Analysis of Morphological Variability, Correlation and Principal Component in a Cultivated Population of an Important Medicinal Plant, *Atractylodes macrocephala* Koidz. (Asteraceae)

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Abstract: Although *Atractylodes macrocephala* is an important economically medicinal plant with a centuries' cultivation history, our understanding of its morphological variation remains rudimentary. Here, in order to generate information on character association, and influence of characters on rhizome yield of cultivated *Atractylodes macrocephala*, variability, correlation and principal component analysis for 21 morphological characters were studied on 100 morphologically distinct accessions of this medicinal crop. The significant and positive correlation for dry rhizome yield per plant was observed with the largest diameter, number of buds, number of branches and shape of the rhizome, and closely followed by primary branches per plant, plant height, plant crown, and apical lobule length and width of the largest lower leaf. Factor analysis was also used for defining of the determinant factors and the characters constituted in each factor. In Principal component analysis (PCA), the first four main and independent factors could explain 65.75% of the total variation related to main effective characters. Additionally, the results grouped the accessions into two clusters based the scatter plot of principal component analysis defined by the first two axes, which separated accessions with more than two-branched rhizome from other accessions. This characterization on the basis of morphological analysis will help in identification of economically useful accessions for further germplasm conservation programmes and crop improvement.

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1. Introduction

Atractylodes macrocephala Koidz., a perennial herb belonging to the Asteraceae family, is a major high value medicinal crop widely cultivated in China. The dried rhizome of *A. macrocephala* , also known as Atractylodes Macrocephala Rhizoma, is widely used in traditional herbal remedies in Asia(Shiba et al., 2006; Shi et al., 2012). It was reported that the essential oil of Atractylodes Macrocephala Rhizoma possesses an array of biologically active secondary compounds, including those that are gastroprotective(Wang et al., 2010), anti-inflammatory(Wang et al., 2009), anti-carcinogenic (Cao et al., 2002) and anti-microbial(Kim et al., 2007)activity according to pharmacological investigations.In the Chinese market, it is estimated that about 7,000 tonnes of dried Atractylodes Macrocephala Rhizoma are demandedannually (Peng et al., 2011). Among the production areas, Zhejiang Province is well known for its high quality of Atractylodes Macrocephala Rhizoma, while Bozhou City in Anhui Province is now the largest producer(Zheng et al., 2012).

However,as a morphologically diverse species, little was known on the variability of this medicinal crop. Fu *et al.* (2003) reported positive correlation of plant height, branch number, and leaf number with fresh and dry rhizome weight from study on five main production areas of Zhejiang province. The correlationbetweenspecific leafweight anddryweight of rhizomewassignificant inbiennial*Atractylodes macrocephala*, but wasnot obvious inannual plants according to the study by Bai *et al.* (2009).

To our knowledge, rhizome yield is a complex character governed by polygene and is the ultimate result of a complex relationship among different yield components, along with other morphological characteristics. Thus, for this medicinal plant, improvement in rhizome yield/plant is very difficult to achieve by direct selection. Therefore, it is imperative to determine major morphological characters affecting rhizome yield and also to know the relationship among these characters.The aim of the present study was to generate information on character association, and influence of characters on rhizome yield of cultivated *A. macrocephala*.

2. Material and Methods

Plant Material

The material for the present investigation consisted of 100 biennial plants of cultivated *A. macrocephala* from the Chinese medicinal materials base in Panan, Zhejiang province in December 10,2012. Germplasm of this medicinal crop were collected from more than 20 main production areas and cultivated in the base for mass selection by crossing since 2005. Thus, the population was rich in germplasm resources and suitable for analysis of morphological variability and correlation of different characters.

Morphological characterization

100 individuals were randomly taken from the base to record 21 morphological characters on plant, leaf, bract, capitula and rhizome, respectively (Table 1). The length and width of the largest lower and upper leaf on each individual was measured, and the length-to-width ratio was calculated. This ratio was served as an indicator of leaf shape. The weight of each rhizome was weighed separately, after oven drying at 70℃ for 48 h. Character statistics were listed in supplementary table 1.

Statistical Analysis

Data analyses were performed using the statistical procedures in SPSS version 16.0 software (SPSS Inc, Chicago, IL). The coefficients of simple correlation between various characters were worked out as per standard procedure following the formula described by Anandhi *et al.* (2013). Principal component factor analysis was also conducted for defining of the determinant factors and the characters constitutedineachfactor.

Table 1. Morphological characters used in the descriptive statistics and phenetic analysis.

The position of plant	Character	Abbreviation	Description
Plant	Primary branches per plant	PPB	Number of stems branched from the base of the plant
	Height	PH	Height of the plant (cm)
	Crown	PC	Crown of the plant (cm)
	Height/crown ratio	PHCR	The ratio of plant height to crown
Lower leaf	No. of leaflets	LNL	Number of leaflets of matured lower leaf
	Petiole length	LPL	Length of petiole of matured lower leaf (cm)
	Apical lobule length	LALL	Length of the apical lobule of matured lower leaf (cm)
	Apical lobule width	LALW	Width of the apical lobule of matured lower leaf (cm)
	Length/width ratio	LLWR	The ratio of leaf length to leaf width of apical lobule
Upper leaf	Length	UL	Length of the apical lobule of upper leaf (cm)
	Width	UW	Width of the apical lobule of upper leaf (cm)
	Length/width ratio	ULWR	The ratio of leaf length to leaf width
Bract	Shape	BS	Pinnatisect (1), pinnatipartite (2)
	Length	BL	The ratio of leaf length to leaf width
Capitula	No. of plies of involucres	CNP	Number of plies of involucres
	Diameter	CD	Diameter of the capitula(cm)
Rhizome	Shape	RS	Drumstick-shaped (1), frog-shaped (2), two branches (3), more than two branches (4)
	No. of branches	RNB	Branch number of the rhizome
	No. of buds	RNBU	Number of buds
	Largest diameter	RLD	The largest diameter of the rhizome (cm)
	Dry weight	RDW	The dry weight of the rhizome per plant (g)

3. Results

Correlation Studies

The highest and positive significant correlation for dry rhizome yield/plant (g) was observed with the largest diameter (0.684), number of buds (0.656), number of branches (0.647) and shape (0.640) of the rhizome, and closely followed by primary branches per plant (0.345), plant height (0.344), plant crown (0.325), and apical lobule length (0.300) and width (0.327) of the largest lower leaf (Table 2).

Positive significance intercorrelations were observed for the shape, number of branches, number of buds, and the largest diameter of the rhizome. Similarly, primary branches per plant showed positive significance correlation with plant height/crown ratio (0.374), shape (0.546) and number of branches (0.574) of the rhizome. Plant height showed positive significance correlation with plant crown (0.253), plant height/crown ratio (0.449), and the largest diameter of rhizome (0.351). While number of leaflets of lower leaf showed positive significance with apical lobule length/width ratio (0.291), upper leaf length/width ratio (0.287) and the largest diameter of the rhizome (0.260).

Factorial analysis

Principal Component Analysis a multivariatetechnique that detects associations and oppositionsexisting between variables (morphological characters in our case), measuringtheir contribution to the total inertia for each factor.In the end, this analysis results in the identification of major attributes that are responsible for theobserved variation within a given collection(Mezghani et al., 2013).

Table 3. Eigenvalues, percentage variation, andCumulativevariation explained by the first fourprincipal factors of principal component analysis.

Principal factor	Eigenvalue	Variation of eachfactor (%)	Cumulative variation (%)
1	5.14	24.49	24.49
2	3.39	16.14	40.63
3	3.06	14.55	55.18
4	2.22	10.57	65.75

Table 4. Correlation between the characters and thetwo firstprincipal factors of principal component analysis.

Character	Factor 1	Factor 2
Primary branches per plant	**0.58**	-0.39
Plant height	0.30	-0.12
Plantcrown	0.19	0.49
Plant height/crown ratio	-0.04	**0.51**
No. of leaflets of lower leaf	-0.22	-0.31
Petiole length of lower leaf	0.08	-0.50
Apical lobule length of lower leaf	0.39	**0.55**
Apical lobule width of lower leaf	**0.52**	**0.70**
Length/width ratio of lower leaf	0.39	0.48
Upper leaf length	-0.07	0.43
Upper leaf width	0.25	0.38
Length/width ratio of upper leaf	0.33	0.05
Bract shape	-0.02	-0.07
Bract length	-0.21	0.38
No. of plies of involucres	-0.50	-0.01
Capitula diameter	-0.16	0.42
Rhizome shape	**0.80**	-0.20
No. of branches of rhizome	**0.79**	-0.26
No. of buds of rhizome	**0.64**	-0.17
Largest diameter of rhizome	**0.55**	-0.10
Dry weight of rhizome	**0.86**	-0.02

Values in bold represent the coordinates of the most importantmorphological characters supporting the formation of the twofirst principal factors.

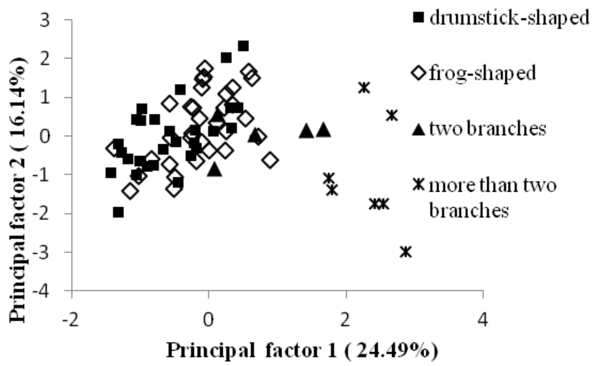

Figure 1.**S**catter plotgrouping of cultivated *Atractylodes macrocephala*accessions based on the firsttwo principal factors of principal component analysis.

Table 2. Simple correlation coefficients between different morphological characters in *Atractylodes macrocephala*.

	PPB	PH	PC	PHCR	LNL	LPL	LALL	LALW	LLWR	UL	UW	ULWR	BS	BL	CNP	CD	RS	RNB	RNBU	RLD	RDW
PPB	1.000																				
PH	0.004	1.000																			
PC	-.292*	.253*	1.000																		
PHCR	.374**	.449**	-.703**	1.000																	
LNL	-.270*	0.223	0.050	0.082	1.000																
LPL	.298**	0.023	-0.119	0.165	0.159	1.000															
LALL	0.016	0.162	.338**	-0.172	-.269*	-0.112	1.000														
LALW	0.129	0.085	0.193	-0.100	-.364**	-.285*	.760**	1.000													
LLWR	-0.171	0.025	0.041	-0.023	.291**	.318**	-0.077	-.674**	1.000												
UL	-0.227	0.045	0.118	-0.060	0.094	-0.072	0.142	0.130	-0.038	1.000											
UW	0.024	0.019	-0.009	0.003	-0.172	-0.082	0.122	.285*	-.303**	.511**	1.000										
ULWR	-.234*	-0.020	0.210	-0.011	.287*	0.068	-0.041	-.235**	.335**	0.223	-.698**	1.000									
BS	-0.100	-0.071	-0.059	-0.005	0.068	0.011	-0.074	-0.138	.266*	0.045	0.015	-0.036	1.000								
BL	-.245*	-0.061	0.059	-0.096	0.119	-0.082	0.009	0.127	-0.095	.352**	-0.037	.346**	.334**	1.000							
CNP	-.281*	-0.091	-0.115	-0.008	0.214	-0.014	-.232*	-.303**	0.200	0.144	0.017	0.143	-0.073	.275*	1.000						
CD	-.254*	-0.022	.250*	-0.221	0.055	0.022	0.061	0.122	-0.098	0.137	0.019	0.090	0.015	.500**	.263*	1.000					
RS	.546**	0.183	0.067	0.125	0.036	0.116	0.109	0.215	-0.170	-0.065	0.124	-.242**	0.102	-0.030	-.245*	-0.048	1.000				
RNB	.574**	0.198	0.064	0.159	-0.117	.247*	0.072	0.209	-0.201	-0.156	-0.027	-0.134	0.117	-0.016	-.379**	-0.125	.770**	1.000			
RNBU	0.205	0.037	0.169	-0.051	-0.029	0.133	0.151	0.063	0.084	-0.087	0.049	-0.161	0.002	-0.176	-0.227	-0.077	.506**	.504**	1.000		
RLD	0.096	.351**	0.178	0.119	.260*	0.042	0.103	0.102	-0.007	0.170	0.076	0.040	0.045	0.003	0.031	0.032	.544**	.351**	.464**	1.000	
RDW	.345**	.344**	.325**	0.026	-0.037	0.080	.300**	.327**	-0.167	0.029	0.123	-0.147	0.020	-0.146	-.321**	-0.066	.640**	.647**	.656**	.684**	1.000

*, significant at 0.05 level; **, significant at 0.01 level; letters represent the abbreviation of characters described in table 1.

The result of principal component analysis showed thatthe first four principal factors accounted for 65.75% ofthe total variance (Table 3). Factor 1 explained 24.49% of the total variance and waspositivelycorrelated with shape, number of branches, number of buds, the largest diameter and dry weight of the rhizome, and primary branches of each plant. Factor 2 accounted for 16.14% of totalvariance and was positively correlated with apical lobule length and width of lower leaf, and plant height/crown ratio.

The scatter plot of principal component analysis defined by the two first axes (Figure 1)separated accessions with more than two branched rhizome from other accessions, suggesting the importance of rhizome shape along with its associated characters in the total variance of morphological characters. The average rhizome yield/plant for different rhizome shape in this study were calculated, and the results showed that more than two branches (74.2) > two branches (37.7) > frog-shaped (35.3) > drumstick-shaped (27.8).

4. Discussions

Association Analysis

The ultimate goal of crop improvement in*A. macrocephala* is to achieve improved rhizome weight with a good shape, and active ingredientscontent. Being a complex trait, the rhizome shape and weight are largely influenced by many associated traits. The information on strength and direction of correlation of these component characters on rhizome would be useful in formulating selection criteria to design breedingprogrammes for yield improvement. Our morphological data provideconsiderable information that is useful to distinguish characters associated with rhizome yield of this crop.

In this study, dry rhizome yield/plant was significant and positively correlated with the largest diameter, number of buds, number of branches and shape of the rhizome, and closely followed by primary branches per plant, plant height, plant crown, and apical lobule length and width of the largest lower leaf.

Positive correlation of fresh and dry rhizome weight with plant height, branch number, leaf number was reported by Fu *et al.* (2003). Our study confirmed the correlation of rhizome yield/plant with plant height and branch number. This analysis revealed that selecting plants with more plant height, plant crown, number of primary branches per plant, and apical lobule length and width of the largest lower leaf were desirable for future crop improvement programme for developing high- yielding varieties.

Factorial analysis

The analysis of morphological variation of the population for mass selecting showed high diversity. The use of multivariate analysis of principal component analysis showed that the first four main and independent factors could explain 65.75% of the total variation, and rhizomes and leaves tend to show more phenotypicplasticity, in comparison with other organs. Besides, the scatter plot of principal component analysis defined by the first two axespermitted the subdivision of accessions with more than two-branched rhizome from the other accessions. In this investigation, the average dry rhizome yield/plant of individuals with more than two-branched rhizome was significant higher than those of individuals with other rhizome shape.

The results of this study not only showed high variation for the studied morphological characters, but also some characters were clearly shown their valuable breeding potential in some agronomical traits for breeding programs on yielding purposes, e.g. primary branches per plant, apical lobule length and width of lower leaf.

Furthercollection missions, e.g. wild germplasm resources, are necessary to acquire additionalaccessions to enrich the analysis. This research will also be continued by combining morphological,chemical and moleculardata in order to confirm the diversity observed and improve germplasm management and variety improvement.

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Supplementary table 1. Characters statistics of 100 accessions of cultivated *Atractylodes macrocephala*

Accession no.	PPB	PH	PC	PHCR	LNL	LPL	LALL	LALW	LLWR	UL	UW	ULWR	BS	BL	CNP	CD	RS	RNB	RNBU	RLD	RDW
1	1	50	30	0.60	2	4.8	4.2	1.6	0.38	6.5	2.5	0.38	1	3.3	8	3.7	1	1	2	2.0	13.4
2	1	43	30	0.70	2	5.5	9.5	3.7	0.39	6.5	1.5	0.23	1	4.5	8	3.5	1	1	1	4.0	22.8
3	1	39	29	0.74	2	8.5	9.0	2.9	0.32	11.5	2.2	0.19	1	5.0	8	4.4	1	1	1	3.5	15.4
4	1	40	28	0.70	2	4.0	8.0	3.5	0.44	8.0	2.0	0.25	1	3.7	6	3.5	1	1	7	6.0	45.3
5	1	30	24	0.80	2	6.5	5.5	1.7	0.31	8.0	2.6	0.33	1	4.0	9	3.8	1	1	3	3.2	15.0
6	1	44	30	0.68	2	8.5	9.5	2.7	0.28	9.5	3.0	0.32	1	3.6	6	3.0	1	1	2	2.7	38.4
7	1	60	23	0.38	2	3.6	7.2	3.2	0.44	9.0	2.2	0.24	1	5.1	7	3.1	1	1	2	3.8	16.0
8	1	40	32	0.80	2	4.6	8.0	2.8	0.35	10.0	2.0	0.20	1	4.5	7	2.6	1	1	5	4.2	51.6
9	1	40	30	0.75	2	5.0	11.0	2.2	0.20	8.5	2.0	0.24	2	4.8	8	2.8	1	1	3	4.5	31.8
10	1	45	32	0.71	1	4.0	14.8	5.5	0.37	9.5	3.0	0.32	1	5.0	8	4.0	1	1	3	3.5	53.6
11	1	48	30	0.63	2	4.5	8.0	3.1	0.39	10.0	2.6	0.26	1	3.0	8	3.2	1	1	4	4.4	55.0
12	1	40	23	0.58	2	6.0	9.5	4.0	0.42	11.0	4.4	0.40	1	3.4	7	3.0	1	1	4	4.3	37.0
13	1	35	24	0.69	2	5.0	6.7	3.0	0.45	7.0	2.5	0.36	1	3.8	8	3.2	1	1	4	4.5	32.8
14	1	46	26	0.57	2	4.5	14.0	5.2	0.37	8.0	1.8	0.23	1	3.5	6	3.4	1	1	3	4.5	35.9
15	2	43	22	0.51	2	7.0	9.5	3.0	0.32	7.5	2.0	0.27	1	3.2	8	2.9	1	1	1	3.5	18.3
16	2	40	20	0.50	2	5.0	8.7	3.5	0.40	7.0	2.2	0.31	1	3.8	7	3.4	1	1	1	3.0	25.5
17	1	45	20	0.44	2	4.5	8.0	2.2	0.28	10.0	2.2	0.22	1	3.0	9	2.8	1	1	2	3.5	13.4
18	1	36	30	0.83	2	4.0	9.0	4.1	0.46	9.3	2.2	0.24	1	5.2	9	3.3	1	1	3	4.2	31.7
19	1	36	23	0.64	2	5.5	7.5	2.5	0.33	8.4	1.5	0.18	1	5.5	10	3.5	1	1	2	4.0	24.3
20	1	32	15	0.47	2	3.7	5.6	1.6	0.29	9.6	1.8	0.19	1	5.2	9	3.6	1	1	4	4.3	18.5
21	1	42	25	0.60	2	5.2	9.5	2.3	0.24	8.5	1.9	0.22	1	3.8	8	3.0	1	1	4	3.5	22.8
22	1	38	40	1.05	2	4.2	13.0	4.6	0.35	10.5	2.6	0.25	1	4.8	8	3.1	1	1	6	5.0	40.9
23	1	36	28	0.78	4	5.5	6.0	2.0	0.33	12.0	2.5	0.21	1	5.0	10	3.1	1	1	3	4.0	21.7
24	1	44	30	0.68	2	4.5	7.5	2.6	0.35	11.0	2.2	0.20	1	4.5	10	4.0	1	1	1	4.8	41.8
25	1	37	30	0.81	2	5.5	10.0	2.8	0.28	9.0	2.0	0.22	1	5.2	8	4.7	1	1	3	3.0	23.4
26	2	35	32	0.91	2	3.5	7.0	2.5	0.36	7.6	2.0	0.26	1	4.7	8	4.0	1	1	1	2.0	16.3
27	1	34	24	0.71	2	5.5	6.8	2.5	0.37	6.5	2.0	0.31	1	3.5	8	3.2	1	1	3	2.0	10.9
28	1	52	23	0.44	4	6.6	6.6	1.7	0.26	7.2	1.5	0.21	1	4.0	10	3.5	1	1	2	4.5	16.7

29	1	42	24	0.57	2	3.5	6.0	1.7	0.28	9.5	2.5	0.26	1	4.2	10	3.3	1	1	3	6.0	15.0
30	1	41	30	0.74	2	8.8	9.0	2.9	0.32	11.7	2.2	0.21	1	5.0	8	4.4	1	1	1	3.5	15.4
31	1	45	31	0.68	2	8.8	9.5	2.7	0.30	9.7	3.0	0.34	1	3.6	6	3.0	1	1	2	2.7	38.4
32	1	44	33	0.80	2	4.9	8.0	2.8	0.35	10.2	2.0	0.22	1	4.5	7	2.6	1	1	5	4.2	51.6
33	1	49	31	0.63	2	4.8	8.0	3.3	0.39	10.2	2.6	0.28	1	3.0	8	3.2	1	1	4	4.4	55.0
34	1	41	24	0.58	2	6.3	9.8	4.0	0.42	11.2	4.4	0.42	1	3.4	7	3.0	1	1	4	4.3	37.0
35	1	46	26	0.57	2	4.8	14.0	5.2	0.37	8.2	1.8	0.25	1	3.5	6	3.4	1	1	3	4.5	35.9
36	2	41	21	0.50	2	5.3	8.7	3.5	0.40	7.2	2.2	0.33	1	3.8	7	3.4	1	1	1	3.0	25.5
37	1	37	31	0.83	2	4.3	9.0	4.1	0.46	9.5	2.2	0.26	1	5.2	9	3.3	1	1	3	4.2	31.7
38	1	33	16	0.47	2	4.0	5.6	1.6	0.29	9.8	1.8	0.21	1	5.2	9	3.6	1	1	4	4.3	18.5
39	1	39	41	1.05	2	4.5	13.0	4.6	0.35	10.7	2.6	0.27	1	4.8	8	3.1	1	1	6	5.0	40.9
40	1	45	31	0.68	2	4.8	7.5	2.6	0.35	11.2	2.2	0.22	1	4.5	10	4.0	1	1	1	4.8	41.8
41	2	36	33	0.91	2	3.8	7.0	2.5	0.36	7.8	2.0	0.28	1	4.7	8	4.0	1	1	1	2.0	16.3
42	1	48	30	0.63	4	7.0	4.5	1.5	0.33	8.1	2.8	0.35	1	4.1	10	3.3	2	1	2	5.8	32.2
43	1	32	24	0.75	1	2.7	10.3	4.5	0.44	9.8	3.0	0.31	1	4.5	8	3.0	2	1	4	3.2	13.4
44	1	50	31	0.62	2	2.5	8.0	2.5	0.31	10.0	3.5	0.35	1	5.5	11	3.8	2	1	3	4.5	44.7
45	1	45	20	0.44	2	3.2	8.5	4.0	0.47	9.5	2.4	0.25	1	6.0	8	4.0	2	1	3	4.5	23.5
46	1	58	34	0.59	4	3.0	8.5	2.5	0.29	9.0	2.2	0.24	1	4.8	9	3.8	2	1	2	6.3	54.3
47	1	41	26	0.63	4	7.5	6.5	1.3	0.20	9.2	1.8	0.20	2	5.8	8	4.1	2	1	2	5.0	29.2
48	1	40	33	0.83	2	4.0	8.0	2.6	0.33	10.0	2.8	0.28	1	3.0	7	3.6	2	1	6	5.2	32.8
49	1	44	22	0.50	2	6.0	11.0	4.8	0.44	12.0	4.2	0.35	1	5.2	10	4.3	2	1	4	6.3	48.3
50	1	42	29	0.69	2	5.0	9.5	3.2	0.34	11.0	3.0	0.27	1	5.4	9	3.5	2	1	1	4.0	15.2
51	1	33	17	0.52	2	3.6	5.5	2.2	0.40	7.8	3.0	0.38	2	4.3	9	3.3	2	1	1	3.3	13.3
52	1	45	30	0.67	2	4.5	10.0	2.4	0.24	7.5	1.8	0.24	1	3.5	7	3.0	2	1	2	5.3	32.9
53	1	45	19	0.42	4	5.5	7.0	2.3	0.33	8.5	2.0	0.24	1	6.0	10	3.8	2	1	2	5.3	16.8
54	1	51	30	0.59	2	3.1	9.0	3.7	0.41	9.0	2.2	0.24	1	4.0	10	3.3	2	1	2	4.6	36.8
55	1	40	22	0.55	4	5.5	7.5	2.5	0.33	8.7	1.7	0.20	1	4.5	8	3.5	2	1	2	6.5	36.8
56	1	50	29	0.58	4	6.2	6.5	2.1	0.32	9.5	2.7	0.28	1	4.8	8	3.5	2	1	1	5.0	24.2
57	1	24	20	0.83	2	5.0	6.0	2.0	0.33	8.5	1.8	0.21	1	4.5	10	4.2	2	1	1	4.0	17.8
58	1	60	31	0.52	2	4.5	10.0	3.5	0.35	9.0	2.7	0.30	1	3.0	6	3.2	2	1	2	6.5	40.1

59.	1.	40.	26.	0.65 .	2.	4.2 .	7.0 .	2.5 .	0.36 .	10.2 .	2.7 .	0.26 .	1.	4.2 .	7.	3.5 .	2.	1.	1.	5.0 .	38.4 .
60.	2.	40.	27.	0.68 .	2.	4.2 .	8.0 .	4.0 .	0.50 .	10.0 .	2.2 .	0.22 .	1.	4.6 .	6.	3.0 .	2.	1.	1.	5.5 .	48.3 .
61.	1.	50.	26.	0.52 .	4.	4.0 .	11.0 .	3.5 .	0.32 .	10.0 .	2.0 .	0.20 .	1.	3.3 .	8.	3.1 .	2.	1.	4.	5.3 .	40.2 .
62.	1.	45.	30.	0.67 .	2.	3.0 .	8.5 .	2.5 .	0.29 .	7.5 .	2.1 .	0.28 .	1.	3.0 .	8.	3.6 .	2.	1.	5.	6.0 .	54.3 .
63.	1.	40.	30.	0.75 .	2.	5.5 .	9.5 .	3.5 .	0.37 .	8.0 .	2.0 .	0.25 .	1.	4.1 .	11.	3.8 .	2.	1.	8.	6.5 .	53.4 .
64.	1.	40.	43.	1.08 .	2.	3.6 .	9.0 .	4.0 .	0.44 .	8.5 .	2.2 .	0.26 .	1.	4.0 .	8.	4.2 .	2.	1.	3.	6.6 .	63.5 .
65.	1.	51.	30.	0.59 .	2.	5.2 .	9.5 .	3.8 .	0.40 .	10.0 .	3.0 .	0.30 .	1.	4.2 .	10.	4.5 .	2.	1.	3.	7.0 .	43.6 .
66.	1.	41.	33.	0.80 .	2.	3.5 .	11.0 .	4.1 .	0.37 .	9.5 .	2.7 .	0.28 .	1.	3.5 .	8.	3.2 .	2.	1.	1.	5.0 .	43.6 .
67.	1.	43.	33.	0.77 .	3.	5.5 .	11.5 .	5.0 .	0.43 .	10.0 .	2.6 .	0.26 .	1.	5.5 .	9.	4.6 .	2.	1.	3.	4.0 .	30.9 .
68.	1.	46.	30.	0.65 .	2.	5.2 .	13.0 .	5.2 .	0.40 .	7.5 .	1.9 .	0.25 .	1.	6.0 .	10.	5.0 .	2.	1.	2.	5.0 .	30.2 .
69.	2.	33.	22.	0.67 .	2.	3.7 .	10.0 .	4.8 .	0.48 .	9.8 .	3.3 .	0.34 .	1.	4.5 .	8.	3.8 .	2.	1.	1.	4.8 .	27.5 .
70.	1.	38.	27.	0.71 .	4.	4.3 .	8.5 .	2.7 .	0.32 .	10.5 .	3.2 .	0.30 .	1.	3.3 .	9.	3.5 .	2.	1.	3.	5.8 .	31.9 .
71.	1.	37.	30.	0.81 .	2.	6.0 .	9.0 .	2.2 .	0.24 .	7.0 .	2.7 .	0.39 .	1.	3.0 .	8.	4.1 .	2.	1.	18.	5.5 .	58.5 .
72.	1.	44.	33.	0.75 .	2.	5.2 .	7.8 .	3.2 .	0.41 .	12.0 .	3.0 .	0.25 .	1.	5.0 .	8.	4.6 .	2.	1.	4.	5.0 .	31.8 .
73.	1.	50.	42.	0.84 .	3.	4.3 .	11.2 .	3.0 .	0.27 .	9.5 .	2.4 .	0.25 .	1.	3.7 .	7.	4.1 .	2.	1.	8.	4.0 .	38.8 .
74.	1.	42.	33.	0.79 .	2.	6.0 .	10.5 .	2.4 .	0.23 .	10.6 .	2.5 .	0.24 .	1.	4.0 .	10.	2.8 .	2.	1.	3.	5.0 .	17.1 .
75.	1.	51.	32.	0.62 .	2.	2.8 .	8.0 .	2.5 .	0.31 .	10.2 .	3.5 .	0.37 .	1.	5.5 .	11.	3.8 .	2.	1.	3.	4.5 .	44.7 .
76.	1.	59.	35.	0.59 .	4.	3.3 .	8.5 .	2.5 .	0.29 .	9.2 .	2.2 .	0.26 .	1.	4.8 .	9.	3.8 .	2.	1.	2.	6.3 .	54.3 .
77.	1.	45.	23.	0.50 .	2.	6.1 .	11.0 .	4.8 .	0.42 .	12.2 .	4.2 .	0.37 .	1.	5.2 .	10.	4.3 .	2.	1.	4.	6.3 .	48.3 .
78.	1.	34.	18.	0.52 .	2.	3.9 .	5.5 .	2.2 .	0.40 .	8.0 .	3.0 .	0.40 .	2.	4.3 .	9.	3.3 .	2.	1.	1.	3.3 .	13.3 .
79.	1.	46.	20.	0.42 .	4.	5.8 .	7.0 .	2.3 .	0.33 .	8.7 .	2.0 .	0.26 .	1.	6.0 .	10.	3.8 .	2.	1.	2.	5.3 .	16.8 .
80.	1.	41.	23.	0.55 .	4.	5.8 .	7.5 .	2.5 .	0.33 .	8.9 .	1.7 .	0.22 .	1.	4.5 .	8.	3.5 .	2.	1.	2.	6.5 .	36.8 .
81.	1.	25.	21.	0.83 .	2.	5.3 .	6.0 .	2.0 .	0.33 .	8.7 .	1.8 .	0.23 .	1.	4.5 .	10.	4.2 .	2.	1.	1.	4.0 .	17.8 .
82.	1.	41.	27.	0.65 .	2.	4.5 .	7.0 .	2.5 .	0.36 .	10.4 .	2.7 .	0.28 .	1.	4.2 .	7.	3.5 .	2.	1.	1.	5.0 .	38.4 .
83.	1.	41.	23.	0.56 .	4.	5.8 .	7.5 .	2.5 .	0.33 .	8.9 .	1.7 .	0.19 .	1.	4.5 .	8.	3.5 .	2.	1.	2.	6.5 .	36.8 .
84.	1.	40.	28.	0.70 .	3.	4.2 .	9.5 .	3.8 .	0.40 .	8.3 .	2.8 .	0.34 .	1.	3.0 .	8.	2.8 .	3.	1.	4.	5.0 .	51.7 .
85.	2.	28.	30.	1.07 .	2.	5.0 .	8.5 .	3.3 .	0.39 .	8.0 .	2.2 .	0.28 .	1.	4.6 .	6.	4.0 .	3.	2.	3.	3.2 .	15.7 .
86.	2.	42.	20.	0.48 .	2.	4.5 .	9.5 .	3.0 .	0.32 .	8.5 .	2.3 .	0.27 .	1.	3.5 .	8.	3.2 .	3.	1.	3.	3.5 .	27.5 .
87.	3.	42.	20.	0.48 .	1.	4.0 .	9.0 .	5.0 .	0.56 .	8.0 .	3.0 .	0.38 .	1.	3.6 .	7.	3.0 .	3.	2.	2.	4.0 .	33.4 .
88.	2.	50.	32.	0.64 .	2.	5.0 .	10.5 .	4.5 .	0.43 .	8.5 .	2.5 .	0.29 .	1.	3.8 .	6.	3.3 .	3.	4.	3.	4.0 .	60.1 .

89	2	29	31	1.07	2	5.3	8.5	3.3	0.39	8.2	2.2	0.30	1	4.6	6	4.0	3	2	3	3.2	15.7
90	2	51	33	0.64	2	5.3	10.5	4.5	0.43	8.7	2.5	0.31	1	3.8	6	3.3	3	4	3	4.0	60.1
91	2	44	24	0.55	2	6.5	9.2	3.5	0.38	6.5	2.0	0.31	1	3.0	6	2.7	4	5	10	6.0	70.2
92	1	48	32	0.67	2	4.0	9.5	4.5	0.47	11.5	3.0	0.26	2	7.2	6	4.0	4	5	9	7.0	76.7
93	1	46	36	0.78	3	3.5	10.0	5.0	0.50	8.0	2.1	0.26	1	4.5	6	3.5	4	6	12	6.0	78.1
94	4	40	22	0.55	1	6.5	9.0	3.5	0.39	7.3	2.7	0.37	1	3.3	8	2.6	4	5	7	5.5	60.3
95	4	52	15	0.29	2	9.0	8.2	2.7	0.33	9.4	2.5	0.27	1	3.2	7	3.3	4	5	10	7.0	91.9
96	2	52	41	0.79	2	8.0	8.0	2.5	0.31	7.5	1.8	0.24	1	4.5	8	3.9	4	5	6	6.5	67.5
97	2	42	28	0.67	3	6.0	9.0	2.5	0.28	9.5	2.4	0.25	1	4.2	8	2.7	4	2	16	7.6	75.0
98	1	47	37	0.78	3	3.8	10.0	5.0	0.50	8.2	2.1	0.28	1	4.5	6	3.5	4	6	12	6.0	78.1
99	4	53	16	0.29	2	9.3	8.2	2.7	0.33	9.6	2.5	0.29	1	3.2	7	3.3	4	5	10	7.0	91.9
100	2	43	29	0.67	3	6.3	9.0	2.5	0.28	9.7	2.4	0.27	1	4.2	8	2.7	4	2	16	7.6	75.0

*, Letters represent the abbreviation of characters described in table.