EFFECTS OF DIFFERENT NUMERICAL TECHNIQUES ON PHENETIC CLASSIFICATION OF *MOSLA* COMPLEX (LABIATAE) AT POPULATION LEVEL[1,2]

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Abstract: The present study aims to evaluate the clustering pattterns obtained from various numerical techniques applied to 16 natural populations with 16 morphological characters. Seven similarity coefficients and three clustering methods were used. Twenty-one phenograms were drawn from the results and were also compared with taxonomic hierarchies determined by traditional methods. Consequently two numerical techniques were suggested for further taxonomic study on this group of plants.

INTRODUCTION

The plants of the genus *Mosla* are one of the most complicated groups in Formosan Labiatae. In 1978 Huang and Cheng identified the following four taxa of this genus: 1. *M. chinensis* Maxim., 2. *M. dianthera* (Buch-Ham) Maxim., 3. *M. dianthera* var. *nana* (Hara) Ohwi, and 4. *M. punctulata* (J. F. Gmel.) Nakai. Also, three insufficient taxa including *M. formosana* Maxim., *Orthodon pseudohirtum* Fujita, and *O. taikeiense* Fujita were reported by them. Among these taxa, only *M. chinensis* Maxim is recognized as a distinctive taxon, while the others showed various degrees of integradation which is causing some taxonomic confusion.

Various numerical techniques have been recommended to obtain a better taxonomic understanding in many plant groups (Bemis *et al.*, 1974; Cheng, 1977; Crawford and Reynolds, 1974; Crovello, 1965, 1968a, and 1968b; Rhodes *et al.*, 1968; and Taylor, 1966). However, different numerical methods resulted in different classification, and it is therefore necessary to choose an applicable method (Sokal and Michener, 1967; Sokal and Sneath, 1973). The present study aims to evaluate the clustering patterns obtained from seven similarity coefficients applied to three clustering procedures by using 16 natural populations of *Mosla* complex, and the results were also compared with taxonomic hierarchies determined by traditional methods. From the present study the appropriate numerical techniques of classificatory stability for taxonomic studies on this group of plants were suggested.

MATERIALS AND METHODS

Sixteen operational taxonomic units (OTU's) representing 16 natural populations were treated for this study. The code numbers, localities, and habitates are listed in Table 1, and the code number will be applied in the following sections in this paper. Five plants were collected randomly from each sampled population which consisted of at least 15 plants. Sixteen morphological characters as shown in Table 2 were examined for assessing the over all phenetic similarity in each pair of OTU's. The character value were obtained by the average of three

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(3) 鄭武燦, Department of Botany, N. T. U., Taipei, R. O. C.

Table 1. Code numbers, localities, and habitats of populations forming the basis of OTU's in the present study

Code number	Locality	Habitat
	TAIPEI COUNTY (臺北縣)	
3514	Santiaolien (三貂嶺)	Hill path
3515	Santiaolien (三貂嶺)	Hill path
3518	Santiaolien (三貂嶺) to Chung Keng	Hill path
3519	Santiaolien (三貂嶺) to Chung Keng	Paddy field
3538	Pitauchiao (鼻頭角)	Grass field near coast
3540	Pitauchiao (鼻頭角) to Wentze Keng	Rocky coast
3542	Wentze Keng (蚊子坑)	Highway near coast
3543	Pihu (碧湖)	Pei-I highway
3544	Pihu (碧湖)	Pei-I highway
3545	Yingtzulai (鶯仔瀨)	River side
3547	Yingtzulai (鶯仔瀨)	River Side
3555	Tonghou (桶後)	Hill side
3556	Tonghou (桶後)	Hill side
3575	Mucha (木柵)	Orchard
	ILAN COUNTY (宜蘭縣)	
3558	PAULUN MT. (匏崙山)	Mountain slope
3563	Paulun (匏崙)	Paddy field

Table 2. Code numbers and characters used in the present study

Code number	Character	Code number	Character
	STEM		BRACT
1	Pubescent on node	11	Ratio of width/length
2	Pubescent on ridge of internode	12	Ratio of length of bract/length of pedicel
3	Pubescent on groove of internode		CALYX
	LEAF BLADE	13	Ratio of length of upper lip/length of calyx
4	Pubescent on upper surface		
5	Pubescent on lower surface	14	Ratio of length of central tooth on upper lip/length of upper lip
6	Number of pairs of teeth		
7	Ratio of width/length	15	Pubescent on calyx outside
	FLORAL AXIS		NUTLET
8	Pubescent on node	16	Ratio of width/length
9	Pubescent on ridge of internode		
10	Pubescent on groove of internode		

measurements from each of five plants of a population. Variation within population was not considered. A 16×16 data matrix for the characters of all OTU's was constructed, from which a similarity matrix was constructed. The similarity coefficients used in the present

study include (1) Correlation coefficient, (2) Gower's coefficient, (3) Canberra coefficient, (4) Divergent coefficient, (5) Euclidean distance coefficient, (6) Manhattan distance coefficient, and (7) Minkowski distance coefficient with index of 3. The formula and explanation of symbols are listed in Table 3. The correlation coefficient and Gower's coefficient represented the degree of similarity, but the other coefficients symbolize the degree of dissimilarity.

Table 3. Similarity coefficients used in the present study*

Simlarity coefficient	Formula
1 Correlation coefficient	$r_{jk}=\frac{\sum_{i=1}^{n}(X_{ij}-\bar{X}_i)(X_{ik}-\bar{X}_i)}{\sqrt{\sum_{i=1}^{n}(X_{ij}-\bar{X}_i)^2\sum_{i=1}^{n}(X_{ik}-\bar{X}_i)^2}}$
2 Gower's coefficient	$G_{jk}=\sum_{i=1}^{n}[1-\lvert X_{ij}-X_{ik}\rvert/R_i]/NV$
3 Canberra distance coefficient	$d(j,\ k)=\sum_{i=1}^{n}\left(\frac{X_{ij}-X_{ik}}{X_{ij}+X_{ik}}\right)$
4 Divergent coefficient	$CD_{jk}=\left[\frac{1}{n}\sum_{i=1}^{n}\left(\frac{X_{ij}-X_{ik}}{X_{ij}+X_{ik}}\right)^2\right]^{1/2}$
5 Euclidean distance coefficient	$\triangle jk=\left[\sum_{i=1}^{n}(X_{ij}-X_{ik})^2\right]^{1/2}$
6 Manhattan distance coefficient	$d(j,\ k)=\sum_{i=1}^{n}\lvert X_{ij}-X_{ik}\rvert$
7 Minkowski distance coefficient with index of 3.	$d_3(j,\ k)=\left(\sum_{i=1}^{n}\lvert X_{ij}-X_{ik}\rvert^3\right)^{1/3}$

* j=the jth OTU
k=the kth OTU
n=the number of characters sampled
X_{ij}=the value of the ith character of the jth OTU
$\bar{X}_i$=the value of the ith character for all OTU's
X_{ik}=the value of the ith character of the kth OTU
R_i=tne range of the ith character
NV=the number of characters

Three methods of cluster analysis were performed by using each type of similarity coefficients. These methods are single linkage cluster analysis (SLCA), complete linkage cluster analysis (CLCA), and the unweighted pair-group method using arithmetical averages (UPGMA). From the results of clustering the phenograms were drawn among OTU's. In the following sections of this report, the phenograms were represented by the combination of abbreviations shown as follows.

S =Single linkage cluster analysis
C =Complete linkage cluster analysis
U =Unweighted pair-group method using arithmatical averages
CO =Correlation coefficient
GO =Gower's coefficient
CA =Canberra coefficient
DI =Divergent coefficient
EU =Euclidean distance coefficient

MA = Manhattan distance coefficient

MI3 = Minkowski distance coefficient with index of 3

For example, phenogram SCO represents phenograms resulting from single linkage cluster analysis with correlation coefficient, and phenogram UMA represents phenograms obtained from cluster analysis by unweighted pair-group method using arithmatical averages with Manhattan distance coefficient.

To compare with the results obtained from phenograms, the sixteen populations studied were also identified by utilizing conventional methods (Table 4). From the traditional classification, six populations including 3515, 3519, 3544, 3545, 3547, and 3563 were referred to *M. dianthera* and seven populations including 3514, 3518, 3538, 3540, 3542, 3543, and 3575 were referred to *M. punctulata*. However, populations 3555, 3556, and 3558 could not exactly be identified as either *M. dianthera* or *M. punctulata* and were referred as unconfirmed taxa. These three groups of populations were coded with "D", "P", and "U" respectively.

The computations were carried out on CDC 3150 computer at the Electronic Computer Center of National Taiwan University. The program used was derived from the N. T. class program written by Dr. Neely at the University of Kansas.

Table 4. The sixteen operational taxonomic units (OTU's) and the taxa they belong to based on traditional taxonomy

	Taxa		
	M. dianthera	*M. punctulata*	Unconfirmed
Code numbers of OT's	3515	3514	3555
	3519	3518	3556
	3544	3538	3558
	3545	3540	
	3547	3542	
	3563	3543	
		3575	

RESULTS

Single Linkage Cluster Analysis (SLCA)

Seven phenograms obtained from the similarity coefficients (Table 3) which apply to single linkage cluster analysis (SLCA) are shown in Fig. 1-7. In general, all phenograms except SGO appear as a chaining effect with respect to the overall arrangement of OTU's and no demarcation line can be used at the two species level corresponding with the traditional taxonomic information about this group of plants (Table 4). The six OTU's referred to *M. dianthera* (Table 4), formed an integrity cluster in one phenogram (SGO) only, and the seven OTU's, referred to *M. punctulata* (Table 4), joined together in the upper part of two chained phenograms (SCA and SDI). The three OTU's referred to unconfirmed taxa (Table 4), never join together into a closer cluster in any phenogram.

In phenogram SCO, OUT's 3518, 3540, 3542, 3514, and 3543 (*M. punctulata*) formed a cluster, and this cluster joined with the group which is composed of closely related OTU's 3545, 3563, 3544, 3547, 3515, and 3519 (*M. dianthera*). The OTU's 3555 and 3558 (unconfirmed taxa) and OTU 3538 (*M. punctulata*) formed a cluster, and joined above cluster. Then OTU 3556 (unconfirmed taxon) and OTU 3575 (*M. punctulata*) joined singlely

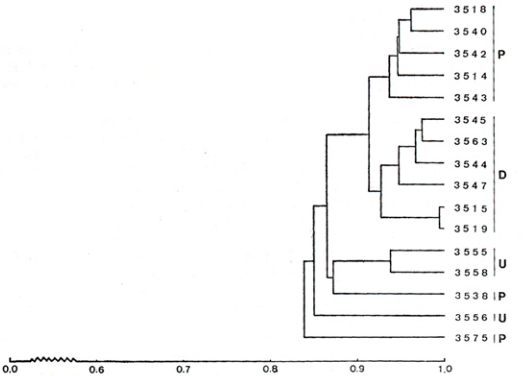

Fig. 1. Phenogram (SCO) resulting from Single Linkage Cluster Analysis (SLCA) based on Correlation coefficient (CO).

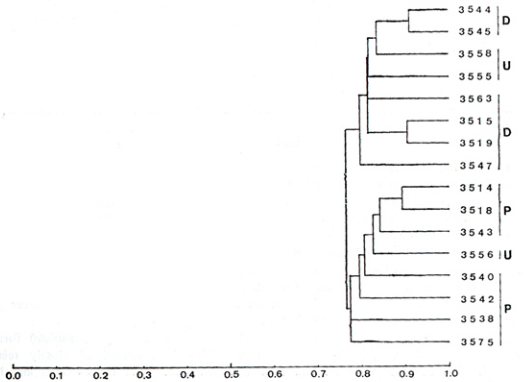

Fig. 2. Phenogram (SGO) resulting from Single Linkage Cluster Analysis (SLCA) based on Gower's coefficient (GO).

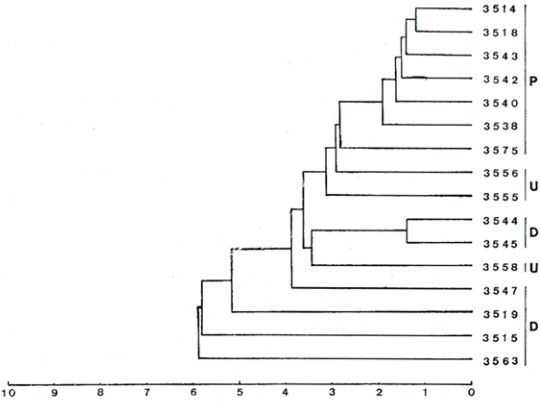

Fig. 3. Phenogram (SCA) resulting from Single Linkage Cluster Analysis (SLCA) based on Canberra distance (CA).

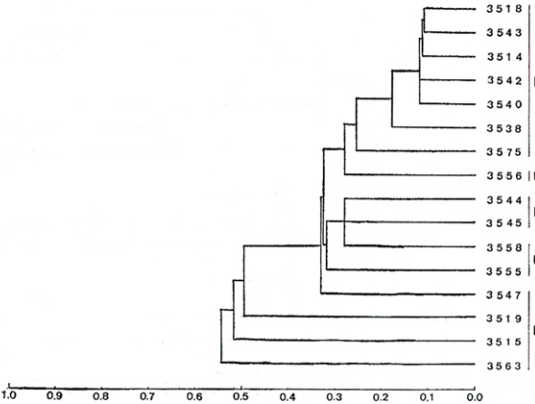

Fig. 4. Phenogram (SDI) resulting from Single Linkage Cluster Analysis (SLCA) based on Divergent distance (DI).

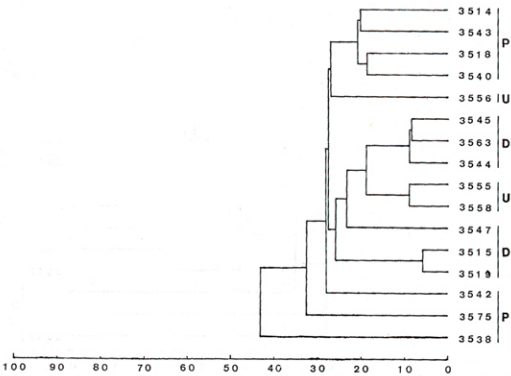

Fig. 5. Phenogram (SEU) resulting from Single Linkage Cluster Analysis (SLCA) based on Euclidean distance (EU).

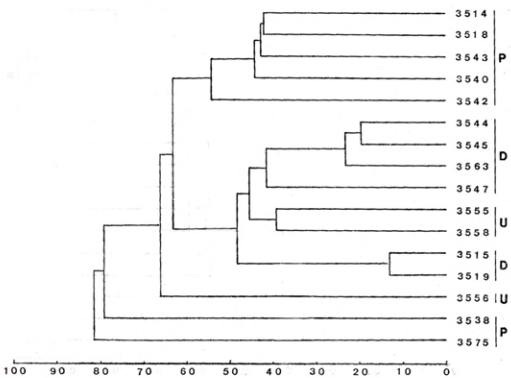

Fig. 6. Phenogram (SMA) resulting from Single Linkage Cluster Analysis (SLCA) based on Manhattan distance (MA).

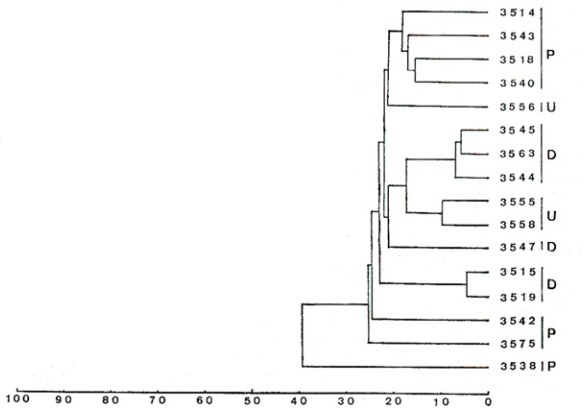

Fig. 7. Phenogram (SMIB) resulting from Single Linkage Cluster Analysis (SLCA) based on Minkowski distance with index of 3 (MI3).

in later clustering cycles. This phenogram presents a well-defined cluster of *M. dianthera*, but appears discordant in the lower side of the phenogram with the traditional taxonomic information (Table 4). Phenogram SGO presents two well-defined groups. The first group is composed of all OTU's of *M. dianthera* and OTU's 3558 and 3555 (unconfirmed taxa). All OTU's of *M. punctulata* and OTU 3556 (unconfirmed taxon) form the second group. This phenogram (SGO) provides a hierarchy of two species levels which is acceptable with respect to the conventional taxonomic concept. Phenograms SCA and SDI are alike in their general arrangement of OTU's: the upper part consisting of seven OTU's of *M. punctulata*, the middle part consisting of two OTU's of *M. dianthera* and all OTU's of unconfirmed taxa, and the lower part consisting of four OTU's of *M. dianthera*. The apparent chaining effect in both phenograms is of little classificatory significance.

In phenogram SEU, there is an acceptable cluster in the middle part of the phenogram which is composed of all OTU's of *M. dianthera* and OTU's 3555 and 3558 (unconfirmed taxa). Four OTU's 3514, 3543, 3518, and 3540 (*M. punctulata*) and OTU 3556 (unconfirmed taxon) formed a cluster at the upper part of the phenogram. The OTU's 3542, 3575 and 3538 (*M. punctulata*) joined above cluster singlely at the last three clustering cycles. Phenogram SMA shows a similar clustering pattern to phenogram SEU and both of them have two closely related clusters and three single OTU's, but the position of OTU's 3556 (unconfirmed taxon) and 3542 (*M. punctulata*) alternate with each other in the phenogram SMA. Phenogram SMI3 is identical to phenogram SEU in the arrangement of OTU's except that OTU's 3515 and 3519 (*M. dianthera*) are segregated from the well-defined group of *M. dianthera*. Manhattan distance coefficient and Euclidean distance coefficient are practically the same as Minkowski distance coefficient with index of 1 and 2 respectively (Table 3). Because a smaller distance among

OTU's in the similarity matrix is obtained when the index value is increased, the phenogram becomes more compact in its general appearance (Fig. 1a-g).

Complete Linkage Cluster Analysis (CLCA)

Fig. 8-14 depicts seven phenograms of complete linkage cluster analysis (CLCA). Four phenograms (CCO, CGO, CMA, and CMI3) present two clusters and three phenograms (CCA, CDI, and CEU) show two clusters and one single OTU. The seven OTU's of *M. punctulata* formed distinct groups in two phenograms (CGO and CMA) and they joined together at the upper part in two phenograms (CCA and CDI). The six OTU's of *M. dianthera* formed a closely related cluster in two phenograms (CCO and CMA). The three OTU's of unconfirmed taxa joined closely with one another in four phenograms (CCA, DCI, CEU and CMA).

In phenogram CCO, the upper cluster is acceptable that is composed of six OTU's (3518, 3540, 3514, 3542, 3545 and 3575) of *M. punctulata* and OTU 3556 (unconfirmed). The lower cluster consists of two subclusters, one is a well-defined group containing all OTU's of *M. dianthera* and the other is a questionable group consisting of two OTU's (3555 and 3558) of unconfirmed taxa and OTU 3538 (*M. punctulata*) which segregated from the upper cluster of *M. punctulata*.

Phenogram CGO shows two well-grouped clusters. All OTU's (3558, 3555 and 3556) of unconfirmed taxa joined with all OTU's of *M. dianthera* to form a cluster, and all OTU's of *M. punctulata* formed another cluster. It provides a suggestable classification. Phenograms CCA and CDI depict the same clustering patterns. All OTU's of *M. punctulata*, all OTU's of unconfirmed taxa, and one OTU (3519) of *M. dianthera* formed a loosely related cluster, and four OTU's (3544, 3545, 3547 and 3575) of *M. dianthera* formed another cluster. A single OTU 3563 (*M. dianthera*) joined the above cluster last.

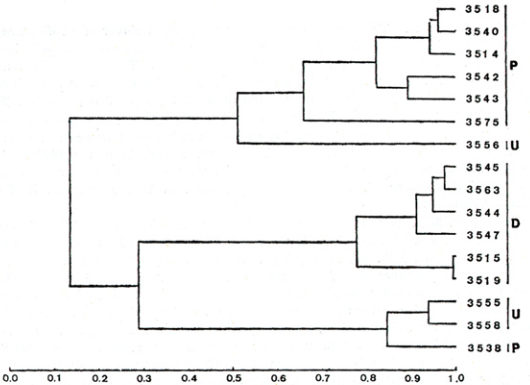

Fig. 8. Phenogram (CCO) resulting from Complete Linkage Cluster Analysis (CLCA) based on Correlation coefficient (CO.)

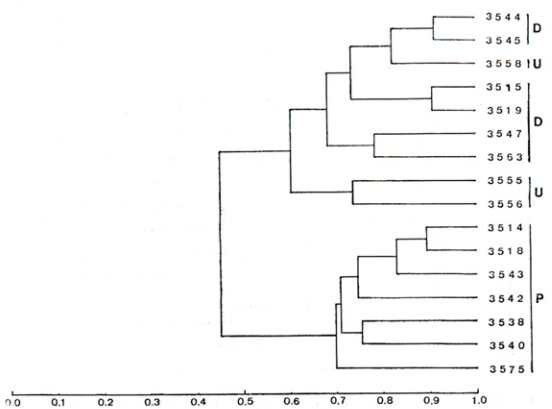

Fig. 9. Phenogram (CGO) resulting from Complete Linkage Cluster Analysis (CLCA) based on Gower's coefficient (GO).

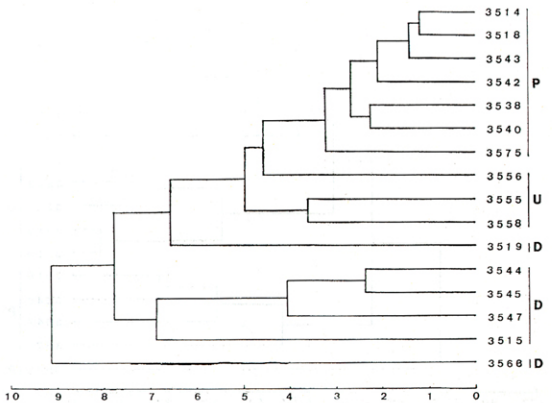

Fig. 10. Phenogram (CCA) resulting from Complete Linkage Cluster Analysis (CLCA) based on Canberra distance (CA).

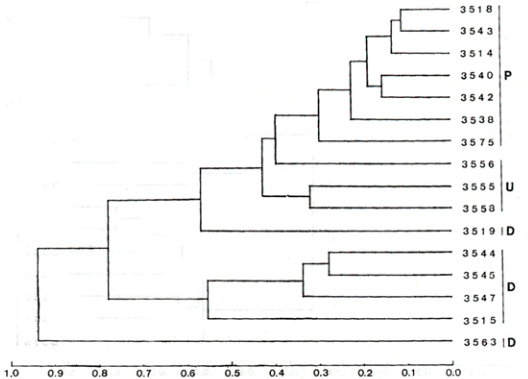

Fig. 11. Phenogram (CDI) resulting from Complete Linkage Cluster Analysis (CLCA) based on Divergent distance (DI).

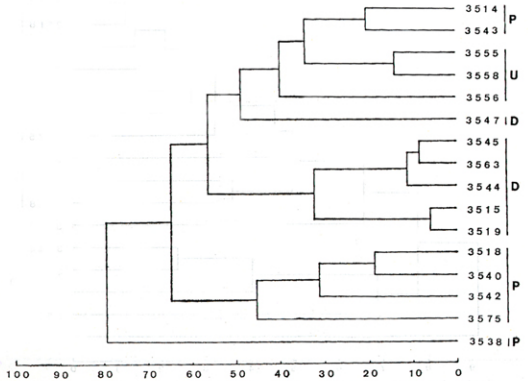

Fig. 12. Phenogram (CEU) resulting from Complete Linkage Cluster Analysis (CLCA) based on Euclidean distance (EU).

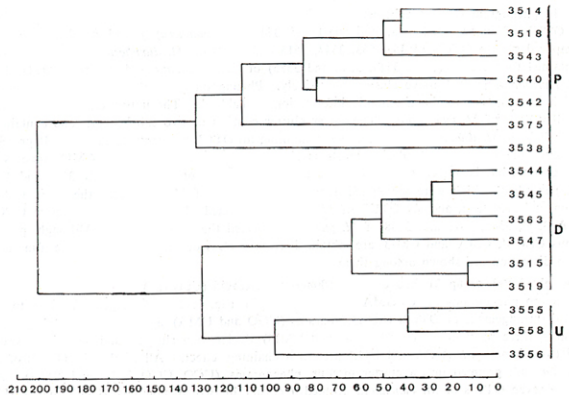

Fig. 13. Phenogram (CMA) resulting from Complete Linkage Cluster Analysis (CLCA) based on Manhattan distance (MA).

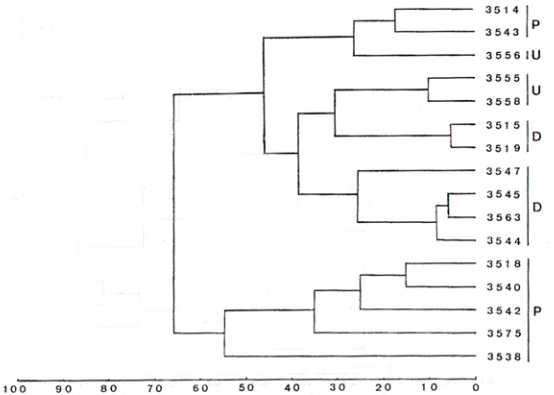

Fig. 14. Phenogram (CMI3) resulting from Complete Linkage Cluster Analysis (CLCA) based on Minkowski distance with index of 3 (MI3).

In phenogram CEU, a subcluster containing two OTU's (3514 and 3543) of *M. punctulata*, all OTU's of unconfirmed taxa, and one OTU 3547 (*M. dianthera*) joined another subcluster composed of five OTU's (3545, 3563, 3544, 3515 and 3519) of *M. dianthera*. A cluster which contained four OTU's (3518, 3540, 3542 and 3575) of *M. punctulata* and a single OTU 3538 (*M. punctulata*) jointed above cluster successively. Phenogram CMA shows a clustering pattern which is congruent to the taxonomic information in Table 4. The upper cluster is composed of all OTU's of *M. punctulata*. The lower cluster consists of two subclusters: one containing all OTU's of *M. dianthera* and the other containing all OTU's of unconfirmed taxa. It presents the same hierarchy of two species levels as phenogram CGO. Phenogram CMI3 appears as two clusters but is not congruent with the two species concept. Two OTU's 3514 and 3543 (*M. punctulata*) which were segregated from the boundary of *M. punctulata*, the three OTU's of unconfirmed taxa, and six OTU's of *M. dianthera* formed the upper cluster. Five OTU's 3518, 3540, 3542, 3575 and 3538 of *M. punctulata* formed the lower cluster. Although phenograms CEUM, CMA and CMI3 are obtained from a class of Minkowski distance functions, some distortion are shown among them.

Unweighted Pair-group Method Using Arithmetical Averages (UPGMA)

Seven phenograms of UPGMA are presneted in Fig. 15-21. In a general view to the overall arrangement of OTU's two phenograms (UGO and UMA) appear as two well-grouped clusters, three phenograms (UCO, UEU and UMI3) depict two clusters and one single OTU, and two phenograms (UCA and UDI) present a chaining effect. All of the six OTU's of *M. dianthera* are grouped into a cluster in four phenograms (UCO, UGO, UEU and UMA). All of the seven OTU's of *M. punctulata* formed a cluster in two phenograms (UGO and HMA), and they joined together into a chaining cluster in two phenograms (UCA and UDI).

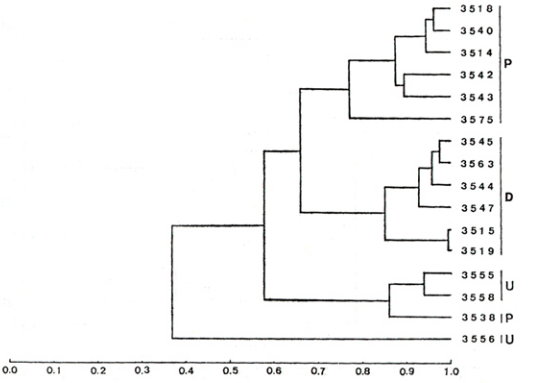

Fig. 15. Phenogram (UCO) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Correlation coefficient (CO).

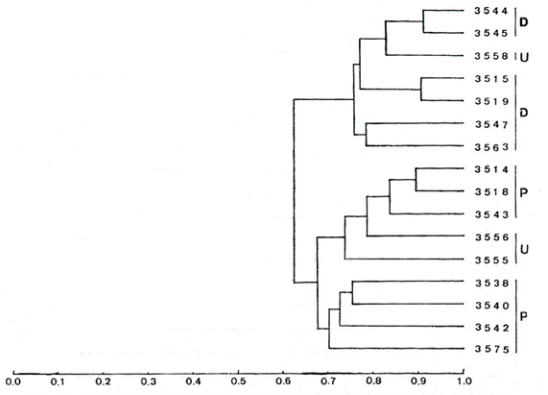

Fig. 16. Phenogram (UGO) resulting from Unweighted pair-grouped Method using Arithmetic Average (UPGMA) based on Gower's coefficient (GO).

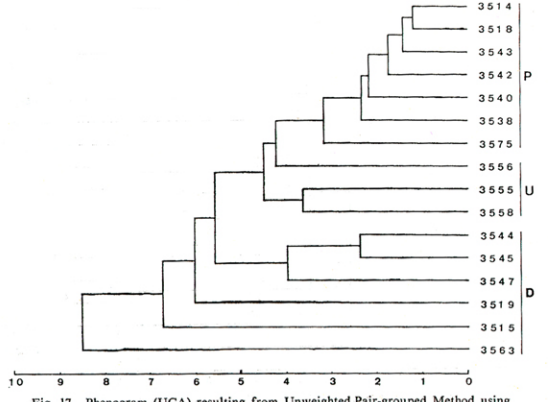

Fig. 17. Phenogram (UCA) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Canberra distance (CA).

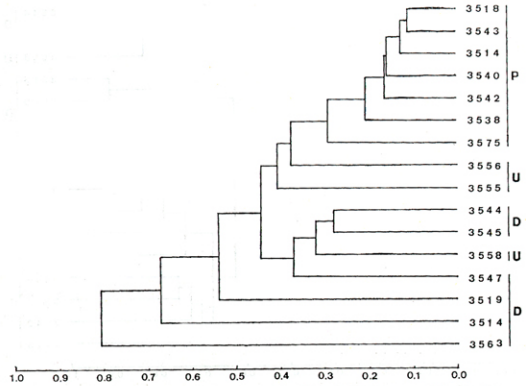

Fig. 18. Phenogram (UDI) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Divergent distance (DI).

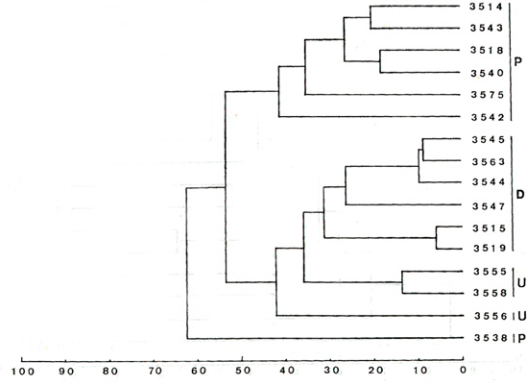

Fig. 19. Phenogram (UEU) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Euclidean distance (EU).

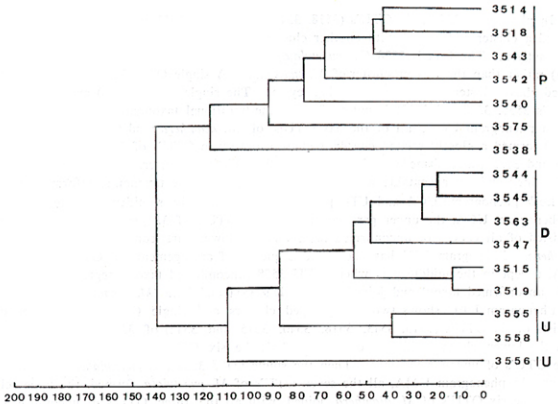

Fig. 20. Phenogram (UMA) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Manhattan distance (MA).

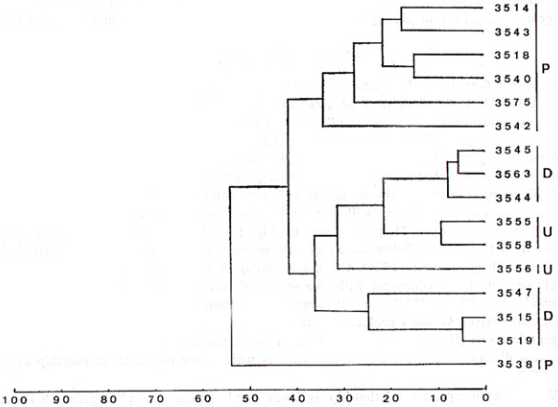

Fig. 21. Phenogram (UMI3) resulting from Unweighted Pair-grouped Method using Arithmetic Average (UPGMA) based on Minkowski distance with index of 3 (MI3).

In phenogram UCO, six OTU's (3518, 3540, 3514, 3542, 3543 and 3575) of *M. punctulata* formed a cluster and joined with another cluster which was composed of all the six OTU's of *M. dianthera*. The OTU's 3538 (*M. punctulata*) joined with OTU's 3555 and 3558 (unconfirmed taxa) rather than the former cluster of *M. punctulata*. A single OTU 3556 (unconfirmed taxon) joined above cluster at the last clustering cycle. The single OTU (3556) and the last cluster (OTU's 3555, 3558 and 3538) do not conform to the traditional taxonomic information (Table 4).

In phenogram UGO, all of the six OTU's of *M. dianthera* and OTU 3558 (unconfirmed taxon) formed a closely related cluster, and all of the seven OTU's of *M. punctulata* and OTU's 3556 and 3555 (unconfirmed taxa) formed another distinct cluster. These two clusters are well-defined and are acceptable when they are compared to the taxonomic information.

Both phenograms UCA and UDI present no taxonomically significant clustering patterns. In phenogram UCA, the upper part consisted of all OTU's of *M. punctulata*, the middle part consisted of all OTU's of unconfirmed taxa, and the lower part consisted of all OTU's of *M. dianthera*. Phenogram UDI has the same sequence of arrangement of OTU's as phenogram UCA, except in the middle part where OTU 3558 (unconfirmed taxon) segregated from OTU 3555 (unconfirmed taxon) and joined with OTU's 3544 and 3545 (*M. dianthera*).

Phenogram UEU shows two well-grouped clusters and single OTU. The upper cluster consists of six OTU's (3515, 3543, 3518, 3540, 3575 and 3542) of *M. punctulata*, and joined with the lower cluster which is composed of all the six OTU's of *M. dianthera* and all the three OTU's of unconfirmed taxa. Then the single OTU 3538 (*M. punctulata*) joined the above cluster. In phenogram UMA, all the seven OTU's of *M. punctulata* formed the upper cluster, and all the six OTU's of *M. dianthera* joined with all the three OTU's of unconfirmed taxa forming the lower cluster. Phenogram UMI3 has the same clustering pattern as phenogram UEU except the six OTU's of *M. dianthera* split into two small clusters, one consisting of OTU's 3545, 3563 and 3544, the other consisting of 3547, 3515 and 3519. Also the general arrangement of OTU's in phenogram UMI3 is more compact than that in phenogram UEU.

DISCUSSION AND CONCLUSION

In recent floristic study, Hatusima (1971), Huang and Cheng (1978), and Ohwi (1965) distinguished *Mosla dianthera* from *M. punctulata* by using the characters of (1) floral axis, (2) calyx tooth and nutlet, and (3) both of stem and floral axis respectively, while in the present study the grouping of OTU's into a cluster was based on the phenetic similarity by considering of 16 morphological characters (Table 2) simultaneously. It is expected to the 16 studied populations that two clusters will emerge in each phenogram: one cluster contains 6 populations of *M. dianthera*, the other cluster contains 7 populations of *M. punctupata*, and the three populations of unconfirmed taxa will join with one or both of the clusters.

An examination over 21 phenograms in Fig. 1 to Fig. 21 suggested that classification resulted from Gower's coefficient have more advantages than those resulted form other similarity coeffients. All phenograms (SGO, CGO, and UGO) derived from Gower's coefficient show two clusters which are congruent with two species of traditional taxonomy. The similar effect was obtained by Cheng (1977) in his numerical taxonomic study of Labiatae, where three phenograms derived Gower's coefficient agreed very well with the conventional study at species and generic levels (Huang and Cheng, 1978). Two phenograms (CMA and UMA) derived from Manhattan distance coefficient appear two clusters which have the same membership as phenogram CGO.

When the infraspecific relationship is investigated among five phenograms SGO, CGO, UGO, CMA, and UMA, it appears that the OTU 3558 joins constantly with the cluster of *M. dianthera* in all phenograms, and OTU's 3555 and 3556 join with the cluster of *M. dianthera*

in three (CGO, CMA, and UMA) of the five phenograms. This can be explained the frequency distribution of hybrid index in 16 studied populations by scoring 5 characters which are highly significant difference between two species (the test not shown here). Population 3558 is next to *M. dianthera* along the hybrid index scale, and populations 3556 and 3555 are almost at the middle part between *M. dianthera* and *M. punctulata*, but a slightly closer to *M. dianthera*. The clustering patterns in phenograms CGO, CMA, and UMA are more congruent with hybrid index analysis than that in phenogram UGO. However, Arroyo (1873) used Gower's coefficient applied to the unweighted pair-group method using arithmetical averages on *Limnanthes floccosa* and presented a revision.

As to clustering procedures, single linkage cluster analysis formed more clustering cycles (Table 5) and produced a chaining effect (Fig. 1 a-g). The complete linkage cluster analysis and unweighted pair-group method using arithmetical averages clustered OTU's into more dendritic structure, but the later derived phenograms in more compact form.

Table 5. The number of clustering cycles formed during the clustering procedure of numerical techniques used in the present study

Similarity coefficients	Clustering methods		
	SLCA	CLCA	UPGMA
a. Correlation coefficient	8	8	8
b. Gower's coefficient	8	7	7
c. Canberra distance coefficient	13	11	12
d. Divergent coefficient	12	12	12
e. Euclidean distance coefficient	9	8	8
f. Manhattan distance coefficient	9	7	7
g. Minkowski distance coefficient with index of 3	9	7	8

In conclusion, Gower's coefficient and Manhattan distance coefficient applied to the complete linkage cluster analysis and unweighted pair-grouped method using arithmetical averages are suggested to further study in plants of this group. Since the Manhattan distance coefficient increases with the number of characters, it is not available in practical work. Thus the Gower's coefficient is recommended.

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