CHAPTER 4

RESULTS

The bees collected in 12 regions of Thailand and Malaysian Peninsula could be clustered morphometrically into 3 groups. The groups were biologically representative of the separated geographic areas. Each groups can be named according to its distribution: as northern lattitude bee, southern lattitude bee and Samui Island bee. The results were recorded in two phases: the analysis on each character to find the differences within 12 regions, and the multivariate analysis simultaneous using every characters in finding the groups of the bees.

4.1 Characters Analysis

The analysis was conducted on 127 samples from 12 regions. Each of 58 characters was tested by two different statistical procedures, namely F-test and means comparison (Student-Newman-Keuls multiple range test) within 12 regions.

4.1.1 F-test

F-value of each characters at degree of freedom 11 and 115 were examined at significant level $P<0.01$ and $P<0.05$ as shown in table 3, 4 and 5. The differences were apparent when means of even only two regions were significantly different. The analysis was done on means of each character within 12 regions.

F-test on 22 characters of fore and hind wing within 12 regions showed that 16 characters were highly significantly different (P<0.01), cubital index and angle 33 were significantly different (P<0.05) and fore wing index, angle 36, 38 and 20 were nonsignificantly different (P>0.05) (table 3).

F-test on 6 characters of hind leg within 12 regions showed that 5 characters were highly significantly different (P<0.01) and basitarsus length was nonsignificantly different (P>0.05) (table 4).

F-test on 12 characters of mouthparts within 12 regions showed that all of them were highly significantly different (P<0.01) (table 4).

F-test on 5 characters of sternite 3 within 12 regions showed that 4 of them were highly significantly different (P<0.01) and wax mirror index was nonsignificantly different (P>0.05) (table 5).

F-test on sternite 6 within 12 regions showed that the longitudinal and transversal lengths were highly significantly different (P<0.01) (table 5).

F-test on 8 characters of tergites 3 and 4 showed that the width of tergite 3, 4 and the summation of the width of tergite 3 and tergite 4 were highly significantly different (P< 0.01). The width of tomentum A (light band with hair on tergite 4) and tomentum B (dark band on tergite 4) were highly significantly different (P<0.01). The pigmentation of tergite 2 was highly significantly different (P<0.01). The pigmentation of tergite 3 and 4 were significantly different (P<0.05) (table 5).

Pigmentation of sclerite S, K were highly significantly different (P<0.01) and pigmentation of sclerite B was significantly different (P<0.05) (table 5).

4.1.2 Student-Newman-Keuls (S-N-K) Multiple Range Test

S-N-K multiple range test was done on means of 58 characters among 12 regions (alpha = 0.05). The results are shown in table 3, 4 and 5.

By comparing means of 58 characters, it was found that the bees can be grouped by the body size and wing venation angles into three groups. The bees from regions 0, 1, 2, 3, 5, 6 constituted a group that will be called the northern lattitude bee. The bees from region 7, 9, C, M, S constituted another group that will be called the southern lattitude bee. The last and smallest group was the bee from region 8 (Samui Island) that will be called Samui Island bee.

Length and width of fore wing and hind wing showed greater sized wings in the northern lattitude bee than in the southern lattitude bee. The wing size of the Samui Island bee was found to be in between the two groups (table 3). The fore wing index which is the result from the fore wing length divided by fore wing width, showed no significant difference within 12 regions. The hind wing index showed significant difference between the region 5 and M, C, 9, 8. However, most of them are greatly overlapping (table 3).

Comparison of cubital index means within each region showed no significant difference. It was indicated that the proportion of the cubital vein a and b among each region were quite similar (table 3).

The number of hamuli was significantly greater in northern lattitude bee than in the southern lattitude bee but similar in the Samui Island bee and the northern lattitude bee (table 3).

Means of angle 29 was significantly greater in northern lattitude bee. That of the Samui Island bee was intermediate (table 3).

Means of angle 30 and angle 32 were greater in northern lattitude bee. Most of them are not significantly different. Means of the Samui Island bee was intermediate (table 3).

Means of angle 31 and angle 33 were greater in southern lattitude bee. However, most of them were not significantly different. Means of the Samui Island bee was also intermediate. Most of means of angle 34, 35 and 36 within 12 regions were not significantly different (table 3).

Angle 39 showed greater means in the southern lattitude bee than the northern lattitude bee and Samui Island bee, but also showed the wide range of overlapping (table 3).

Angle 40, 42 and 43 showed significant difference between the sample from Samui Island bee (region 8) and that from the other regions (table 3).

The length of tibia, femur, basitarsus and the width of basitarsus were greater in the northern lattitude bee than in the southern lattitude bee while the Samui Island bee had very small tibia and femur but very large basitarsus (table 4).

Leg length (the combination of tibia, femur and basitarsus length) of the northern lattitude bee was longer than that of the southern lattitude bee (table 4).

The postmentum of the southern lattitude bee was greater than that of the northern lattitude bee. The smallest one belonged to the Samui Island bee. The greatest means was found in the bee from region S (table 4).

The glossa of the bee from region 8, 7, 9 were smaller than those of the bees from the other regions. The greatest means was found in the bee from region S (table 4).

Tongue length (the combination of postmentum and glossa showed the greatest means in the bee from region S and the smallest means from region 7, 8, 9 (table 4).

Measurements on proximal segment of labial palpi in the bee of the southern lattitude were greater in region S and lesser in region 9, 7. That of the bees of the region C, M and the other bee were intermediate. Measurements on distal segment of labial palpi in the bee of the southern lattitude were greater in region S and lesser in region 7, M, 9, C while the others were intermediate. The labial palpi of the bees in region S significantly longer than those of the closer area and longest of all the bees in this study. The labial palpi length of the Samui Island bee was closed to those of the northern lattitude bee (table 4). The labial palpi index (proximal segment divided by distal segment) were higher in southern lattitude bee and Samui Island bee, but lowest in region 7 bee (table 4).

The length of sternite 3, wax mirror and the width of wax mirror were greater in the northern lattitude bee than in the southern lattitude and Samui Island bee (table 5).

The distance between wax mirror were not significantly different but showed tendency of greater distance in southern lattitude bee. The shortest distance belonged to the Samui Island bee (table 5).

Means of wax mirror index comparing among each region showed no significant difference among them. This implied that the shape of the wax mirror plate were similar in bees from every regions (table 5).

The width of tergite 3 and 4 were significantly different between region 5 which had the largest means and region 7, the smallest one. Most of the southern lattitude bee had the lower means except for the bee from region S (table 5).

The width of tomentum A and B were significantly different between the bee in region 5 and 7, 9. Means of tomentum A were greater in region 5 and lower in region 7 and 9, contrast to the means of tomentum B which was lower in region 5 and greater in region 7 and 9 (table 5).

The bee of region 7 had the smallest size of sternite 6 as it had the shortest length in longitudinal and transversal plane (table 5).

There were no significant differences within the regions in pigmentation of tergite 2, 3 and 4 but there were significant differences in pigmentation of the scutellums. The means of pigmentation scores of cupola (PIGS) was greater in region 3 and 8 while lower in region 1 and S. The means of pigmentation scores of the metanotum, the small sclerites at the base of the scutellum (PIGB) and the triangular lateral segment of the mesonotum (PIGK) showed the greatest value in region 8 and lowest region S and M (table 5).

4.1.3 Correlations between body size and appendages

The correlation between the bee body size and its appendage lengths were plotted in order to find their relatioinships of the characters. Body size characters were represented by sternite 3 length and tergite 3 + 4, appendages were represented by fore wing length, hind wing length and hind leg length. The correlation coefficient showed that body size and appendages were highly correlated (Table 6 , Figure 20-25).

4.2 Grouping Analysis

Grouping analysis were conducted by two different multivariate analysis procedures, namely discriminant analysis and clustering analysis, in Statistics Analyzing Software (SAS).

4.2.1 Discriminant Analysis

Discriminant analysis used in this study is the canonical discriminant analysis performed by CANDISC procedure in SAS. Canonical discriminant analysis was conducted on 127 samples of A. cerana which were divided 12 groups geographically. The scatter plots showed that the bees were discriminated into three groups. The results of discriminant analysis, confirmed by S-N-K multiple range test, showed that the three groups of bees were the same. Hence, the three groups of the bees from discriminant analysis will be named as northern lattitude bee, southern lattitude bee and Samui Island bee.

Northern lattitude bee represented the bees from region number 0, 1, 2, 3, 5 and 6. This ranged from Northern Thailand to Central Thailand.

Southern lattitude bee represented the bees from region number 7, 9, C, M and S. This ranged from Chumporn, the province in the upper part of Southern Thailand to Johor, the province in the Southern part of Malaysian Peninsula.

Samui Island bee represented the bees from region 8, Samui Island in the southern part of Thailand.

The scattergrams of canonical discriminant analysis were plotted between canonical discriminant function 1 (CAN1) and canonical discriminant function 2 (CAN2). The first run of CANDISC procedure on 52 characters resulted in three discriminated groups. The second run was done on 46 characters. Pigmentation of tergite 2, 3, 4, cupola (PIGS), mesonotum: the small sclerites at the base of the scutellum (PIGB) and the triangular lateral segment of the mesonotum (PIGK) were excluded from the analysis in the second run with the attempt to use only the structural characters. The result was the same as the first run. The third run was done on 44 characters in which postmentum and glossa were excluded because the distribution of postmentum showed a bimodality caused by the the irregular shape formed during slide mounting. Some of postmentums were bent or broken making digitizing difficult. The distribution of glossa was not in the normal curve because some of them contracted or protracted.

Mahalanobis' distance among 13 regions confirmed the discriminant analysis. The distances between the bee in the same discriminant group were shorter than the distances between the bee in different groups. Region 4 showed great distances from the other regions but was not raised as a different group because it consisted of only one colony from Ubonratchathani. To eliminate the confusion that might occur, this colony was deleted from the analysis as it was an outlier. The Samui Island bee showed great distances from the northern and southern lattitude bee confirming its isolation (table 7).

4.2.2 Clustering Analysis

Clustering analysis was done to arrange the group for 129 samples with unknown groups. All samples were run by the FASTCLUS procedure in SAS which was provided for running many samples (N>100). The same sets of characters (52, 46, and 44 characters) as in discriminant analysis were used. The amount of cluster were 3, 4 and 5. From the analysis, the samples were members of two separated groups, northern and southern lattitude. The northern lattitude group consisted of the bee from region 0, 1, 2, 3, 5 and 6. The members of the southern lattitude group were from region 7, 8, 9, C, M and S. The Samui Island bee was included with the southern lattitude group.

From tables 8, 9 and 10, the samples were put into three clusters A, B and C. Most northern lattitude bees were members of cluster A while most southern lattitude bees were in cluster B. Cluster C consisted of 6 samples in table 8 and only one sample (K3001)* in tables 9 and 10.

From tables 11, 12 and 13 the samples were put into four clusters A, B, C and D. Most northern lattitude bees were members of cluster A and most of the southern lattitude bees were in cluster B. Cluster C consisted of 6 samples in table 11 and 2 samples in table 12 and none in table 13. Cluster D consisted of only one sample (K3001) in tables 11, 12 and 13.

From tables 14, 15 and 16, the samples were put into five clusters A, B, C, D and E. In table 14, most northern lattitude bees were members of cluster A and most southern lattitude bees were in clusters B and C. Cluster D consisted of 5 samples and only one sample (K3001) was in cluster E. In table 15 most northern lattitude bees were in cluster A while most southern lattitude bees were in clusters B and C. Clusters D and E consisted of one sample each. In table 16, most northern lattitude bees were in clusters A and C, and most southern lattitude bees were in cluster B. Clusters D and E consisted of one sample each.

* K3001 was the sample from region 5 and formed a unique cluster.

Table 3 Analysis of variance on wing characters among 12 regions of *Apis cerana* in Thailand and Malaysian Peninsula

Variable	Characters	F-Value	Highest means ± s.d.	Lowest means ± s.d.	SNK-test among 12 regions
FWLN	fore wing length	10.74**	7.8653 ± 0.0936	7.4999 ± 0.0984	0 2 5 1 3 6 C 8 9 S M 7
FWWD	fore wing width	8.52**	2.7398 ± 0.0475	2.6081 ± 0.0338	0 5 1 2 3 6 8 C 9 S M 7
HWLN	hind wing length	9.13**	3.7366 ± 0.0600	3.5499 ± 0.0596	0 2 5 1 3 6 8 C 9 S M 7
HWWD	hind wing width	8.29**	1.5440 ± 0.0434	1.4385 ± 0.0352	5 1 0 2 3 6 8 C S 9 7 M
CUBINDEX	cubital index	1.92*	4.2207 ± 0.3227	3.5308 ± 0.4882	8 9 0 1 2 S M 5 7 6 C 3
FWINDEX	fore wing index	1.64ns	2.8947 ± 0.0160	2.8565 ± 0.0450	9 C M S 6 7 0 2 8 5 3 1
HWINDEX	hind wing index	4.74**	2.4905 ± 0.0177	2.3984 ± 0.0511	M C 9 8 S 0 7 3 2 6 1 5
HAMU	hamuli	6.27**	17.8111 ± 0.7467	16.1000 ± 0.6124	2 3 0 6 8 5 1 9 7 C S M
AN29	angle 29	11.84**	33.8779 ± 0.6197	30.7484 ± 1.1339	7 9 M C S 3 8 1 6 2 5 0
AN30	angle 30	4.29**	110.5905 ± 2.1380	105.9746 ± 1.4132	5 0 2 6 1 3 C 8 S 7 9 M
AN31	angle 31	5.56**	98.6719 ± 1.5922	94.4768 ± 1.5098	C M 7 9 3 8 S 0 5 1 2 6
AN32	angle 32	4.15**	21.4984 ± 0.6599	19.8725 ± 0.5666	5 6 C 0 1 3 S 2 8 7 9 M
AN33	angle 33	2.10*	90.9624 ± 2.0578	87.9698 ± 2.2588	M S 7 C 2 6 8 5 1 9 0 3
AN34	angle 34	3.69**	51.8027 ± 1.6239	47.4312 ± 1.5946	M 7 1 9 8 6 C S 2 5 3 0
AN35	angle 35	2.46**	32.7266 ± 3.4206	27.4927 ± 1.8494	S M 7 1 C 5 2 9 0 6 8 3
AN36	angle 36	1.16ns	68.0836 ± 1.3462	65.0937 ± 1.7861	9 0 3 1 6 5 C 8 7 2 S M
AN38	angle 38	1.57ns	99.8120 ± 1.0656	97.3594 ± 1.4885	M 0 9 8 C 1 3 2 5 7 6 S
AN39	angle 39	3.26**	38.7747 ± 1.2393	36.2331 ± 0.6049	7 9 S C M 5 8 1 6 2 0 3
AN40	angle 40	3.10**	35.1610 ± 1.0434	30.2755 ± 1.4435	8 9 0 6 2 S C 1 5 M 7 3
AN42	angle 42	12.11**	112.5581 ± 0.6341	107.1949 ± 1.2045	8 9 S 0 M 3 7 6 1 C 2 5
AN43	angle 43	4.73**	76.6791 ± 1.2294	73.1926 ± 0.8658	2 M 6 S 0 1 3 5 9 7 C 8
AN20	angle 20	1.44ns	14.6786 ± 0.7170	13.8200 ± 0.5295	9 C 7 5 S 8 M 3 1 6 2 0

significant level : ** P<0.01, * P<0.05, ns P>0.05 (nonsignificant)

―: regions in the same range are not significantly different (alpha=0.05)

Table 4 Analysis of variance on mouthpart and hind leg characters among 12 regions of *Apis cerana* in Thailand and Malaysian Peninsula

Variable	Characters	F-Value	Highest means ± s.d.	Lowest means ± s.d.	SNK-test among 12 regions
TBLN	tibia length	6.55**	2.8264 ± 0.0411	2.7172 ± 0.0370	2 0 5 6 3 1 C S 9 M 8 7
FELN	femur length	8.32**	2.2359 ± 0.0320	2.1463 ± 0.0271	2 0 5 3 6 1 C S 9 M 7 8
TRLN	basitarsus length	1.76ns	1.7212 ± 0.0130	1.6996 ± 0.0206	8 2 3 0 5 1 6 M S 9 C 7
TRWD	basitarsus width	7.36**	0.9718 ± 0.0179	0.9116 ± 0.0088	2 8 3 5 6 0 1 M 9 S 7 C
LEG	hind leg length	4.92**	6.7717 ± 0.0928	6.5416 ± 0.0928	2 0 5 3 6 1 S C 8 9 M 7
TRINDEX	basitarsus index	6.35**	1.8345 ± 0.0122	1.7542 ± 0.0224	C S 7 9 M 8 1 0 2 3 5 6
POST	postmentum	16.50**	0.2650 ± 0.0029	0.1594 ± 0.0054	S M 5 7 9 C 6 2 1 0 3 8
GLOS	glossa + mentum	12.01**	4.2575 ± 0.1901	3.1658 ± 0.0998	S 5 6 M C 2 1 0 3 8 7 9
TONGUE	tongue length	12.00**	4.5225 ± 0.1890	3.4089 ± 0.1019	S 5 6 M C 2 1 0 3 8 7 9
LPSEG	left proximal segment	6.77**	1.1426 ± 0.0506	1.0385 ± 0.0170	S 8 0 5 1 6 M 2 3 C 9 7
LDSEG	left distal segment	7.94**	0.4365 ± 0.0245	0.4009 ± 0.0073	S 6 5 0 1 8 2 3 7 M 9 C
RPSEG	right proximal segment	7.63**	1.1610 ± 0.0511	1.0367 ± 0.0208	S 8 0 5 M 1 6 2 3 C 9 7
RDSEG	right distal segment	9.07**	0.4350 ± 0.0242	0.3981 ± 0.0113	S 5 6 2 0 1 3 8 7 M 9 C
LPALP	left labial palpi	8.74**	1.5791 ± 0.0737	1.4510 ± 0.0317	S 8 0 5 6 1 2 M 3 C 9 7
RPALP	right labial palpi	8.78**	1.5960 ± 0.0721	1.4493 ± 0.0322	S 8 5 0 6 1 2 3 M C 9 7
LPINDEX	left labial palpi index	3.76**	2.6767 ± 0.0414	2.5244 ± 0.0841	C M 8 S 9 0 1 2 5 3 6 7
RPINDEX	right labial palpi index	6.71**	2.7086 ± 0.0612	2.5185 ± 0.0814	8 C M S 9 0 1 6 2 5 3 7
PINDEX	labial palpi index	5.74**	2.6911 ± 0.0479	2.5215 ± 0.0814	C 8 M S 9 0 1 2 5 3 6 7

significant level : ** $P<0.01$, * $P<0.05$, ns $P>0.05$ (nonsignificant)

1: regions in the same range are not significantly different (alpha=0.05)

Table 5 Analysis of variance on sternite and tergite characters among 12 regions of *Apis cerana* in Thailand and Malaysian Peninsula

Variable	Characters	F-Value	Highest means ± s.d.	Lowest means ± s.d.	SNK-test among 12 regions
STLN	sternite 3 length	10.19**	2.2590 ± 0.0460	2.1255 ± 0.0461	5 2 0 3 1 6 S C 8 M 9 7
WXLN	wax mirror length	5.93**	0.8992 ± 0.0087	0.8234 ± 0.0083	3 2 0 1 C 5 6 M 8 S 9 7
WXWDA	wax mirror width	11.48**	1.8657 ± 0.0282	1.7427 ± 0.0211	0 5 2 1 6 3 M C 8 9 S 7
WXWDB	distance between wax mirror	2.98**	0.3202 ± 0.0264	0.2626 ± 0.0086	S 9 C 7 M 5 2 6 1 3 0 8
WXINDEX	wax mirror index	2.14*	0.4905 ± 0.0042	0.4722 ± 0.0137	3 C 2 1 S 8 0 9 M 6 7 5
TER3	tergite 3 width	2.72**	1.7206 ± 0.0408	1.6583 ± 0.0196	5 S 2 0 1 6 3 M 9 8 C 7
TER4	tergite 4 width	5.72**	1.7059 ± 0.0388	1.6192 ± 0.0234	5 2 1 0 S 6 3 M 8 9 C 7
TER3_4	tergite 3 + 4	4.17**	3.4266 ± 0.0787	3.2775 ± 0.0411	5 2 S 0 1 6 3 M 8 9 C 7
TOMA	tomentum A	9.08**	0.2242 ± 0.0409	0.1127 ± 0.0178	5 3 0 2 1 8 C 6 S M 7 9
TOMB	tomentum B	5.92**	0.9206 ± 0.0341	0.8009 ± 0.0467	9 M 7 S 8 6 2 0 C 1 3 5
ST6L	sternite 6 longitudinal	8.05**	2.0766 ± 0.0485	1.9625 ± 0.0365	5 2 0 1 3 6 S C M 8 9 7
ST6T	sternite 6 transversal	4.39**	2.4724 ± 0.0473	2.3439 ± 0.0449	2 0 5 6 C 1 M 3 S 9 8 7
PIG2	pigmentation of tergite 2	2.80**	7.3889 ± 0.5016	6.9600 ± 0.1265	2 0 5 C 3 6 7 8 9 S M 1
PIG3	pigmentation of tergite 3	2.09*	7.2778 ± 0.4609	7.0000 ± 0	2 0 5 1 3 6 7 8 9 C M S
PIG4	pigmentation of tergite 4	1.94*	7.2211 ± 0.4158	7.0000 ± 0	0 5 1 3 2 6 7 8 9 C M S
PIGS	pigmentation of sclerite S	2.78**	7.0200 ± 0.0837	5.4600 ± 1.3957	3 8 7 5 0 2 C 6 9 M 1 S
PIGK	pigmentation of sclerite K	3.11**	3.6600 ± 0.2608	1.4800 ± 1.1054	8 3 7 6 5 0 2 C 9 1 M S
PIGB	pigmentation of sclerite B	2.21*	2.3200 ± 0.4550	0.7800 ± 0.3834	8 3 7 6 5 9 2 0 1 C S M

significant level ; ** P<0.01, * P<0.05, ns P>0.05 (nonsignificant)

]: regions in the same range are not significantly different (alpha=0.05)

TABLE 6 CORRELATION COEFFICIENTS BETWEEN BODY SIZE CHARACTERS AND APPENDAGE CHARACTERS OF APIS CERANA IN THAILAND AND MALAYSIAN PENINSULA (N=128)

	FORE WING LENGTH	HIND WING LENGTH	HIND LEG LENGTH
TERGITE 3 + 4	0.71629	0.67562	0.75422
STERNITE 3 LENGTH	0.81543	0.78397	0.80606

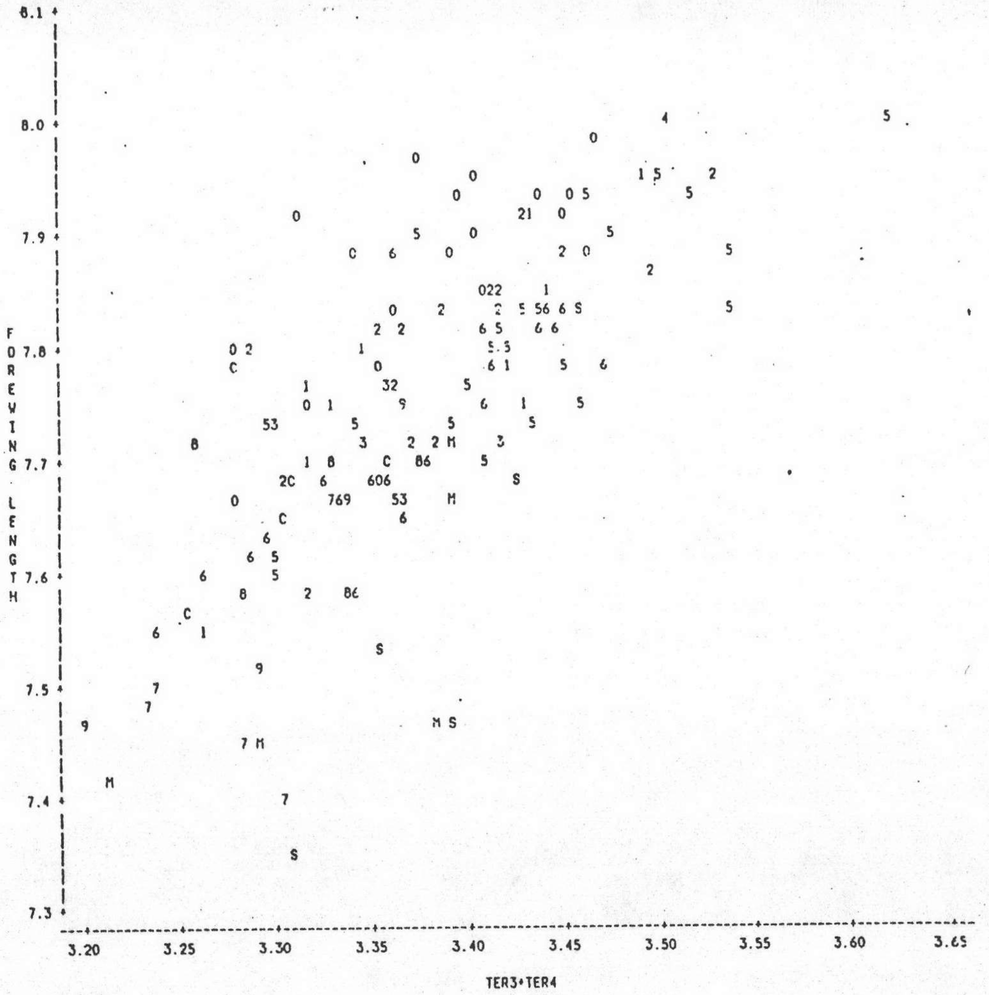


Fig. 19 Correlations between fore wing length and tergite 3 + 4

* Symbol is value of REGION

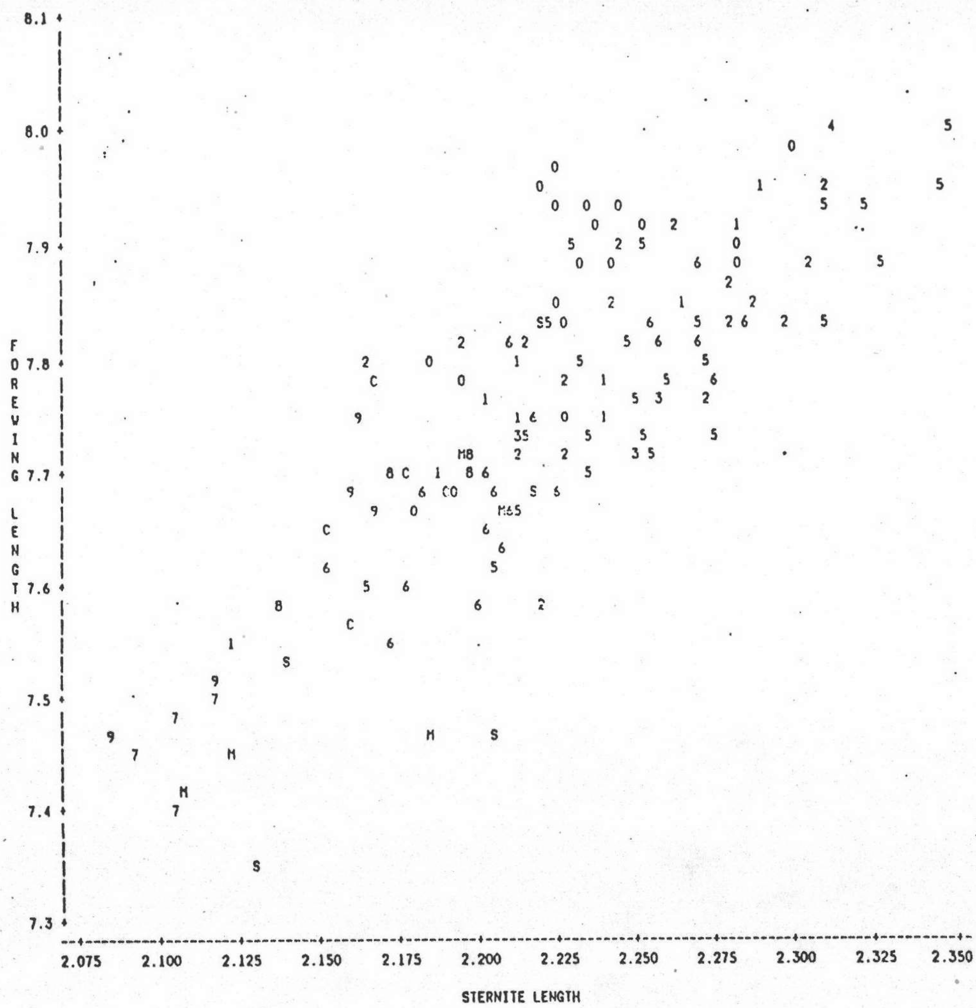


Fig. 20 Correlations between fore wing length and sternite 3

* Symbol is value of REGION

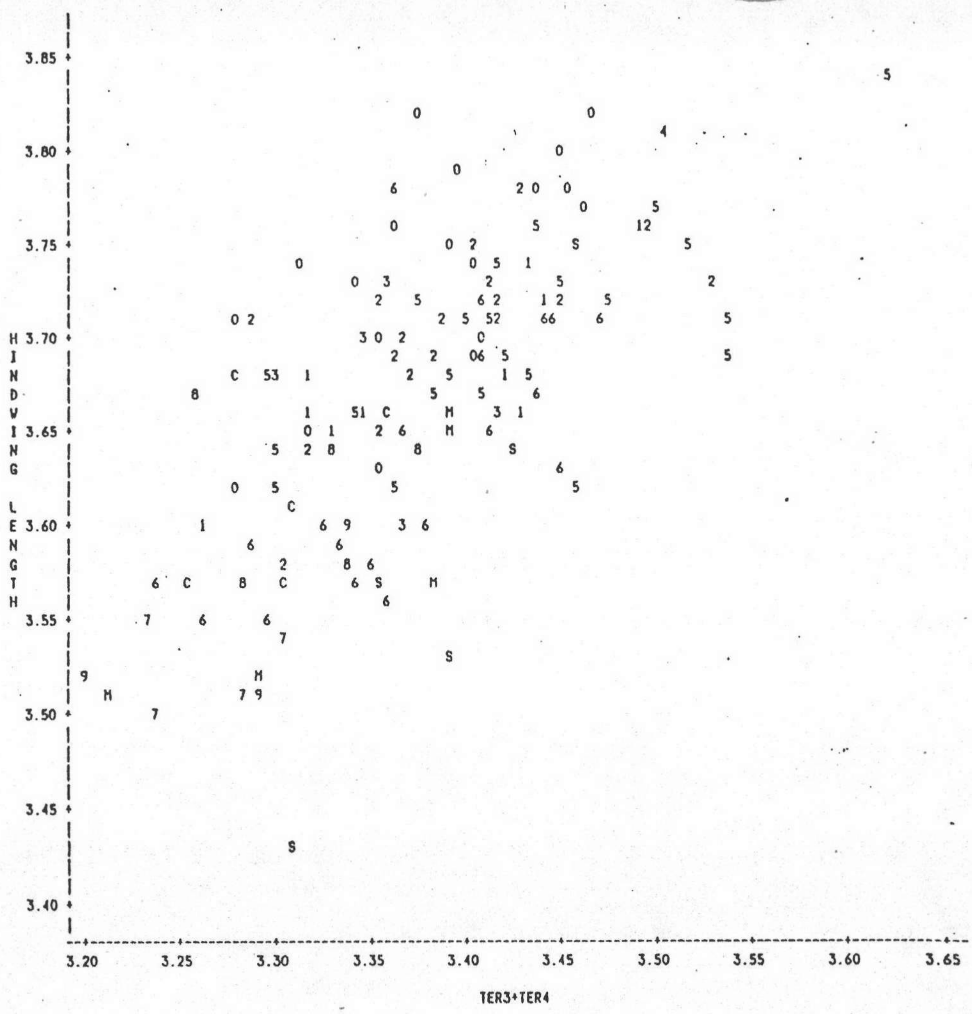


Fig. 21 Correlations between hind wing length and tergite 3 + 4

* Symbol is value of REGION

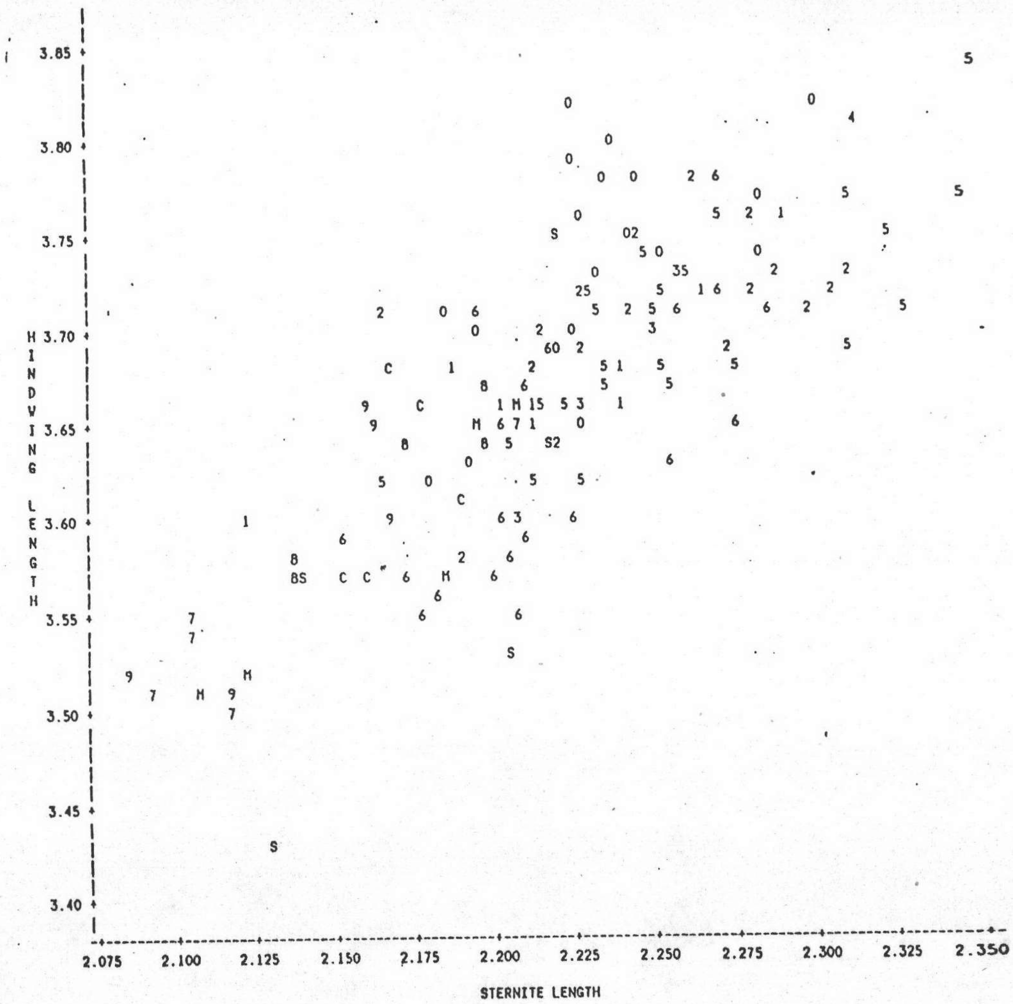


Fig. 22 Correlations between hind wing length and sternite 3

* Symbol is value of REGION

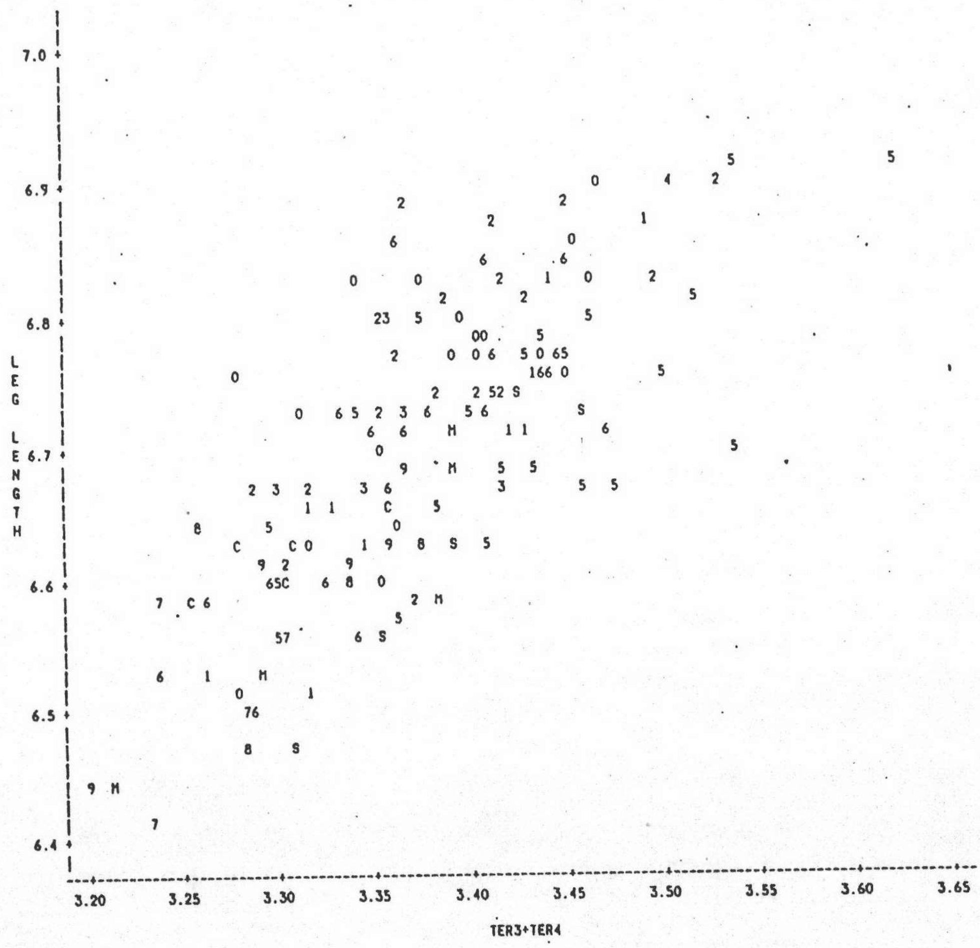


Fig. 23 Correlations between leg and tergite 3 + 4

* Symbol is value of REGION

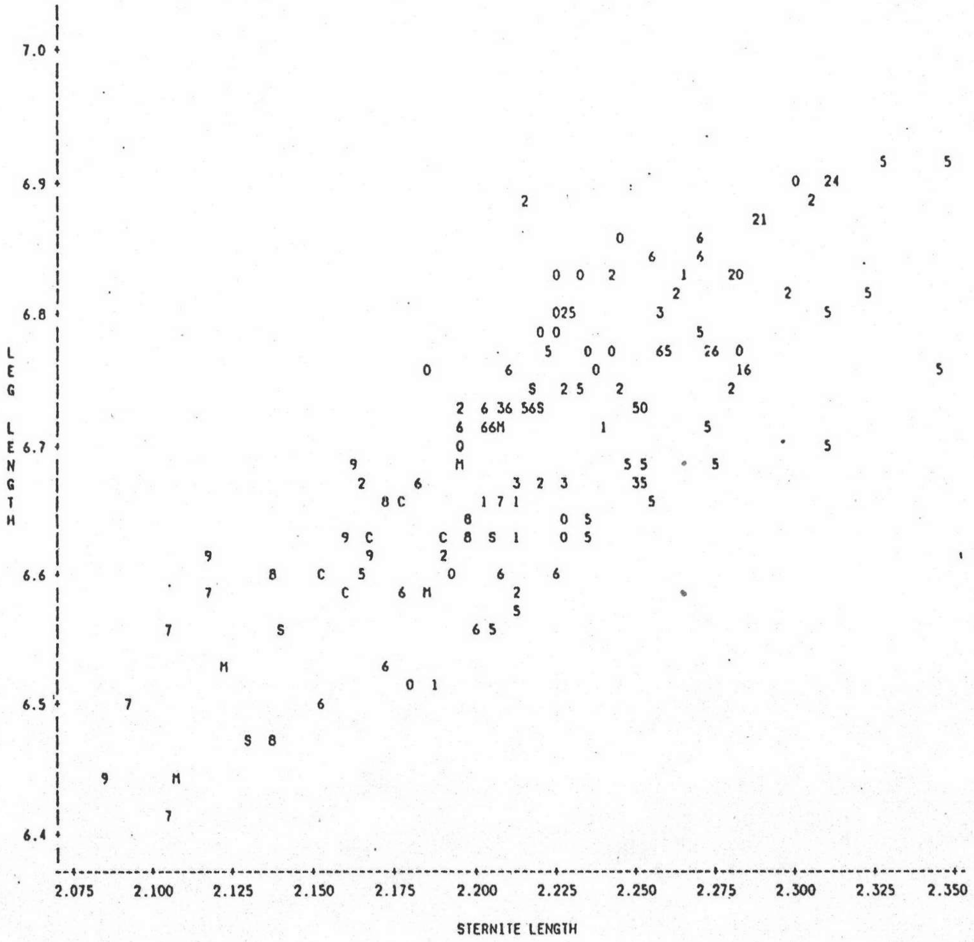


Fig. 24 Correlations between leg and sternite 3

* Symbol is value of REGION

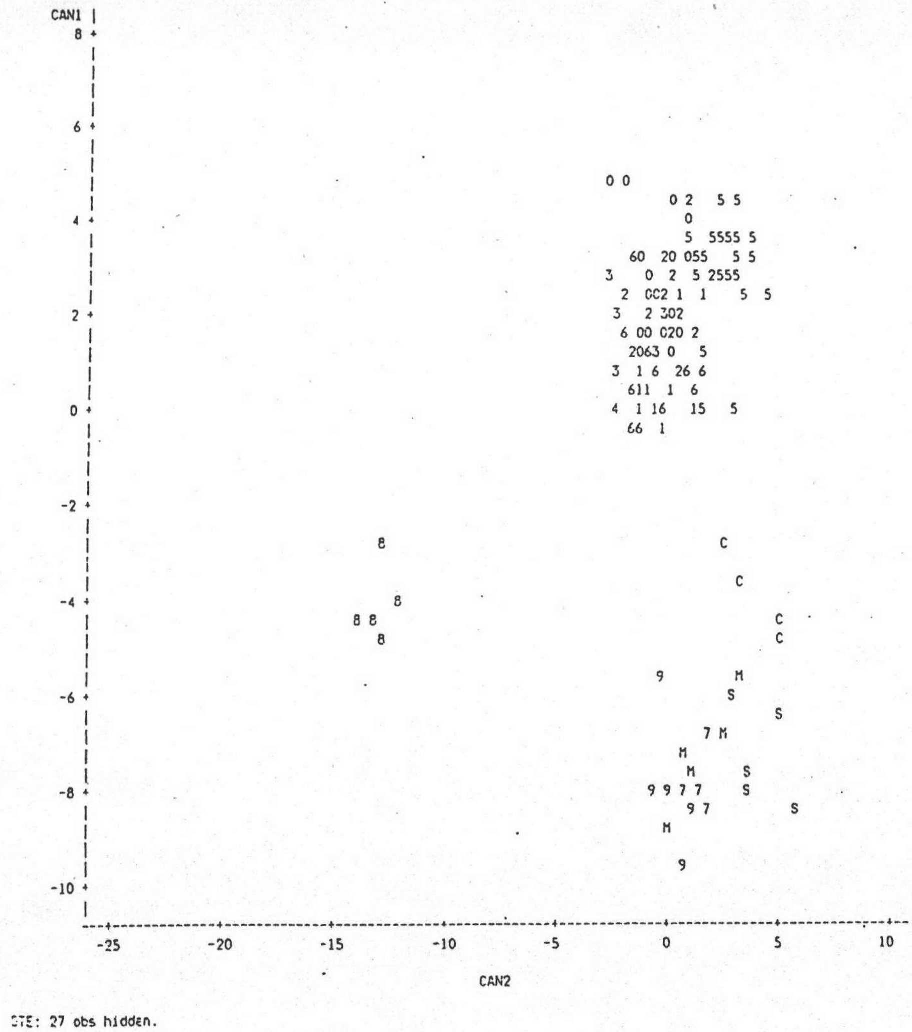


Fig. 25 Discriminant analysis of <u>Apis cerana</u> in Thailand and Malaysian Peninsula (all linear combinations of variables are excluded

* symbol is value of region

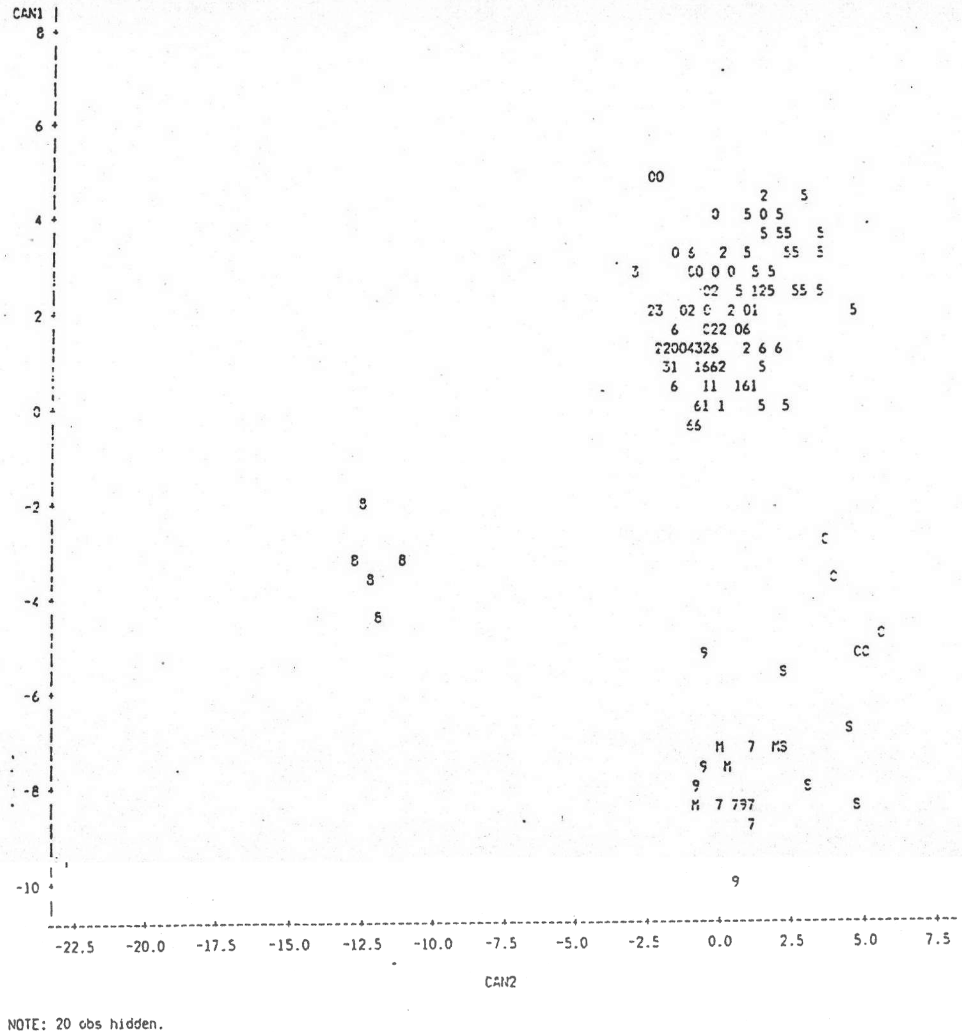
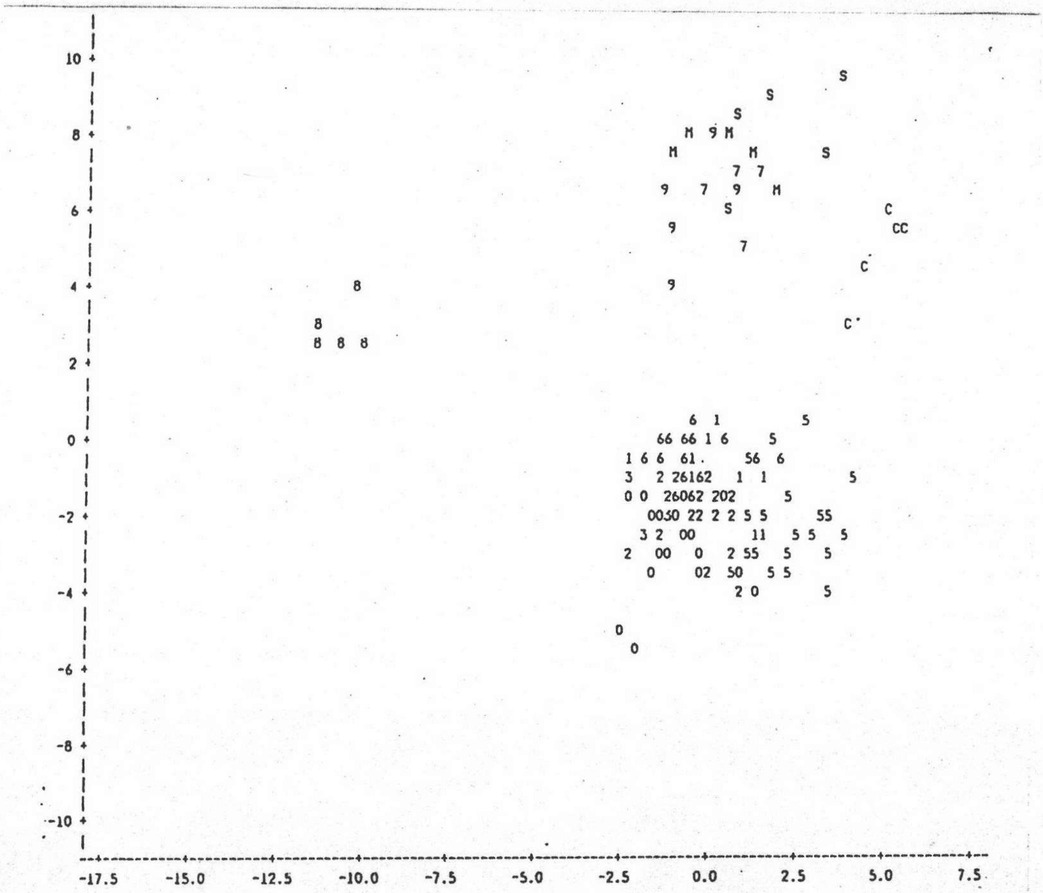


Fig. 26 Discriminant analysis of Aois ceranan in Thailand and Malaysian Peninsula (all linear combinations of variables, pigment variables are excluded)

* Symbol is value of REGION



NOTE: 19 obs hidden.

Fig. 27 Discriminant analysis of <u>Aois</u> <u>cerana</u> in Thailand and Malaysian Peninsula (all linear combinations of variables, pigment variables, postmentum and glossa are excluded)

* Symbol is value REGION

TABLE 7 MAHALANOBIS' DISTANCE AMONG 13 REGIONS OF A. CERANA FROM THAILAND & MALAYSIAN PENINSULA

DISCRIMINANT ANALYSIS   PAIRWISE SQUARED DISTANCES BETWEEN GROUPS

$$D^2(i|j) = (\bar{X}_i - \bar{X}_j)' \, COV^{-1} \, (\bar{X}_i - \bar{X}_j)$$

Squared Distance to REGION

From REGION	0	1	2	3	4	5	6	7	8	9
0	0	20.09045	16.82378	39.03247	127.27779	31.49312	33.47108	153.48529	197.33014	136.67497
1	20.09045	0	14.79558	42.09004	127.62086	19.97830	15.88420	109.28519	184.52021	115.17174
2	16.82378	14.79558	0	32.51385	98.52942	24.47433	13.42521	129.57672	197.31893	123.68480
3	39.03247	42.09004	32.51385	0	149.46997	61.85336	49.10929	150.28178	198.74435	159.52564
4	127.27779	127.62086	98.52942	149.46997	0	133.09139	117.46577	224.22037	262.26595	199.03708
5	31.49312	19.97830	24.47433	61.85336	133.09139	0	25.18703	156.94322	238.96257	162.40045
6	33.47108	15.88420	13.42521	49.10929	117.46577	25.18703	0	124.39306	176.70159	127.00413
7	153.48529	109.28519	129.57672	150.28178	224.22037	156.94322	124.39306	0	254.18207	33.58255
8	197.33014	184.52021	197.31893	198.74435	262.26595	238.96257	176.70159	254.18207	0	236.78223
9	136.67497	115.17174	123.68480	159.52564	199.03708	162.40045	127.00413	33.58255	236.78223	0
C	124.36961	100.52440	131.63638	155.05087	236.67166	117.61701	131.73583	129.81666	307.94683	123.77319
M	142.81231	100.15563	117.58557	151.58772	201.85419	133.73311	96.82874	78.72539	219.17632	80.18059
S	172.56904	124.46004	147.06147	169.85851	275.02705	145.25098	118.78114	101.44305	282.16899	132.91910

Squared Distance to REGION

From REGION	C	M	S
0	124.36961	142.81231	172.56904
1	100.52440	100.15563	124.46004
2	131.63638	117.58557	147.06147
3	155.05087	151.58772	169.85851
4	236.67166	201.85419	275.02705
5	117.61701	133.73311	145.25098
6	131.73583	96.82874	118.78114
7	129.81666	78.72539	101.44305
8	307.94683	219.17632	282.16899
9	123.77319	80.18059	132.91910
C	0	125.73525	129.30374
M	125.73525	0	69.25922
S	129.30374	69.25922	0

TABLE 8 CLUSTERING ANALYSIS OF *APIS CERANA* IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATIONS OF VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 3

	CLUSTER A		CLUSTER B		CLUSTER C	
REGION	OBS.	%	OBS.	%	OBS.	%
0	12	63.2	3	15.8	4	21.0
1	5	50.0	5	50.0	-	-
2	15	83.3	2	11.1	1	5.6
3	4	80.0	1	20.0	-	-
5	24	92.3	1	3.8	1	3.8
6	13	65.0	7	35.0	-	-
7	-	-	5	100.0	-	-
8	1	20.0	4	80.0	-	-
9	-	-	5	100.0	-	-
C	-	-	5	100.0	-	-
M	-	-	5	100.0	-	-
S	2	40.0	3	60.0	-	-

TABLE 9 CLUSTERING ANALYSIS OF <u>APIS</u> <u>CERANA</u> IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATION OF VARIABLES AND PIGMENT VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 3

	CLUSTER A		CLUSTER B		CLUSTER C	
REGION	OBS.	%	OBS.	%	OBS.	%
0	16	84.2	3	15.8	-	-
1	5	50.0	5	50.0	-	-
2	15	83.3	3	6.7	-	-
3	4	80.0	1	20.0	-	-
5	22	84.6	3	11.5	1	3.8
6	12	60.0	8	40.0	-	-
7	-	-	5	100.0	-	-
8	-	-	5	100.0	-	-
9	-	-	5	100.0	-	-
C	-	-	5	100.0	-	-
M	-	-	5	100.0	-	-
S	2	40.0	3	60.0	-	-

TABLE 10 CLUSTERING ANALYSIS OF APIS CERANA IN THAILAND AND MALAYSIAN PENINSULA ALL LINEAR COMBINATION OF VARIABLES, PIGMENT VARIABLES, POSTMENTUM AND GLOSSA EXCLUDED

MAXIMUM CLUSTERS = 3

	CLUSTER A		CLUSTER B		CLUSTER C	
REGION	OBS.	%	OBS.	%	OBS.	%
0	16	84.2	3	15.8	-	-
1	5	50.0	5	50.0	-	-
2	15	83.3	3	16.7	-	-
3	4	80.0	1	20.0	-	-
5	22	84.6	3	11.5	1	3.8
6	12	60.0	8	40.0	-	-
7	-	-	5	100.0	-	-
8	1	20.0	4	80.0	-	-
9	-	-	5	100.0	-	-
C	-	-	5	100.0	-	-
M	-	-	5	100.0	-	-
S	2	40.0	3	60.0	-	-

TABLE 11 CLUSTERING ANALYSIS OF APIS CERANA IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATION OF VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 4

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	12	63.2	3	15.8	4	21.0	-	-
1	5	50.0	5	50.0	-	-	-	-
2	15	83.3	2	11.1	1	5.6	-	-
3	4	80.0	1	20.0	-	-	-	-
5	21	80.8	3	11.5	1	3.8	1	3.8
6	13	65.0	7	35.0	-	-	-	-
7	-	-	5	100.0	-	-	-	-
8	1	20.0	4	80.0	-	-	-	-
9	-	-	5	100.0	-	-	-	-
C	-	-	5	100.0	-	-	-	-
M	-	-	5	100.0	-	-	-	-
S	2	40.0	3	60.0	-	-	-	-

TABLE 12 CLUSTERING ANALYSIS OF <u>APIS CERANA</u> IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATION OF VARIABLES AND PIGMENT VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 4

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	16	84.2	3	15.8	-	-	-	-
1	5	50.0	5	50.0	-	-	-	-
2	15	83.3	3	16.7	-	-	-	-
3	4	80.0	1	20.0	-	-	-	-
5	23	88.5	2	7.7	-	-	1	3.8
6	13	65.0	7	35.0	-	-	-	-
7	-	-	5	100.0	-	-	-	-
8	1	20.0	4	80.0	-	-	-	-
9	-	-	5	100.0	-	-	-	-
C	-	-	5	100.0	-	-	-	-
M	-	-	5	100.0	-	-	-	-
S	-	-	3	60.0	2	40.0	-	-

TABLE 13 CLUSTERING ANALYSIS OF *APIS CERANA* IN THAILAND AND MALAYSIAN PENINSULA ALL LINEAR COMBINATION OF VARIABLES, PIGMENT VARIABLES POSTMENTUM AND GLOSSA EXCLUDED

FASTCLUS PROCEDURE MAXCLUSTERS = 4

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	16	84.2	3	15.8	-	-	-	-
1	5	50.0	5	50.0	-	-	-	-
2	15	83.3	3	16.7	-	-	-	-
3	4	80.0	1	20.0	-	-	-	-
5	22	84.6	3	11.5	-	-	1	3.9
6	12	60.0	8	40.0	-	-	-	-
7	-	-	5	100.0	-	-	-	-
8	-	-	5	100.0	-	-	-	-
9	-	-	5	100.0	-	-	-	-
C	-	-	5	100.0	-	-	-	-
M	-	-	5	100.0	-	-	-	-
S	2	40.0	3	60.0	-	-	-	-

TABLE 14 CLUSTERING ANALYSIS OF APIS CERANA IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATION OF VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 5

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D		CLUSTER E	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	11	57.9	4	21.0	-	-	4	21.0	-	-
1	5	50.0	5	50.0	-	-	-	-	-	-
2	15	83.3	3	16.7	-	-	-	-	-	-
3	2	40.0	3	60.0	-	-	-	-	-	-
5	21	80.8	3	11.5	-	-	1	3.8	1	3.8
6	12	60.0	8	40.0	-	-	-	-	-	-
7	-	-	1	20.0	4	80.0	-	-	-	-
8	-	-	5	100.0	-	-	-	-	-	-
9	-	-	3	60.0	2	40.0	-	-	-	-
C	-	-	5	100.0	-	-	-	-	-	-
M	-	-	3	60.0	2	40.0	-	-	-	-
S	2	40.0	2	40.0	1	20.0	-	-	-	-

TABLE 15 CLUSTERING ANALYSIS OF <u>APIS</u> <u>CERANA</u> IN THAILAND AND MALAYSIAN PENINSULA

ALL LINEAR COMBINATION OF VARIABLES AND PIGMENT VARIABLES EXCLUDED

MAXIMUM CLUSTERS = 5

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D		CLUSTER E	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	16	84.2	3	15.8	-	-	-	-	-	-
1	5	50.0	5	50.0	-	-	-	-	-	-
2	15	83.3	3	16.7	-	-	-	-	-	-
3	2	40.0	3	60.0	-	-	-	-	-	-
5	21	80.8	4	15.4	-	-	-	-	1	3.8
6	11	55.0	9	45.0	-	-	-	-	-	-
7	-	-	-	-	5	100.0	-	-	-	-
8	-	-	5	100.0	-	-	-	-	-	-
9	-	-	1	20.0	4	80.0	-	-	-	-
C	-	-	-	-	5	100.0	-	-	-	-
M	-	-	2	40.0	3	60.0	-	-	-	-
S	-	-	2	40.0	1	20.0	2	40.0	-	-

TABLE 16 CLUSTERING ANALYSIS OF <u>APIS</u> <u>CERANA</u> IN THAILAND AND MALAYSIAN PENINSULA ALL LINEAR COMBINATION OF VARIABLES, PIGMENT VARIABLES, POSTMENTUM AND GLOSSA EXCLUDED

MAXIMUM CLUSTERS = 5

	CLUSTER A		CLUSTER B		CLUSTER C		CLUSTER D		CLUSTER E	
REGION	OBS.	%	OBS.	%	OBS.	%	OBS.	%	OBS.	%
0	12	63.2	1	5.2	6	31.6	-	-	-	-
1	4	40.0	3	30.0	3	30.0	-	-	-	-
2	8	44.4	1	5.6	9	50.0	-	-	-	-
3	4	80.0	-	-	1	20.0	-	-	-	-
5	17	65.4	-	-	8	30.8	-	-	1	3.8
6	12	60.0	4	20.0	4	20.0	-	-	-	-
7	-	-	5	100.0	-	-	-	-	-	-
8	1	20.0	4	80.0	-	-	-	-	-	-
9	-	-	5	100.0	-	-	-	-	-	-
C	-	-	5	100.0	-	-	-	-	-	-
M	-	-	5	100.0	-	-	-	-	-	-
S	-	-	3	60.0	-	-	2	40.0	-	-