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Differentiation of petals in the *Malva alcea* L. populations from the region of Central and Eastern Europe

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Abstract: *Malva alcea* is a relict of old cultivation and its today's presence is related to the remains of medieval settlements and anthropogenic habitats located in their vicinity (roadsides, roadside ditches and thickets). The article covers the results of studies on the variability of *Malva alcea* corolla in seventeen localities in Central and Eastern Europe, in the whole habitat spectrum of the species under study. The largest petals (length and width) were found in Germany and two Ukrainian populations. The same populations reached the biggest values with respect to two other traits: the petal length from its base to the point of incision as well as the incision depth. Analysing the relation between the petal's length and the incision depth it has been found that the largest petal incisions can be found among specimens of population from North-East Poland, and the smallest ones in German population, Polish population from the Poznań region and two Ukrainian ones. The Principal Component Analysis (PCA) showed differentiation between specimens from particular populations. The specimens formed two groups. The first group consists of plants from Polish populations, one Ukrainian and some specimens from the second population from Ukraine. The second group is made up of specimens from localities in Germany and the last two populations from Ukraine. The cluster analysis performed on the basis of the Euclidean distance indicated two similar groups of populations. The results should be interpreted through the prism of prehistoric and medieval cultivation of *Malva alcea* in the vicinity of defensive strongholds and settlements, as well as ancient and contemporary spreading of the species to anthropogenic habitats.

Key words: *Malva alcea*, *Malva excisa,* Malvaceae, corolla petals, variation, biometry

1. Introduction

Malva alcea is an old cultural species numbered among the relicts of former cultivation. Its contemporary occurrence is above all related to archaeological sites, primarily medieval strongholds and settlements, as well as castles. In some parts of Central and Eastern Europe, it shows tendencies for dispersing from its former places of cultivation to anthropogenic habitats. *Malva alcea* was cultivated in prehistoric and medieval times, in gardens near strongholds, for healing, dyeing, decorating and magical purposes. Today it is rarely used as a decorative and healing plant (Celka 1998).

In the geobotanical literature, apart from the data on *Malva alcea,* one can find also an information about the occurrence of a very similar species, *Malva excisa*, in Central and Eastern Europe (among others: Walas 1959; Il'in 1974; Olyanitskaya 1999; Majorov 2006; Bojňanský & Fargašová 2007). Traits which differentiate the two species are the type and size of hair covering the stem as well as the incision depth of petals. Bearing in mind the important taxonomical role of petals in the *Malva alcea* complex, the aim of this work is to verify the hypothesis that morphological traits of petals would help to make a clear distinction between *Malva alcea* and *Malva exisa*.

2. Materials and methods

In 2006-2007, thirteen populations were chosen from the area of Central Europe and four from Eastern Europe (Fig. 1, Table 1). Samples were taken from the sites representing the whole habitat spectrum (strongholds, roadsides, roadside ditches, cemeteries, thickets), where the mallow is numerous. On most sites, if the population

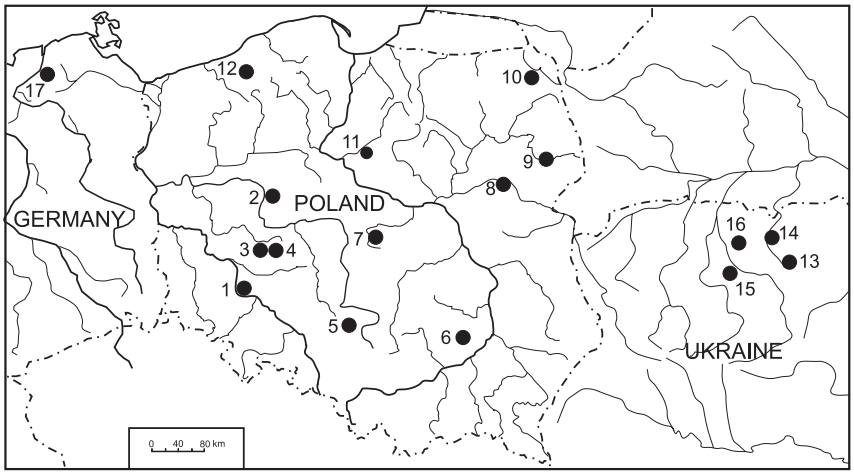

Fig. 1. Location of the studied sites in Central and Eastern Europe
For explanation see Table 1

size allowed it, the flowers were collected from about thirty specimens, on average, three flowers in full bloom from each one. One flower was taken from the upper stem, the second from the bottom and the third one from the lateral shoot. Additionally, in each locality, from one specimen picked randomly all flowers were taken to check the intraindividual variability. The herbarium material was deposited at the Herbarium of the Department of Plant Taxonomy of the Adam Mickiewicz University in Poznań (POZ).

Table 1. Localities and habitats of the studied populations of *Malva alcea*

Number	Locality	Habitat	Collection date	Geographical location
1	Mojęcice (Wołów district, Śląsk region, Poland)	roadside, roadside ditch	05.07.2006	N 51º17`28.0`` E 16º35`41.4``
2	Koziegłowy (Poznań district, Wielkopolska region, Poland)	roadside, roadside ditch	20.07.2006	N 52º28`25.1`` E 16º58`55.3``
3	Daleszyn (Gostyń district, Wielkopolska region, Poland)	cone-shaped mound of the late medieval earthwork	25.07.2006	N 51º56`00.4`` E 17º00`05.1``
4	Dusina (Gostyń district, Wielkopolska region, Poland)	cone-shaped mound of the early medieval earthwork	25.07.2006	N 51º55`17.7`` E 17º01`15.2``
5	Pątnów (Wieluń district, Łódzkie region, Poland)	roadside ditch	28.07.2006	N 51º08`06.3`` E 18º36`30.7``
6	Bliżyn (Skarżysko-Kamienna district, Świętokrzyski region, Poland)	roadside ditch	29.07.2006	N 51º06`51.6`` E 20º44`31.0``
7	Tum near Łęczyca (Łęczyca district, Łódzkie region, Poland)	valley of the early medieval rampart	29.07.2006	N 52º03`22.5`` E 19º13`57.9``
8	Wirów near Drohiczyn on the Bug (Siemiatycze district, Podlaskie region, Poland)	cemetery (roadside, roadside ditch)	31.07.2006	N 52º26`35.7`` E 22º32`12.3``
9	Płoski on the Narew (Białystok district, Podlaski region, Poland)	roadside near a bridge on the Narew river	31.07.2006	N 52º54`13.1`` E 23º13`58.5``
10	Sucha Wieś (Suwałki district, Podlaski region, Poland)	roadside, roadside ditch	01.08.2006	N 53º57`31.6`` E 22º49`20.5``
11	Ostrowite-Napole (Golub-Dobrzyń district, Kujawsko-Bydgoski region, Poland)	embankments of the early medieval rampart	01.08.2006	N 53º08`46.5`` E 18º57`03.7``
12	Sławsko (Sławno district, Zachodniopomorskie region, Poland)	wasteland and roadside (near the medieval rampart)	03.08.2006	N 54º23`13.9`` E 16º42`50.6``
13	Pidluby (Zhytomyr region, Ukraine)	roadside, roadside ditch	17.07.2007	N50º55`14.6`` E27º45`08.3``
14	Olevsk (Zhytomyr region, Ukraine)	roadside	17.07.2007	N51º12`26.0`` E27º39`41.0``
15	Gubkiv (Rivne region, Ukraine)	garden and roadside	18.07.2007	N50º49`34.1`` E27º02`42.2``
16	Rokytne (Rivne region, Ukraine)	old cemetery	19.07.2007	N51º16`59.4`` E27º12`29.2``
17	Teterow (Meclenburg-Vorpommern, Germany)	meadow on an island near the embankments of the early medieval rampart	14.08.2007	N53º47`22.6`` E12º35`52.3``

The following morphological traits of petals were analysed: length, width, length from the petal base to the incision point, incision depth and petal length/ incision depth ratio (Fig. 2, Table 2). The measurement data were subject to statistical calculations with the use of Statistica for Windows (version 7.1). The basic characteristics of traits were calculated and a correlation analysis between the traits and a single factor analysis of variance (ANOVA-MANOVA) were performed. The complete linkage method of cluster analysis based on Euclidean distances and the principal component analysis were performed using the matrix of the population mean values (Morrison 1990; Sokal & Rohlf 1997).

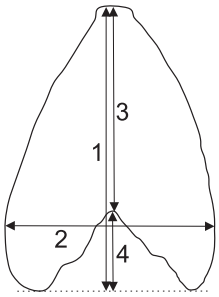

Fig. 2. *Malva alcea* petal with traits subject to examination
For explanations – see Table 2

Table 2. List of the analyzed morphometric traits

Trait number	Traits' description
1	length of a petal
2	width of a petal
3	length from the base to the petal incision point
4	depth of the incision
5	petal length/incision depth ratio

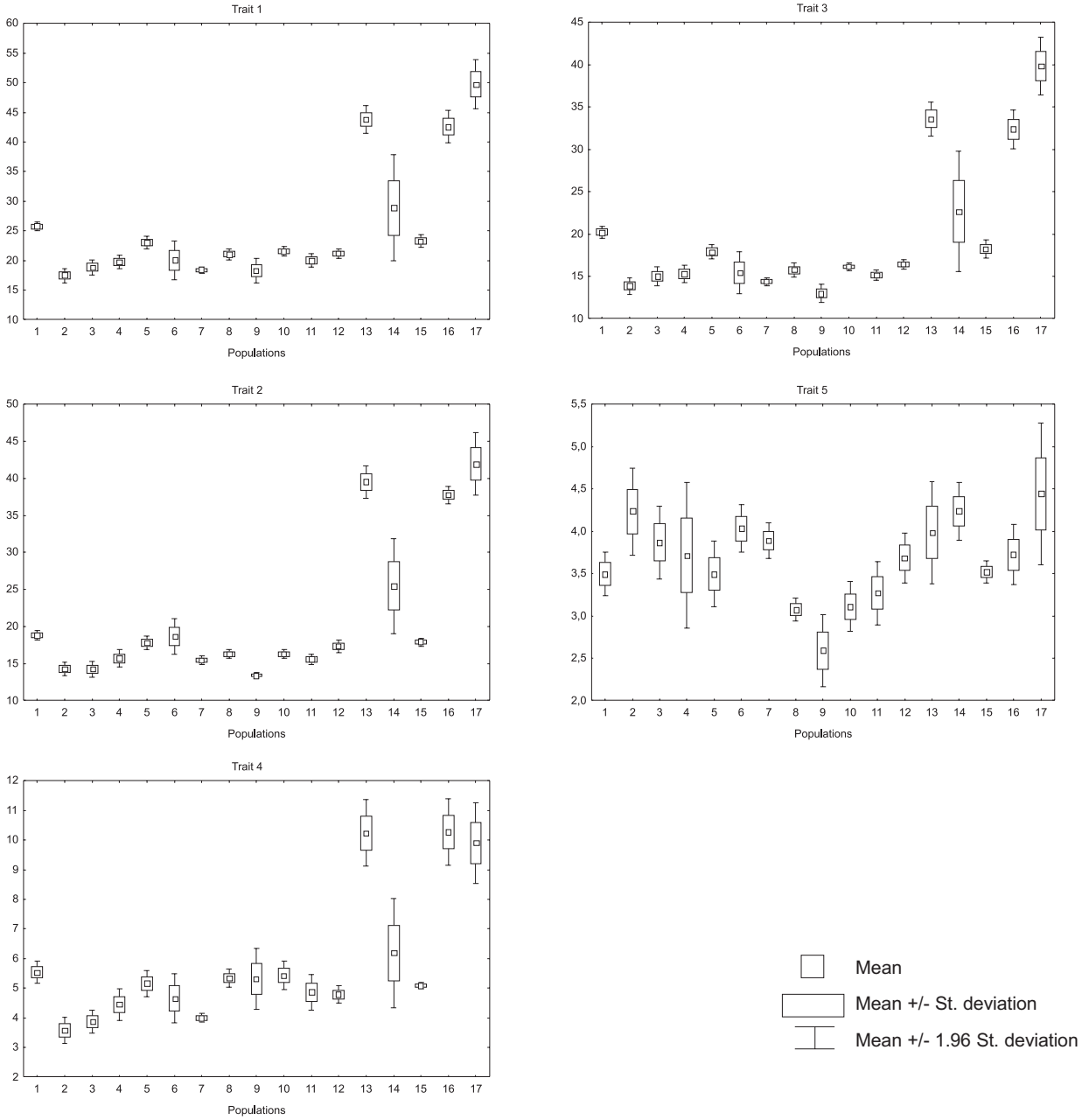

Fig. 3. Box plots for comparison of 17 populations of *Malva alcea* according to five morphological traits of petals

3. Results

The Multivariate analysis of variance (MANOVA) showed significant statistical differences between the studied populations in terms of all analysed traits (F =92.08***, the level of significance was at p<0.05). Also the variation analysis ANOVA calculated for particular morphological traits proved that statistically, the traits significantly differentiate populations under analysis (Table 3). The biggest sizes (length and width) were found among petals of population 13, 16 and 17 (Fig. 3). Similar results were obtained for two other traits: the petal length from its base to the incision point and the depth of incision. The basic characteristics of morphological traits are presented in Appendix 1. Analysing the petal length/incision depth ratio it was discovered that the biggest petal incisions can be found in specimens from populations 8, 9, 10 and 11. The biggest length/incision depth ratio and, at the same time, the smallest incision, was found in populations 2, 7, 13 and 14 (Fig. 2).

The principal component analysis (PCA) showed differentiation between specimens from particular populations. Morphological traits 1-4 had a statistical impact on the calculation of PCA1, whereas trait 5 – on the calculation of PCA2 (Table 4). The analysis of principal components PCA divides the specimens into two groups. The first group includes plants from populations 1-12, 15 and some from population 14. The second group consists of specimens from sites 13, 16 and 17, as well as some from 14 (Fig. 4).

Similar results were obtained through the cluster analysis performed on the basis of the Euclidean distance. Two separate population groups were distinguished. The first group form East European populations no. 13 and 16 and Central European population no. 17. The second

Table 3. The F statistics and results of the Scheffé test for each trait separately for all populations (1-17) *Malva alcea* (*** – p<0.001, ** – p<0.05)

Trait	F	Scheffé test[1]
1	92.00***	51
2	123.45***	55
3	85.94***	57
4	39.86***	46
5	3.58**	1

Explanation: [1]Number of statistically significant differences between pairs of populations per all 126 possible pairs

Table 4. The loadings of 5 characters for the first two principal components (PCA1 and PCA2). *** – p<0.001 – values strongly correlated with principal components

Trait	PCA1	PCA2
1	-0.99***	0.03
2	-0.97***	0.16
3	-0.98***	0.15
4	-0.92***	-0.37
5	0.05	0.99***

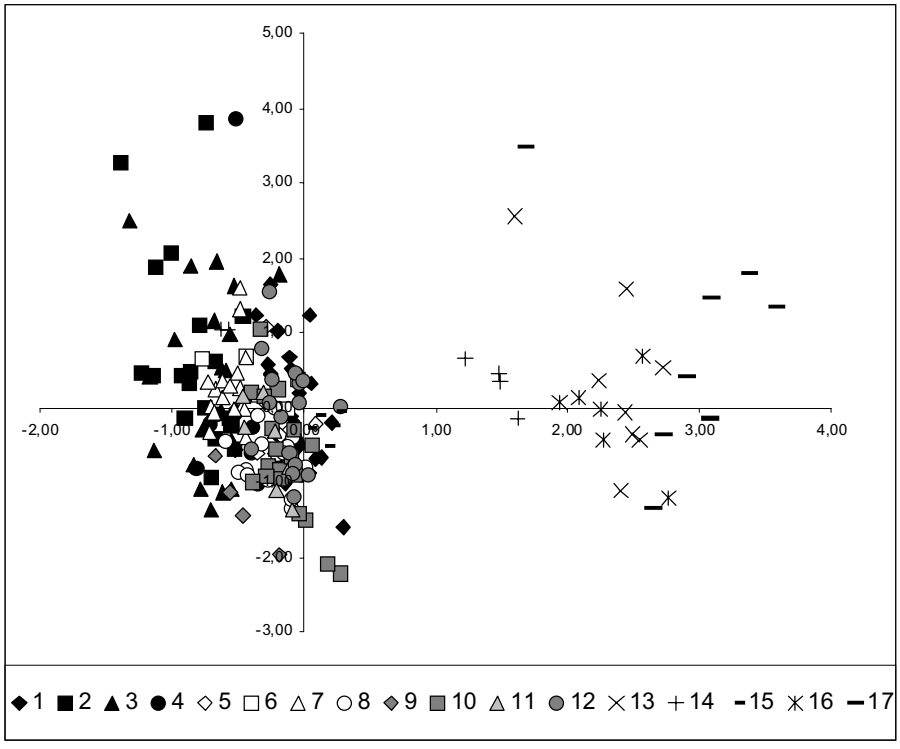

Fig. 4. Principal Component Analysis (PCA) – scatter diagram of specimens from 17 populations of *M. alcea*

group make up Central European populations no. 1-12 and two East European populations no. 14 and 15. Within the latter group, population no. 14 visibly diverge from others (Fig. 5).

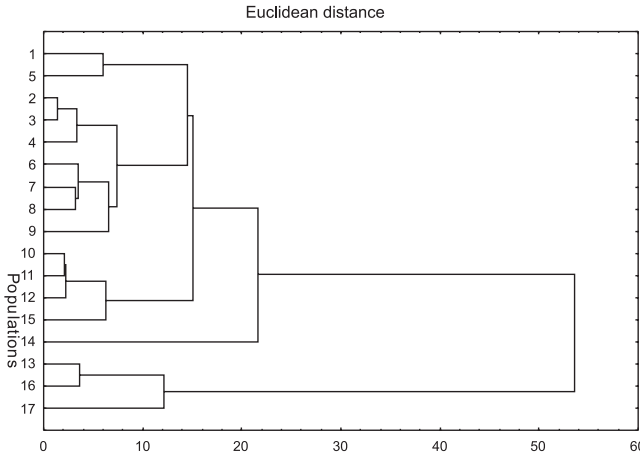

Fig. 5. A dendrogram of the studied populations of *Malva alcea* constructed on the basis of the shortest Euclidean distances according to the single linkage method using set of 5 traits

4. Discussion

Studies on the representatives of *Malvaceae* family involve their ecology, phytosociological affiliation, morphological differentiation and genetic variation. In *Malva* genus, studies were carried out, among others, on the selected sequences of DNA (Tate *et al*. 2005), epidermal structures and hairs (Inamdar & Chohan 1969; Inamdar *et al*. 1983a; Celka *et al*. 2006b), pollen morphology (El Naggar 2004), internodal vessel elements (Inamdar *et al*. 1983b), differentiation of seeds (Celka *et al*. 2006a), structure of seed coat (Kumar & Dalbir Singh 1991) and taxonomical differentiation (among others Krebs 1994; Ray 1995, 1998).

Distinguishing two closely related species of *Malva alcea* and *Malva excisa* is based on the differentiation of hairs on a stem and the depth of the incision of petals (Walas 1959; Il'in 1974). For *Malva excisa* the top of the petals is described as deeply, singly or doubly incised (Fig. 6), whereas for *Malva alcea* as shallowly and mildly incised (Fig. 7) (Reichenbach 1841). In the literature on the subject,

Fig. 6. *Malva excisa* (after Reichenbach 1841)

Fig. 7. *Malva alcea* (after Reichenbach 1841)

Malva alcea is said to come from Western and Central Europe, rarely from Eastern Europe (Walas 1959; Il'in 1974; De Lange *et al*. 1978; Stace 1997; Olyanitskaya 1999; Majorov 2006), whereas *Malva excisa* from Eastern Europe, less frequently from Central Europe (among others, Abromeit *et al*. 1898; Walas 1959; Il'in 1974; Tzvelev 2000). *Malva excisa* is often described as the most extreme variant of *Malva alcea* (Dalby 1968).

The studies on the variability of petals confirm the information in literature that the analyzed traits are extremely variable (compare Dalby 1968; Hlavaček 1982; Slavik 1992). The populations from Central and Eastern Europe permeate one another in terms of petal traits. Some *Malva alcea* populations from Eastern Europe (no. 13, 15 and some individuals from 14) show greater similarity to the population from Central Europe (no. 1-12) than to other populations from Ukraine (compare Fig. 4). The petal length/incision depth ratio shows that the biggest petal incisions are characteristic of the populations in Central Europe (compare Fig. 3). They are the populations found in north-eastern Poland, collected in different habitats (roadsides, cemeteries, strongholds). The smallest petal incisions can be found in *Malva alcea* populations from Eastern and Central Europe (compare Fig. 3). Their habitats include roadsides, roadside ditches and a meadow on a lake island.

The results of the studies confirm information placed in the flora of the Czech Republic that, because of a great variability of key features as well as a lack of geographical and ecological correlations, the distinction of *Malva excisa* is not possible (Slavík 1992).

The obtained results should be interpreted in direct connection with prehistoric and medieval cultivation of *Malva alcea* in the vicinity of strongholds and settlements as well as with ancient and contemporary spreading of the species to anthropogenic habitats. At the present stage of research, our studies failed to confirm the hypothesis on the distinct character of *Malva alcea* and *M. excisa*. Further investigation of the *M. alcea-M. excisa* complex will be focused on hair differentiation and genetic studies (isoenzymes and DNA) of the populations from Central and Eastern Europe.

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Appendix 1. Basic characteristics of analysed traits

Trait	Mean	Min.	Max.	St. Dev.	Trait	Mean	Min.	Max.	St. Dev.
		Site 1					Site 10		
1	25.74	21.29	30.39	2.05	1	21.56	19.05	25.80	1.91
2	18.79	15.32	22.20	1.68	2	16.29	13.66	19.20	1.33
3	20.20	16.30	24.60	1.94	3	16.13	14.68	17.69	0.99
4	5.54	3.79	8.07	1.03	4	5.43	3.92	8.11	1.081
5	3.50	2.32	4.97	0.68	5	3.11	1.94	4.61	0.66
		Site 2					Site 11		
1	17.46	11.47	22.00	2.70	1	20.02	18.15	21.87	1.46
2	14.25	11.36	17.77	1.98	2	15.54	14.39	16.86	0.93
3	13.87	9.69	18.28	2.17	3	15.17	13.95	16.57	0.84
4	3.58	1.71	5.06	0.97	4	4.85	3.79	5.98	0.80
5	4.23	2.80	7.05	1.15	5	3.27	2.56	3.87	0.51
		Site 3					Site 12		
1	18.84	12.22	27.10	3.14	1	21.16	18.68	24.82	1.60
2	14.22	9.81	19.67	2.51	2	17.34	13.95	21.00	1.79
3	14.98	10.39	21.67	2.65	3	16.38	14.36	19.18	1.15
4	3.86	1.83	5.43	0.93	4	4.78	3.72	5.83	0.62
5	3.87	2.41	5.91	1.03	5	3.69	2.70	5.10	0.62
		Site 4					Site 13		
1	19.75	16.80	22.03	1.75	1	43.83	35.74	47.95	3.55
2	15.69	12.60	18.76	1.82	2	39.50	35.25	46.15	3.37
3	15.30	12.44	17.27	1.61	3	33.60	27.33	36.19	3.07
4	4.45	2.64	5.66	0.82	4	10.24	7.30	12.37	1.71
5	3.72	2.75	7.11	1.31	5	3.985	2.94	5.81	0.92
		Site 5					Site 14		
1	23.05	21.27	25.79	1.49	1	28.85	14.08	38.97	11.18
2	17.80	16.11	19.91	1.24	2	25.47	15.19	31.64	7.99
3	17.90	16.07	19.98	1.19	3	22.67	10.84	30.86	8.87
4	5.16	4.05	5.81	0.60	4	6.19	3.24	8.11	2.31
5	3.50	2.97	4.54	0.52	5	4.24	3.59	4.71	0.43
		Site 6					Site 15		
1	20.06	15.66	23.04	3.37	1	23.30	21.41	24.56	1.25
2	18.66	15.56	21.19	2.42	2	17.88	17.05	18.73	0.62
3	15.39	11.99	17.72	2.54	3	18.22	16.35	19.47	1.20
4	4.67	3.67	5.43	0.85	4	5.08	4.89	5.19	0.12
5	4.03	3.64	4.26	0.29	5	3.52	3.29	3.68	0.15
		Site 7					Site 16		
1	18.34	16.56	20.49	1.17	1	42.64	38.11	46.86	3.45
2	15.45	13.48	17.44	1.22	2	37.77	36.51	40.46	1.49
3	14.38	12.69	16.03	1.03	3	32.36	28.70	37.06	2.92
4	4.00	3.43	4.65	0.32	4	10.27	9.38	12.91	1.39
5	3.89	3.30	5.08	0.45	5	3.72	2.97	4.29	0.45
		Site 8					Site 17		
1	21.07	17.73	24.22	1.94	1	49.73	37.04	56.67	5.97
2	16.28	13.67	18.33	1.22	2	41.98	34.54	49.98	6.09
3	15.74	12.63	18.37	1.75	3	39.84	31.53	46.20	4.90
4	5.34	4.20	6.67	0.63	4	9.89	5.51	12.24	1.97
5	3.07	2.60	3.64	0.28	5	4.44	2.82	6.71	1.21
		Site 9							
1	18.30	16.16	21.08	2.10					
2	13.43	13.14	14.01	0.39					
3	12.99	11.87	14.36	1.06					
4	5.31	4.29	6.72	1.04					
5	2.59	2.09	3.11	0.43					