy is an important factor. I have therefore focused on studying morphological differences among cytotypes ascertained cytometrically, neglecting possible agmatoploid cytotypes altogether.

Aneuploidy.

The sensitivity of even the best cytometer is an order of magnitude lower than would be needed to detect aneuploidy involving one or a few chromosomes.

2C value ratios.

The estimated nuclear DNA content of hexaploids is somewhat higher than the 2C value of tetraploids multiplied by 1.5 Figure 3.5. The significance of this finding will possibly become apparent in light of future revelations. It could well be caused by methodical error, or it may reflect the fact that hexaploids are not immediate descendants of recent tetraploids. Further research is needed.

Hybridization

Nothing in my results suggests the occurrence of hybrids between tetraploids and hexaploids. No pentaploid was detected. Hybridization might be rare if it happens at all. Cleistogamy, together with a possible phenological shift, would certainly minimize its frequency despite the close contact in which tetra- and hexploids often grow.

Mixed ploidy populations

During FCM analyses I had to cope with contamination of samples by plants of a differing cytotype. The incidence of mixed samples was fairly high, and even when I attempted to analyse individual plants, a small second peak that corresponded to the other cytotype occasionally showed up. This is easy to explain. Seeds from different individuals get randomly shuffled in water, mud or soil only to germinate side by side forming a pseudo tuft. Subsequent close examination of the voucher, localization of the source of the contamination and a re-run of the analysis always resulted in two identifiable samples.

Although hexaploid-only populations were by far the most numerous, mixed tetraploid/hexaploid populations were discovered commonly in some regions visited. On the contrary, exclusively tetraploid populations were dearly rare (see subsection 3.1.2). It is likely that a much higher proportion of populations in fact comprised both ploidy levels, and that the second cytotype just went undetected.

The questions is: are mixed tetraploid/hexaploid populations a result of independent colonization by two unrelated cytotypes, or have hexaploids arisen polytopically from tetraploid progenitors? It is needless to say that the former would support the separation of two distinct, though cryptic, taxa while the latter would be a good reason not to separate the two cytotypes at all.

Geographic distribution, ecological preferences and phenology

Distribution

I cannot say anything new about the distribution of the tetraploid cytotype of *J. bufonius* s. l. in general besides that it certainly is not rare or endangered. I did fail to find tetraploids in some regions I visited (notably the Ukrainian Carpathians, south Carpathians and south-east Slovakia), but in areas where tetraploids were detected they appear to be fairly abundant. Tetraploids are common in Bohemia, less so in Moravia, but it is too early to say. Of course, population numbers fluctuate depending on natural conditions, such as weather, succession, and oft times also the extent of disturbance by human activity, so the occurrence of *J. bufonius* of both cytotypes is largely unpredictable.

Ecology

Differences in ecological requirements between *J. minutulus* and *J. bufonius* s. str. are frequently mentioned in the literature (*e. g.*, Kirschner, 2002*a,d*; see subsection 1.2.4), but the frequency with which tetraploid and hexaploid plants co-occur in mixed populations in various different habitats makes me believe that, for the most part, the ecological preferences of both cytotypes can be considered identical—at least in the areas where I collected them.

Phenology

Despite not having collected any data on the phenology of tetraploids and hexaploids, I partly agree with all previous authors that tetraploids occur somewhat earlier and that they mature more rapidly than hexaploids. However, this can be observed only within mixed populations that are not subjected to any ecological gradient, as micro-habitat conditions easily overshadow any difference. This is nonetheless my opinion based on subjective observations, and a proper study should be conducted to ascertain whether there is a true and constant phenological difference between the two cytotypes.

Morphometric separation of *Juncus minutulus* from *J. bufonius* s. str.

Multivariate analyses.

The results of ordination and discriminant analyses (see subsection 3.3.5) lead me to the conclusion that it is impossible to reliably identify *J. minutulus* on the basis of the supposedly diagnostic morphological characters mentioned in the literature. It has been stated by all previous authors (*e. g.*, Chicouène, 1996; Cope and Stace, 1978, 1985; Harmaja, 2003; Holub, 1976; Kirschner, 2002*b*; Mičieta and Mucina, 1983; van Loenhoud and Sterk, 1976) that values of the given quantitative traits overlap in the two species. The novelty of my findings resides in the extent of the overlaps, which effectively precludes any reliable discrimination between the tetraploid and hexaploid level. Thus, I opine that *J. minutulus*, as a tetraploid, cannot be safely identified on the basis of traditional morphological characters, be it in sympatric or allopatric populations of the two cytotypes. I cannot, however, take a stance on the phylogenetic relationship between the two ploidy levels (see discussion below), so *J. minutulus* may still be a separate taxon from a biosystematic perspective, albeit one that is impossible to identify with reasonable certainty.

My results, herbarium vouchers and subjective experience all indicate that the vast morphological variability within both cytotypes of *J. bufonius* s. l.—as depicted, for example, in Figure 1.2.2—is not discreet but rather continuous and that individual forms are connected by intermediates, hiding the differences between the two cytotypes. Based on my results, I support the view of Cope and Stace (1983) that the supposed morphological distinctions between *J. minutulus* and *J. bufonius* s. str. are fuzzy at the level of the individual and that tetraploids should be pooled together with hexaploids within *J. bufonius*, at least until their position is proved to be separate by use of molecular markers (see discussion below). I view *J. minutulus* and *J. bufonius* s. str. as two distinct cytotypes of a single, variable polyploid taxon. Although the two cytotypes might bear constant cytological distinctions and be mostly or completely reproductively isolated, their morphology does not differ sufficiently to allow a line to be drawn between them. The relationship between the cytotypes might be even more complicated, as hexaploids could have originated through multiple polyploidization events in different times and places. Some of today's populations could even be a mixture of not two but multiple evolutionary lineages of two ploidy levels which are more or less reproductively isolated from each other by developmental as well as cytological barriers (*i. e.,* cleistogamy, phenological shift and polyploidy).

The ecologically conditioned morphological polymorphism of *J. bufonius* s. l. is so great that it overshadows differences associated with ploidy level polymorphism, essentially precluding the possibility of reliable cytotype identification using the given set of morphological characters. I therefore propose to abandon the use of the name *J. minutulus* for tetraploids of the *J. bufonius* complex in favour of accepting the broadly defined species *J. bufonius* L., which comprises two cytotypes (at least). I, personally, will not be presenting '*J. minutulus*' to anybody without using a cytometer beforehand.

Stamens.

That tetraploid individuals with six stamens and tristaminate hexaploid individuals occur has been noted by previous authors. My results clearly show that both tri- and hexastaminate flowers frequently occur on the same plant; moreover, flowers with two, four or rarely five stamens are rarely present as well. Some plants, be it tetraploid or hexaploid, had many anthers present either at the ends of filaments, attached to the side of the capsule or to the stigma on top of it while many other plants had only a few or no anthers at all. In both cytotypes I have rarely found noticeably elongated anthers (up to 2.5 mm), which sometimes even exceed the length of the filaments they are on: a similar finding as that of (Shah, 1963). Extremely long anthers in my collections are not a stable trait but rather an anomaly found in some flowers of some plants in some populations, and not all anthers in a flower are always elongated. The really extremely long anthers are black, which makes me think that they are a result of an infection.

Results of previous studies.

Why do the results of my measurements contradict those of Mičieta and Mucina (1983)? Firstly, Mičieta and Mucina included in their analyses only eight tetraploid accessions from six localities (two were sampled twice) and compared them to seventeen accessions of hexaploid plants, of which mere three were from mixed ploidy (see. Table 1.2). On the contrary, I studied both allopatric and sympatric occurrences of the two cytotypes in 49 populations, of which many were mixed ploidy. It is likely that I managed to sample a broader part of the actual range of values of quantitative values natural populations of the two cytotypes, better reflecting the variability of the species.

Chromosome counting presents a relatively large investment of effort compared to flow cytometry. This possibly led some authors to analyse karyologically populations which showed observable morphological differentiation in order to minimize 'wasted' karyological effort. On the contrary, I have not studied the morphology of toadrush populations in detail prior to surveying them for ploidy levels but rather performed FCM analyses indiscriminately without assessing morphology beforehand. Although this approach resulted in a vast amount of mixed ploidy samples and thus 'wasted' FCM runs, it allowed me to investigate morphological differentiation (or non-differentiation) right in the region of morphological overlap of the two cytotypes. Hence, different sampling methods are to blame for the disparate results. In other words, I think that previous authors who claim the cytotypes can be identified easily have mostly selected—intentionally or not—populations that showed relatively large morphological differences, which allowed them to separate the cytotypes, while my sampling method, exploiting the advantages of flow cytometry, included many cases in which tetraploids are virtually indistinguishable from hexaploids.

Because the two ploidy levels may be misidentified so easily, I think it is very probable that many of the 26 localities keyed out by Holub

(1976) are erroneous. Exactly how many is impossible to tell. Holub (1976) claims being able to reliably tell apart *J. minutulus* and nanomorphs of *J. bufonius* s. str., but with my experience I cannot imagine how this could be achievable.

As mentioned in the introduction, van Loenhoud and Sterk (1976) claimed that certain quantitative characters are diagnostic on the basis of a series of Wilcoxon tests (see subsection 1.2.2). My ordination and discriminant analyses have not found any evidence to support the hypothesis that any of the characters can be used for identifying the two cytotypes despite the fact that Wilcoxon rank sum tests for each of the characters lead to the rejection of the null hypothesis that tetraploid and hexaploid values have the same continuous distribution (with p-values < 0.0000). One could also do T tests for variables that have a normal distribution (see Table 3.8), but such univariate tests are not meaningful for studying multivariate data and classifying observations into groups. I therefore suspect that many of the 584 herbarium sheets van Loenhoud and Sterk (1976) classified using their 'diagnostic' characters have been identified erroneously. They probably misidentified many hexaploids as tetraploids and *vice versa*. I hence consider their conclusions regarding differences in ecology and distribution between *J. minutulus* and *J. bufonius* as at least partially misleading.

Clues based on results of the pilot isozyme study

The series of isozyme pilot analyses served as a preliminary assessment of the utility of this method in the study of the *J. bufonius* polyploid complex. Its limited results do provide some clues as to the composition of isozyme alleles in the group, which allow some speculation about reproductive behaviour, but a thorough isozyme study would be necessary to allow general conclusions to be drawn. This would be desirable in the future.

The *J. hybridus* accession is predominantly (or possibly completely) homozygous at seven loci. This might suggest an autogamous mode of reproduction. Both tetraploids and hexaploids exhibit fixed heterozygous configurations, which might be a indication of their allopolyploid origin. Despite this tentatively allopolyploid fixation, tetraploids are often homozygous, which might suggest a high degree of autogamy over a prolonged period of time. The hexaploid from Bakuriani has either unique alleles or allelic configurations.

Shortcoming of this study

There are several areas that would have deserved attention which were not addressed sufficiently or at all during the course of this study. It would make sense to study seed ornamentation, stomatal length, dimensions of other types of cells (on the capsule surface, for example) and so on as well as other traits, possibly also under controlled growth conditions, including those found not to be diagnostic in this thesis.

Prospects for future research

The still unanswered taxonomic questions merit the application of additional modern methods, especially molecular markers with sufficient resolution at the population level. Further research focusing on the phylogenetic relationships would be beneficial. Depending on future molecular findings, *J. minutulus* might be either a found to be a cryptic species or a part of the variability of *J. bufonius* s. l. If hexaploids are phylogenetically independent of tetraploids or a result of one or a few polyploidization events in ancient tetraploids, then the separation of the *J. minutulus* from *bufonius* could be justified even if individual plants cannot be unequivocally identified using morphological traits. If, however, molecular phylogenetics show that hexaploids have arisen repeatedly from recent tetraploids and perhaps still arise to the present day—as hypothesized by (Cope and Stace, 1985)—then idea of treating tetraploids separately should be abandoned entirely.

Expressing the opinion that the two cytotypes should not be regarded as distinct species does not, however, imply that their existence shall be ignored—quite the opposite. This tetraploid/hexaploid polyploid complex maybe offers an opportunity to study two related (how closely remains to be seen) polyploid cytotypes that live their own lives thanks to strong reproductive isolation. Furthermore, the hypothesized multiple origins of the cytotypes is another exciting possibility in as much as products of polyploidization are likely to be preserved thanks to their probable autogamous mode of reproduction and an ecological strategy ensuring abundance when conditions are favourable. The species' ecological strategy may present a set of complications for the researcher in the field. Its highly opportunistic behaviour causes a certain unpredictability in natural populations can be turned into an advantage when it comes to cultivation experiments, as germination and cultivation is comparatively straightforward and requiring little more than water, light and soil. Low outcrossing rates can also be exploited, for the progeny is likely to be genetically rather uniform. The fact that chasmogamy is more common in hexaploids as opposed to tetraploids is another interesting topic. Why is it that a higher polyploid opens its flowers more often than its progenitor of a lower ploidy level. And is it really so? If the two cytotypes are found to be immediately related, they could serve as study material for exploring physiological, phenological, microecological and other differences stemming from differences in nuclear genome size alone, as they are morphologically almost identical. Certain tendencies, however obscured by phenotypic plasticity under natural conditions, might show up as significant when conditions are controlled. The ease of cultivation together with an autogamous mode of reproduction in my opinion make *J. bufonius* s. l. a very suitable model for such experiments. All in all, different cytotypes are captivating in their own right even if their classification as separate, morphologically diagnosable taxa is untenable.

5

Conclusion

To conclude, lets summarize the answers to the questions posed in section 1.3.

1. Populations of *J. bufonius* s. l. consist of either tetraploid or hexaploid individuals or both, mixed ploidy populations being a regular occurrence.

2. Tetraploids differ from hexaploids (and diploids) in both nuclear DNA content and chromosome number; therefore, I consider true polyploidy, as opposed to agmatoploidy, as the primary source of karyological differences.

3. Tetraploid and hexaploid individuals of *J. bufonius* s. l. cannot be reliably distinguished using previously mentioned quantitative morphological characters. In a discriminant analysis almost half of the individuals were misclassified.

4. Differentiation in quantitative morphological characters between the two cytotypes of *J. bufonius* s. l. is far smaller than previously thought. The overlapping of values of characters is far greater than is presented as diagnostic in all published determination keys. In fact, the results of this study suggest that these characters should not be considered diagnostic at all.

Literature cited

Abramoff, M. D., P. J. Magelhaes and S. J. Ram (2004). 'Image processing with ImageJ'. *Biophotonics International* **11**(7), 36–42. 56

Albert, A. and E. Jahandiez (1908). *Catalogue des plantes vasculaires du departament du Var*. Paris. 29, 30, 32

Ascherson, P. (1871). 'Über die Beständigung bei Juncus bufonius L.'. *Botanische Zeitung* **24**, 551–555. 49

Ascherson, P. (1872). 'Noch einige Beobachtungen über die Bestäubung bei Juncus bufonius L'. *Botanische Zeitung* **30**, 697–699. 49

Babock, E. G. and G. L. Stebbins (1938). 'The American species of Crepis: their relationships and distribution as affected by polyploidy and apomixis'. *Carnegie Institution of Washington Publication.* 39

Batalin, A. (1871). 'Die Selbstbestäubung bei Juncus bufonius'. *Botanische Zeitung* **29**, 388. 49

Bernhardt, K. G. (1993). 'Populationsbiologische Untersuchungen an Juncus bufonius an sekundären Abgrabungsstandorten'. *Zeitschrift für Ökologie und Naturschutz* **2**(3), 13–19. 50

Bremer, K. and T. Janssen (2006). Gondwanan origin of major monocot groups inferred from dispersal-vicariance analysis. In J. T. Columbus, E. A. Friar, J. M. Porter, L. M. Prince and M. G. Simpson (Eds.). 'Monocots: Comparative biology and evolution. Excluding Poales'. Vol. 22. Rancho Santa Ana Botanical Garden. Claremont, Ca. Aliso. pp. 22–27. 27

Brown, M. B. and A. B. Forsyth (1974). 'Robust tests for equality of variances'. *Journal of the American Statistical Association* **69**, 364–367. 61

Buchenau, F. (1870). 'Kleinere beiträge zur Naturgeschichte der Juncaceen'. *Abhandlungen naturwissenschaftlichen verein zu Bremen* **2**, 365–404. 49

Buchenau, F. (1871). 'Über die Dimerie bei Juncus'. *Abhandlungen naturwissenschaftlichen verein zu Bremen* **2**(3), 368. 49

Cherepanov, S. K. (1973). *Svod dopolnenii i izmenenii k "Flore SSSR" (TT. I-XXX)*. Nauka. Leningrad. 32

Chicouène, D. (1996). 'Complements pour la determination des Joncacees armoricaines: I. Le groupe se Juncus bufonius'. *E. R. I. C. A., Bulletin de Botanique Armoricaine* **8**, 52–56. 44, 45, 46, 48, 50, 119

Cope, T. A. and C. A. Stace (1973). 'The segregates of Juncus bufonius agg.'. *Watsonia* **9**(4), 426. 30, 37

Cope, T. A. and C. A. Stace (1978). 'The Juncus bufonius L. aggregate in western Europe'. *Watsonia* **12**(2), 113–128. 43, 119

Cope, T. A. and C. A. Stace (1983). 'Variation in the Juncus bufonius L. aggregate in western Europe'. *Watsonia* **14**(3), 263–272. 35, 36, 37, 39, 40, 67, 120

Cope, T. A. and C. A. Stace (1985). 'Cytology and hybridization in the Juncus bufonius L. aggregate in western Europe'. *Watsonia* **15**(4), 309–320. 29, 37, 39, 40, 42, 50, 119, 123

Dean, P. N., C. B. Bagwell, T. Lindmo, R. F. Murphy and G. C. Salzman (1990). 'Data file standard for flow cytometry'. *Cytometry* **11**, 323–332. 59

Delay, C. (1947*a*). 'Recherches sur la structure des noyaux quiescents chez les phanérogames'. *Revue de Cytologie et de Cytophysiologie. Végétales* **9**, 169–223. 43

Delay, C. (1947*b*). 'Recherches sur la structure des noyaux quiescents chez les phanérogames'. *Revue de Cytologie et de Cytophysiologie. Végétales* **10**, 103–229. 43

Doležel, J. and J. Bartoš (2005). 'Plant DNA flow cytometry and estimation of nuclear genome size'. *Annals of Botany* **95**, 99–110. 60

Drábková, L., J. Kirschner and Č. Vlček (2006). 'Phylogenetic relationships within Luzula DC. and Juncus L. (Juncaceae): A comparison of phylogenetic signals of trnL-trnF intergenic spacer, trnL intron and rbcL plastome sequence data'. *Cladistics* **22**, 132–143. xi, 27, 28

Drábková, L., J. Kirschner, O. Seberg, G. Petersen and Č. Vlček (2003). 'Phylogeny of the Juncaceae based on rbcL sequences, with special emphasis on Luzula DC. and Juncus L.'. *Plant Systematics and Evolution* **240**, 133–147. 27

Drábková, L., J. Kirschner, Č. Vlček and V. Pačes (2004). 'TrnL-trnF intergenic spacer and trnL intron define clades within Luzula and Juncus (Juncaceae)'. *Journal of Molecular Evolution* **59**(1), 1–10. 27

Ertter, B. (2000). 'Keys to Juncus and Luzula of California'. prepared for and modified during Friends of the Jepson Herbarium Weekend Workshop on Juncaceae, July, 2000. 37

et al Hitchcock, C. L. (1969). *Vascular plants of the Pacific Northwest*. Vol. 1. Seattle and London. 32

et al Prain, D. (Ed.) (1921). *Index Kewensis plantarum phanerogamarum. Supplementum quintum*. Oxonii. 29, 32

Foerster, E. (1969). 'Die Juncus bufonius-Gruppe'. *Gött. Flor. Rundbriefe* **1**, 31–32. Neudruck 1969. 30

Galbraith, D. W., G. M. Lambert, J. Macas and J. Dolezel (1998). Analysis of nuclear dna content and ploidy in higher plants. In J. P. Robinson, Z. Darzynkiewicz, P. N. Dean, L. G. Dressler, A. Orfao, P. S. Rabinovitch, C. C. Stewart, H. J. Tanke and L. L. Wheeless (Eds.). 'Current protocols in cytometry'. John Wiley & Sons. New York. p. 7.6.1–7.6.22. 60

Hämet-Ahti, L. and V. Virrankoski (1970). 'Chromosome numbers of some vascular plants of north Finland'. *Annales botanici Fennici* **7**, 177. 43

Harmaja, H. (2003). 'Notes on Juncus minutulus, `http://www.fmnh.helsinki.fi/users/harmaja/Juncus_minutulus.htm`'. Latest revision December 14, 2004. 42, 44, 45, 47, 50, 56, 119

Harriman, N. A. and D. Redmond (1976). 'Somatic chromosome numbers for some North American species of Juncus'. *Rhodora* **78**, 727–738. 43

Hartman, C. J. (1858). *Handbok i Skandinaviens Flora*. 7 edn. Zacharias Haeggström. Stockholm. 30

Hill, A. W. (1917). 'XXIX.—The flora of the Somme battlefield'. *Bulletin of Miscellaneous Information* **9** & **10**, 297–300. 50

Holub, J. (1976). 'Juncus minutulus přehlížený nový druh druh československé květeny. (Juncus minutulus a neglected new species of the Czechoslovac flora)'. *Preslia* **48**(4), 329–339. 30, 32, 34, 35, 50, 51, 119, 121, 122

Hultén, E. (1971). *Atlas över växternas utbredning i Norden*. Generalstabens litografiska anstalts förlag. Stockholm. xi, 31

Jørgenson, C. A., Th. Sørensen and M. Westergaard (1958). 'The flowering plants of Greenland. A taxonomical and cytological survey'. *Biologiske Skrifter Danske Videnskabernes Selskab* **9**(4), 47. 43

Kirschner, J. (2002*a*). 134. Juncaceae Juss. - sítinovité. In K. Kubát, L. Hrouda, J. jun. Chrtek, Z. Kaplan, J. Kirschner and J. Štěpánek (Eds.). 'Klíč ke květeně České republiky [Key to the Flora of the Czech Republic]'. Academia. Praha. 29, 46, 50, 119

Kirschner, J. (2002*b*). *Juncaceae 1: Rostkovia to Luzula, Species Plantarum: Flora of the World Part 6*. ABRS, Canberra. 119

Kirschner, J. (2002*c*). *Juncaceae 2: Juncus subg. Juncus, Species Plantarum: Flora of the World Part 7*. ABRS, Canberra. 28

Kirschner, J. (2002*d*). *Juncaceae 3: Juncus subg. Agathryon, Species Plantarum: Flora of the World Part 8*. ABRS, Canberra. 29, 30, 42, 44, 45, 46, 50, 51, 119

Kreczetovich, V. I. and N. F. Gontscharov (1935). Sem. XXXII. Sitnikovyje — Juncaceae Vent.. In V. I. Komarov, B. K. Shishkin and al. (Eds.). 'Flora SSSR 3.'. Vol. 3. Akademiia nauk SSSR. Leningrad. pp. 504–576. 32, 34, 35, 44, 45, 46, 47

Leitch, I. K., D. E. Soltis, P. S. Soltis and M. D. Bennet (2005). 'Evolution of DNA ammounts accross land plants (Embryophyta)'. *Annals of Botany* **95**, 207–217. 27, 39

Löve, Á. (1980). 'Chromosome Number Reports LXIX'. *Taxon* **29**(5/6), 703–730. 43

Löve, Á. and D. Löve (1948). *Chromosome numbers of northern plant species.* Iceland University, Institute of Applied Sciences, Department of Agriculture, Report B. Reykjavic. 43

Löve, Á. and D. Löve (1961). 'Chromosome numbers of Central and Northwest European plant species'. *Opera Botanica.* 28

Löve, A. E. (1981). 'Chromosome number reports LXXIII'. *Taxon* **30**, 829–861. 43

Marie, D. and S. C. Brown (1993). 'A cytometric exercise in plant dna histograms, with 2c values for 70 species'. *Biology of the Cell* **78**, 41–51. 60

Mičieta, K. (1980). Rod Juncus L. na Slovensku. (The genus Juncus L. in Slovakia). PhD thesis. Univerzita Komenského. Bratislava. 30

Mičieta, K. and L. Mucina (1983). 'A numerical taxonomic study of the Juncus bufonius aggregate (Juncaceae) in Slovakia'. *Plant Systematics and Evolution* **142**(3–4), 137–148. xiii, 29, 35, 36, 38, 119, 121

Moerman, D. E. (1998). *Native American Ethnobotany.* Timber Press. 51

Novikov, V. S. (1978). 'Synopis speciorum generis Juncus L. ex Asia Media'. *Novitates systematicae plantarum vascularium* **15**, 77–93. 30, 35

Otto, F. (1990). Dapi staining of fixed cells for high-resolution flow cytometry of nuclear dna. In H. A. Crissman and Z. Darzynkiewicz (Eds.). 'Methods in Cell Biology'. Vol. 33. Academic Press. New York. pp. 105–110. 59

Ovchinnikova, P. N. and A. P. Chukavina (1963). Sem. 24. Sitnikovyje — Juncaceae Vent. (Addenda). In Ovchinnikov and al. (Eds.). 'Flora Tadžikskoj SSR'. Vol. 2. Nauka. Moskva & Leningrad. pp. 159–178. 50

Podlech, D. and A. Dieterle (1937). 'Chromosomenstudien an afghanistanischen Pflanzen'. *Candollea* **24**, 185–243. 43

R Development Core Team (2008). *R: A Language and Environment for Statistical Computing.* R Foundation for Statistical Computing. Vienna, Austria. ISBN 3-900051-07-0. 61

Rasband, W. S. (1997–2007). 'ImageJ'. 56

Rohweder, H. (1937). 'Versuch zur Erfassung der mengenmässigen Bedeckung des Darss und Zingst'. *Planta* **27**, 501–549. 43

Schubert, R., E. Jäger and K. Werner (1987). *Exkursionflora für die Gebiete der DDR und der BRD. Atlas der Gefässpflanzen*. Volk und Wissen Volkseigener verlag. Berlin. xi, 35, 40

Segal, S. (1962*a*). 'Het soortsbegrip bij het Juncus bufonius complex'. *Jaarb. Kon. Ned. Bot. Ver.* pp. 58–59. 32, 43

Segal, S. (1962*b*). 'On the species concept in the Juncus bufonius complex'. Jubilee meeting of the Czechoslovak Botanical Society, July 1962, Prague. Summary of a lecture. 32, 43

Sell, P. and G. Murrell (2006). *Flora of Great Britain and Ireland: Butomaceae – Orchidaceae*. Vol. 5. Cambridge University Press. 42

Shah, C. K. (1963). 'The life history of Juncus bufonius Linn.'. *Journal of the Bombay Natural History Society* **42**, 238–251. 121

Snogerup, S. (1959). In R. Dahlgren (Ed.). 'Frøan Lunds Botaniska Förenings Förhändlinger'. Vol. 112. pp. 101–110. 43

Snogerup, S. (1971). Juncaceae.. In K. H. Rechinger (Ed.). 'Flora Iranica'. 75. Akademische Druck und Verlagsanstalt. Graz. 32, 36, 37, 43, 44, 45, 46

Snogerup, S. (1980). Juncus bufonius group. In T. T. G., V. H. Heywood, N. A. Burges, D. H. Valentine, S. M. Walters and W. D. A. (Eds.). 'Flora Europaea'. Vol. 5. Cambridge University Press. pp. 107–108. 30, 36

Snogerup, S. (1985). Juncus L.. In P. H. Davis (Ed.). 'Flora Turkey and the east Aegean islands'. Vol. 9. Edinburgh University Press. Edinburgh. pp. 1–25. xi, 29, 37, 44, 45, 46, 47

Stace, C. A. (1992). *Plant Taxonomy and Biosystematics*. Cambridge University Press. 42

Stace, C. A. and H. Thompson (1997). *New Flora of the British Isles*. Cambridge University Press. 42

Stasiak, J. (1978*a*). 'Populacyjna zmiennosc i studia systematyczno-geograficzne nad wybranymi gatunkami rodzaju Juncus L. w Polsce.

Cz. 1. Zmiennosc morfologiczna-anatomiczna Juncus compressus Jacq. i J. gerardi Lois. [Populational variability and systematic-geographical studies of selected species of the genus Juncus l. in Poland. Part 2. The morphological variability of Juncus compressus Jacq. and J. gerardii Lois'. *Fragm. Flor. Geobot.* **24**(4), 529–591. 35

Stasiak, J. (1978*b*). 'Populacyjna zmiennosc i studia systematyczno-geograficzne nad wybranymi gatunkami rodzaju Juncus L. w Polsce. Cz. 2. Zmiennosc morfologiczna Kompleksu Juncus bufonius L. [Populational variability and systematic-geographical studies of selected species of the genus Juncus l. in Poland. Part 2. The morphological variability of the Juncus bufonius L. complex.]'. *Fragm. Flor. Geobot.* **24**(4), 593–619. 30, 35, 36

Uhriková, A. (1974). In J. *et* al. Májovský (Ed.). 'Index of chromosome numbers of Slovakian flora (Part 4)'. Vol. 23. pp. 1–23. 43

van Loenhoud, P. J. and A. A. Sterk (1976). 'A study of the Juncus bufonius complex in the Netherlands'. *Acta Botanica Neerlandica* **25**(3), 193–204. xi, 29, 30, 33, 34, 35, 36, 43, 44, 46, 50, 119, 122

Weimarck, H. (1963). *Skøanes Flora*. Lund. 43

Wulff, H. D. (1937). 'Karyologische Untersuchungen an der Halophytenflora Schleswig-holsteins'. *Jahrbuch für Wissenschaftlich der Botanik* **84**, 812–840. 32, 43

A

Morphometric data set

Table A.1: Primary morphological data. See section 2.3 for an explanation of the gathering process. PH – plant height, Number of Flowers, ToS – thickness of stem at base, CL – capsule length, CW – capsule width, OTL1–3 – outer tepal length, ITL1–3, inner tepal length, NoS – number of stamens, FL1–4 – filament length, AL1-4 – anther length. For the purpose of printing, the values have been rounded to two decimal places. See Table A.2 for data matrix used in multivariate analyses.

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
39A	39Aa	6	17	9		0	69	30	113	115	119	90	91	96	3	25	26			9			
39A	39Aa	6				0	64	29	122	124	107	80	81	86	6	21	26			9	10		
39A	39Aa	6				0	65	22	132	113	131	90	87	88	3	27	26	25		9			
39A	39Ab	6	20	21		0	75	22	154	123	155	100	96	95	3	30	31			8	9	10	
39A	39Ab	6				0	74	29	128	117	129	92	93	92	3	32	27			9	10	10	
39A	39Ab	6				0	70	26	144	108		87	85		3	26	31						
39A	39Ac	6	17.5	15		0	72	23	135	109	129	95	93	90	3	32	42			9	9	10	
39A	39Ac	6				0	70	25	126	128	107	94	95	93	3	30	29	32					
39A	39Ac	6				0	69	24	105	102	116	79	81	80	6	24	25	22		9			
39A	39Ad	6	19.5	22		0	70	28	127	145	143	86	97		3	33				10	11		
39A	39Ad	6				0	68	27	104	109	114	86	88	89	6	27	31			10	10	9	
39A	39Ad	6				0	71	21	126	106		91	92	91	6	26	30			9	10		
39A	39Ae	6	16.5	8		0	74	27	120	145	147	85	86		3	35	30	29		8	9		
39A	39Ae	6				0	66	28	104	109	107	87	86	85	3	32	28						
39B	39Ba	4	9.5	6		0	74	26	109	107	103	71	76	79	3	22	23			9	8		
39B	39Ba	4				0	69	25	95	103	103	74	76	77	3	29	30			9			
39B	39Ba	4				0	72	26	101	107	100	82	86		3	27	26						
39B	39Bb	4	9.5	14		0	63	24	102	102		66	80	57	3	24	26						
39B	39Bb	4				0	60	25	97	108	105	85	81	86	3	22							
39B	39Bb	4				0	71	26	110	111	97	78	79	81	3	23	26						
39B	39Bb	4				0	74	26	117	118	99	83	86	83	3	30	28			15	15	14	
39B	39Bb	4				0	63	25	87	88	89	76	79	87	3	25	27			9	9	9	
39B	39Bc	4	9	7		0	76	21	100	106	116	84	81	87	3	26	25						
39B	39Bc	4				0	70	24	104	105	98	72	74	70	3	25	26						
39B	39Bc	4				0	76	28	96	103	107	77	90	72	3	26	27			16	15	15	
39B	39Bd	4	11	15		0	68	19	129	100	123	77	80	86	3	25							
39B	39Bd	4				0	66	27	91	104	103	77	80	86	3	25							
39B	39Bd	4				0	79	25	107	105	98	82	86	93	3	28	26			14	14		
39B	39Be	4	9.5	8		0	68	20	107	139	127	81	82	84	3	30	28						
39B	39Be	4				0	72	22	91	105	95	76	77		3	27	29			7			
39B	39Be	4				0	69	25	91	107	108	71	77	76	6	28	26			8			
102	102a	4	19	11		0	65	23	98	106	102	76	77		3	26	30			9	8		
102	102a	4				0	68	23	89	100	105	80	81	82	3	27							
102	102a	4				0	62	23	106	97		72	61		3	24	26	26	30	6			
102	102a	4				0	71	22	96	85	97	70			3	29							
102	102b	4	21	15		0	64	16	130	107	132	86	80	87	3	23	25						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
102	102b	4				0	60	16	121	123	104	87	76	81	3	24	24						
102	102b	4				0	62	20	85	80	86	67	68	70	3	22	26			6			
102	102b	4				0	68	21	104	107	93	70	79	80	3	26	25						
102	102b	4				0	69	21	86	87	81	70	70	70	3	24							
102	102c	4	18	12		0	67	18	120	133	117	77	76	86	3	30				10	11	10	
102	102c	4				0	50	14	80	80	76	66	64	65	3	19	20			9	8		
102	102c	4				0	59	15	102	94	91	72	71	70	3	27				6			
102	102c	4				0	50	17	80	102	103	80	70	70	3	29	24			7			
102	102d	4	17	9		0	61	22	82	96	100	66	73	70	3	31	25						
102	102d	4				0	65	20	95	96	86	71	72	73	3	26	22						
102	102d	4				0	60	23	89	96	97	76	75	80	3	26	26			10	8	10	
102	102e	4	21	11		0	61	17	107	102	108	79	68		3	22	20			7			
102	102e	4				0	55	16	111	112		79	94		3	18				10			
102	102e	4				0	61	24	94	91	87	84	83	86	3	26	27			13	12		
102	102e	4				0	67	24	86	104	103	75	77		3	29							
102	102f	4	19	14		0	73	16	104	125	116	83	76		3	25				9			
102	102f	4				0	63	23	107	98	106	67	78		3	24	26			8			
102	102f	4				0	65	20	91	84	78	84	76	77	3	28	27			8			
102	102f	4				0	61	18	99	94	164	79	78	81	3	32	32	31					
132	132a	6	7.5	5		0	103	25	129	139		91	100		6	25	30	29		12	11	10	12
132	132a	6				0	98	31	111	116		95	100		6	20	25			13	10		
132	132b	6	6.5	3		0	96	30	121	110		91	96		6	25	25			11	12		
132	132b	6				0	95	55	111	105		94	90	86	6	23	25			16	14		
132	132b	6				0	99	35	120	124		100	100		6	25	30			11	11	12	14
132	132c	6	4.5	4		0	93	26	101	112	124	92	96		6	26	26			15	11		
132	132c	6				0	89	30	113	109	111	107	91		6	25	25			12	11		
132	132c	6				0	100	32	120	109		96	105		6	26	28			11	11	11	
132	132d	6	4.5	4		0	95	31	111	108		89	90		6	24	25			16	15		
142	142a	6	6	6		0	77	25	113	115	104	84	89	90	3	23				17	17		
142	142a	6				0	72	33	105	106	93	82	87	83	3	31	30						
142	142a	6				0	70	30	91	90	96	77	78	76	3	29							
142	142b	6	7	10		0	78	26	124	124	110	94	78	96	3	28							
142	142b	6				0	68	28	108	109	103	87	89	86	6	25	24			14	13		
142	142b	6				0	65	29	94	105	107	83	86	85	3	30	30			12	11		
142	142c	6	7.5	6		0	64	28	104	96	107	77	86	83	3	32							
142	142c	6				0	56	23	80	96	95	71	68	96	6	23	30	29		9	7	7	

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
142	142c	6				0	65	25	103	90	98	75	82	76	3	29							
146-29	146-29a	6	13	6	12	0	70	28	97	94		77	77		3	26				10			
146-29	146-29a	6				0	66	34	100	103		76	83		3	36	26			8	8	8	
146-29	146-29a	6				0	61	30	98	89		72	75		3								
146-29	146-29a	6				0	65	29	105	90		88			3	28							
146-29	146-29b	6	9	10	9	0	51	22	88	86		67			3	23							
146-29	146-29b	6				0	50	22	80	81		70			6	20				9			
146-29	146-29b	6				0	55	20	80	79		75			3	11							
146-29	146-29b	6				0	50	21	80			70			3	20				10	11	8	
146-29	146-29b	6				0	58	24	86	89		79			3	21				8			
146-5	146-5a	6	18.5	6	8	0	64	22	105	95		73	71		5	20				7			
146-5	146-5a	6				0	67	25	90	90		65			6	21				9	9		
146-5	146-5a	6				0	61	28	102	86	100	67			6	22	20			7	8		
146-5	146-5b	6	15	9	7	0			100	90		80			6	28				9			
146-5	146-5b	6				0	66	23	90	96		85	78		3	26							
146-5	146-5b	6				0	64	25	107	105		76	74		6	26	22						
146-10	146-10a	6	9	7	10				105	115		66	62		3								
146-10	146-10a	6							100	110		63	65		3	22	20			20	21		
146-10	146-10a	6							93	98		65			3	20				20	20		
146-9	146-9a	6	13.5	12	12	0	46	19	59	50		49	45		6	20	18			12	10		
146-9	146-9a	6				0	63	24	82	76		65	65		6	20	20						
146-9	146-9b	6	12.5	7	10	0	64	23	86	81		68	65		6	24	20						
146-9	146-9b	6				0	60	25	84	83	80	65	69	68	6	21	20			11	10		
146-4	146-4a	6	14.5	6	12	0	60	22	110			76	80		3	26							
146-4	146-4a	6				0	65	22	85	95		75	72		6	26				16			
146-4	146-4b	6	17.5	7	14	0	64	20	108	100	102	91	90	80	3	24				18			
146-4	146-4b	6				0	72	21	116	94		70	80		6	25							
146-4	146-4b	6				0	60	20	95	87		69	59		6	17							
146-4	146-4c	6	12	8	10	0	70	23	105	90		80	84		6	34	26			20			
146-4	146-4c	6				0	60	22	105	90		80	83		6	29							
146-4	146-4c	6				0	66	22	105	108		85	86		6	30	26						
146-15	146-15a	4	7.5	6	8	0	55	17	97	89	86	66	70		3	24	21			12	14		
146-15	146-15b	4	10	8	9	0	59	26	99	90		81	71		6	22							
146-15	146-15c	4	12	8	10	0	65	25	96	95		72			3	25				14			
146-15	146-15c	4				0	70	15	82	96		66	61		3	25	26			12	12		
146-15	146-15d	4	13	8	10	0	70	20	110	114	105	82	90	91	3	27							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
146-15	146-15d	4				0	71	10	105	107		82	81		3	25							
146-15	146-15d	4				0	62	18	105	107		71	76	78	6	23	22			50	18		
146-15	146-15d	4				0	68	22	115	110		87	84		3	27							
146-15	146-15d	4				0	62	24	110	110		76	78		4	21							
146-15	146-15d	4				0	59	20	107	107		68			3	22							
146-6	146-6a	4	23	7	13	0	71	27	102	100	110	94	86		6	27				18			
146-6	146-6a	4				0	65	23	102	105		75	81	83	6	23							
146-6	146-6a	4				0	60	22	95	100	102	89	86		5	25							
146-6	146-6b	4	21	15	12				110	115		87			6	30	28						
146-6	146-6b	4				0	71	23	111	110		85	84		6	26	25						
146-6	146-6b	4				0	62	24	85	4		65	75		6	25							
146-6	146-6b	4				0	62	24	100	107		85	87		6	27				14			
146-6	146-6b	4				0	66	24	93	92		70	80		6	22							
146-6	146-6b	4				0	65	30	105	104		80	80		6	25	24			20	20		
146-6	146-6c	4	19	11	12	0	73	25	100	100	95	80	85	82	6	27				18			
146-6	146-6c	4				0	66	26	104	95	98	80	79		3	29							
146-6	146-6c	4				0	69	26	111	110	100	70	80		4	21							
146-6	146-6d	4	14.5	4	10	0	76	26	130	100		82			6	31							
146-6	146-6d	4				0	71	25	120	127		86	91		3	23	26						
146-6	146-6e	4	20	15	12	0	78	30	142	112	115	100	101		6	28				28			
147-1	147-1a	6	6.5	4	8	0	60	21	112	114		76			3	16	17			7			
147-1	147-1a	6				0	56	29	92		67	76	72		3	20				9			
148-1	148-1a	6	8.5	5	10	0	61	30	102	104		91	86		6	26				10			
149-1	149-1a	6	13.5	6		0	72	35	142	144	128	77	84	84	6	28	27						
149-1	149-1a	6				0	75	33	128	130	104	84	81	87	6	27	26			8	10	9	8
149-1	149-1b	6	12	4		0	76	27	119	120	107	84	82	83	6	30	29			12	10		
149-1	149-1b	6				0	64	25	97	104	105	80	86	81	6	33	32			9	10		
150-1	150-1a	6	6.5	5	9	0	60	30	99	92		80	81		6	21				11			
150-1	150-1a	6				0	59	26	107	105		85	86		6	21							
150-1	150-1b	6	5.5	6	10	0	60	26	91	92		70	71		6	30				7			
150-1	150-1b	6				0	60	27	104	83		75	68		6	30	22						
151-1	151-1a	6	10	3		0	69	22	122	107	126	89	89	94	3	31	31			11	11		
151-1	151-1a	6				0	65	29	104	105	99	81	83	81	3	27	34			12			
151-1	151-1a	6				0	60	21	88	82	87	71	74	72	3	28				11	11	10	
154-1	154-1a	6	12.5	20	12	0	65	19	103	114		70	69		3	26							
154-1	154-1a	6				0	61	29	88	81		72	68		3	22							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
154-1	154-1a	6				0	68	30	96	109		81			3	26				12			
154-1	154-1a	6				0	65	35	80	82		79	63		3	25							
154-1	154-1a	6				0	73	40	100	97		79	77		3	24							
154-1	154-1a	6				0	76	34	104	101		81	75		6	24	22						
154-1	154-1a	6				0	68	30	94	91		82	86		6	20	22			6	7		
154-1	154-1a	6				0	68	31	95	97		71			3	26							
154-2	154-2a	6	7.5	8	10	0	60	21	94	95		68	73		6	21							
154-2	154-2a	6				0	57	22	86	80	85	65			6	26	24						
154-2	154-2b	6	7	5	9	0	55	27	96			67	68	71	3	22							
154-2	154-2b	6				0	61	26	87	80		64	71		3	28							
154-2	154-2c	6	6	4	8	1	54	27	91	90		70			4	27	28						
154-2	154-2d	6	7.5	4	10	0	59	28	95	95		71	70		3	22				7	7		
165-3	165-3a	6	6.5	5	7	0	68	29	91		75	81			3	25							
165-3	165-3a	6				0	60	26	87		71				3	19				10			
165-3	165-3a	6				0	62	26	96	92	61	70			3	22							
166-1	166-1a	6	23.5	46		0	64	25	118	102	107	84	86	85	3	29	27	31		10	10		
166-1	166-1a	6				0	72	20	107	115	109	95	88		6	23	22			12	12		
166-1	166-1a	6				0	72	20	104	98		90	91	94	6	30				12			
166-1	166-1a	6				0	73	20	108	107	115	99	101	99	6	26	22			15	18		
166-1	166-1b	6	21.5	38		0	63	20	119	113		90	91	93	3	25	26			13	14		
166-1	166-1b	6				0	68	25	89	77	91	70	73	70	6	27	27			10	10		
166-1	166-1b	6				0	76	24	103	105	93	92	85	89	6	23	30	28		12	10		
166-1	166-1b	6				0	70	25	105	118		89	91		6	26	26	25		12	11	12	
166-1	166-1b	6				0	62	19	102	107	103	92	97	94	6	25	23			11	12		
166-1	166-1c	6	16	24		0	71	26	101	94	91	71	80	82	3	28							
166-1	166-1c	6				0	78	25	103	104	97	84	86	85	6	28	26			14	15		
166-1	166-1c	6				0	66	22	79	89	96	69	74	70	3	27				12			
171-1	171-1a	6	12	4		0	70	16	154	105		77	88	91	3	21							
171-1	171-1a	6				0	62	20	87	67		66	67		3	25	26			8			
171-1	171-1a	6				0	60	18	83	79	84	70	70	70	3	20	24	27		12			
171-1	171-1b	6	6.5	11		0	58	18	81	80	73	63	65		3	22	23			8			
171-1	171-1b	6				0	65	29	90	89	91	79	75		3	27	35						
171-1	171-1c	6	9	6		1	55	17	105	107		94	77		2	23	23						
171-1	171-1c	6				0	64	25	81	85	113	61	63	62	3	37	30	31		6	15	7	
171-1	171-1c	6				0	51	16	96	77	78	60	49		3	28	27	26					
171-1	171-1d	6	12	14		0	59	21	92	78	87	66	64	61	3	22	20						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
171-1	171-1d	6				0	57	22	72	80	73	67	68		3	32				6	7		
171-1	171-1d	6				0	54	16	73			67	65		3	22				6			
171-1	171-1e	6	14	9		0	60	19	82	87		57	57		3	27	28						
171-1	171-1e	6				0	66	25	123	106		76	75	75	3	31	9			8	8	9	
172-1	172-1a	6	16	10		0	70	20	116	142	141	89	90	92	3	30	32	31		6	7		
172-1	172-1a	6				0	65	30	97	105	104	81	76	82	6	30	27	28		9			
172-1	172-1a	6				0	63	18	105	106	108	81	77	78	6	22	20	25		10			
172-1	172-1b	6	13	15		0	70	26	162	153		72	91	88	3	30	26			8	9		
172-1	172-1b	6				0	64	26	112	130	121	58	72	71	6	24	25			9	10	10	
172-1	172-1b	6				0	68	25	128	110	131	88	85	87	6	30	29	30		10	9	9	
172-1	172-1b	6				0	65	22	112	113	104	97	91	94	3	30	29			11	10		
173-1	173-1a	4	14.5	30		0	45	16	101	89	102	65	64	1	3	29	20						
173-1	173-1a	4				0	55	23	92	94	75	59	65	64	3	25	22	26					
173-1	173-1a	4				0	51	21	72	76	86	56	57	67	3	22	24						
173-1	173-1a	4				0	57	22	94	93	85	64	65		3	24	22						
173-1	173-1a	4				0	58	23	71	91	90	63	70	64	3	21							
173-1	173-1a	4				0	61	25	81	68	77	72	67	76	3	28	27	25		6			
173-1	173-1a	4				0	55	23	107	109	85	64	60	67	3	23							
173-1	173-1b	4	12.5	12		0	59	28	77	86	85	69	75	66	3					5	5	6	
173-1	173-1b	4				0	59	21	81	91	92	65	66	68	3	22							
173-1	173-1b	4				0	60	22	93	96	86	60	63	65	3	26							
173-1	173-1b	4				0	61	26	85	105	107	71	80	73	3	24							
173-1	173-1c	4	8.5	15		0	45	17	77	78	107	54	55		3	29							
173-1	173-1c	4				1	50	20	77	78		54	55		2	21							
173-1	173-1c	4				0	50	24	97	93	79	57	55	52	3	20							
173-1	173-1c	4				0	50	21	73	81	85	48	50	52	3	22							
173-1	173-1c	4				0	50	19	55	62	63	55	52	51	3	21							
173-1	173-1c	4				0	46	16	136	137		75	52										
173-1	173-1d	4	7.5	9		0	45	17	57	80	81	47	52		3	21							
173-1	173-1d	4				0	50	17	105	102	98	55	51		3								
173-1	173-1d	4				0	49	21	76	80	82	57	66		3	25							
173-1	173-1e	4	12	9		0	45	22	108	101	87	76	74		3	45	40			4			
173-1	173-1e	4				0	61	21	97	97		76	74		3	23							
173-1	173-1e	4				0	63	23	82	96	97	70	60		3								
173-1	173-1e	4				0	65	21	105	107	87	72	74		3	72	25						
173-1	173-1e	4				0	63	23	87	84	96	75	72		3	25							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
173-2A	173-2Aa	4	11.5	11		1	51	23	88	95		69	51		2	23							
173-2A	173-2Aa	4				0	49	19	73	71		59	55	66	3	25	24						
173-2A	173-2Aa	4				0	61	22	93	94	89	67	68		3	21							
173-2A	173-2Aa	4				0	50	20	71	65	74	61	58	65	3	23							
173-2A	173-2Ab	4	7	8		0	57	20	92	81		66	71		3	20							
173-2A	173-2Ab	4				0	54	21	76	88	86	61	59	60	6	19				9	8		
173-2A	173-2Ac	4	7.5	10		0	60	23	100	101	94	66	70	67	3	21				11			
173-2A	173-2Ad	4	11.5	9		0	60	17	102	101	107	75			3	29	22			6	5		
173-2A	173-2Ad	4				1	60	22	108	105		68	77		2	21							
173-2	173-2e	4	10.5	7		0	55	24	103	104	89	70	71	69	3	22	24						
173-6	173-6a	6	10.5	27	14	0	73	20	114	102		92	75		6	29				7			
173-6	173-6a	6				0	60	24	111			80			5	24	29			11			
173-6	173-6a	6				0	61	25	83			73			6	24				9			
173-6	173-6a	6				0	62	21	96	99		62			6	29				8			
173-6	173-6b	6	11	20	13	0	59	24	85	84		58			6	17				7			
173-6	173-6b	6				0	54	22	87	90		54	64		6	24				6			
173-7	173-7a	4	6	7	7	0	52	20	80	81	76	52	60		3	20				10			
173-7	173-7a	4				0	48		90	91		60	50	45	3	13				4			
173-7	173-7b	4	7	12	8	0	60	16	136			70	70		3	23	22						
173-5	173-5a	6	8.5	17	8	0	65	17	86	100		70	70		6	25							
173-5	173-5b	6	17	15	9	0	59	20	87			60			6	25	20						
173-5	173-5b	6				0	47	18	65	70		50	56		6	15	15						
173-5	173-5b	6				0	53	25	80			62	60		6	25							
173-5	173-5b	6				0	52	20	70			45			6	18	28						
173-5	173-5b	6				0	65	20	98	69		52			6	30							
173-5	173-5b	6				0	57	21	65	70		45			6	22							
173-5	173-5b	6				0	40	20	65	66		40			6	27							
174-1A	174-1Ab	4	22	44		0	68	26	145	119		86	89		3	22							
174-1A	174-1Ab	4				0	55	17	85	83		70	71		6	23	25			11	9	10	
174-1A	174-1Ab	4				0	59	25	91	95		61	66		6	24							
174-1A	174-1Ac	4	21	30		0	65	25	147	152		84	77		3	24	26			11			
174-1A	174-1Ac	4				0	51	21	105	109		63	60		6	25	26			9			
174-1A	174-1Ac	4				0	61	20	107	108		61	65		6	22							
174-1A	174-1Ad	4	26	29		0	63	21	80	97		65	62		6	18				18			
174-1A	174-1Ad	4				0	69	26	96	95	90	70	73		6	18	20			14	18		
174-1A	174-1Ad	4				0	69	20	102	105		71	70		6	20				20	19		

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
174-1A	174-1Ad	4				0	61	20	95	94		64	71		6	20	15			16	17		
174-1A	174-1Ae	4	22	20		0	64	26	130	117		71	82	86	3	26							
174-1A	174-1Ae	4				0	59	18	104			86			6	21				17	16		
174-1A	174-1Ae	4				0	57	19	95	94		66	64		6	12	16			15	18		
174-1A	174-1Ae	4				0	65	26	94	107		76	74		6	22							
174-1A	174-1Ae	4				0	64	27	102	44		85	77		6	21				19			
174-1A	174-1Af	4	25	21		0	60	28	100	107		61	66		6	21	25			7			
174-1A	174-1Ag	4	20.5	35		0	61	21	103	93		69	60		3	25							
174-1A	174-1Ag	4				0	60	21	102	101		80	76		6	18	20						
174-1A	174-1Ag	4				0	61	19	107	104		74	77		6	24	25						
174-1A	174-1Ag	4				0	49	21	92	91		84	75		6	19	20						
174-1A	174-1Ag	4				0	54	24	102	107		70	79		6	20				9	12		
174-1B	174-1Ba	6	34	57		0	84	33	111	124		90	96		6	28	27	29					
174-1B	174-1Ba	6				0	76	33							6	25	26			17	14		
174-1B	174-1Ba	6				0	77	29	105	107		91	91		6	26				15			
174-1B	174-1Ba	6				0	75	36	109	107		95	91	92	6	21	25			12	13		
174-1B	174-1Ba	6				0	90	31	140	109		96	100	101	6	22				13			
174-1B	174-1Ba	6				0	91	30	107	107	110	96	92		6	23	25						
174-1B	174-1Bb	6	30	31		0	81	31	121	105		98	96		6	27							
174-1B	174-1Bb	6				0	79	28	104	102		92	91		6	25	29			12			
174-1B	174-1Bb	6				0	74	21	120	121		97	96		6	23	24						
174-1B	174-1Bb	6				0	78	30	118	120		97	96		6	24	29						
174-1B	174-1Bb	6				0	74	29	104	104		73	74		6	20							
174-1B	174-1Bb	6				0	76	27	112	109		98	100		6	26	26						
174-1B	174-1Bc	6	31.5	50		0	60	16	121	144		82	86		6	19				9			
174-1B	174-1Bc	6				0	64	22	79	81		71	61		6	21							
174-1B	174-1Bc	6				0	60	20	107	105		64			6	23							
174-1B	174-1Bc	6				0	72	24	85	88		69	70		6	26							
174-1B	174-1Bc	6				0	61	22	85	72		66	65		6	21							
174-1B	174-1Bc	6				0	69	27	122	125		90	87	88	6	24				14			
174-2A	174-2Aa	4	22	55		0	80	20	114	107	110	74			6	25				9			
174-2A	174-2Aa	4				0	74	27	130	135		93			6	25				8			
174-2A	174-2Aa	4				0	71	23	125	126		93			6	22				10			
174-2A	174-2Aa	4				0	70	20	98	100		86	90		6	21							
174-2A	174-2Aa	4				0	72	27	131	126		105	96		6	16							
174-2A	174-2Ab	4	30	80		0	64	25	100	108	101	71	70		3	25				9			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
174-2A	174-2Ab	4				0	59	20	123			96			6	29	25			6	12	12	
174-2A	174-2Ab	4				0	72	31	121	124		101	101	103	6	26	20			8	12	12	
174-2A	174-2Ab	4				0	70	26	102	109	110	75	81		6	16				10			
174-2A	174-2Ab	4				0	70	9	140	121		100	101		6	20				12			
174-2A	174-2Ab	4				0	61	28	86	91		65			6	15				8			
174-2A	174-2Ab	4				0	61	22	111	118		96	80		6	19				16	11		
174-2A	174-2Ac	4	26	63		0	70	28	101	105		87			6	21				15			
174-2A	174-2Ac	4				0	75	29	125	127		95			6	21				12			
174-2A	174-2Ac	4				0	71	29	107			87			6	19				11			
174-2A	174-2Ac	4				0	66	24	107	112		84	84		6	23	23			11			
174-2A	174-2Ac	4				0	67	7	91	96		60			6	22	19			11	9		
174-2A	174-2Ac	4				0	62	25	113	112	110	95	100		6	26				12	13		
174-2A	174-2Ac	4				0	86	30	103	104		75	91		6	25				12			
174-2A	174-2Ac	4				0	74	30	112	114	110	93	85		6	14				13			
174-2A	174-2Ac	4				0	71	22	107	102		90	91		6	20				10			
174-2A	174-2Ad	4	24.5	36		0	61	16	125	117	88	70	68	71	3	20	19	21		9			
174-2A	174-2Ad	4				0	63	15	108	86	107	81	76	75	6	26	25			11	12		
174-2A	174-2Ad	4				0	59	16	82	93	97	69	75	74	6	17	17	18	23				
174-2A	174-2Ad	4				0	61	25	88	105	104	64	66	81	6	25	24	26		20	18	15	
174-2A	174-2Ad	4				0	50	21	75	96	86	67	72	62	6	20	19			18			
174-2A	174-2Ad	4				0	55	21	97	102	104	70	76	68	6	20	21			29			
174-2A	174-2Ad	4				0	55	17	77	80	70	62	64		6	27	25	20		10	9		
174-2A	174-2Ae	4	26	35		0	73	18	107	112	114	77	73	72	3	18	20						
174-2A	174-2Ae	4				0	64	21	96	108	106	75	77	82	3	26	30			15	14		
174-2A	174-2Ae	4				0	53	20	92	98	80	78	74	74	6	20				14	15		
174-2A	174-2Ae	4				0	69	22	127	103		80	81	82	3	27	26						
174-2A	174-2Ae	4				0	52	29	108	107	99	73	88	75	6	28	26			15	15		
174-2A	174-2Ae	4				0	60	24	113	115	102	90	85	79	6	22	24	20		29			
174-2A	174-2Ae	4				0	62	24	104	102	95	82	74	76	6	20	27						
174-2A	174-2Ae	4				0	65	25	112	117	97	75	96	75	6	30	27						
174-2A	174-2Ae	4				0	61	23	80	104	106	82	81	77	6	23				20	23	22	23
174-2A	174-2Af	4	25	37		0	63	16	104	105	104	68	77	95	6	23	21						
174-2A	174-2Af	4				0	58	21	92	93	83	73	73	67	6	23	20	21		20	20		
174-2A	174-2Af	4				0	58	22	88	106		73	72		6	25				16	18		
174-2A	174-2Af	4				0	65	70	112	113		80	78	80	6	23				17	30		
174-2A	174-2Af	4				0	59	17	104	100	85	104	100	86	6	26				28			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
174-2A	174-2Af	4				0	59	20	92	90	94	82	72	72	6	25	21			17	20		
174-2A	174-2Ag	4	29	69		0	67	33	114	109		68	79		6	21	22			9	10		
174-2A	174-2Ag	4				0	64	25	103	100	102	79	78	83	6	26	28			9	13		
174-2A	174-2Ag	4				0	65	24	92	92	97	89	87	81	6	27	21			10	11		
174-2A	174-2Ag	4				0	70	30	107	105	103	77	80	72	6	22	29			10			
174-2A	174-2Ag	4				0	65	29	117	125	127	102	102		6	24	22	23		18	16	15	
174-2A	174-2Ag	4				0	65	24	102	103	86	77	78		6	27	24			7	9		
174-2A	174-2Ag	4				0	56	28	125	128	138	100	106		6	27	25			10	7		
175-1	175-1a	6	20	41		0	70	22	121	108		97	77	88	6	28	28	27		13			
175-1	175-1a	6				0	65	15	104	107	112	72	69		6	25	28			8	8		
175-1	175-1a	6				0	63	16	93	70	96	68	71	70	6	23				6	6		
175-1	175-1a	6				0	68	20	95	108	109	69	70	73	6	27	28			8	8		
175-1	175-1a	6				0	66	17	88	89	74	74	57		6	26	27			5	6		
175-1	175-1b	6	24	22		0	54	23	126	107	112	99	99	98	6	30	29			10	12		
175-1	175-1b	6				0	71	30	108	105	106	97	94	99	6	25	27			14	14	14	
175-1	175-1c	6	23.5	21		0	68	18	121	123	103	82	78	84	3	29							
175-1	175-1c	6				0	65	20	106	85		73			6	21	24			10	9		
175-1	175-1c	6				0	65	25	132	134	111	85	91	85	6	30	27			11			
175-2	175-2a	6	21.5	22		0	55	22	103	104	106	71	70	72	3	23	25			8	10		
175-2	175-2a	6				0	71	24	95	97	92	71	67	70	6	24	25			7	8	8	
175-2	175-2a	6				0	66	16	117	93		86	76	81	6	24	25						
175-2	175-2a	6				0	79	19	112	108	129	91			6	26	25						
175-2	175-2b	6	13.5	19		0	73	24	123	114		92	87	86	6	28	25			10			
175-2	175-2b	6				0	73	22	108	111	107	81	90		6	28	27			9			
175-2	175-2b	6				0	72	19	101	113	98	90			6	27	28	30					
175-2	175-2c	6	12	22		0	70	24	88	90		76	59	64	3	27				10			
175-2	175-2c	6				0	65	21	96	90		84	67	71	6	23				9			
175-2	175-2c	6				0	77	29	96	76		70	66		6	25	20			9	7		
175	175a	6	22	34		0	63	21	115	107		77	75	78	6	26	25	27	26	11	10	10	
175	175a	6				0	64	19	92	98	109	77	77	78	6	25	26	24		10	9		
175	175a	6				0	70	27	103	106	93	72	77		6	23	27	25					
175	175a	6				0	73	19	128	95		75	74		6	29	23	23		10			
175	175a	6				0	65	18	97	111	108	77	78	80	6	26	29			10	10	11	
175	175a	6				0	73	25	97	102	105	77	79	73	6	26	28						
175	175b	6	7	9		0	71	19	93	96	97	91	86		6	23	24						
175	175b	6				0	68	17	95	98	96	69	67		6	26				7			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
175	175b	6				0	56	16	76	66		47			6	25	22			6	9		
175	175b	6				0	60	20	93	83		62	57		6	26	25			9	9		
175	175b	6				0	58	14	81	75	83	78	57	61	6	22				9			
175	175c	6	17.5	20		0	55	26	102	86	100	57	61	68	6	21	19	21		5	6	5	
175	175c	6				0	82	20	136	109		92	97		6	31	32			10			
175	175c	6				0	82	21	164	107	98	82	77	82	6	27	24			7			
175	175c	6				0	75	24	118	113	108	83	91	79	6	30	26			16			
175	175c	6				0	71	27	107	113	128	83	83		6	29	31	27	25	10			
175	175d	6	13	15		0	59	18	97	104	103	78	80	77	6	30	28	27		10	8	8	
175	175d	6				0	71	27	103	105	104	75	78		6	25	23			11	10		
175	175d	6				0	71	22	80	87		66	67		6	25	26	26		9	9	9	
175	175d	6				0	76	26	83	91	92	76	77	75	6	26	27	26		9			
175	175d	6				0	71	27		102	103	80	79	75	6	25	27			16	15	13	
177-5	177-5a	6	2	2		0	65	25	82	102	105	71	65	76	3	27	28			9			
177-5	177-5a	6				0	62	25	82	73		70	71	63	3	27	25						
177-4	177-4a	6	4.5	6		0	69	22	101	104	107	76	76		3	26							
177-4	177-4a	6				0	68	18	86	102	97	74	75	70	3	29	30			9			
177-4	177-4a	6				0	77	24	86	99	101	73			3	23	28			10			
177-4	177-4a	6				0	61	28	81	82	84	74	65		3	28	27			8	9		
177-7	177-7a	6	7	11		0	61	24	104	105	95	87	82	90	3	26	22	30		12	12	12	
177-7	177-7a	6				0	64	23	103	104		74	76		6	27	22	24		10	10		
177-7	177-7a	6				0	75	34	107	105	100	92	90		6	22	30	26		10	11	10	
177-7	177-7b	6	6.5	6		0	54	22	86	79	72	61	68	62	6	26	25			11			
177-7	177-7b	6				0	76	25	104	102	95	81	82	80	6	27	28			10	10	11	
177-7	177-7b	6				0	76	24	103	102	101	80	77	77	3	26	27			15			
177-7	177-7b	6				0	66	20	91	90	84	76	79	78	6	22	31			10			
177-7	177-7b	6				0	65	22	92	95	83	69	70	70	3	28	30	30					
177-3	177-3a	6	3	10		0	51	24	75	64	80	55	61	64	3	30	26						
177-3	177-3a	6				0	52	23	70	67		53	60	61	6	22	22						
177-3	177-3a	6				0	64	23	79	80	74	76	75		3	23							
177-3	177-3a	6				0	63	24	77	66		59	64		6	29	28						
177-3	177-3b	6	2.5	4		0	64	23	94	90	87	76	71		6	23	21						
177-3	177-3b	6				0	62	21	87	88	88	62	68	68	3	21	22			10	10		
177-6	177-6a	4	6	7		0	51	23	75	98	92	56	61	63	3	28	26			6			
177-6	177-6a	4				0	50	19	83	94	77	56	60		6	26	24			5	4		
177-6	177-6a	4				0	60	22	107	92	107	60	63	62	3	26	23						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
177-6	177-6a	4				0	53	21	83	87	84	55	66		3	26	29						
177-14	177-14a	4	6.5	4		1	51	22	170	103		77	67		2	31	30						
177-14	177-14a	4				0	55	18	84	104	110	70	63		3	24	25						
177-14	177-14a	4				0	45	18	67	75	80	62	63	64	3	24	23						
180-1	180-1a	4	21	45	11	0	54	20	102	98	101	53	61	60	6	22	20			6	5		
180-1	180-1a	4				0	58	20	88	106	108	61	62	62	6	21	25	22		5			
180-1	180-1a	4				0	62	23	168	159	139	76	80	78	6	25				7			
180-1	180-1a	4				0	66	22	152	156	95	70	76		6	29	30	22	30	8			
180-1	180-1a	4				0	66	25	147	106		66	63	77	6	25	26			9	10		
180-1	180-1b	4	15	32	10	0	68	17	147	126	137	84	83	66	6	26				7			
180-1	180-1b	4				0	61	16	138	137		67			6	27	26						
180-1	180-1b	4				0	52	19	81	103	100	56			6	25	26			6			
180-1	180-1b	4				0	55	20	132			69	62		6	25	28			6	4		
180-1	180-1c	4	8.5	7	8	0	56	16	79	77	73	57	75		6	25	22			6	6	5	
180-1	180-1c	4				0	56	22	80	80		66	74		3	29	23						
180-1	180-1c	4				0	55	22	84	80	80	56			3	23	21			5			
180-1	180-1d	4	7	5	8	0	50	20	80	73	77	69	66		3	25	21			5	6		
180-1	180-1d	4				0	59	21	88	85	71	65	81		3	22	28	27		6			
180-1	180-1e	4	7	7	8	0	55	13	142	139		65	55	61	3	24	25			5			
180-1	180-1e	4				0	51	16	104	103		71	66	70	3	17	23						
180-1	180-1e	4				0	48	14	83	84		76	76	74	3	23				5			
180-1	180-1f	4	9	7		0	53	22	75	73		65	59	62	3	24	26			10	9	7	
180-1	180-1f	4				0	54	18	72	66	71	52	61		3	22	23						
180-1	180-1f	4				0	62	23	72	79		69	61		3	25	21						
180-1	180-1f	4				0	59	28	82	82		62	63		6	27				7	7		
180-1	180-1g	4	10	6		0	60	24	77	82		58	58		3	24	21						
180-1	180-1g	4				0	56	21	74	81	68	65	57		3	26	27						
180-1	180-1g	4				0	60	25	81	82	67	60	66		6	20							
180-1	180-1h	4	10	15		0	69	23	154	156	151	84			3	31				6			
180-1	180-1h	4				0	57	20	93	94		96	71		3	26							
180-1	180-1h	4				0	63	20	91	91	75	56	65		6	27	29						
180-1	180-1h	4				0	60	19	96	90	77	60	67		3	30							
180-1	180-1h	4				0	59	22	81	87		66	71		3	30							
180-1	180-1i	4	8.5	8		0	63	16	86	87	82	61	66	62	6	27							
180-1	180-1i	4				0	61	23	75	86	75	67	64	66	6	24							
180-1	180-1i	4				0	60	23	76	75		60	56		3	22							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
180-2	180-2a	4	9.5	6	9	0	61	24	105	82		55	66		3	25							
180-2	180-2a	4				0	66	25	98	88	99	76	76	74	3	23	27						
180-2	180-2a	4				0	55	17	70	76		55	66		3	20	24			7	8		
180-2	180-2b	4	9	7	10	0	55	13	82	95	77	61	67		3	27				7			
180-2	180-2b	4				0	47	19	75	77	70	62			3	19							
180-2	180-2b	4				0	49	20	75	74	75	56	57		3	21							
180-2	180-4a	4	15	7	12	0	61	17	76	66	99	57	62	64	3	26				9			
180-2	180-4a	4				0	59	20	90	77	92	74	67		6	27				7			
180-2	180-4a	4				0	56	24	94	94	78	58	64	62	3	28	25						
180-2	180-4a	4				0	60	18	84	87	78	69	66	65	6	28							
180-2	180-4a	4				0	61	25	87	82	93	64	73	68	3	25				10	9		
180-2	180-4a	4				0	60	20	106	108		73	69	63	3	35	24						
180-2	180-4b	4	10	8	11	0	59	21	79	85	90	59	65	67	3	22	24						
181-1	181-1a	4	17	14		1	66	25	195	193		85	97		2	38							
181-1	181-1a	4				0	59	21	105	107	160	62			3	32				4			
181-1	181-1a	4				0	58	20	85	99	95	62	63		3	24							
182-2	182-2a	4	11	8		1	58	20	103	102		67	53		2	31							
182-2	182-2a	4				0	48	15	78	79	77	64	66	63	3	26	28			6	6		
184-1	184-1a	4	12.5	20		0	66	20	100	99		80	76	80	3								
184-1	184-1a	4				1	62	22	96	107		66	72		2	23				7			
184-1	184-1a	4				0	60	20	90	93	76	70	69	66	3	27							
184-1	184-1a	4				0	61	20	81	79	87	64	67	60	3	27							
184-1	184-1a	4				0	65	23	98	97	80	72	75		3	28							
184-1	184-1b	4	14	18		1	60	19	101	99		69	70		2	26							
184-1	184-1b	4				0	59	20	93	95	97	69	74		6	35	34			8	6		
184-1	184-1b	4				0	64	20	118	123	163	81	78	79	3	28							
184-1	184-1b	4				0	65	20	110	109		70	68	73	3	26	28			7			
184-1	184-1c	4	9	6		0	65	22	116	107		83	78		2	36	27						
184-1	184-1c	4				1	58	18	92	92	89	67	69	67	3	28	27			8	7		
184-1	184-1d	4	7	12		0	52	16	95	97	77	60	63		3	27							
184-1	184-1d	4				0	56	17	94	97	83	58	62	65	3	28							
184-3	184-3a	4	7.5	6		1	55	15	97	96		81	68		2	27				5			
184-3	184-3a	4				0	46	16	87	88	62	54	50		3	20	21			5			
184-5	184-5a	4	10.5	5		0	60	23	86	90	84	67	64	70	3	24							
184-5	184-5b	4	10.5	5		0	60	23	86	90	84	67	64	70	3	24							
189-1	189-1a	4	18	25		0	70	24	93	99	101	71	76		6	28	27			10	11		

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
189-1	189-1a	4				0	60	29	85	96	97	67	65	66	6	30	29			9	8	10	
189-1	189-1a	4				0	65	23	91	93	94	86	74		6	31	30			10	11		
189-1	189-1b	4	17.5	30		0	66	22	124	122	112	74	75	72	3	34	32						
189-1	189-1b	4				0	62	23	104	102	107	66	73		6	29	28			11			
189-1	189-1b	4				0	48	25	97	91	84	55	63	58	6	22	21			10			
189-1	189-1c	4	19	50		0	61	18	83	82		55	65	70	6	23	24	22		6			
189-1	189-1c	4				0	66	20	108	111	103	82	73		6	22	27			11	15		
189-1	189-1c	4				0	62	22	104	109	103	82	73		6	31	28			10			
189-1	189-1c	4				0	66	22	95	105	107	71	76	77	6	32	28			13	12		
189-1	189-1d	4	17	13		0	68	27	102	108	113	74	76	78	3	30							
189-1	189-1d	4				0	66	21	94	98	86	78	72	74	6	29	27			10	9		
189-1	189-1d	4				0	56	26	82	98	96	72	75	81	6	24	31			9	10		
189-1	189-1e	4	19	71		0	76	27	104	102	105	80	76	86	6	30	27						
189-1	189-1e	4				0	64	24	105	107	98	77	68	67	6	29	30			10	11		
189-1	189-1e	4				0	64	22	103	102	89	67	64	73	6	28	27			11			
189-1	189-1e	4				0	68	24	125	126	94	73	94	84	6	28	30			14	13		
189-1	189-1e	4				0	65	20	81	104	100	72	62	77	6	33	31			10			
189-1	189-1e	4				0	63	20	88	87	75	61	72	71	6	28	29	30		10	10		
189-1	189-1e	4				0	65	22	85	103	92	68	76		6	26	30	29		16	12	13	
189-1	189-1f	4	17.5	29		0	62	22	86	88	90	63	55		3	35	25			9			
189-1	189-1f	4				0	66	24	96	101		60	83		6	22	25	26		9			
189-1	189-1g	4	18	33		0	56	22	86	96	97	62	67		6	27	28	25	22	9	9	9	17
189-1	189-1g	4				0	57	25	83	82	76	67	65	67	6	31	28			7	8	9	
189-1	189-1g	4				0	65	27	87	91	101	60	66	76	6	25	24			17	10	10	11
189-1	189-1g	4				0	61	22	96	97	84	69	71	70	6	23	22	26		10	9		
189-1	189-1g	4				0	66	23	85	82		66	66	71	6	28	29	27		11	9		
189-1	189-1h	4	17.5	14		0	70	30	104	107	107	76	76	78	6	28	29			9	10		
189-1	189-1h	4				0	72	28	107	94	104	77	75		6	31	29			11	15		
189-1	189-1i	4	16	56		0	66	24	88	104	103	70	72	70	6	25	30			10	9		
189-1	189-1i	4				0	65	23	107	102	101	76	71		6	24	25			9			
189-1	189-1i	4				0	69	20	104	105	102	72	74		6	26	27			12	11		
189-1	189-1i	4				0	67	25	93	102	96	75	78	74	6	27	26			10			
189-1	189-1i	4				0	62	24	86	74	85	63	68		6	34	31			10	7		
189-1	189-1j	4	17	33		0	60	22	87	90	97	67	63		3	30	33			10			
189-1	189-1j	4				0	64	24	94	95	90	66	62		6	38				10			
189-1	189-1j	4				0	58	23	82	71	85	54	55	60	6	22	26			9			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
189-1	189-1j	4				0	68	25	97	105		76	72		6	15	28			10			
189-1	189-1j	4				0	65	28	96	98	87	57	69	70	6	31	29			12			
189-1	189-1j	4				0	65	24	103	85	109	61	81		6	27	28			9	10		
189-1	189-1k	4	19	31		0	70	26	119	123	118	81			6	28	27						
189-1	189-1k	4				0	60	25	102	99		65	64		6	24	25	26		10	9	10	
189-1	189-1k	4				0	70	24	120	95	114	67	75	73	6	26	27			10	10		
189-1	189-1k	4				0	71	25	119	107		81	67	73	6	24	26			10			
189-1	189-1l	4	18.5	61		0	70	25	103	117		90	85	73	6								
189-1	189-1l	4				0	66	24	104	102	84	70	76		6	22	24			10	11		
189-1	189-1l	4				0	66	21	112	97		84	70		6	26	27						
189-1	189-1l	4				0	59	23	65	81	78	54	51		6	30	26						
189-1	189-1l	4				0	55	24	91	77		61	62	74	6	27	28						
190-1	190-1a	6	17	20		0	82	29	117	106	122	93	91	89	4	25				11			
190-1	190-1a	6				0	82	28	115	134		94			3	26	24	31		12	12		
190-1	190-1a	6				0	75	34	130	135	108	85	85	93	3	28	27			13			
190-1	190-1a	6				0	75	30	123	121	124	80	91	96	3	22	29			10			
190-1	190-1a	6				0	64	30	122	102	105	87	87	90	6	29	29			10	12		
190-1	190-1b	6	12.5	12		0	65	29	112	110		76	70		3	24				6			
190-1	190-1b	6				0	66	29	103	91	104	76	76	69	3	28	27						
190-1	190-1b	6				0	64	29	87	98	93	68	71	76	3	27				9	9		
190-1	190-1b	6				0	75	26	104	95	107	90	90	87	3	30	29						
190-1	190-1c	6	9.5	14		0	66	22	94	86	91	62	59	63	3	24	25			6	6		
190-1	190-1c	6				0	71	19	106	122	124	81	82		3	23	26	25		9	9	10	
190-1	190-1c	6				0	56	24	107	109	87	84	80	83	3	29				13			
190-1	190-1c	6				0	68	26	85	77		62	77	70	3	23				9			
190-1	190-1c	6				0	65	24	87	80	81	75	70		3	24							
190-2	190-2a	6	8.5	7		0	44	19	91	86	90	68	69		3	25				7	6		
190-2	190-2a	6				0	42	17	98	102	103	71	77	63	3	23							
190-2	190-2a	6				0	66	21	81	88	87	66	68	69	3	23	28			13	14		
190-2	190-2a	6				0	61	17	88	92	85	81	83	79	3	26				8			
190-2	190-2b	6	9.5	11		0	60	20	75	76	71	60	61		3	29							
190-2	190-2b	6				0	62	23	94	91	85	70	63	65	3	29	28			7	7		
190-3	190-3a	6	11.5	16		0	70	20	105	109	103	80	81	88	3	27	30			12	7	7	
190-3	190-3a	6				0	66	25	80	95	90	64	64		3	21				10			
190-3	190-3a	6				0	57	24	110	114	99	70	73	78	3	28				6			
190-3	190-3a	6				0	70	22	96	95	88	72	73		3	27				8	8		

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
190-3	190-3a	6				0	73	22	90	79	96	72	73	71	6	27	22	23		8	8		
190-3	190-3a	6				0	53	20	71	83	85	59	57		6	22	22			7			
190-3	190-3b	6	9	7		0	72	26	91	103	99	88	87		3	30							
190-3	190-3b	6				0	72	25	104	86		86	76		6	31	29			11			
190-3	190-3b	6				0	65	17	111	72	61	71			3	23				8			
192-1	192-1a	6	25	51		0	86	24	105	108	107	57	100		6	25	25	26		13	13		
192-1	192-1a	6				0	80	31	99	107		88	97		6	24	25			14	14	13	
192-1	192-1a	6				0	80	28	105	105	106	97	96	97	6								
192-1	192-1a	6				0	77	28	56	104	103	94	97		6	25	23			13			
192-1	192-1a	6				0	82	29	111	112	111	100	100	100	6	22				14			
192-1	192-1a	6				0	77	28	103	104	105	95	94	96	6	28				15	12	11	15
192-1	192-1a	6				0	84	27	108	121	116	104	103	100	6	26	14			14	14		
192-1	192-1a	6				0	79	33	124	126	105	98	94	92	6	27				14	14	15	15
192-1	192-1b	6	26	45		0	75	23	105	95	98	95	82	85	3	26	25	30					
192-1	192-1b	6				0	78	31	103	100		90	88		3	28	25			14	13		
192-1	192-1b	6				0	75	32	105	101	102	90	89		6	27				12			
192-1	192-1b	6				0	69	28	112	104	93	80	81		4	32	28	28		12	11		
192-1	192-1b	6				0	70	26	104	103	103	90	90	89	6	29	25			11	15		
192-1	192-1b	6				0	62	23	87	88	95	79	77		6	30	26	25		13	12		
192-1	192-1b	6				0	76	28	95	91		83	82		6	30	20			12			
192-1	192-1b	6				0	72	27	94	88		91	90	80	6	27	27	25					
192-1	192-1c	6	27	57		0	64	21	153	123		87	88		6	27	23	27					
192-1	192-1c	6				0	64	21	78	87		69	68		6	25	25			10			
192-1	192-1c	6				0	83	30	95	96		83	84		6	25	28	26					
192-1	192-1c	6				0	65	19	83	81	76	73	69	69	6	29	20	23		9	8	10	
192-1	192-1c	6				0	70	30	99	99	91	86	84		6	29	27	25		10	10		
192-1	192-1c	6				0	76	24	90	99		89	75		6	30	28						
192-1	192-1c	6				0	81	25	123	122	108	95	90		6	26	25			14	14		
192-1	192-1c	6				0	80	23	105	92	106	89	84		6	25				15			
192-1	192-1d	6	26.5	34		0	82	27	117	106	106	97	88	87	6	29	22	27	23	12	11	15	14
193	193a	6	17.5	14		0	60	16	94	104		59	58	65	3	20							
193	193a	6				0	72	15	65	56		74	40		3	20							
193	193a	6				0	55	15	57	70	72	47	40	43	3	21							
193	193a	6				0	70	19	107	77		63	65	70	3	30							
193	193a	6				0	53	25	65	79	65	50	56		3	23							
193	193a	6				0	66	21	105	93	107	64	56		6	27	24						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
193	193a	6				0	60	19	83	87		65	56		3	23	27						
193	193b	6	13	13		0	68	12	97	93		48	55		3	26	24						
193	193b	6				0	55	20	102	108	91	71	63		3	30	32						
193	193b	6				0	54	17	101	99	95	60	61	65	3	30	20						
193	193b	6				0	55	15	76	91		64	63	75	3	31							
193	193b	6				0	55	15	88	76		62			3	27							
193	193c	6	11.5	6		0	50	27	82	100	95	65	67	63	3	25	26			10	9	10	
193	193c	6				0	62	18	91	100	93	66	71		3	26	26						
193	193c	6				0	57	16	75	70	77	60	63	60	3	24	25						
193	193c	6				0	65	20	96	98	82	71	75		3	33	24			12			
193	193d	6	10.5	13		0	60	20	105	126	128	83	86	82	6	31	30			9			
193	193d	6				0	69	20	86	76	84	62	69		3	35	26						
193	193d	6				0	62	21	71	72		52	52										
193	193d	6				0	65	21	85	87	75	65	57		3	31	25	30					
193	193d	6				0	50	18	74	75		57	55		3	22	20			8			
193	193d	6				0	70	25	82	86	86	64	67		3	29	30						
193	193e	6	12	15		0	56	20	95	108	107	63			3	31							
193	193e	6				0	70	25	88	103	99	82	90		6	27	28			9			
193	193e	6				0	58	24	87	85	102	61	61	63	3	29	29	30		7			
193	193e	6				0	53	19	71	82	83	54	55		3	22	21						
193	193f	6	11	16		0	72	23	107	112	97	76	77	75	3	28	22						
193	193f	6				0	65	21	76	92	93	80	71		6	30	25	24					
193	193f	6				0	65	24	101	100		72	69	67	3	26	28	30					
193	193f	6				0	65	19	83	93	95	56	61	63	3	29	33						
193	193f	6				0	60	21	71	68		66	51		3	22							
193	193g	6	11	6		0	60	20	100	98		69	80		3	27	30			11	11		
193	193g	6				0	59	24	97	101	103	76	76	77	3	29	23						
193	193h	6	12.5	15		0	62	21	95	93		66	63		3	32	31						
193	193h	6				0	70	20	111	114	104	82	85		3	31							
193	193h	6				0	64	21	103	95	81	71	72		3	32	30			9			
193	193h	6				1	55	17	81	82		65	57		4	27	28			5	6	4	
193	193h	6				1	60	22	77	81		56	65		4	32	32						
193	193i	6	11.5	7		0	56	19	80	81	79	67	68		6	30	29	35					
193	193i	6				0	56	21	76	75	74	65	70	65	3	24	22						
193	193i	6				0	50	20	71	72	70	55	60		6	21	21						
193	193i	6				0	60	20	101	102	97	71	70	72		40							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
193	193j	6	7	4		0	50	16	76	91	80	60	59		3	25				6			
193	193j	6				0	53	19	90	91	91	63	50		3	23				9			
193	193j	6				0	57	18	75	80		61	46		2	21				9			
194-3	194-3a	6	17	18		0	70	20	107	99	78	83	79		3	20	25						
194-3	194-3a	6				0	55	21	105	102		85	86		3	22	24			10			
194-3	194-3a	6				0	69	20	95	87	83	69	72		3	31	29						
194-3	194-3a	6				0	71	21	96	107	87	72	67		3	29	31			14			
194-3	194-3a	6				0	65	20	85	89	83	75	70	67	6	24	27			12	13		
194-3	194-3a	6				0	71	17	104	96	107	82	83		3	26	30			12			
194-3	194-3a	6				0	75	21	96	100		81	92	96	3	29	29	31					
194-3	194-3a	6				0	59	20	81	83	86	81	71		6	31	32	29					
194-3	194-3b	6	17	6		0	63	21	91	86		71	71	70	6	28	20						
194-3	194-3b	6				0	55	20	95	76	92	70	80		6	30				9			
194-3	194-3c	6	16.5	12		0	65	19	147	96		74	72	76	3	26							
194-3	194-3c	6				0	65	22	95	96	81	66	65	80	3	28	27						
194-3	194-3c	6				0	56	18	101	99		71	56		6	26							
194-3	194-3c	6				0	65	21	86	87		74	68		6	30	31						
194-3	194-3c	6				0	60	20	74	82	82	56	64		6	28							
194-3	194-3c	6				0	70	22	107	103		65	70		6	30							
194-3	194-3c	6				0	65	21	97			75	64		3	21				10			
194-3	194-3c	6				0	64	18	87	88		57			3	23							
194-3	194-3c	6				0	57	19	77	85	84	60	62		6								
194-3	194-3d	6	16.5	11		0	56	31	95	91	81	76	68		3	29	26						
194-3	194-3d	6				0	60	23	103	95	99	75	76	81	6	31	26						
194-3	194-3d	6				0	55	21	85	80	84	67	66		3	29	30	28					
194-3	194-3d	6				0	65	22	93	91		71	74	78	6	34							
194-3	194-3d	6				0	63	23	76	81		61	67		3	25				8			
194-3	194-3d	6				0	57	20	101	84		80	72		6	28	28						
194-3	194-3e	6	13	10		0	60	16	81	82	80	61	59		3	30							
194-3	194-3e	6				0	53	21	82	87	83	58	61		6	35							
194-3	194-3e	6				0	60	20	82	75	83	61	62		6	23							
194-3	194-3e	6				0	61	35	75	87	88	72	63	51	6	27	30						
194-3	194-3f	6	15.5	10		0	71	27	97	104	105	73	61		3	31							
194-3	194-3g	6	18	6		0	64	22	82	83	89	62	96	67	6	28							
194-3	194-3g	6				0	52	17	71	84	87	60	51	62	6	24	23						
194-3	194-3g	6				0	54	23	78	75	75	61	64		6	32	30	28					

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
194-3	194-3g	6				0	75	21	107	103		80	75		3	31							
194-3	194-3h	6	16	22		0	76	27	107	82	102	82			6	23							
194-3	194-3i	6	16	18		0	71	23	92	96	108	86	84		6	25				11			
194-3	194-3i	6				0	54	21	74	82	75	73	67	57	3	31	29			9			
194-3	194-3i	6				0	70	24	81	93	101	81	79	75	6	28							
194-3	194-3i	6				0	75	20	91	111	94	90	89	86	6	35	34						
194-3	194-3i	6				0	58	22	100	103	94	77	78	70	6	28	29						
194-3	194-3i	6				0	62	21	85	83		70	71		6	31	30						
194-5	194-5a	6	18.5	11		0	69	23	100	96		82	84	73	3	26	20						
194-5	194-5a	6				0	67	27	93	95	99	81	82	86	3	29				12			
194-5	194-5a	6				0	62	27	85	87		76	71		3	29	26			5			
194-5	194-5a	6				0	66	25	93	97	94	85	91		3	26	27			17	15		
194-5	194-5a	6				0	70	26	92	93	94	89	78	80	3	27				17	14		
194-5	194-5b	6	20.5	29		0	62	22	95	104	105	70	75	71	3	35	25			10			
194-5	194-5b	6				0	66	22	91	100	95	66	74	69	3	27				6			
194-5	194-5b	6				0	73	70	104	103	105	76	75	94	4	35	25	27		9			
194-5	194-5b	6				0	59	30	124	135	110	79	75	76	3	20	20	29					
194-5	194-5b	6				0	65	22	98	91	92	62	75		3	20				14	10	11	
194-5	194-5c	6	15	5		0	65	29	75	100		61	56	61	6	22	25						
194-5	194-5c	6				0	64	28	86	75		66	65		3	25	21						
194-5	194-5c	6				0	60	27	85	77	85	63	68	71	3	21	27			10	9		
194-5	194-5d	6	13.5	14		0	55	22	116	99	89	65	56		3	24	20	22					
194-5	194-5d	6				0	55	29	86	80		64	64		3	22							
194-5	194-5d	6				0	60	27	93	68	92	70	67	61	3	28							
194-5	194-5d	6				0	61	27	95	90	79	62	60	56	3	20	22			9			
194-5	194-5d	6				0	56	25	79	80	78	72	62	61	3	26	26						
194-5	194-5d	6				0	62	24	75	72	71	66	62		3	20	17			11			
194-5	194-5e	6	15.5	20		0	70	19	122	106		61	71	67	3	21							
194-5	194-5e	6				0	66	22	102	103	79	71	78	73	3	21	19			9			
194-5	194-5e	6				0	65	23	88	87	84	75	73		3	28	21			10			
194-5	194-5e	6				0	71	24	75	104		76	69		3	27	27	26					
194-5	194-5e	6				0	66	28	105	102	86	73	71		3	19	21			10			
194-5	194-5e	6				0	68	22	85	84	83	74	76		3	27				9			
194-5	194-5e	6				0	73	25	103	98		81	67	80	6	27							
194-5	194-5f	6	14.5	13		0	70	22	112	97		81	86		3	31	28	25		7			
194-5	194-5f	6				0	62	19	95	91		72	71		3	25				12			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
194-5	194-5f	6				0	75	26	104	111	119	87	88	85	3	32	26	29					
194-5	194-5f	6				0	68	24	95	103		81	77	79	3	28	25			15	14		
194-5	194-5f	6				0	68	28	87	91	95	70	79		3	28	22			13			
194-5	194-5g	6	16.5	14		0	76	28	104	103	99	98	87	85	6	28	27			10	11		
194-5	194-5g	6				0	75	32	103	106	105	92	82	85	3	26	27						
194-5	194-5g	6				0	75	23	98	97	96	78	85	83	3	27	21			11	10	11	
194-5	194-5g	6				0	71	26	100	96	98	86	72		3	27	27						
194-5	194-5g	6				0	64	28	101	104	107	85	92		3	26				11	12		
194-6	194-6a	6	11	10		0	50	20	79	85	86	70	68	71	3	21	25			6			
194-6	194-6a	6				0	58	24	75	80	82	64	68	56	3	26	22						
194-6	194-6a	6				0	70	22	104	105	95	79	80	72									
194-6	194-6a	6				0	72	22	102	89		71	70		3	30	26						
194-6	194-6b	6	9	7		0	60	20	85	89	95	62	75		3	31				7			
194-6	194-6b	6				0	52	21	58	66	72	50	55	50	3	26	22						
194-6	194-6b	6				0	50	22	71	63	68	52	54		6	22							
194-6	194-6b	6				0	52	21	76	83		66			3	23							
195-1	195a	6	8	22		0	61	27	72	87		57	65	55	3	28	72			7			
195-1	195a	6				0	60	18	68	72	75	54	56		3	25	26						
195-1	195a	6				0	61	20	91	92	79	64	65		3	26	28						
195-1	195a	6				0	53	17	81	83	71	69	70	70	6	21				5			
195-1	195a	6				0	57	20	81	81	74	68	65	59	6	26	22			6			
195-1	195a	6				0	58	24	75	74		46	53		6	26				7			
195-1	195a	6				0	61	25	77	76	71	62	63	54	6	25				6			
195-1	195b	6	6	12		0	53	19	81	68	78	56	59	65	6	28	22	26	24	8	9		
195-1	195b	6				0	61	19	53	88	53	63	59	65	6	28	30						
195-1	195b	6				0	66	20	83	75	81	62	67		6	28	25			7	8	8	
195-1	195b	6				0	69	15	87	83	91	70	69		6	23							
195-1	195b	6				0	52	19	77	75	76	63	61	71	6	26	25	29		7			
195-1	195c	6	5	14		0	59	19	82	89	91	67	50	72	6	23	23	24		9	9	8	
195-1	195c	6				0	62	20	116	103	113	73	74		6	31	32						
195-1	195c	6				0	55	19	80	74		59	68		6	27				8			
195-1	195c	6				0	51	22	73	77	85	49	67		6	19	17						
195-2	195-2a	6	9.5	27		0	66	18	108			75	74		3	23	25			12	11		
195-2	195-2a	6				0	50	22	91	97		81	71		6	23	24	27	30	10			
195-2	195-2a	6				0	63	22	82	83	81	59	65		6	24	25			10			
195-2	195-2a	6				0	58	19	83	97	90	70	66	73	6	23	23			9			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
195-2	195-2a	6				0	50	19	85	87	82	70	71		6	19	25			8	9		
195-2	195-2b	6	15	10		0	66	22	92	102	101	74			3	27	22			9			
195-2	195-2b	6				0	71	25	87	92	98	70	74		3	22							
195-2	195-2b	6				0	65	21	101	103	93	86	83	80	6	30	30			11			
195-2	195-2b	6				0	59	23	90	83	79	77	89	79	3	22	25			7			
195-2	195-2c	6	11	12		0	66	30	106	109		68	76		6	28	25	30		10	7	10	
195-2	195-2c	6				0	68	31	95	96	93	79	82	82	6	25	26	30		11	12	12	
198-1	198-1a	6	7	10		0	45	24	85	79	72	66	65		3	17				9	6	7	
198-1	198-1a	6				0	58	30	69	83	84	70	67	66	3	26	23			6			
198-1	198-1b	6	7	11		0	62	24	97	95	77	69	68	72	3	20	21			5	5	7	
198-1	198-1b	6				0	66	25	83	86		75	78		3	25	27			6			
198-1	198-1b	6				0	68	26	84	85		77	76		3	26				6			
198-1	198-1b	6				0	57	20	84	80	86	70	66	71	3	25	27			5	6		
198-1	198-1c	6	7	22		0	52	21	66	79	73	77	56		3	21				9			
198-1	198-1c	6				0	56	26	66	73		54	46		3	24				6	6		
198-1	198-1c	6				0	55	26	76	74		50	50		3	21				6			
198-1	198-1c	6				0	57	21	86	77		65	70	51	3	24							
198-1	198-1c	6				0	54	18	74	74		63	51		3	27	24			7			
198-1	198-1d	6	7.5	16		0	58	22	98	99	96	66	73		6	25	26	26		10			
198-1	198-1d	6				0	65	24	92	86	91	81	77	75	6	22	25			13			
198-1	198-1d	6				0	60	25	77	83	86	58	66	74	6	23	24			7			
198-1	198-1d	6				0	60	24	82	79	85	68	72	81	4	23	22			10	10		
198-1	198-1d	6				0	65	25	81	82	72	66	66	70	6	25	24			10	10		
198-2	198-2a	6	25.5	69		0	62	27	191	187		120	106	130	6	26	40	30		11			
198-2	198-2a	6				0	61	25	127	131	106	92	88		6	31	27	26		9	7		
198-2	198-2a	6				0	86	35	129	153		98	103	108	6	25	28			10	11		
198-2	198-2a	6				0	75	34	102	106	101	88	89		6	23	22			10	14		
198-2	198-2a	6				0	80	36	157	133		104	105		6	35	33			26			
198-2	198-2a	6				0	81	30	153	136		107	102		6	35	31			21			
198-2	198-2a	6				0	76	35	134	172		103	101		6	28	32	35		20	12	16	
198-2	198-2b	6	23	27		0	66	32	116	119	121	87	94	95	6	29	28	30		20			
198-2	198-2b	6				0	63	30	115	119		84	87	82	6	31	26			10	10		
198-2	198-2b	6				0	74	35	102	105	102	81	81	86	6	25	24	24		10			
198-2	198-2c	6	25	36		0	81	35	261	127		101	107		6	28	30	31	30	10	15		
198-2	198-2c	6				0	75	35	120	141		104	107	95	6	24	38			15	14		
198-2	198-2c	6				0	66	29	143	148		94	105	104	6	28	30	36		10			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
198-2	198-2d	6	25	48		0	85	33	144	132	123	98	96	95	6	27	26	31		16	15		
198-2	198-2d	6				0	80	30	151	147		84	83	96	6	32	27	23		15	12		
198-2	198-2d	6				0	75	36	143	169		103	102		6	34	20			13	14		
198-2	198-2d	6				0	77	34	112	122		91	92	96	6	20	21			21	19		
198-2	198-2d	6				0	74	27	137	108	123	85	86	101	6	28	27			12	13		
198-2	198-2d	6				0	70	30	112	109	114	80	84	80	6	25	24	23		12	22		
198-2	198-2e	6	19.5	41		0	76	34	131	134	128	102	91	93	6	30	31			15			
198-2	198-2e	6				0	74	35	121	123	116	81	90	80	6	30	31	32		14			
198-2	198-2e	6				0	78	40	133	161	153	96	97	99	6	31	32			22	12		
198-2	198-2e	6				0	71	29	124	123	103	85	79	81	6	27	26			18			
198-2	198-2e	6				0	76	34	105	107	104	92	89	87	6	35	25	25		15	13		
198-2	198-2e	6				0	76	24	116	111	107	77	83		6	26	29			12			
199-3	199-3a	6	14	17		0	52	23	75	76	90	59	60	61	6	25	24			9			
199-3	199-3a	6				0	59	20	74	75	72	66	64	66	6	25	22			9			
199-3	199-3b	6	14.5	16		1	65	16	104	95		67	77		2	25							
199-3	199-3b	6				0	46	14	77	79		55	62		3	27	24			7	6		
199-3	199-3b	6				0	46	19	75	80	84	65	96	63	3	19	22	25		5	6		
199-2	199-2a	6	12	8		0	52	25	80	84	75	64	61		6	26	30	25		7			
199-2	199-2a	6				0	52	21	75	79	62	62	61	59	3	24	25			6			
199-2	199-2b	6	10	25		0	57	26	103	128	131	81	82		3	29				9			
199-2	199-2c	6	14.5	9		0	62	25	102	98		70	70	68	6	23	24			10	10		
199-2	199-2c	6				0	58	28	98	97	75	64	71	63	6	24	25			6	10		
199-2	199-2d	6	12.5	8		0	60	23	81	113	108	59	74		3	22	29						
199-2	199-2d	6				0	60	21	91	86	97	66	72		6	29	29	30		10			
199-2	199-2e	6	15	13		0	53	23	102	101	98	70	67	66	3	30				5			
199-2	199-2e	6				0	63	18	103	101	83	82	96	61	6	24	25						
199-2	199-2e	6				0	61	19	91	93		68	72		4	27	24			6			
200-14	200-14a	4	16	40	7	0	78	25	133	126	81	83	66		3	28							
200-14	200-14a	4				0	66	19	114	103	102	81	80		3	30							
200-14	200-14a	4				1	63	25	104	102		81	76		3	28				11			
200-14	200-14a	4				0	72	21	111	109		81	79		6	21							
200-14	200-14b	4	19	37	9	0	73	25	150	130		80	76		3	21	22						
200-14	200-14b	4				0	71	23	110	111		70			3	35	29						
200-14	200-14b	4				0	73	22	100	90	101	74			3	24				10			
200-14	200-14b	4				0	75	18	123	132		95	99		6	32	30						
200-14	200-14b	4				0	69	24	102	101		95	70	67	6	29							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
200-14	200-14b	4				0	62	21	102	95		54			3	21							
200-14	200-14b	4				0	86	22	108	98		97			4	23							
200-14	200-14b	4				0	69	19	87	91		72	74		3	25				5			
200-14	200-14b	4				0	67	20	70	87		55	64		3	20							
200-14	200-14b	4				0	80	22	132	109		91	92		3	27				7			
200-14	200-14c	4	9	5	7	0	62	21	93	100	92	70	73		3	40	20						
200-14	200-14c	4				0	52	18	80	95		70	69		3	24							
200-14	200-14c	4				0	40	11	70	70		61			3	17							
200-14	200-14d	4	13.5	7	8	0	52	19	100	98	96	82			3								
200-14	200-14d	4				0	51	22	104	102		71	80		3	20							
200-14	200-14d	4				0	54	20	89	96	93	66	65		3	20							
200-9	200-9a	4	15.5	13	10	0	56	12	100	70		59	36		3	30				9			
200-9	200-9a	4				0	64	17	75	74		59			3	25	30			8			
200-9	200-9a	4				0	64	20	83	86	80	65	58		3	30				6			
200-9	200-9a	4				0	60	19	72	78	58	59			3	26				9			
200-9	200-9a	4				0	61	12	76	79		69	60		3	28							
200-9	200-9a	4				0	61	19	85	104		64	69		3	27							
200-9	200-9b	4	17.5	18	11	0	62	10	74			64	68		3	20							
200-9	200-9b	4				0	61	17	81	70		50	57		3	17							
200-9	200-9b	4				0	56	18	65	71		51	48		3	25				9			
200-9	200-9b	4				0	64	19	79	87		55			3	23							
200-9	200-9b	4				0	67	20	86	88	81	60	61		3	22	13			9			
200-9	200-9c	4	20	8	11	0	71	21	110	107		90	83		3	30				15			
200-9	200-9c	4				0	73	24	111	114		89	90		6	28							
200-9	200-9c	4				0	53	13					50		3	24							
200-9	200-9c	4				0	48	14	66	54	61	46	48		3	22							
200-9	200-9c	4				0	52	14	63	60		40	42		3	20							
200-9	200-9c	4				0	50	16	70	70		51	50		3	20	23						
200-9	200-9d	4	18.5	9	11	0	59	14	86	87		62	65		3	31							
200-9	200-9d	4				0	61	16	89	86	87	57	55		4	30							
200-9	200-9d	4				0	63	15	92	81	93	66	63		3	31							
200-9	200-9d	4				0	60	21	82	76		67			3	20				8			
200-9	200-9d	4				0	65	20	84	86		66			3	18							
200-9	200-9e	4	18	16	10	0	65	15	97			74			3	21							
200-9	200-9e	4				0	62	25	86	72		51			2	20							
200-9	200-9e	4				0	64	20	77	75		61			3	18	20						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
200-9	200-9e	4				0	62	26	87	81		75	76		3	20				12	10		
200-9	200-9e	4				0	58	18	73	71		60			2								
200-9	200-9e	4				0	60	16	87	93		66			3	21							
200-5A	200-5Aa	4	14	5	8	1	62	15	100			66			2	15							
200-5A	200-5Aa	4				0	60	22	100	100		60			2	15				5			
200-5A	200-5Aa	4				0	62	24	85	82		65	60		2	24							
200-5A	200-5Aa	4				0	60	21	95	93		55	61		2	17							
200-5B	200-5Ba	6	21	7	11	0	62	25	120	125		85	81		3	25	26			10			
200-11	200-11a	4	11	16	9	1	60	20	110	119		70	65		2	15							
200-13	200-13a	4	17	9	9	0	63	15	101	102		60			3	23							
200-13	200-13a	4				0	70	21	90	91	85	70			3	30							
200-13	200-13a	4				0	67	21	91	96		46	60		3	25							
200-18	200-18a	4	10.5	14	7	1	61	16	91	95		71	69		3	30							
200-18	200-18a	4				0	61	10	86			73	76		3	20							
200-18	200-18a	4				0	60	16	96	97	83	65	70		3	15	20						
200-18	200-18a	4				0	59	16	85	84	75	47	68		3	18							
200-18	200-18a	4				0	50	14	83	82	83	47			3	26	23						
200-18	200-18b	4	7	6	6	1	58	20	86	80		63	68		2	20							
200-2	200-2a	6	9	17	9	0	70	22	107	89		78	73	74	3	30							
200-2	200-2a	6				0	57	20	92	91		67	72		4	23							
200-2	200-2a	6				0	71	21	93			57	76		3	22	23						
200-2	200-2a	6				0	54	17	90	85		60	62		3	22				7			
200-2	200-2a	6				0	50	18	95	97		68	66		4	18							
200-2	200-2a	6				0	61	16	74	73		60	62		3	22							
200-2	200-2a	6				0	60	20	76	94		55			3	24							
200-2	200-2b	6	14.5	9	10	0	61	15	105	90		73			3	19							
200-2	200-2b	6				0	61	20	94	87		63	69		3	21	21			11	9		
200-2	200-2b	6				0	56	19	79	80		60	64		3	22				10			
200-2	200-2b	6				0	65	20	97	96		75	73		3	20							
200-2	200-2b	6				0	60	21	94	86		70			3	26							
200-2	200-2c	6	13	19	9	0	70	20	60	80		80	76		6	52							
200-2	200-2c	6				0	60	20	81	80		57	55		3	24							
200-2	200-2c	6				0	60	17	80	85	85	78	67	63	4	24	20						
200-2	200-2c	6				0	70	15	82	96		71	80	76	4	23							
200-2	200-2c	6				0	64	20	83	71		70	71		4	15	20						
200-2	200-2c	6				0	65	16	110	100	90	60	60	65	3	20				10			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
200-2	200-2c	6				0	60	20	100	105		75			3	15	25						
200-2	200-2c	6				0	60	14	85	80		70	75		3	22							
200-2	200-2d	6	14	9	9	0	75	21	105			80	81		3	25							
200-2	200-2d	6				0	65	25	90	91					3	24							
200-2	200-2d	6				0	70	12	95	86		66			3	20	26			20			
200-2	200-2d	6				0	70	12	92			70			4	20				30			
200-2	200-2e	6	13.5	7	10	0	76	11	85			65			6	25	25						
200-2	200-2e	6				0	74	11	110	100		76	75			30							
200-2	200-2e	6				0	70	11	90	102		62			4	22	21						
200-2	200-2e	6				0	71	12	85			62			3	22							
200-2	200-2f	6	9.5	16	8	0	66	26	96	91		76	66		2	27	22						
200-2	200-2f	6				0	52	20	86	91		67	60		3	24	30	20					
200-2	200-2f	6				0	69	25	83	87		71	71		4	24	21						
200-2	200-2f	6				0	59	27	85	82	83	71	72		6	29	26						
200-2	200-2f	6				0	46	21	69	71	70	62	61		6	13	18						
200-22	200-22a	6	19	11	11	0	60	17	111	96	110	77	79		6	54	25						
200-22	200-22a	6				0	59	20	90			61			6	52				10			
200-22	200-22a	6				0	60	19	103	80		70	78		6	56				18			
200-23	200-23a	6	15.5	10	9	0	66	16	100	96		74			3	20							
200-23	200-23a	6				0	51	15	87	92		60			3	20							
200-23	200-23a	6				0	58	15	81	84		62	66		3	21	23						
200-23	200-23a	6				0	62	17	97	90	90	76			4	24							
200-23	200-23a	6				0	66	30	89	90		81	80		3	25				6			
200-23	200-23b	6	13	12	9	0	57	18	100			57			5	20							
200-23	200-23b	6				0	50	13	72	79		55			5	20	25			5			
200-23	200-23b	6				0	58	21	100	90		74			3	22				5			
200-23	200-23b	6				0	65	22	89	86		63			3	23							
200-23	200-23b	6				0	60	27	78			70			6	21				3			
200-26	200-26a	6	14	16	11	0	71	26	102			75			6	22							
200-26	200-26a	6				0	71	25	91			70			4	19				5			
200-26	200-26a	6				0	68	24	91	80		86	71		6	24				5			
200-26	200-26a	6				0	69	27	110	120	105	75	85	81	6	35							
200-17	200-17a	6	11.5	11	8	0	66	20	99	82	74	67			6	42	18			18			
200-17	200-17a	6				1	50	17	72	71		69			2	42	16			16			
200-17	200-17b	6	9	7	7	1	39	12	65	63		30			2	32							
200-17	200-17c	6	9	7	6	1	45	15	63	62		52	55		2	26				10			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
200-17	200-17c	6				0	54	15	80	69		50			3	28							
200-16	200-16a	6	14.5	8	9	0	63	19	125	100		86			6	20	25						
200-16	200-16a	6				0	56	13	80	79		69	63		3	24							
200-16	200-16a	6				0	55	14	58			55			3	13				8			
200-12	200-12a	6	22	12	9	0	61	15	112	110		80	66		6	26	20			20			
200-12	200-12a	6				0	75	21	100	92		71			6	30				10			
200-12	200-12a	6				0	66	29	90	95		72	73		6	25				22			
200-12	200-12a	6				0	60	22	91	79	80	72	71		6	19	20			18			
200-12	200-12a	6				0	81	25	102	87		82	79		6	20				20			
200-12	200-12a	6				0	70	25	81	82		70			6	21				34			
200-12	200-12a	6				0	75	24	84	89		52	61		6	23							
200-12	200-12b	6	13.5	8	7	0	54	25	71	65		60	60		6	20	21						
200-12	200-12b	6				0	56	20	71	80		60			6	23							
200-12	200-12b	6				0	55	20	93	86		66	67		6	26							
200-12	200-12c	6	18	12	9	0	65	20	105	85		53			6	22							
200-12	200-12c	6				0	69	21	90	100		69	80		6	35	25			18			
200-12	200-12c	6				0	61	20	95	100		70	75		6	21				28			
200-12	200-12c	6				0	66	21	91	95		66	75		6	20				20			
200-15	200-15a	4	20	4	11	0	71	25	120	85		85			6	30							
200-15	200-15a	4				0	75	15	85	65		65			3	20							
200-15	200-15a	4				0	71	15	95	110		85			6	25	26			10			
200-15	200-15a	4				0	66	25	80			75			6	30							
200-15	200-15b	4	17	17	10	0	65	15	121	119		92			3	19							
200-15	200-15b	4				0	63	21	100	93		65			3	32	25			8			
200-15	200-15b	4				0	58	20	77			64			3	24							
200-15	200-15c	4	16.5	10	10	0	59	12	107			74			3	27							
200-15	200-15c	4				0	60	18	83	91		62			6	26							
200-15	200-15c	4				0	60	19	82	82		68	66		3	20							
200-15	200-15c	4				0	59	19	82	72		55			3	19							
200-15	200-15d	4	24	10	11	0	75	16	120			70			6	20							
200-15	200-15d	4				0	70	20	100	90		84			6	25	30						
200-15	200-15d	4				0	70	20	80	90		50			6	21	33						
200-15	200-15d	4				0	70	20	95	105		75			6	25							
200-15	200-15d	4				0	70	20	85			75			6	10	25			10	20		
200-15	200-15d	4				0	70	22	90	85		75	75		6	10							
200-15	200-15d	4				0	65	20	90			80			6	15							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
200-15	200-15d	4				0	70	15	120			85	85		6	25							
200-15	200-15d	4				0	70	30	80			70			6	26				24			
200-24	200-24a	4	18	2	9	0	65	19	100	92		62	61		4	15							
200-24	200-24a	4				0	56	16	90	85		65	70		4	20							
200-8	200-8a	4	15	12	8	0	62	16	105			55			3	22							
200-8	200-8a	4				0	63	14	104	96		62	80		3	20							
200-8	200-8b	4	12	12	8	0	53	16	90	90	80	50	60		3	19	26			12			
200-8	200-8b	4				0	54	17	75	73		49	55		4	34							
200-8	200-8b	4				0	61	20	100	100	90	66			3	48	25						
200-7	200-7a	6	19	15		0	81	20	129	104	117	80	90	85	3	27							
200-7	200-7a	6				0	75	22	109	96		95	89		6	28	27	32	32	12			
200-7	200-7a	6				0	79	25	94	105		77	86	80	3	31	29	27					
200-7	200-7a	6				0	72	27	95	102	98	75	74		6	31	35	29	27	12			
200-7	200-7a	6				0	72	21	82	85	86	72	71	74	3	27	25						
200-7	200-7b	6	16	17		0	76	28	104	105	103	86	95	88	6	27	30						
200-7	200-7b	6				0	80	30	105	106	108	91	94	97	5	34	30	31		12			
200-7	200-7b	6				0	67	28	88	97	96	77	77		6	30	34	32		9	8		
200-7	200-7b	6				0	74	30	96	104	107	89	92	83	3	27	33						
200-7	200-7b	6				0	75	32	111	104	110	101	94	94	3	30	33	31					
200-7	200-7c	6	14.5	13		0	65	21	102	106	109	88	89	85	3	29	31	25	29	8	10		
200-7	200-7c	6				0	70	22	94	90	92	83	77	84	6	25	27						
200-7	200-7c	6				0	67	20	81	80	85	73	63	80	3	26	27	27		9	11		
200-7	200-7c	6				0	71	22	84	87	89	95	78		3	25							
200-7	200-7d	6	13	12		0	69	24	94	91	81	71	77		3	25	26						
200-7	200-7d	6				0	68	22	96	87	80	80	70	71	3	29	27			10	11	12	
200-7	200-7d	6				0	65	21	90	90	90	75	74	73	3	24	26						
200-7	200-7d	6				0	66	23	83	93	89	70	66		6	26	24						
201	201a	6	7.5	19		0	59	20	125	106	117	57	82	87	6	27	29			15	13	10	
201	201a	6				0	62	25	90	93	92	48	78		6	24	25	23		11	12		
203-1	203-1a	4	26	20		0	65	20	133	94	31	72	70		3	25				9			
203-1	203-1b	4	21	2		0	87	36	130	142		82	95		6	26	25	34					
203-1	203-1b	4				0	75	34	142	167	141	82	96	98	6	25	29						
203-1	203-1c	4	16	34		0	66	26	117	176	124	82	76		3								
203-1	203-1c	4				0	71	28	161	156	116	83	87		3	31				10			
204-16	204-16a	6	13	19	14	0	71	20	109	110		71	72		3	31	27						
204-16	204-16a	6				0	56	22	101	99		61	69		3	28							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
204-16	204-16a	6				0	64	22	97			74			3	23							
204-16	204-16a	6				0	56	18	98	107	89	56	56		6	20							
204-16	204-16a	6				0	70	20	112	107		63			3	21	22						
204-19	204-19a	4	8.5	7	6	0	54	17	87	86	90	56	61		2	17							
204-19	204-19a	4				0	60	16	91	79		68											
204-19	204-19a	4				0	58	20	79	87		60	57			15							
204-19	204-19a	4				0	54	15	64	66		50			3	20							
204-19	204-19a	4				0	51	19	63	67		51			3	18							
204-19	204-19b	4	10	16	8	0	53	18	86	90		57			3	23	25			10			
204-19	204-19b	4				1	46	19	64	66		47			2	17							
204-19	204-19b	4				0	55	13	81														
204-19	204-19b	4				0	53	20	60	45		46	45		2	26							
204-19	204-19b	4				1	53	14	67			57			2	18							
204-19	204-19c	4	8.5	8	7	1	58	18	107	109		56	60		2	21							
204-19	204-19c	4				1	60	24	107	102		65	72		3	24							
204-19	204-19c	4				0	63	24	111	107		73	75		3	17							
204-19	204-19d	4	14.5	13	8	0	75	16	95	81		56	65		3	40							
204-19	204-19d	4				0	56	20	86			50	50		3	36							
204-19	204-19d	4				0	56	22	96	85		56	50		3	45				20			
204-19	204-19d	4				0	63	24	86			50			3	20				12			
204-19	204-19d	4				0	54	20	65	63		46	48		2	30							
204-19	204-19d	4				0	46	13	50	60	71	40			2	31							
204-19	204-19e	4	13	10	8	0	65	21	100	110		79	74	72	3	22	56			10			
204-19	204-19e	4				0	61	21	96	101		56	66		3	21	21	23					
204-19	204-19e	4				0	60	20	91	83		60	62		3	30							
204-19	204-19f	4	15	10	9	0	65	17	95	81		60			3					10			
204-19	204-19f	4				0	55		86	92		46			3								
204-19	204-19f	4				0	61	15	91	90		54			3	21							
204-19	204-19f	4				0	64	20	81			60			3	20							
204-9	204-9a	4	12	11	7	1	57	15	100	95		59			2	20							
204-9	204-9a	4				0	62	21	85	84		72			2	15							
204-9	204-9a	4				0	51	10	63			51			2	18							
204-9	204-9a	4				0	61	26	84	80		64	65		2	15							
204-9	204-9a	4				0	57	17	85	71		52			3	15							
204-7	204-7a	4	17.5	20	9	1	70	14	103	102		85	82		2	21							
204-7	204-7a	4				0	58	21	92	90	92	55	61		3	21	19						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
204-7	204-7a	4				0	53	22	80	72		53			3	17				9			
204-7	204-7a	4				0	61	19	82	74		52			3	24							
204-7	204-7a	4				0	56	16	62	60		57	59		2	25							
204-7	204-7b	4	24	91	11	0	52	13	89	91	76	46	54		3	20							
204-7	204-7b	4				0	46	18	71	77		53	52		2	15				7			
204-7	204-7b	4				0	47	17	69	68		60	61		3	18				8			
204-7	204-7b	4				1	52	17	74			50			2	16							
204-7	204-7b	4				0	54	20	91	81		60			3	19							
204-7	204-7b	4				0	68	20	80	85	104	73	70		3	30							
204-7	204-7b	4				0	70	22	98	102		71	65		6	23	24						
204-7	204-7b	4				0	59	24	98	76		50	61		6	25	24			9			
204-7	204-7b	4				0	60	25	89	91		60			3	24							
204-7	204-7b	4				0	65	25	91	101		55			3	21	26						
204-7	204-7b	4				0	75	31	104	124		65	81	71	6	25							
204-7	204-7b	4				0	80	28	140	115		95			3	22	20			18			
204-7	204-7b	4				0	80	30	154	146		85	97		3	21							
204-7	204-7b	4				0	69	26	151	121		70	89		3	19	25						
204-7	204-7b	4				1	49	21	98			61	62		2	21							
204-2	204-2a	4	18	12	10	0	61	23	101	81	82	66	75	76	3	25							
204-2	204-2a	4				0	68	25	90	91	92	62			3	22							
204-2	204-2a	4				1	66	25	80	81		61	67		2	26							
204-2	204-2a	4				0	70	21	102	104		76	72		3	26							
204-2	204-2a	4				0	60	25	95	99		95	97	91	2								
204-2	204-2b	4	20	37	10	0	76	23	101	90		81	83		3	22							
204-2	204-2b	4				0	53	18	80	82		52	50		3	22							
204-2	204-2b	4				0	65	20	95	94		73	61		3	20							
204-2	204-2b	4				0	57	14	87	82		78	66		3	21	20						
204-2	204-2b	4				0	61	17	92	89		79			3	21							
204-2	204-2b	4				0	60	16	91	98		60	56		3	23							
204-2	204-2c	4	16	15	8	0	61	16	84	91		63			3	21							
204-2	204-2c	4				0	50	13	65	64		52	51		3	14	17						
204-2	204-2c	4				1	47	16	81	74		55	61		3	19							
204-2	204-2c	4				1	46	19	83	72		62	59		2	14							
204-2	204-2c	4				0	60	21	75	76		51	51		3	13							
204-10	204-10a	6	12	11	8	0	59	15	91			50			3	27							
204-10	204-10a	6				0	59	12	75			47			3	16							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
204-10	204-10a	6				1	47	11	64			52			2	20							
204-10	204-10a	6				0	58	21	100			50			3	17							
204-10	204-10a	6				1	59	21	81			61			2	26							
204-10	204-10b	6	9	5	8	1	72	23	123	119		63			2	24							
204-10	204-10c	6	6	5	8	1	69	25	107			65			2	15							
204-10	204-10c	6				0	64	16	90	91		57			2	13							
204-10	204-10c	6				0	50	19	83	91	93	66	67		2	29							
204-11	204-11a	4	20.5	18	9	0	65	18	96	109		62	70		3	16							
204-11	204-11a	4				0	69	24	102	111	110	81	70		3	27							
204-11	204-11a	4				0	58	19	87	84		75	72		3	29	24			11	11		
204-11	204-11a	4				0	68	18	93	82		73	76		6	26							
204-11	204-11a	4				0	62	20	96			80	76		6	20				16	12		
204-11	204-11a	4				0	61	21	78	92		71			6	25							
204-11	204-11b	4	15	17	8	0	60	21	112	113		63	73		6	25	22						
204-11	204-11b	4				0	41	16	83	60		44	43		3	21	23						
204-11	204-11b	4				0	49	19	76	81		60	61		2	23							
204-11	204-11b	4				0	67	22	107	103		75			3	24							
204-11	204-11b	4				0	54	20	88	84		79			6	22	23						
204-11	204-11b	4				0	53	19	80	89		60			6	27							
204-11	204-11b	4				0	45	16	70	70	69	58			6	17							
204-11	204-11b	4				1	61	20	82	85		79			2	19							
204-18	204-18a	4	11.5	13	8	0	63	19	112	104		63	64		6	22							
204-18	204-18a	4				0	70	22	94			57			6	24							
204-18	204-18a	4				0	73	20	85	94		72			3	29							
204-18	204-18a	4				0	64	17	89	85		64	57		3	26							
204-18	204-18a	4				0	67	19	108	111		66	70		3	21							
204-18	204-18a	4				0	75	20	104	102		80	78		6	17							
204-18	204-18b	4	12.5	7	8	0	55	19	90			59			3	20							
204-18	204-18b	4				0	56	20	105	112	114	64	66	68	3	18							
204-15	204-15a	4	17	16	10				75	90		65				20							
204-15	204-15a	4				0	50	15	80			60	56	51	3	17							
204-15	204-15a	4				0	55	12	92	80		52	70		3								
204-15	204-15a	4				0	55	15	100			52			3								
204-15	204-15a	4				0	46		90			60			3	25							
204-15	204-15a	4				0	55	12	80	80		60	70		3	20							
204-15	204-15a	4				0	50	15	80	55		45	50										

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
204-15	204-15a	4				0	50	13	60			60	52		3	20							
204-15	204-15a	4				0	65	12	85	68		63	76		2	26							
204-15	204-15a	4				0	65	15	70	80		70	70		2	20							
204-15	204-15a	4				1	50	13	85	82		42	45		2								
204-15	204-15a	4				0	65	12	65			50											
204-15	204-15a	4				0	75	15	72	71		55			3	25							
204-15	204-15b	4	16	15	9	1	60	12	75			55											
204-15	204-15b	4				0	62	16	64	84		40			3	25							
204-15	204-15b	4				0	65	20	90	85		55			3	22							
204-15	204-15b	4				0	65	20	86			70	65		3	25							
204-15	204-15b	4				0	60	15	86			60			2	26							
204-8	204-8a	6	6	2	9	0	70	26	100			85			6	26	30						
204-8	204-8b	6	9	11	9	0	60	23	150	140		90	95		3	31	26						
204-8	204-8b	6				1	60	25	82	90		70			2	30							
204-8	204-8c	6	16	8	10	0	55	25	80	90		80			2	25							
204-8	204-8c	6				0	62	12	115	116		81			3	20							
204-8	204-8c	6				0	63	20	120	100		80	82		3	26							
204-8	204-8c	6				0	55	20	110	105		75			3	25							
204-8	204-8d	6	22	23	11	1	75	25	155	120		90	95		2	21							
204-8	204-8d	6				0	55		100	98		65			3	15	24						
204-8	204-8d	6				0	70	26	100	120		80	95		3	20							
204-8	204-8d	6				0	58	22	83	100		61	62		3	20	20			5			
204-8	204-8d	6				0	65	22	120	130		65	75		4	26	25						
204-8	204-8d	6				0	60	25	90	95		45	60		2	20	16						
204-8	204-8d	6				0	62	25	100	90		70			4	25	20						
204-8	204-8d	6				0	65	26	90	85		70	70		3	25							
204-8	204-8d	6				0	72	28	120	130		66	65		2								
204-8	204-8d	6				0	70	27	120			75	65		4	16							
204-8	204-8d	6				0	55	20	55	56		50	49		3	20							
204-8	204-8d	6				1	60	12	150	150		66	110		3	23	21			6			
204-8	204-8d	6				1	60	25	110			90	60		3	20	22			18			
204-8	204-8d	6				1	60	20	100			60	65		3	20	24						
204-8	204-8d	6				0	55	20	90			70			3	20	30	20		8	16		
204-8	204-8d	6				1	50	12	90	90	80	60	52		3	20				10			
205-1	205-1a	4	9	7		0	60	15	127	102		85	76		3	28							
205-1	205-1a	4				0	67	18	107	124	123	72	74		3	24	23			9			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
205-1	205-1a	4				0	50	20	94	91	101	71	73	76	3	28	29						
205-1	205-1a	4				0	69	21	116	154	104	82	78	82	3	28	33						
205-1	205-1a	4				0	55	18	94	107	107	73	74		3	25	26			10	8		
205-1	205-1b	4	12	15		0	65	17	107	102	109	69	70	65	3	22				7			
205-1	205-1b	4				0	55	17	96	104	99	66	64		3	22							
205-1	205-1b	4				0	69	26	109	107		66	75	73	3	28	24			9			
205-1	205-1b	4				0	52	14	75	90	87	53	35	50	3	20				6			
205-1	205-1b	4				0	56	16	100	102	75	61	62		3	22							
205-1	205-1b	4				0	56	15	72	95	89	59	61		3	22				7			
205-1	205-1c	4	8.5	7		1	59	21	78	94	103	74	70		2	21							
205-1	205-1c	4				0	48	22	75	83	87	61	62		3	25							
205-1	205-1c	4				0	56	23	77	90	87	64	65	73	3	26				5			
205-1	205-1d	4	6.5	12		0	59	21	80	81	80	69	60		3	27							
205-1	205-1d	4				0	53	19	70	77	82	61	59	60	3	23							
205-1	205-1d	4				0	55	17	86	87	79	53	56		3	20							
205-1	205-1e	4	5	7		0	52	17	83	84	60	48	57	52	3	19	19						
205-1	205-1e	4				0	53	18	70	87		52	53		3								
205-1	205-1e	4				0	48	18	61	76	80	62	56		2	23							
205-1	205-1f	4	6	10		1	54	20	91	102	82	72	69		2	31							
205-1	205-1f	4				0	61	21	80	100	101	65	75		3	26				8			
205-3	205-3a	4	24	13		0	70	25	128	126	104	72	67		3	32							
205-3	205-3a	4				0	72	26	129	134	109	72	76	69	3	31	27						
205-3	205-3a	4				0	73	19	103	102	91	75	80	92	6	32							
205-3	205-3a	4				0	74	22	103	102	97	85	68	83	6	20	33			10			
205-3	205-3b	4	14	9		1	51	12	100	103		73	72		3	27	29						
205-3	205-3b	4				0	60	17	83	86	71	66	60		3	29	27						
205-3	205-3b	4				0	55	19	80	82	72	58	60		3	31	25			6	7		
205-3	205-3b	4				0	63	21	94	96		61	61		3	28	23			7	8		
205-3	205-3b	4				0	56	23	84	85	74	58			3	26				8	8	9	
205-3	205-3c	4	16.5	15		0	60	19	95	84		53	55		3	20	27			5	8		
205-3	205-3c	4				0	60	22	90	98	84	62	63		3	29	24			9	8	9	
205-3	205-3d	4	9	17		0	62	20	102	102	92	75	66	60	3	26	26						
205-3	205-3d	4				0	50	19	80	97	82	56	67		3	27				5	6		
205-3	205-3d	4				0	57	20	103	105	91	66	66		3	22							
205-3	205-3d	4				0	61	20	100	92	97	72	72	70	3	27	25			5			
205-3	205-3e	4	12	11		0	66	22	85	96	97	72	93		3	31	30						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
205-3	205-3e	4				0	65	22	98	92	89	67	73		3	27				7			
205-3	205-3e	4				0	55	15	86	83	76	63	62	64	3	24							
205-3	205-3e	4				0	65	22	96	98	80	71	72		3	26				5			
205-3	205-3e	4				0	59	21	82	83	87	70	71	72	3	25				6			
205-3	205-3f	4	13	19		0	61	20	176	147	126	74	73		3	32							
205-3	205-3f	4				0	62	19	92	73		63	67	77	3	27				5			
205-3	205-3f	4				0	46	18	70	77	81	57	60	63	3	20	18	25		5			
205-3	205-3g	4	14	6		0	72	30	106	107	108	70	74		3	16	31	30		11			
205-3	205-3h	4	9.5	10		0	60	20	97	99	79	70	70	66	3	27							
205-3	205-3h	4				0	60	22	99	100	89	75	70		3	21							
205-3	205-3h	4				0	50	19	84	83	76	57	60	65	3	20				4			
205-3	205-3i	4	4	9		1	50	17	87	90		67	67		2	23	21						
205-3	205-3i	4				1	48	16	72	74		54	50		2	20							
207-2	207-2a	6	14	21		0	75	20	103	131	107	71	77	79	3	23	24			10			
207-2	207-2a	6				0	68	18	105	101	84	75			3	35	26			9			
207-2	207-2a	6				0	69	19	104	105		72	71	83	3	29				10			
207-2	207-2a	6				0	79	24	106	100	97	80	76		3	23	25			10			
207-2	207-2a	6				0	81	21	125	97	114	81	81		3	30	25						
207-2	207-2b	6	9.5	23		0	76	19	102	97		70	66		3	31				8			
207-2	207-2b	6				0	66	15	97	105	86	65	74		3	29				10	9		
207-2	207-2b	6				0	70	17	104	107		73	90	77	3	27	23						
207-2	207-2b	6				0	61	15	72	81	86	63	62		3	17	26						
207-2	207-2b	6				0	65	21	90	85		76	80		6	22	23			8	9		
207-2	207-2c	6	17.5	29		0	63	12	108	81	95	68	71	67	3	30	26	31		11	10	7	
207-2	207-2c	6				0	76	15	85	104	107	83	81		3	25	27			9			
207-2	207-2c	6				0	71	17	103	98		71	74		3	27							
207-2	207-2c	6				0	75	16	100	102		75	62	72	3	32				10			
207-2	207-2c	6				0	72	28	92	102	100	76	77	78	3	30	31						
207-1	207-1a	6	14	9		0	51	17	90	98	87	83	70	73	3	26	28			9			
207-1	207-1a	6				0	60	21	95	93		74	80	82	6	24	23	29		9	8	8	6
207-1	207-1a	6				0	62	22	109	106	103	80	80	83	6	28	20			10	12		
207-1	207-1b	6	11.5	11		0	65	20	109	123		67	67		6	27	29			9	10		
207-1	207-1b	6				0	53	19	99	87	77	60	67		6	23	24						
207-1	207-1b	6				0	66	22	84	82		71	79	76	6	25	24			5	7		
207-1	207-1b	6				0	66	17	87	90		66			6	20	23	26					
207-1	207-1b	6				0	65	22	77	73	75	70	66	63	3	25	26			8			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
207-1	207-1c	6	13	5		0	49	19	72	80	81	53	55	51	6	19	18			6	5		
207-1	207-1c	6				0	64	25	98	97		84	82		6	25	24			15			
207-1	207-1d	6	11	8		0	50	17	84	90		57	59		3	22	23	23					
207-1	207-1d	6				0	47	18	94	91		72	77		3	25	26			8			
207-1	207-1e	6	14	9		0	52	19	95	96		72	60	56	3	24	26			6			
207-1	207-1e	6				0	50	18	72	73	70	61	60	61	3	24	24			5			
207-1	207-1e	6				0	54	15	80	81	67	60	60		3	23	25						
219-1	219-1a	4	8.5	18		0	61	20	97	93	77	74	65	65	3	31							
219-1	219-1a	4				0	64	25	78	76	78	57	59		3	25				6	7		
219-1	219-1a	4				0	58	23	67	65	60	57	59		3	24	23			6			
219-1	219-1b	4	10	17		0	62	19	92	93	87	70	71	74	3	15	24			8			
219-1	219-1b	4				0	58	19	79	88	89	68	75	74	3	27	26			9	9	9	
219-1	219-1b	4				0	58	22	103			77	73	74	3	31				7	8	6	7
219-2	219-2a	4	7	16		0	65	20	108	111	98	71	70	80	3	35	26						
219-2	219-2a	4				0	56	24	91	101	87	65	71	69	6	23	22			9	8		
219-2	219-2a	4				0	48	23	66	80	78	59	61	62	6	24	21	20					
219-2	219-2a	4				0	61	25	86	91		66	66	65	3	18	22			10	10	9	
219-2	219-2b	4	7.5	12		0	58	26	97	96	91	71	66	66	3	20	25	27					
219-2	219-2b	4				0	64	25	86	104	102	68	69	77	3	22	21	19					
219-2	219-2b	4				0	48	23	71	88	77	60	60	61	6	28				6			
219-2	219-2b	4				0	64	26	85	100	104	71	76	84	3	24	25	31					
219-2	219-2b	4				0	60	24	86	99	100	71	73	74	3	30	28			10			
219-2	219-2b	4				0	51	21	71	77	77	56	60	56	3	22	23	20		8			
219-3	219-3a	6	6.5	15		0	58	20	88	93	98	67	76		3	25	26			7	8	6	
219-3	219-3a	6				0	57	17	90	90	90	64	65		3	26	31			7			
219-3	219-3b	6	5.5	19		0	66	19	99	95	90	87	90		6	23	20			10	7		
222-1	222-1a	6	22.5	73		0	70	30	117	112		87	99	96	6	30	30			7	8		
222-1	222-1a	6				0	80	31	114	107	109	98	95	96	6	32	35			7			
222-1	222-1a	6				0	76	29	119	121	107	95	98	100	6	27	29			9	8	9	
222-1	222-1a	6				0	70	30	104	105	107	96	96	93	6	31	30						
222-1	222-1a	6				0	76	22	109	113		87	97	98	3	32	30			10	12	11	
222-1	222-1a	6				0	79	33	117	119	124	98	101	102	3	31	32	30					
222-1	222-1b	6	23	68		0	70	29	106	100		94	84	80	6	23	33			10			
222-1	222-1b	6				0	70	26	95	102	104	80	92	87	3	24	25	29		12	11		
222-1	222-1b	6				0	80	32	127	112		108	107	108	6	30	31	32		19	17		
222-1	222-1b	6				0	72	30	116	109	111	97	96		6	29	30			19			

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
222-1	222-1b	6				0	77	31	118	107	109	97	101	100	6	31	30			17	18	16	
222-1	222-1c	6	22.5	80		0	84	30	100	107	108	90	91	95	6	35	34			9	8		
222-1	222-1c	6				0	78	30	117	105	101	96	97		3	26	29						
222-1	222-1c	6				0	69	30	103	102	105	89	100	81	6	25	24			15	17	16	
222-1	222-1c	6				0	73	34	105	102	114	101	102	98	6	32	28			21	20	19	
222-1	222-1c	6				0	80	39	98	109		93	98		6	30	31			14			
222-1	222-1d	6	21.5	46		0	69	27	112	143		76	85	77	3	29	28			9	8	9	
222-1	222-1d	6				0	70	27	102	109	112	92	96	85	6	24	25			7	8	7	
222-1	222-1d	6				0	75	28	100	113	103	80	86		3	32	33						
222-1	222-1e	6	22	91		0	69	25	102	103	113	82	93		3	33	30			8	9		
222-1	222-1e	6				0	70	29	122	107	113	97	99	100	6	34	33			12	13		
222-1	222-1e	6				0	72	29	104	112		92	87		3	33				12	13		
222-3	222-3a	6	17	80		0	68	28	134	108	119	100	101	99	3	22	22			12			
222-3	222-3a	6				0	68	28	122	135	134	102	97		3	23	22			18	19		
222-3	222-3a	6				0	68	27	118	107	112	96	97		6	35	26	30					
222-3	222-3a	6				0	64	22	103	107	107	85	93	86	3	22	31			13			
222-3	222-3a	6				0	68	28	105	113	115	96	96	99	6	24	24						
222-3	222-3a	6				0	68	24	115	115	117	101	99	103	3	33	28			15	12	13	
222-3	222-3a	6				0	56	21	91	92	93	86	87	88	4	31	23						
222-3	222-3a	6				0	60	23	122	127	120	96	95	100	6	32				15	14	15	
222-3	222-3a	6				0	62	28	107	107	108	86	94	92	6	26	33						
222-3	222-3b	6	27	50		0	72	23	124	123	121	86	92	90	3	27							
222-3	222-3b	6				0	74	29	107	111		74	98	86	6	30	41	38	40				
222-3	222-3b	6				0	80	20	112	111	110	104	92	95	3	33	36			14	13		
222-3	222-3b	6				0	78	27	107	118	117	98	86		3	35	32			14	13	15	
222-3	222-3b	6				0	65	24	107	108	110	86	87	89	3	29	31			15	16		
69	69-a	4	10.5	11		0	61	25	86	103	104	66	67	67	3	24	25			8	7	8	
69	69-a	4				0	66	21	98	102	92	86	79	75	3	25				12	11	10	
69	69-b	4	9.5	7		0	62	21	94	98		65	65		3	20	25						
69	69-b	4				0	60	19	78	86		58	58		3	25	27						
69	69-c	4	13.5	9		0	62	18	67	76	77	54			3	23				8			
69	69-c	4				0	60	20	76	95	97	57	63	66	3	19	20			9			
69	69-d	4	14	20		0	55	14	80	88	93	76	75	72	3	21	26			6	7		
69	69-d	4				0	60	20	90	88	93	76	75	72	3	26	21						
69	69-d	4				0	60	20	86	113		70	71		3	18	24						
69	69-e	4	7	8		1	55	14	77	77		54			2	23							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
69	69-e	4				0	53	15	67	69		41	40		3	17	16			6	7		
209-5	209-5a	4	8	11		1	55	20	77	78		62	57		2	19	25						
209-5	209-5a	4				0	55	22	73	71		58	59	55	3	17	22			6			
209-5	209-5a	4				1	55	17	70	76		67			2	30	30						
209-5	209-5a	4				0	61	20	80	87		72	59		3	27				7			
209-5	209-5b	4	9	12		1	50	18	90	97		85			2	19	23						
209-5	209-5b	4				0	60	11	97	98		69	65		3	16				6			
209-4	209-4a	4	10	13		1	58	16	72	92		60	51		3								
209-4	209-4a	4				0	55	15	82	69	80	50	54		3	12				6			
209-4	209-4a	4				0	66	18	70	74	75	42	46		3	20							
209-4	209-4a	4				0	55	14	83	92	70	44	51	55	3	30	26						
209-4	209-4b	4	8	5		0	49	11	92	95		51	55	71	3	18							
209-4	209-4b	4				0	59	21	74	92		46	72	80	3	26				5			
209-3	209-3a	4	6.5	16		0	45	14	62	56		45			3	27	25			5			
209-3	209-3a	4				0	44	15	60	68	68	55	50		3	19	20			6			
209-3	209-3a	4				0	45	16	64	55	65	35			3	20				5			
209-3	209-3b	4	6.5	2		0	44	16	89	84	82	40	42		3	24				6			
209-3	209-3c	4	13	17		0	54	16	82	71		67	62		3	17				6			
209-3	209-3c	4				0	51	14	75	76	62	54	60	51	3	20				6			
209-3	209-3c	4				0	62	17	74	72		51	61		3	28				10	10		
209-11	209-11a	4	9.5	11		0	51	15	88	63		54	48		3	19	20			6			
209-11	209-11a	4				0	47	18	62	65		40	47		3	23							
209-11	209-11b	4	7.5	7		0	53	12	83	85	71	50	50		3	23	26			10			
209-11	209-11b	4				0	50	12	77	75		52	50		3	20							
209-11	209-11b	4				0	50	14	82			67	45	57	3	26				11			
87	87a	6	2.5	5		0	51	23	91	77	57	61	81		3	27	21			6			
87	87a	6				1	47	19	71	71	72	65	56	68	3	28	20			7			
87	87b	6	2.5	6		1	50	21	71	67		61	62	61	3	26	23			5			
15	15a	6	18.5	19		0	72	22	97	99		95	93	94	6	22	27	30					
15	15a	6				0	75	29	101	119		98	101	96	3	27	26			20	18	17	
15	15a	6				0	75	30	132	125		91	96	91	6	23	26	25	23	9	11	10	15
15	15a	6				0	74	28	97	99	100	85	86	87	6	20	21	24		15	14	16	
15	15a	6				0	82	24	128	111		88	86		6	26	29			11			
15	15a	6				0	74	26	123	106	108	89	96		6	20	26	24	24	12	11	12	
15	15b	6	14.5	34		0	86	26	81	92	91	77	82	78	6	27	28	30	26	10	9	10	11
15	15b	6				0	70	24	102	94	105	82	71	81	6	22							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
15	15b	6				0	65	26	104	103	101	81	83	80	3	22				11	11	10	
15	15b	6				0	72	21	92	103	104	83	80	82	6	32	27			9	10	10	
15	15b	6				0	76	25	103	104	100	95	97	92	6	20	25			11	15		
15	15b	6				0	70	25	96	100	103	80	92	85	6	24	20			10	10		
15	15b	6				0	70	23	124	120		87	86		6	29	27			17	13		
15	15b	6				0	69	23	99	97	96	82	79	80	6	29	26	25		11	12	12	
15	15b	6				0	75	26	124	119		95	94		6	20	28			16	13		
15	15b	6				0	71	29	109	104		80	87	88	6	26	23			16	18		
15	15c	6	16.5	22		0	64	29	105	102	100	81	86	79	3	22	19			12	12		
15	15c	6				0	65	25	94	102	161	77	75	81	6	25	19			13	12	11	
15	15c	6				0	68	26	123	132	129	104	101	97	3	25	24	26		12			
15	15c	6				0	72	25	126	116	100	96	100		3	26	25						
15	15c	6				0	80	27	147	125	144	99	97	103	6	28	21			17	16		
15	15d	6	12.5	27		0	80	22	87	77	81	66	62	61	3	22							
15	15d	6				0	70	21	103	97	104	72	77		6	32	22	26		13	11	9	
15	15d	6				0	70	31	93	97	98	79	73	79	3	25	19	23		5	10	10	
15	15d	6				0	64	26	110	102	99	86	91	82	3	28	23			12	11		
15	15e	6	18.5	40		0	70	20	89	100	91	87	86	84	6	25	29			6			
15	15e	6				0	75	19	92	96	96	85	84	83	6	27	25	12		10	10		
15	15e	6				0	71	25	117	184	147	92	97	92	6	26	26			10	10		
15	15e	6				0	70	20	102	99	97	85	86		6	25	24			15	14		
15	15e	6				0	65	26	103	104	102	91	92	90	6	25				20	19		
15	15e	6				0	74	19	96	107	104	87	91		6	22	21			15	15		
88	88a	6	11.5	7		0	66	26	108	110	107	81	82	79	3	31	32			10	11	7	
88	88a	6				0	63	25	91	92	86	81	83	84	3	36	35			12			
88	88a	6				0	71	29	87	84	84	76	79	76	3	34	33			11			
88	88b	6	11	6		0	73	26	103	105	107	90	92	93	6	41	36	35		11			
88	88b	6				0	66	26	86	87	90	72	75		3	33	32			10			
88	88b	6				0	51	19	83	79	75	71	72	70	3	31	32			9			
88	88b	6				0	70	20	92	107	107	96	90		3	33	31			10	9		
88	88b	6				0	61	21	91	91		81	83		3	34	32						
88	88c	6	11	7		0	73	21	181	179		96	96	77	6	39	34			10	10		
88	88c	6				0	78	27	105	112	113	92	94	92	6	34	36			14	12		
88	88c	6				0	65	26	86	88	87	76	75	82	6	33	31			7	9	11	
88	88d	6	6	7		0	71	28	104	113		90	99	93	6	39	34			10	8	11	
88	88d	6				0	70	24	115	102	100	94	91	94	4	31	26						

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
88	88d	6				0	71	22	96	99	92	79	78	80	6	30	34						
88	88d	6				0	72	22	104	105	98	84	81	83	3	36	34						
3	3a	4	6.5	5		0	61	20	71			56	52		3	29	21			6	9		
3	3a	4				0	56	20	64	61		60	51		3	29	21			7			
3	3a	4				0	40	20	61	70		57	59		3	19				6			
3	3a	4				0	46	22	71	72		60	57		3	21							
3	3b	4	9.5	6		0	50	20	71	73		61			3	25							
3	3b	4				0	54	28	86	86		52	71		3	21							
3	3b	4				0	53	27	90	73		61	65		3	26							
3	3c	4	8.5	8		0	61	27	89			75	67		3	19				7			
3	3c	4				0	70	27	92	97		85	84		6	20				14			
130-1	130a	4	15.5	6		0	52	28	95	100		75	71		3	20	27						
130-1	130a	4				0	56	20	91	92		61	60		3	20				10			
130-1	130a	4				0	51	21	70	76		53	59		3	20							
130-1	130b	4	8.5	12		0	45	15	72	74		60	55		3	16							
130-1	130b	4				0	42	14	68	67	67	51	56		3	27	19						
130-1	130b	4				0	41	9	81	78	81	57	57	62	3	18				5			
17	17a	4	3.5	6		0	62	25	87	92		60			3	22				12	9		
17	17a	4				0	52	22	65	76		54	55		3	15	20			6			
17	17b	4	4	6		0	65	29	96	94		65			3	21				9			
17	17b	4				0	61	24	82	72		63	66		4	20				9			
17	17b	4				0	63	30	93			67			3	21							
17	17c	4	2.5	3		0	65	27	95	104		76	77		2	25							
17	17c	4				0	54	22	78	77	81	64	66		3	17				9			
17	17d	4	1.7	5		0	60	28	70	99	97	62	67		3	19				8			
17	17e	4	3.5	5		0	58	29	97	104		71			3	22							
16-1	16-1a	6	5.5	18	14	0	68	25	122	115	130	76			3	20							
16-1	16-1a	6				0	74	25	91	94		42			3	18							
16-1	16-1a	6				0	76	23	99	90		66	51		3								
16-1	16-1a	6				0	69	26	89	84		40	51		3	16	18						
16-1	16-1a	6				0	60	25	96	80		60	56	45	3	11							
16-1	16-1b	6	5	10	13	0	66	30	96	80		60	56		6	20							
16-1	16-1b	6				0	67	26	71	82		56	60		3	20							
16-1	16-1b	6				0	65	21	91	72		49	43		3	20							
16-1	16-1b	6				0	62	25	100	101		51	57		3	20							
16-1	16-1c	6	4.5	17	11	0	60	22	103	75		56	59		3	20							

Table A.1: *(continued)*

Voucher	Plant	Ploidy	PH	NoF	ToS	Bilocular	CL	CW	OTL1	OTL2	OTL3	ITL1	ITL2	ITL3	NoS	FL1	FL2	FL3	FL4	AL1	AL2	AL3	AL4
89	89a	6	9.5	4		0	103	25	129	139		91	100		6	25	30	29		12	11	10	12
89	89a	6				0	98	31	111	116		95	100		6	20	25			13	10		
89	89a	6				0	96	30	121	110		91	96		6	25	25			11	12		
89	89a	6				0	95	55	111	105		94	90	86	6	23	25			16	14		
89	89a	6				0	99	35	120	124		100	100		6	25	30			11	11	12	14
89	89a	6				0	93	26	101	112	124	92	96		6	26	26			15	11		
89	89a	6				0	89	30	113	101	111	107	91		6	25	25			12	11		
89	89a	6				0	100	32	126	109		96	105		6	26	28			11	11	11	
89	89a	6				0	95	31	111	108		89	90		6	24	25			16	15		

Table A.2: Matrix of morphometric data used in multivariate analyses calculated from data in Table A.1. See section 2.3 for an explanation of the calculations. CLAVG – mean capsule length, CWAVG – mean capsule width, OTLAVG – mean inner tepal length, ITLAVG – mean inner tepal width, FLMAX – maximum filament length, NoSMOD – modus of number of stamens. Mean anther length (ALAVG) values are omited from this table. For the purpose of printing, the values have been rounded to two decimal places.

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
39Aa	17.0	9	3.30	1.35	5.98	4.38	1.26	1.35	3
39Ab	20.0	21	3.65	1.28	6.61	4.62	1.48	1.60	3
39Ac	17.5	15	3.52	1.20	5.87	4.44	1.48	2.10	3
39Ad	19.5	22	3.48	1.27	6.09	4.50	1.47	1.65	6
39Ae	16.5	8	3.50	1.38	6.10	4.29	1.54	1.75	3
39Ba	9.5	6	3.58	1.28	5.16	3.88	1.31	1.50	3
39Bb	9.5	14	3.31	1.26	5.11	3.96	1.28	1.50	3
39Bc	9.0	7	3.70	1.22	5.19	3.93	1.29	1.35	3
39Bd	11.0	15	3.55	1.18	5.33	4.15	1.30	1.40	3
39Be	9.5	8	3.48	1.12	5.39	3.90	1.40	1.50	3
102a	19.0	11	3.33	1.14	4.91	3.74	1.36	1.50	3
102b	21.0	15	3.23	0.94	5.09	3.80	1.22	1.30	3
102c	18.0	12	2.83	0.80	4.91	3.61	1.24	1.50	3
102d	17.0	9	3.10	1.08	4.65	3.64	1.30	1.55	3
102e	21.0	11	3.05	1.01	5.02	4.03	1.18	1.45	3
102f	19.0	14	3.27	0.96	5.28	3.90	1.41	1.60	3
132a	7.5	5	5.03	1.40	6.19	4.83	1.29	1.50	6
132b	6.5	3	4.83	2.00	5.76	4.69	1.27	1.50	6
132c	4.5	4	4.70	1.47	5.62	4.89	1.30	1.40	6
132d	4.5	4	4.75	1.55	5.47	4.47	1.23	1.25	6
142a	6.0	6	3.65	1.47	5.07	4.14	1.41	1.55	3
142b	7.0	10	3.52	1.38	5.47	4.36	1.37	1.50	3
142c	7.5	6	3.08	1.27	4.83	3.97	1.43	1.60	3
146-29a	13.0	6	3.27	1.51	4.85	3.91	1.45	1.80	3
146-29b	9.0	10	2.64	1.09	4.16	3.61	0.95	1.15	3
146-5a	18.5	6	3.20	1.25	4.77	3.45	1.04	1.10	6
146-5b	15.0	9	3.25	1.20	4.90	3.93	1.27	1.40	6
146-9a	13.5	12	2.73	1.07	3.34	2.80	0.98	1.00	6
146-9b	12.5	7	3.10	1.20	4.14	3.35	1.06	1.20	6
146-4a	14.5	6	3.12	1.10	4.83	3.79	1.30	1.30	3
146-4b	17.5	7	3.27	1.02	5.01	3.85	1.10	1.25	6
146-4c	12.0	8	3.27	1.12	5.03	4.15	1.45	1.70	6
146-15a	7.5	6	2.75	0.85	4.53	3.40	1.12	1.20	3
146-15b	10.0	8	2.95	1.30	4.72	3.80	1.10	1.10	6
146-15c	12.0	8	3.38	1.00	4.61	3.32	1.27	1.30	3
146-15d	13.0	8	3.27	0.95	5.43	4.02	1.19	1.35	3
146-6a	23.0	7	3.27	1.20	5.10	4.24	1.25	1.35	6
146-6b	21.0	15	3.26	1.25	4.73	3.99	1.29	1.50	6

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
146-6c	19.0	11	3.47	1.28	5.07	3.97	1.28	1.45	6
146-6d	14.5	4	3.67	1.27	5.96	4.32	1.33	1.55	6
146-6e	20.0	15	3.90	1.50	6.15	5.03	1.40	1.40	6
147-1a	6.5	4	2.90	1.25	4.81	3.73	0.88	1.00	3
148-1a	8.5	5	3.05	1.50	5.15	4.42	1.30	1.30	6
149-1a	13.5	6	3.67	1.70	6.47	4.14	1.35	1.40	6
149-1b	12.0	4	3.50	1.30	5.43	4.13	1.55	1.65	6
150-1a	6.5	5	2.98	1.40	5.04	4.15	1.05	1.05	6
150-1b	5.5	6	3.00	1.32	4.62	3.55	1.37	1.50	6
151-1a	10.0	3	3.23	1.20	5.11	4.08	1.51	1.70	3
154-1a	12.5	20	3.40	1.55	4.79	3.76	1.19	1.30	3
154-2a	7.5	8	2.92	1.07	4.40	3.43	1.18	1.30	6
154-2b	7.0	5	2.90	1.32	4.38	3.41	1.25	1.40	3
154-2c	6.0	4	2.70	1.35	4.53	3.50	1.38	1.40	4
154-2d	7.5	4	2.95	1.40	4.45	3.70	1.18	1.25	3
165-3a	6.5	5	3.17	1.35	4.09	3.77	1.10	1.25	3
166-1a	23.5	46	3.51	1.06	5.41	4.60	1.31	1.55	6
166-1b	21.5	38	3.39	1.13	5.10	4.34	1.30	1.50	6
166-1c	16.0	24	3.58	1.22	4.74	3.89	1.36	1.40	3
171-1a	12.0	4	3.20	0.90	4.71	3.74	1.19	1.35	3
171-1b	6.5	11	3.08	1.18	4.20	3.52	1.34	1.75	3
171-1c	9.0	6	2.83	0.97	4.64	3.33	1.41	1.85	3
171-1d	12.0	14	2.83	0.98	3.96	3.27	1.20	1.60	3
171-1e	14.0	9	3.15	1.10	4.97	3.40	1.19	1.55	3
172-1a	16.0	10	3.30	1.13	5.69	4.14	1.36	1.60	6
172-1b	13.0	15	3.34	1.24	6.25	4.14	1.41	1.50	3
173-1a	14.5	30	2.73	1.09	4.38	3.08	1.21	1.45	3
173-1b	12.5	12	2.99	1.21	4.49	3.32	1.26	1.45	3
173-1c	8.5	15	2.42	0.98	4.31	2.72	1.13	1.45	3
173-1d	7.5	9	2.40	0.92	4.23	2.73	1.15	1.25	3
173-1e	12.0	9	2.97	1.10	4.75	3.61	1.92	3.60	3
173-2Aa	11.5	11	2.64	1.05	4.06	3.09	1.16	1.25	3
173-2Ab	7.0	8	2.77	1.02	4.23	3.17	0.98	1.00	3
173-2Ac	7.5	10	3.00	1.15	3.38	3.38	1.05	1.05	3
173-2Ad	11.5	9	3.00	0.98	5.23	3.67	1.20	1.45	3
173-2e	10.5	7	2.75	1.20	4.93	3.50	1.15	1.20	3
173-6a	10.5	27	3.20	1.12	5.04	3.82	1.35	1.45	6
173-6b	11.0	20	2.83	1.15	4.33	2.93	1.02	1.20	6

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
173-7a	6.0	7	2.50	1.00	4.62	2.91	0.98	1.15	3
173-7b	7.0	12	3.00	0.80	6.80	3.50	1.12	1.15	3
173-5a	8.5	17	3.25	0.85	4.65	3.50	1.25	1.25	6
173-5b	17.0	15	2.66	1.03	3.66	2.61	1.12	1.50	6
174-1Ab	22.0	44	3.03	1.13	5.15	3.69	1.18	1.25	6
174-1Ac	21.0	30	2.95	1.10	6.07	3.42	1.23	1.30	6
174-1Ad	26.0	29	3.27	1.09	4.74	3.41	0.92	1.00	6
174-1Ae	22.0	20	3.09	1.16	4.93	3.84	0.98	1.30	6
174-1Af	25.0	21	3.00	1.40	5.17	3.17	1.15	1.25	6
174-1Ag	20.5	35	2.85	1.06	5.01	3.72	1.07	1.25	6
174-1Ba	34.0	57	4.11	1.60	5.62	4.71	1.26	1.45	6
174-1Bb	30.0	31	3.85	1.38	5.58	4.62	1.27	1.45	6
174-1Bc	31.5	50	3.22	1.09	5.06	3.75	1.12	1.30	6
174-2Aa	22.0	55	3.67	1.17	5.92	4.55	1.09	1.25	6
174-2Ab	30.0	80	3.26	1.15	5.55	4.38	1.08	1.45	6
174-2Ac	26.0	63	3.57	1.24	5.42	4.35	1.06	1.30	6
174-2Ad	24.5	36	2.89	0.94	4.73	3.53	1.09	1.35	6
174-2Ae	26.0	35	3.11	1.14	5.20	3.95	1.22	1.50	6
174-2Af	25.0	37	3.02	1.38	4.89	3.98	1.14	1.30	6
174-2Ag	29.0	69	3.23	1.38	5.44	4.23	1.23	1.45	6
175-1a	20.0	41	3.32	0.90	4.91	3.67	1.34	1.40	6
175-1b	24.0	22	3.12	1.32	5.53	4.88	1.39	1.50	6
175-1c	23.5	21	3.30	1.05	5.72	4.13	1.31	1.50	6
175-2a	21.5	22	3.39	1.01	5.25	3.77	1.23	1.30	6
175-2b	13.5	19	3.63	1.08	5.47	4.38	1.38	1.50	6
175-2c	12.0	22	3.53	1.23	4.47	3.48	1.19	1.35	6
175a	22.0	34	3.40	1.07	5.21	3.83	1.29	1.45	6
175b	7.0	9	3.13	0.86	4.35	3.38	1.21	1.30	6
175c	17.5	20	3.65	1.18	5.67	3.98	1.32	1.60	6
175d	13.0	15	3.48	1.20	4.82	3.78	1.31	1.50	6
177-5a	2.0	2	3.17	1.25	4.44	3.47	1.34	1.40	3
177-4a	4.5	6	3.44	1.15	4.71	3.64	1.36	1.50	3
177-7a	7.0	11	3.33	1.35	5.14	4.22	1.27	1.50	6
177-7b	6.5	6	3.37	1.13	4.60	3.70	1.36	1.55	6
177-3a	3.0	10	2.88	1.18	3.66	3.14	1.29	1.50	3
177-3b	2.5	4	3.15	1.10	4.45	3.45	1.09	1.15	6
177-6a	6.0	7	2.67	1.06	4.50	3.01	1.30	1.45	3
177-14a	6.5	4	2.52	0.97	4.96	3.33	1.31	1.55	3

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
180-1a	21.0	45	3.06	1.10	6.16	3.38	1.24	1.50	6
180-1b	15.0	32	2.95	0.90	6.12	3.48	1.31	1.40	6
180-1c	8.5	7	2.78	1.00	3.96	3.28	1.19	1.45	3
180-1d	7.0	5	2.73	1.02	3.95	3.51	1.23	1.40	3
180-1e	7.0	7	2.57	0.72	5.46	3.41	1.12	1.25	3
180-1f	9.0	7	2.85	1.14	3.73	3.08	1.20	1.35	3
180-1g	10.0	6	2.93	1.17	3.83	3.03	1.18	1.35	3
180-1h	10.0	15	3.08	1.04	5.14	3.53	1.44	1.55	3
180-1i	8.5	8	3.07	1.03	4.01	3.14	1.22	1.35	6
180-2a	9.5	6	3.03	1.10	4.41	3.34	1.19	1.35	3
180-2b	9.0	7	2.52	0.87	3.89	3.03	1.12	1.35	3
180-4a	15.0	7	2.97	1.04	4.26	3.26	1.32	1.40	3
180-4b	10.0	8	2.95	1.05	4.23	3.18	1.15	1.20	3
181-1a	17.0	14	3.05	1.10	6.49	3.69	1.57	1.90	3
182-2a	11.0	8	2.65	0.88	4.39	3.13	1.42	1.55	2
184-1a	12.5	20	3.14	1.05	4.55	3.53	1.31	1.40	3
184-1b	14.0	18	3.05	0.98	5.56	3.71	1.54	1.75	2
184-1c	9.0	6	3.08	1.00	4.96	3.64	1.48	1.80	2
184-1d	7.0	12	2.70	0.82	4.53	3.08	1.38	1.40	3
184-3a	7.5	6	2.52	0.78	4.30	3.16	1.13	1.35	2
184-5a	10.5	5	3.00	1.15	4.33	3.35	1.20	1.20	3
184-5b	10.5	5	3.00	1.15	4.33	3.35	1.20	1.20	3
189-1a	18.0	25	3.25	1.27	4.72	3.61	1.46	1.55	6
189-1b	17.5	30	2.93	1.17	5.24	3.35	1.38	1.70	6
189-1c	19.0	50	3.19	1.02	5.05	3.62	1.32	1.60	6
189-1d	17.0	13	3.17	1.23	4.87	3.78	1.41	1.55	6
189-1e	19.0	71	3.32	1.14	4.94	3.67	1.45	1.65	6
189-1f	17.5	29	3.20	1.15	4.61	3.26	1.33	1.75	3
189-1g	18.0	33	3.05	1.19	4.44	3.37	1.30	1.55	6
189-1h	17.5	14	3.55	1.45	5.19	3.82	1.46	1.55	6
189-1i	16.0	56	3.29	1.16	4.84	3.60	1.38	1.70	6
189-1j	17.0	33	3.17	1.22	4.62	3.26	1.40	1.90	6
189-1k	19.0	31	3.39	1.25	5.58	3.59	1.29	1.40	6
189-1l	18.5	61	3.16	1.17	4.63	3.54	1.31	1.50	6
190-1a	17.0	20	3.78	1.51	5.94	4.47	1.35	1.55	3
190-1b	12.5	12	3.38	1.41	5.02	3.86	1.38	1.50	3
190-1c	9.5	14	3.26	1.15	4.77	3.65	1.24	1.45	3
190-2a	8.5	7	2.66	0.92	4.55	3.61	1.25	1.40	3

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
190-2b	9.5	11	3.05	1.07	4.10	3.19	1.43	1.45	3
190-3a	11.5	16	3.24	1.11	4.69	3.58	1.24	1.50	3
190-3b	9.0	7	3.48	1.13	4.54	4.08	1.41	1.55	3
192-1a	25.0	51	4.03	1.43	5.33	4.76	1.21	1.40	6
192-1b	26.0	45	3.61	1.36	4.92	4.29	1.35	1.60	6
192-1c	27.0	57	3.64	1.21	5.01	4.06	1.30	1.50	6
192-1d	26.5	34	4.10	1.35	5.05	4.53	1.26	1.45	6
193a	17.5	14	3.11	0.93	4.08	2.86	1.19	1.50	3
193b	13.0	13	2.87	0.79	4.65	3.12	1.38	0.05	3
193c	11.5	6	2.92	1.01	4.41	3.30	1.31	1.65	3
193d	10.5	13	3.13	1.04	4.37	3.27	1.40	1.75	3
193e	12.0	15	2.96	1.11	4.75	3.44	1.34	1.55	3
193f	11.0	16	3.27	1.08	4.57	3.40	1.35	1.65	3
193g	11.0	6	2.98	1.10	4.99	3.78	1.36	1.50	3
193h	12.5	15	3.11	1.01	4.65	3.41	1.53	1.60	3
193i	11.5	7	2.77	1.00	4.08	3.31	1.39	2.00	6
193j	7.0	4	2.67	0.88	4.21	2.83	1.15	1.25	3
194-3a	17.0	18	3.34	1.00	4.67	3.92	1.39	1.60	3
194-3b	17.0	6	2.95	1.02	4.40	3.62	1.30	1.50	6
194-3c	16.5	12	3.15	1.00	4.63	3.36	1.35	1.55	6
194-3d	16.5	11	2.97	1.17	4.46	3.61	1.43	1.70	3
194-3e	13.0	10	2.92	1.15	4.10	3.04	1.45	1.75	6
194-3f	15.5	10	3.55	1.35	5.10	3.35	1.55	1.55	3
194-3g	18.0	6	3.06	1.04	4.25	3.39	1.40	1.60	6
194-3h	16.0	22	3.80	1.35	4.85	4.10	1.15	1.15	6
194-3i	16.0	18	3.25	1.09	4.60	3.85	1.50	1.75	6
194-5a	18.5	11	3.34	1.28	4.68	4.07	1.31	1.45	3
194-5b	20.5	29	3.25	1.66	5.17	3.70	1.31	1.75	3
194-5c	15.0	5	3.15	1.40	4.16	3.19	1.18	1.35	3
194-5d	13.5	14	2.91	1.28	4.24	3.16	1.12	1.40	3
194-5e	15.5	20	3.42	1.16	4.71	3.64	1.18	1.40	3
194-5f	14.5	13	3.43	1.19	5.00	3.98	1.36	1.60	3
194-5g	16.5	14	3.61	1.37	5.06	4.27	1.31	1.40	3
194-6a	11.0	10	3.12	1.10	4.46	3.50	1.25	1.50	3
194-6b	9.0	7	2.67	1.05	3.75	2.90	1.24	1.55	3
195a	8.0	22	2.94	1.08	3.89	3.04	1.48	3.60	6
195b	6.0	12	3.01	0.92	3.83	3.19	1.31	1.50	6
195c	5.0	14	2.84	1.00	4.47	3.22	1.23	1.60	6

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
195-2a	9.5	27	2.87	1.00	4.44	3.52	1.21	1.50	6
195-2b	15.0	10	3.26	1.14	4.67	3.96	1.27	1.50	3
195-2c	11.0	12	3.35	1.52	4.99	3.87	1.37	1.50	6
198-1a	7.0	10	2.58	1.35	3.93	3.34	1.10	1.30	3
198-1b	7.0	11	3.16	1.19	4.29	3.61	1.22	1.35	3
198-1c	7.0	22	2.74	1.12	3.72	2.88	1.18	1.35	3
198-1d	7.5	16	3.08	1.20	4.30	3.55	1.20	1.30	6
198-2a	25.5	69	3.72	1.59	6.93	5.14	1.49	2.00	6
198-2b	23.0	27	3.38	1.62	5.62	4.32	1.36	1.55	6
198-2c	25.0	36	3.70	1.65	7.83	5.11	1.53	1.90	6
198-2d	25.0	48	3.84	1.58	6.49	4.56	1.29	1.70	6
198-2e	19.5	41	3.76	1.63	6.11	4.42	1.46	1.75	6
199-3a	14.0	17	2.77	1.07	3.85	3.13	1.20	1.25	6
199-3b	14.5	16	2.62	0.82	4.24	3.46	1.18	1.35	3
199-2b	10.0	25	2.95	1.32	5.20	3.56	1.25	1.45	6
199-2c	14.5	9	3.00	1.32	4.70	3.38	1.20	1.25	6
200-14a	16.0	40	3.49	1.12	5.42	3.92	1.34	1.50	3
200-14b	19.0	37	3.62	1.08	5.31	3.90	1.30	1.75	3
200-14c	9.0	5	2.57	0.83	4.29	3.43	1.26	2.00	3
200-14d	13.5	7	2.62	1.02	4.86	3.64	1.00	1.00	3
200-9a	15.5	13	3.05	0.82	4.00	2.99	1.40	1.50	3
200-9b	17.5	18	3.10	0.84	3.91	2.86	1.00	1.25	3
200-9c	20.0	8	2.89	0.85	4.03	3.09	1.19	1.50	3
200-9d	18.5	9	3.08	0.86	4.29	3.13	1.30	1.55	3
200-9e	18.0	16	3.09	1.00	4.09	3.31	1.00	1.05	3
200-5Aa	14.0	5	3.05	1.02	4.68	3.06	0.89	1.20	2
200-5Ba	21.0	7	3.10	1.25	6.12	4.15	1.27	1.30	3
200-11a	11.0	16	3.00	1.00	5.72	3.38	0.75	0.75	2
200-13a	17.0	9	3.33	0.95	4.69	2.95	1.30	1.50	3
200-18a	10.5	14	2.91	0.72	4.33	3.26	1.09	1.50	3
200-18b	7.0	6	2.90	1.00	4.15	3.27	1.00	1.00	2
200-2a	9.0	17	3.02	0.96	4.45	3.32	1.15	1.50	3
200-2b	14.5	9	3.03	0.95	4.54	3.42	1.07	1.30	3
200-2c	13.0	19	3.18	0.89	4.31	3.47	1.18	2.60	3
200-2d	14.0	9	3.50	0.88	4.66	3.71	1.15	1.30	3
200-2e	13.5	7	3.64	0.56	4.77	3.40	1.21	1.50	6
200-2f	9.5	16	2.92	1.19	4.14	3.39	1.15	1.50	6
200-22a	19.0	11	2.98	0.93	4.92	3.65	2.34	2.80	6

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
200-23a	15.5	10	3.03	0.93	4.53	3.56	1.11	1.25	3
200-23b	13.0	12	2.90	1.01	4.34	3.19	1.09	1.25	3
200-26a	14.0	16	3.49	1.27	4.99	3.88	1.25	1.75	6
200-17a	11.5	11	2.90	0.92	3.98	3.40	1.48	2.10	6
200-17b	9.0	7	1.95	0.60	3.20	1.50	1.60	1.60	2
200-17c	9.0	7	2.48	0.75	3.42	2.62	1.35	1.40	2
200-16a	14.5	8	2.90	0.77	4.42	3.41	1.02	1.25	3
200-12a	22.0	12	3.49	1.15	4.58	3.54	1.13	1.50	6
200-12b	13.5	8	2.75	1.08	3.88	3.13	1.12	1.30	6
200-12c	18.0	12	3.26	1.02	4.76	3.49	1.23	1.75	6
200-15a	20.0	4	3.54	1.00	4.57	3.88	1.31	1.50	6
200-15b	17.0	17	3.10	0.93	5.10	3.68	1.25	1.60	3
200-15c	16.5	10	2.98	0.85	4.28	3.25	1.15	1.35	3
200-15d	24.0	10	3.50	1.02	4.73	3.75	1.10	1.65	6
200-24a	18.0	2	3.02	0.88	4.59	3.23	0.88	1.00	4
200-8a	15.0	12	3.12	0.75	5.08	3.28	1.05	1.10	3
200-8b	12.0	12	2.80	0.88	4.36	2.80	1.52	2.40	3
200-7a	19.0	15	3.79	1.15	5.01	4.03	1.45	1.75	3
200-7b	16.0	17	3.72	1.48	5.15	4.49	1.55	1.70	3
200-7c	14.5	13	3.41	1.06	4.58	4.07	1.36	1.55	3
200-7d	13.0	12	3.35	1.12	4.43	3.64	1.29	1.45	3
201a	7.5	19	3.02	1.12	5.19	3.52	1.28	1.45	6
203-1a	26.0	20	3.78	1.50	6.12	4.25	1.37	1.70	6
203-1b	21.0	2	4.05	1.75	7.22	4.53	1.39	1.70	6
203-1c	16.0	34	3.42	1.35	7.08	4.10	1.55	1.55	3
204-16a	13.0	19	3.17	1.02	5.15	3.26	1.23	1.55	3
204-19a	8.5	7	2.77	0.87	3.90	2.88	0.88	1.00	3
204-19b	10.0	16	2.60	0.84	3.51	2.44	1.14	1.30	2
204-19c	8.5	8	3.02	1.10	5.36	3.34	1.03	1.20	3
204-19d	14.5	13	2.92	0.96	3.81	2.56	1.68	2.25	3
204-19e	13.0	10	3.10	1.03	4.84	3.35	1.44	2.80	3
204-19f	15.0	10	3.06	0.87	4.40	2.75	1.02	1.05	3
204-9a	12.0	11	2.88	0.89	4.15	3.02	0.83	1.00	2
204-7a	17.5	20	2.98	0.92	4.13	3.15	1.06	1.25	3
204-7b	24.0	91	3.09	1.12	4.92	3.30	1.09	1.50	3
204-2a	18.0	12	3.25	1.19	4.58	3.81	1.24	1.30	3
204-2b	20.0	37	3.10	0.90	4.50	3.36	1.06	1.15	3
204-2c	16.0	15	2.64	0.85	3.83	2.81	0.82	1.05	3

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
204-10a	12.0	11	2.82	0.80	4.11	2.60	1.06	1.35	3
204-10b	9.0	5	3.60	1.15	6.05	3.15	1.20	1.20	2
204-10c	6.0	5	3.05	1.00	4.62	3.19	0.95	1.45	2
204-11a	20.5	18	3.19	1.00	4.75	3.66	1.19	1.45	3
204-11b	15.0	17	2.69	0.96	4.27	3.16	1.12	1.35	6
204-18a	11.5	13	3.43	0.98	4.95	3.35	1.16	1.45	3
204-18b	12.5	7	2.77	0.98	5.26	3.21	0.95	1.00	3
204-15a	17.0	16	2.84	0.68	3.90	2.90	1.08	1.30	3
204-15b	16.0	15	3.12	0.83	4.07	2.88	1.23	1.30	3
204-8a	6.0	2	3.50	1.30	5.00	4.25	1.40	1.50	6
204-8b	9.0	11	3.00	1.20	5.78	4.25	1.45	1.55	3
204-8c	16.0	8	2.94	0.96	5.22	3.98	1.20	1.30	3
204-8d	22.0	23	3.10	1.12	5.20	3.46	1.07	1.50	3
205-1a	9.0	7	3.01	0.92	5.54	3.82	1.36	1.65	3
205-1b	12.0	15	2.94	0.88	4.76	3.10	1.14	1.40	3
205-1c	8.5	7	2.72	1.10	4.30	3.35	1.20	1.30	3
205-1d	6.5	12	2.78	0.95	4.01	2.99	1.17	1.35	3
205-1e	5.0	7	2.55	0.88	3.76	2.71	1.02	1.15	3
205-1f	6.0	10	2.88	1.02	4.63	3.51	1.43	1.55	2
205-3a	24.0	13	3.61	1.15	5.53	3.81	1.46	1.65	3
205-3b	14.0	9	2.85	0.92	4.27	3.16	1.36	1.55	3
205-3c	16.5	15	3.00	1.02	4.73	2.91	1.25	1.45	3
205-3d	9.0	17	2.88	0.99	4.69	3.35	1.27	1.35	3
205-3e	12.0	11	3.10	1.02	4.43	3.54	1.36	1.55	3
205-3f	13.0	19	2.82	0.95	5.26	3.34	1.22	1.60	3
205-3g	14.0	6	3.60	1.50	5.35	3.60	1.28	1.55	3
205-3h	9.5	10	2.83	1.02	4.48	3.33	1.13	1.35	3
205-3i	4.0	9	2.45	0.82	4.04	2.98	1.07	1.15	2
207-2a	14.0	21	3.72	1.02	5.28	3.85	1.33	1.75	3
207-2b	9.5	23	3.38	0.87	4.63	3.62	1.24	1.55	3
207-2c	17.5	29	3.57	0.88	4.91	3.67	1.44	1.60	3
207-1a	14.0	9	2.88	1.00	4.88	3.92	1.27	1.45	6
207-1b	11.5	11	3.15	1.00	4.43	3.42	1.24	1.45	6
207-1c	13.0	5	2.83	1.10	4.28	3.25	1.07	1.25	6
207-1d	11.0	8	2.42	0.88	4.49	3.31	1.19	1.30	3
207-1e	14.0	9	2.60	0.87	3.96	3.06	1.22	1.30	3
219-1a	8.5	18	3.05	1.13	3.84	3.11	1.29	1.55	3
219-1b	10.0	17	2.97	1.00	4.51	3.64	1.23	1.55	3

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
219-2a	7.0	16	2.88	1.15	4.53	3.35	1.17	1.75	3
219-2b	7.5	12	2.88	1.21	4.47	3.39	1.22	1.55	3
219-3a	6.5	15	2.88	0.92	4.58	3.40	1.35	1.55	3
219-3b	5.5	19	3.40	1.23	5.13	4.59	1.29	1.50	6
222-1a	22.5	73	3.76	1.46	5.64	4.81	1.53	1.75	6
222-1b	23.0	68	3.69	1.48	5.45	4.75	1.45	1.65	6
222-1c	22.5	80	3.84	1.63	5.27	4.73	1.47	1.75	6
222-1d	21.5	46	3.57	1.37	5.59	4.23	1.43	1.65	3
222-1e	22.0	91	3.52	1.38	5.47	4.64	1.63	1.70	3
222-3a	17.0	80	3.23	1.27	5.65	4.75	1.38	1.75	3
222-3b	27.0	50	3.69	1.23	5.66	4.51	1.69	2.05	3
69-a	10.5	11	3.17	1.15	4.88	3.67	1.23	1.25	3
69-b	9.5	7	3.05	1.00	4.45	3.08	1.21	1.35	3
69-c	13.5	9	3.05	0.95	4.07	3.00	1.03	1.15	3
69-d	14.0	20	2.92	0.90	4.57	3.67	1.13	1.30	3
209-5a	8.0	11	2.83	0.99	3.83	3.06	1.21	1.50	2
209-4a	10.0	13	2.92	0.79	3.90	2.52	1.10	1.50	3
209-4b	8.0	5	2.70	0.80	4.41	3.12	1.10	1.30	3
209-3a	6.5	16	2.23	0.75	3.11	2.31	1.11	1.35	3
209-3b	6.5	2	2.20	0.80	4.25	2.05	1.20	1.20	3
209-3c	13.0	17	2.78	0.78	3.66	2.90	1.08	1.40	3
209-11a	9.5	11	2.45	0.82	3.48	2.36	1.03	1.15	3
209-11b	7.5	7	2.55	0.63	3.94	2.65	1.19	1.30	3
87a	2.5	5	2.45	1.05	3.66	3.31	1.20	1.40	3
87b	2.5	6	2.50	1.05	3.45	3.07	1.23	1.30	3
15a	18.5	19	3.77	1.32	5.52	4.60	1.21	1.60	6
15b	14.5	34	3.62	1.24	5.13	4.21	1.28	1.60	6
15c	16.5	22	3.49	1.32	6.02	4.56	1.18	1.40	3
15d	12.5	27	3.55	1.25	4.78	3.76	1.22	1.60	3
15e	18.5	40	3.54	1.07	5.35	4.41	1.20	1.45	6
88a	11.5	7	3.33	1.33	4.72	4.01	1.68	1.80	3
88b	11.0	6	3.21	1.12	4.65	4.10	1.68	2.05	3
88c	11.0	7	3.60	1.23	5.94	4.33	1.73	1.95	6
88d	6.0	7	3.55	1.20	5.13	4.36	1.65	1.95	6
3a	6.5	5	2.54	1.02	3.36	2.83	1.17	1.45	3
3b	9.5	6	2.62	1.25	3.99	3.10	1.20	1.30	3
3c	8.5	8	3.27	1.35	4.63	3.89	0.98	1.00	3
130a	15.5	6	2.65	1.15	4.37	3.16	1.09	1.35	3

Table A.2: *(continued)*

	PH	NoF	CLAVG	CWAVG	OTLAVG	ITLAVG	FLAVG	FLMAX	NoSMOD
130b	8.5	12	2.13	0.63	3.67	2.84	1.00	1.35	3
17a	3.5	6	2.85	1.18	4.00	2.82	0.95	1.10	3
17b	4.0	6	3.15	1.38	4.37	3.26	1.03	1.05	3
17c	2.5	3	2.98	1.23	4.35	3.54	1.05	1.25	2
17d	1.7	5	3.00	1.40	4.43	3.23	0.95	0.95	3
17e	3.5	5	2.90	1.45	5.23	3.06	1.00	1.10	3
16-1a	5.5	18	3.47	1.24	4.95	2.71	0.83	1.00	3
16-1b	5.0	10	3.25	1.27	4.33	2.70	1.00	1.00	3
16-1c	4.5	17	3.00	1.10	4.45	2.88	1.00	1.00	3
89a	9.5	4	4.82	1.64	5.75	4.76	1.28	1.50	6