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Original article

Morphometric studies on the microtaxonomy of the species *Apis mellifera* L

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Summary — A principal components analysis was performed on 252 samples of *Apis mellifera* collected from various geographic locations. The result is presented for the first time as a computer generated three-dimensional figure resembling a tripod, with each distinct branch and stem representing one of the four major regions: tropical Africa, western Mediterranean and northern Europe, central Mediterranean and southeastern Europe ending in *A m carnica*, and the Near East ending in *A m caucasica*.

***Apis mellifera* / morphometry / microtaxonomy / subspecies**

INTRODUCTION

Reliable investigations on the taxonomy of *Apis mellifera* based on a large number of well-distributed data are critical to provide a solid basis for understanding the ecology, physiology, behavior and phylogeny of honey bees. Decisive progress in morphometric taxonomy of *Apis mellifera* was attained by introducing multivariate data analyses based on colony means rather than individual bees (DuPraw, 1965). By representing the species as a set of selected samples, and by performing a principal components analysis (PCA) on its morphometric characters, previous work resulted in the definition of 24 well-defined subspecies. The spatial distribution of these subspecies (in the form of clusters) led to the construction of a 3D model in the form of a tripod (Ruttner, 1988, fig 10.7). The first axis of this 3D model represented body size, separating small bees from the tropical zones from larger ones of subtropical or temperate

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areas. The second axis split the bees from the Balkans (and Italy) from all other samples of a similar geographic latitude, giving an overall structure in the shape of the letter 'Y'. On constructing a third axis, it was seen that one branch of the 'Y' consisted of two branches. This was the first indication of the existence of a fourth branch that represents the subspecies of the Near East ending in *A m caucasica*.

The main object of this study was to test if these previous results were still valid when multivariate statistical methods were performed on the species as a whole. We wanted to produce an accurate analysis of the spatial structure of this tripod, and to test whether the subgroups in each branch still persisted. A precise study of the spatial structure of the subgroups was made possible using modern computer-generated 3D imaging. Determining the precise distances between the subgroups of newly selected samples, and improving the basis of morphometric analysis is a constant challenge considering the vast range of variability and the huge range in the geographic distribution of the species.

MATERIALS AND METHODS

A principal components analysis (PCA) was performed on 252 samples representing 21 subspecies of *A mellifera* (table I). Each sample consisted of 15–20 worker bees from individual colonies. The data consisted of 34 characteristics (table II), which were taken from the morphometric data bank of honeybees in Oberursel, Germany (Ruttner et al, 1978).

A standard PCA analysis was used based on the correlation matrix between the morphological characteristics (ALMO Statistic System, Holm, 1996). The technique of principal components analysis is generally used when no previous knowledge of the spatial structure of the data set exists. It reduces the data space into a set of principal axes loaded with various morphometric characteristics. The variance along each principal axis is represented by its eigenvalue of the correlation matrix. Successive principal axes represent decreasing amounts of variation. Taking the first three principal axes, a spatial distribution of the data points appeared as a set of subspecies. Morphometric distances between the same set of *A mellifera* subspecies were also calculated by discriminant analysis (also ALMO Statistics). The only difference from PCA was the allocation of observations to subspecies groups to calculate group centroids and the distances between them. The classification into groups was based on a previous discriminant analysis, which showed a clear separation between all tested subspecies with at least a 75% confidence level.

The same classification was used to tag the observations in the PCA to show their membership to a special group in the diagram. The first three principal component coordinates for every observation were used to create a 3D plot. This plot was then slightly rotated to different positions to display the inherent internal spatial distribution.

Table I. Subspecies.

Race	*Number of samples*
A m anatoliaca	14
A m adami	6
A m cypria	5
A m syriaca	8
A m meda	12
A m caucasica	12
A m lamarckii	7
A m yemenitica	26
A m litorea	10
A m scutellata	22
A m adansonii	27
A m unicolor	8
A m sahariensis	6
A m intermisssa	10
A m iberica	9
A m mellifera	9
A m sicula	10
A m ligustica	12
A m cecropia	9
A m macedonica	10
A m carnica	20
Total	252

Table II. Variables.

Variable
1: hair length
2: tomentum width
3: dark stripe
4: length femur
5: length tibia
6: length mtarsus
7: width mtarsus
8: pigment t3
9: pigment t4
10: length t3
11: length t4
12: length st3
13: length wax mirror
14: width wax mirror
15: dist wax mirror
16: length st6
17: width st6
18: length forewing
19: width forewing
20: pigment scut1
21: pigment scut2
22: cubital 1
23: cubital 2
24: angle A 4
25: angle B 4
26: angle D 7
27: angle E 9
28: angle G 18
29: angle J 10
30: angle J 16
31: angle K 19
32: angle L 13
33: angle N 23
34: angle O 26

RESULTS

The resulting diagrams (figs 1–7) do in fact show a tripod-like distribution consisting of a stem and three branches each representing morphometrically similar types, and at the same time separate parts of the distribution area of *A mellifera*. Thus, the clustering of the samples within the virtual space of the PCA is correlated to the geographic distribution. This indicates that *A mellifera* is not only a polytypic species but that these groups of subspecies correspond to the 'Rassenkreis' of Rensch (1929).

Figures 1 and 2 show a 3D scatter-plot of the scores of the PCA analysis, with the orthogonal axes F1, F2 and F3 representing the principal components 1, 2 and 3. The corresponding eigenvalues are 15.44, 3.98 and 2.75, and the percentage of variation is 45.41, 11.72 and 8.09%, respectively. Thus, the whole diagram accounts for 65.22% of the total variation. Each of the two figures shows four clearly seperated branches: 'A' with samples from tropical Africa, 'C' with samples from southeastern Europe and central Mediterranean, 'M' with samples from western Mediterranean and North Africa, and 'O' with Caucasian and Near East samples.

Figure 1 shows the tripod from the side (plane F1/F3) and figure 2, which is the same plot rotated 72° clockwise about the F3-axis, gives a view on the bottom of the tripod (toward the plane F2/F3). Also in figure 2 the general position and size of the branches C, M and O can be seen.

Figure 3 shows the centroids of the subspecies *A m carnica*, *A m mellifera*, *A m caucasica*, *A m scutellata* and *A m yemenitica*, as computed by a discriminant analysis on the same data set. These centroids again display the general shape of a tripod, and the tips of the legs C, M and O form an irregular triangle, with the distance between M and O being smaller than between M and C or O and C.

The branch 'A' (fig 4) is occupied by the subspecies of tropical Africa: (from the end to the center) *A m yemenitica*, *A m litorea*, *A m adansonii*, *A m scutellata*, *A m unicolor*, and *A m lamarckii*. The *A m lamarckii* samples are spread out more than the other groups, which is an indication that there is more than one subspecies of honeybee in

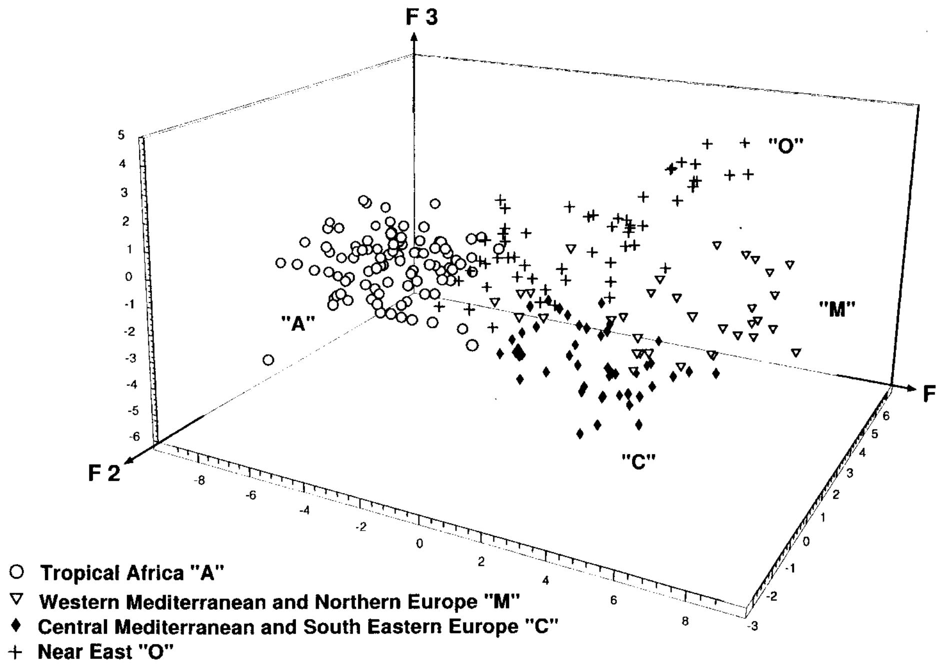

Fig 1. Spatial allocation of groups of subspecies resulting from a principle components analysis on morphometric characteristics (view toward plane F1/F3).

Egypt, which may be due to hybridization with imported bees.

The branch 'O' (fig 5) is occupied by (from the outer tip to the center) *A m caucasica, A m adami, A m anatoliaca, A m meda, A m cypria* and *A m syriaca. A m syriaca* reaches into the A-branch close to *A m scutellata* and *A m unicolor*. In this position, the individual elements of branch 'O' are most clearly demonstrated, but the branch 'M' is completely covered. This is why the model was originally erroneously depicted in a two-dimensional illustration as a 'Y' (Ruttner et al, 1978).

The branch 'M' (fig 6, in this view below branch 'O') is occupied by (from tip to center) *A m mellifera, A m iberica, A m intermissa* and *A m sahariensis. A m sahariensis* according to this analysis seems to belong to the African (A) branch rather than the M-branch, as there is a significant break between *A m sahariensis* and *A m intermissa*.

The branch 'C' (also from tip to center) is occupied by *A m carnica, A m cecropia, A m macedonica, A m ligustica,* and *A m sicula*. This branch does not show any continuity into the A-branch, but rather shows that *A m sicula* is located close to *A m intermissa* from the M-branch.

DISCUSSION

Intraspecific honeybee taxonomy in its present state of knowledge can be considered a

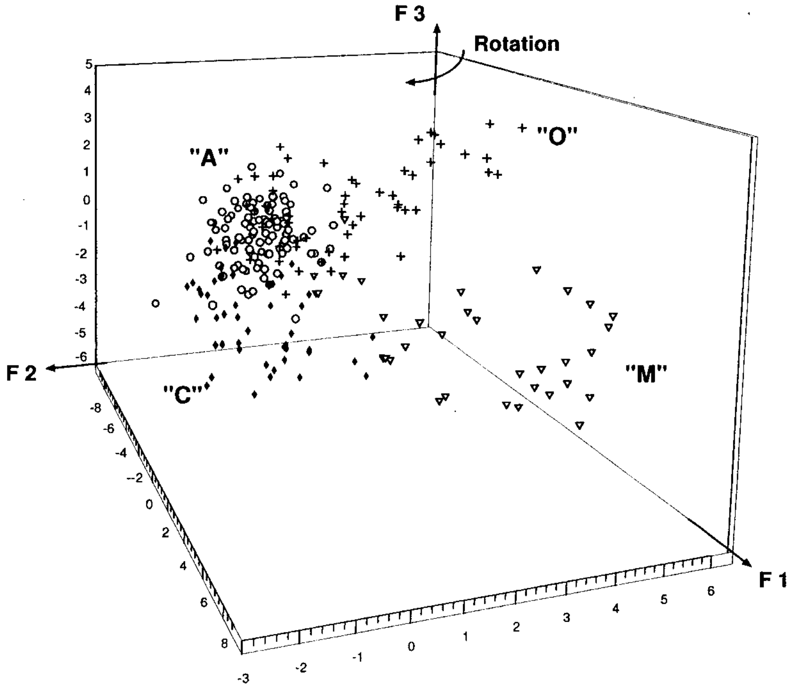

Fig 2. Same plot as figure 1 rotated 72° clockwise about the F3-axis, view on the bottom of the 'tripod' (toward the plane F2/F3)

model of the subspecies concept as defined by Mayr (1942, 1963): "A subspecies is a geographically defined aggregate of local populations which differ taxonomically (that is, by diagnostic morphological characters) from other subdivisions of the species". Therefore, the subspecies concept may be defined by two main criteria:

1) Subspecies have diagnostic morphological differences, which are determined through agreement by working taxonomists. The 75% degree of coincidence between subspecies as proposed by Huxley (1938) has proven to be very satisfactory so far in studies of the microtaxonomy of the honey bees. The diagnostic value of the selected characters is important. The characters have to be geographically variable, genetically determined and exactly measurable or, in some cases, estimated using an easily applicable scale.

2) Subspecies have a defined area of distribution. This geographic component of the definition implies the existence of specific adaptations of subspecies to particular environments. The extremely wide distribution of *A mellifera* across a multitude of different climates results in a great variety of physiology and behavior among the various subspecies (and even among local subpopulations of the subspecies), which can be considered in some cases as the first steps in the process of speciation.

Concerning the morphological differences in the present data set, the majority of the variation is accounted for by factor

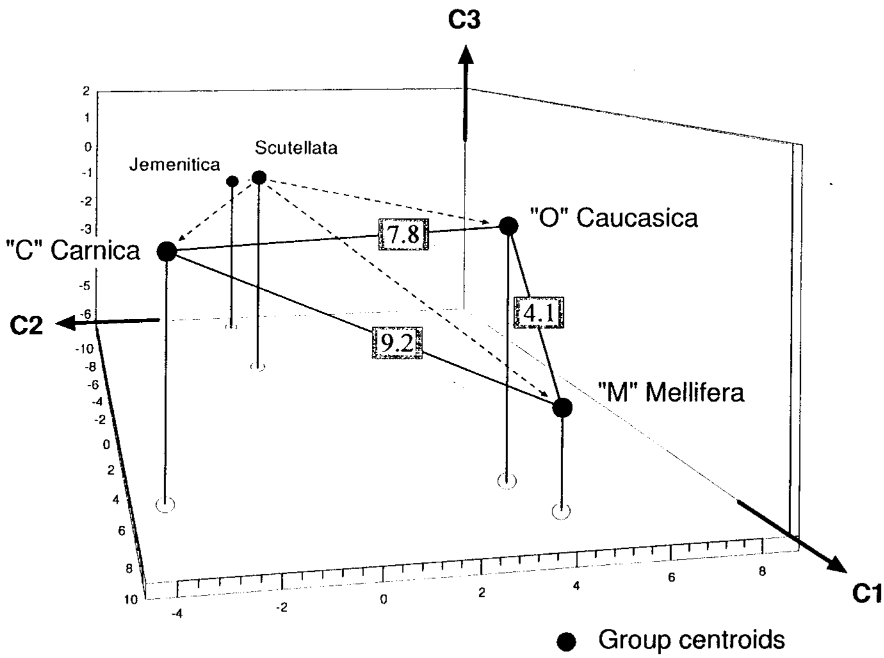

Fig 3. Centroids of the subspecies *A m carnica, A m mellifera, A m caucasica, A m scutellata* and *A m yemenitica*, as computed by a discriminant analysis on the same data set. The tips of the legs C, M and O form an irregular triangle, with the distance between M and O smaller than between M and C or O and C.

1, which comprises mainly size variables (45% of the amount of total variation). The importance of factor 1 is not due to the authors preference for this category of characters, since special care was taken to select the characters from several independent categories. Wing characters, unrelated to size, are almost as frequently represented as those of size (13:14). The predominance of size-related variables stems from a much higher variability than wing venation or hair.

Size is of high adaptive value in many animals (Rensch, 1939), including honey bees (Ruttner 1988). No subspecies of *A mellifera* in temperate zones is characterized by small worker bees. All subspecies of *A mellifera* in the tropics are of small body size except those of tropical mountain regions (eg, *A m monticola*), which are always larger than those of the lowlands. The physiological explanation for this difference may be associated with Bergmann's rule (animals have a lower surface/volume ratio to reduce heat loss in colder climates). On the other hand, with honey bees the situation within the nest may be an additional contradicting factor (smaller bees have more cells and more offspring within the same nest volume as larger bees). Details have still to be examined.

The taxonomic significance of size characters was unintentionally put to the test when honey bees from subsaharan Africa were introduced into South America 40

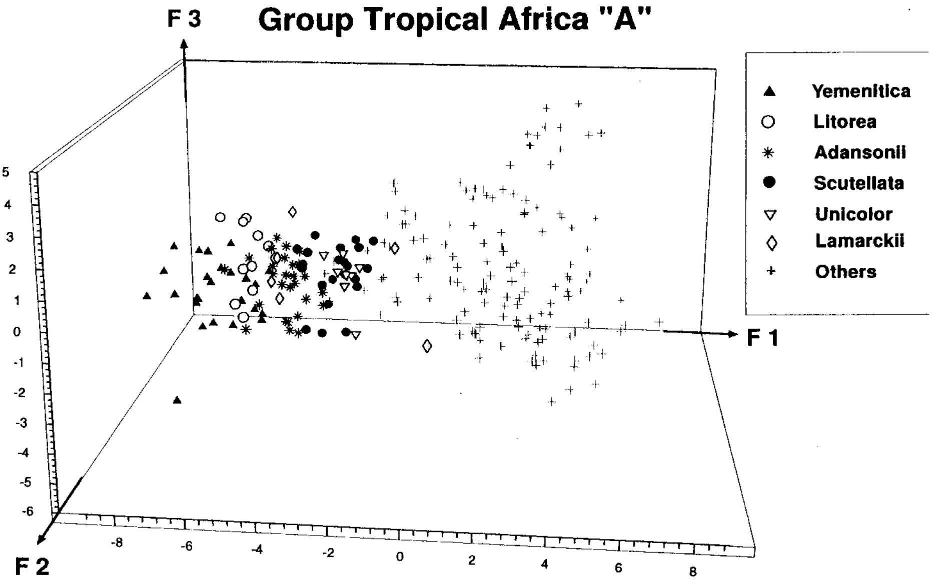

Fig 4. Detailed view on branch 'A': tropical Africa.

years ago. *A m scutellata* originates from the east African highlands (altitude 600–1500 m) and is therefore among the largest of the *mellifera*-bees of the tropics (see fig 4). It is the largest bee at the right end of the A-branch, considering the increasing-size scale going from left to right. The bees of European origin that are encountered in the Americas lie a considerable distance to the right of *A m scutellata* in figure 4 (they are larger). After the process of invasion started in the neotropics, reliable and relatively easy methods of taxonomic identification became of acute significance. Morphometrics was used almost exclusively for routine tests, using a set of already tested characters (Daly and Balling, 1978) or for quick field tests, only a selection of a few size measurements (Rinderer et al, 1987).

The characters of size condensed in factor 1 are a very potent tool in discriminating bee populations from very disparate climatic conditions and to provide a first dispersion of the bulk of similar taxonomic units, but they are by no means sufficient if honey bees from less differing conditions (geographic latitude) are compared. In factor 2 (12% of the total load of variation) mainly wing venation characters are found. Only three angles, B4, E9, J10, and the distance 'A' of the cubital index (see Ruttner, 1988) move the whole 'C' group (the populations form the Balkans and *ligustica*) in direction of the negative pole of factor 2. At the same time angles A4, D7 and G18, as well as distance 'B' and the character 'length of cover hair' shift all other groups of large bees from the temperate zone in the opposite direction of factor 2, providing a very clear, non-overlapping separation resulting in the 'Y'-shaped figure. This effect is used for simple identification of *carnica*-breeding strains by European beekeepers (in most cases it is sufficient to measure only the cubital index and the length of cover hair).

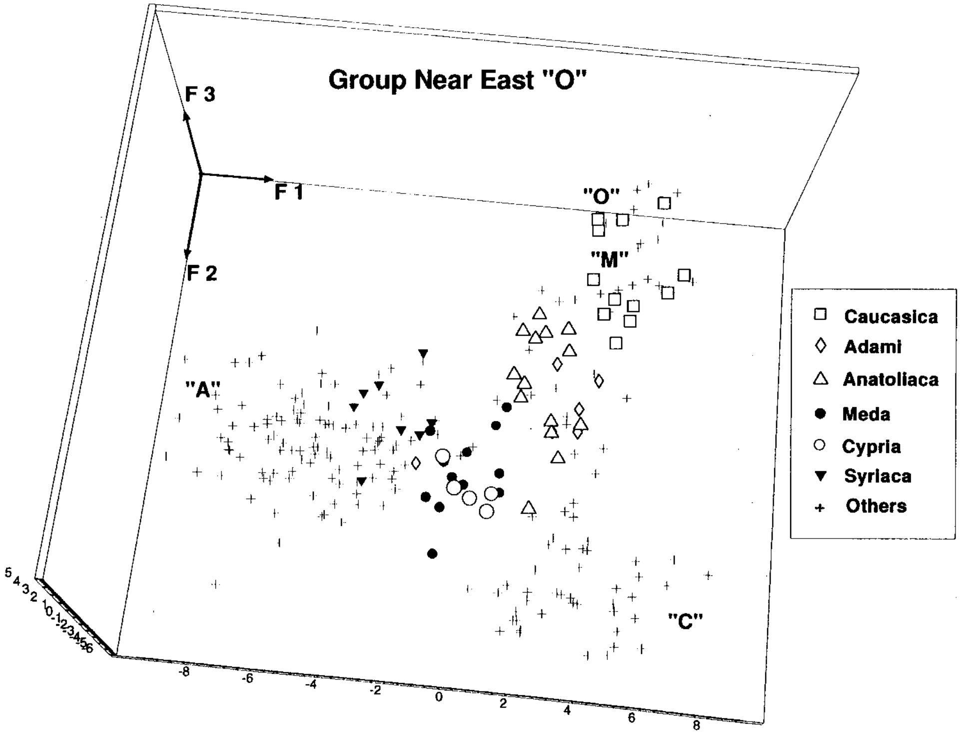

Fig 5. Detailed view on branch 'O': Near East.

It is interesting that in the group of characters loading factor 2, one single measurement of size is found: character No 17, width of sternite 6. This variation, however, does not indicate a change in size (all other characters of size remain unaltered), but a change in proportion: bees with an increased width of sternite 6 have a broad abdomen (like *A m mellifera*); a decrease in this measurement indicates slender worker bees (*carnica, ligustica*).

The introduction of factor 3 (8% of the total variation) splits one branch of the 'Y', containing an agglomeration of middle-sized to large bees of various geographic origins, into two branches, each representing a distinct geographic region: one with seven well-defined subspecies, from Israel across Anatolia and Iran to the Caucasus region (O-branch), the other with four to five subspecies from North Africa to northern Europe (M-branch). The characters tomentum width, color of tergites and scutellum, and two wing venation angles (A4 and J10) are responsible for the position of the clusters of the O-branch on the positive side of the scale of axis 3, whereas the four angles (J16, K19, N23, O26) move the clusters of the M-branch to the negative side. As a result of this last separation, achieved by factor 3, all known subspecies of *A mellifera* are classified into four groups, each corresponding to a distinct geographic area. Only

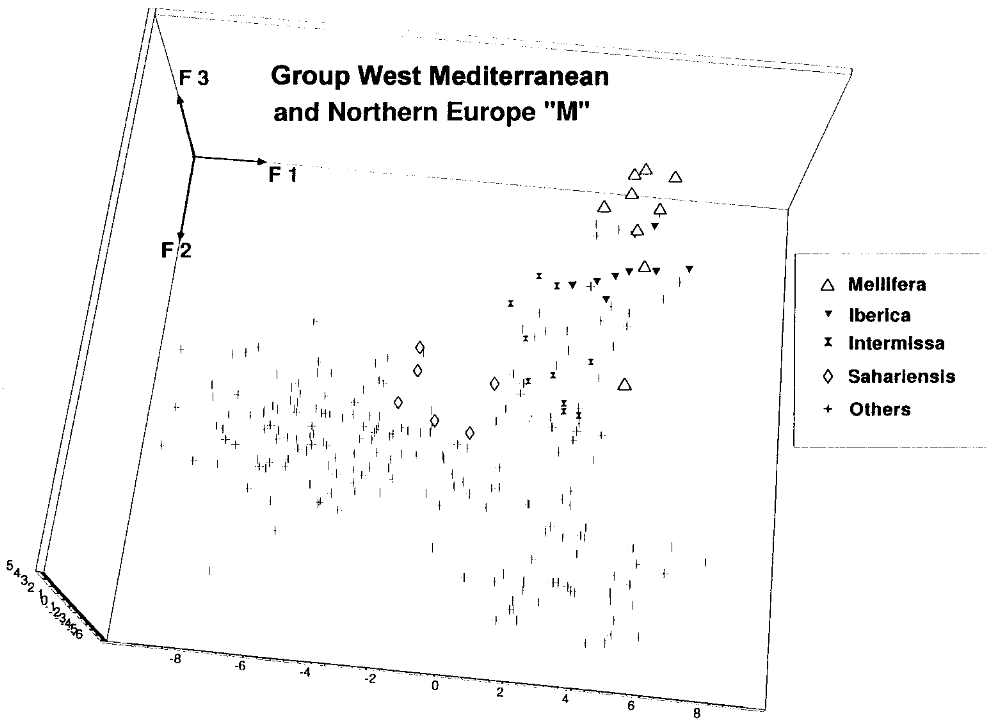

Fig 6. Detailed view on branch 'M': western Mediterranean and nothern Europe.

a few subspecies, located in a transitional position, remain with unclear classification (eg, *A m sicula*).

The three 'legs' of the tripod are distinctly separated from one another. This can be shown in a basal view of the rotated model (fig 3). The relative distance between *mellifera* and *carnica*, for example, was found to be 9.2, while that between *caucasica* and *carnica* was 7.8.

The main point of the investigation is that by mere morphometric analysis of almost all the known subunits of the species *Apis mellifera*, using a great number of selected characters, a separation of subspecies according to their geographical distribution was achieved. The importance of the factor 'size', which separated by linear correlation honey bees from the tropics with numerous specific adaptations (Seeley, 1985) from those of the temperate zone, has already been mentioned. More complex is the taxonomic situation in the 'genetic center' of *Apis mellifera*, the Mediterranean basin and its 'backyard', with many distinct subspecies, but only limited distinction in geographic latitude. The discriminant characteristics found in factors 2 and 3 are only partly of recognizable adaptive value (for instance, length of hair). In wing venation, it is remarkable that groups of subspecies (and with it, regions) are characterized by specific variations in certain wing segments.

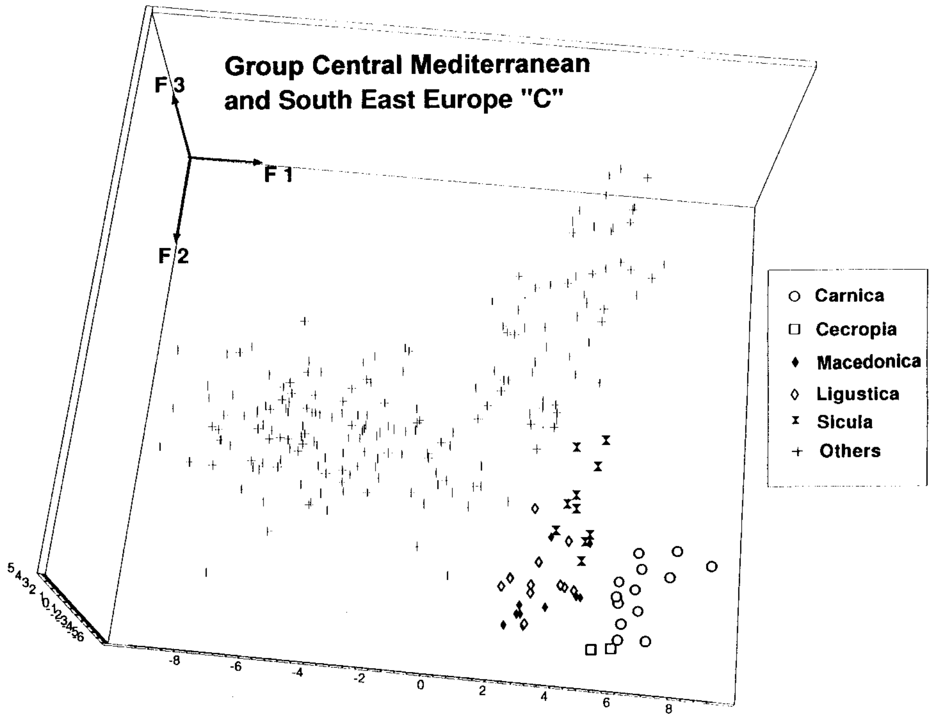

Fig 7. Detailed view on branch 'C': central Mediterranean and southeastern Europe.

In branch C, for example, mainly the apical part of the wing is concerned (angles A4, B4, D7, E9, and cubital distances 'A' and 'B'). For the discrimination of branches M and O, mainly specific variation of the basal venation is decisive (angles J10, J16, K19, N23, O26). Therefore, specific 'key characters' can be ascribed to each of the regions. The more peripherally a subspecies is found on the northern boundary of the *mellifera* area, the further its cluster is on the scale of factors 2 and 3 from the main axis, factor 1.

This group-specific arrangement of characters corresponds to the definition of a subspecies as 'concordant distribution of multiple, independent, genetically-based traits' (Mayr, 1963; O'Brien and Mayr, 1991). The relation of specific morphometric characters to the geographic distribution produces results regarding the development of adaptations in honey bees. Further development in this field can be expected, allowing discrimination of local populations and selected strains (Kauhausen-Keller and Keller, 1994). Further application of the results, especially in direction of phylogeny, can be expected from joint studies with methods of molecular biology. If discrepancies exist in the different fields (Cornuet and Garnery, 1991) only continuing studies may provide the solution.

Résumé — Études morphométriques portant sur la microtaxinomie de l'espèce *Apis mellifera* L. L'analyse statistique de toutes les sous-espèces connues d'*Apis mellifera* peut fournir une meilleure compréhension des relations entre les variétés géographiques de cette espèce très polymorphe. Des résultats satisfaisants n'ont été obtenus que lentement en raison du temps nécessaire pour rassembler un nombre suffisant d'échantillons qui constituent une population représentative de la sous-espèce. Les méthodes statistiques multivariées, qui utilisent les mesures de 34 caractères discriminants de divers types (taille corporelle, vénation alaire, pilosité, coloration) ont donné jusqu'à présent 24 groupes d'échantillons bien séparés les uns des autres qui proviennent chacun d'une région géographique donnée. En conséquence ces groupes peuvent être décrits comme des sous-espèces ou des races géographiques selon la définition en vigueur.

Dans la représentation graphique des résultats d'une l'analyse factorielle, les groupes sont rangés le long de l'axe 1 en fonction de la taille corporelle. L'axe 2 sépare les abeilles des Balkans et de l'Italie des autres échantillons issus de la même latitude, ce qui donne à la structure globale une forme en « Y ». Si l'on ajoute un troisième axe (en essayant d'abord de construire une figure tridimensionnelle à partir de la projection des plans), l'une des branches du « Y » se divise et la figure résultante resssemble à un trépied avec un tronc principal et trois branches correspondant chacune à un groupe de sous-espèces d'une région géographique donnée.

Dans l'étude présente nous avons positionné 252 échantillons appartenant à 21 sous-espèces dans un espace virtuel (figs 1 et 2). Le logiciel statistique Almo permet d'attribuer une couleur aux différents groupes, de leur faire subir une rotation autour de tous les axes et de les analyser sous n'importe quel angle choisi.

Le facteur (axe) 1 regroupe 45 % de la variation totale. Dans le tronc du triépied (branche A), tous les groupes se situent près de l'axe 1 (fig 4). Ils sont tous d'origine tropicale, d'Afrique subsaharienne et d'Arabie, avec à l'extrémité les abeilles les plus petites de l'espèce (*A m yemenitica*). L'existence de trois branches latérales qui partent de l'axe 1 est confirmée : dans la branche O on trouve sept sous-espèces du Proche-Orient (fig 5), séparées par le facteur 3 (8 % de la variation totale) de la branche M, qui comporte les sous-espèces d'Europe septentrionale et occidentale et celles d'Afrique du Nord ; *A m sahariensis* occupe une position de transition avec la branche A (fig 6). La branche C, avec les sous-espèces des Balkans et de l'Italie, depuis *A m carnica* au nord jusqu'à *A m sicula* au sud (fig 7), est identifiée par le facteur 2 (12 % de la variation totale). Cette dernière sous-espèce occupe nettement une position de transition avec les abeilles d'Afrique du Nord, *A m intermissa.*

Nous montrons qu'en utilisant des caractères morphométriques appropriés et les méthodes statistiques multivariées, les sous-espèces d'*Apis mellifera* peuvent être séparées en fonction de leur origine géographique. Le facteur 1, basé sur la taille corporelle, sépare les sous-espèces des tropiques, de petite taille, de celles des climats plus froids, qui sont plus grandes. Le facteur 2, qui comprend plusieurs angles de la vénation de l'extrêmité de l'aile antérieure et la longueur des poils, sépare la branche C des autres sous-espèces de la zone tempérée. Le facteur 3, calculé à partir de plusieurs angles de la vénation de la base de l'aile antérieure principalement, de la largeur du tomentum et de la couleur des tergites, permet de distinguer les branches O et M. Les points centraux (centroïdes) des groupes terminaux de ces trois branches, *A m carnica, A m mellifera* et *A m caucasica*, sont à peu près équidistants (fig 3), c'est-à-dire également distincts d'un point de vue taxinomique. La répartition géographique spécifique des caractères morphométriques est confirmée par un grand nombre d'autres échantillons non inclus dans cette étude. Parce que les différences morphométriques et une répartition géographique spécifique sont des éléments essentiels de la définition d'une sous-espèce (Mayr, 1963), les sous-espèces d'*Apis mellifera* doivent être reconnues comme de véritables entités taxinomiques.

***Apis mellifera* / morphométrie / microtaxinomie / sous-espèce**

Zusammenfassung — Morphometrische Untersuchungen zur Mikrotaxonomie der Spezies *Apis mellifera* L. Die gleichzeitige statistische Untersuchung aller bekannter Unterarten von *Apis mellifera* kann für das Verständnis der Beziehungen der geographischen Varietäten dieser sehr vielgestaltigen Art nützlich sein. Zufriedenstellende Ergebnisse wurden wegen des nur langsamen Prozesses der Aufsammlung genügend umfangreicher Proben der Unterarten nur sehr langsam erzielt. Multivariate statistische Methoden, bei denen 34 Merkmale verschiedener Kategorie (Körpergröße, Winkel des Flügelgeäders, Behaarung, Farbe) an 10–15 Bienen je Probe gemessen wurden, ergaben bisher 24 genügend voneinander getrennte Gruppen von Proben, die jeweils aus spezifischen geographischen Arealen stammten. Deshalb können die Gruppen nach der gültigen Definition als Unterarten (Subspezies) oder geographische Rassen bezeichnet werden.

In der graphischen Darstellung der Ergebnisse einer Faktorenanalyse sind die Gruppen entlang der Achse 1 entsprechend ihrer Körpergröße angeordnet, wobei kleine Bienen aus den Tropen von größeren aus Gebieten mit subtropischem oder gemäßigtem Klima getrennt werden. Faktor 2 spaltet die Bienen vom Balkan und Italien von allen übrigen Proben aus ähnlicher geographischer Breite ab, so daß die gesamte Darstellung die Form des Buchstaben „Y" annimmt. Durch Hinzufügen von Achse 3 (zuerst einfach dadurch versucht, daß mit den drei Ebenen der Analyse eine dreidimensionale Figur konstruiert wurde) entstand die Struktur eines Dreifußes, mit einem Hauptstamm und drei Ästen, von denen jeder eine Gruppe von Unterarten mit bestimmter geographischer Verbreitung enthält. In der gegenwärtigen Untersuchung wurde die genaue Position von 252 Proben aus 21 Unterarten im virtuellen Raum durch Computer unmittelbar berechnet (Abb. 1 und 2). Bei der benutzten ALMO-Statistik-Software werden die verschiedenen Gruppen durch Farben markiert, sie können um alle Achsen rotiert und aus jedem gewünschten Winkel studiert und analysiert werden.

Faktor (Achse) 1 der Analyse, berechnet aus allen Merkmalen der Körpergröße, enthält 45% der Gesamtvariation. Im Stamm des Dreifußes (Ast A) liegen alle Gruppen nahe von Achse 1 (Abb 4). Alle stammen aus den Tropen (tropisches Afrika und Arabien) mit den kleinsten Bienen der Art, *A m yemenitica*, an der äußersten Spitze. Es konnte bestätigt werden, daß vom Hauptstamm drei Seitenäste abzweigen: Im O-Ast befinden sich sieben Subspezies aus dem Nahen Osten (Abb 5), durch Faktor 3 (8% der Gesamtvariation) abgeschieden vom M-Ast, der die Rassen aus Nord- und Westeuropa und aus Nordafrika enthält (Abb 6). *A m sahariensis* nimmt eine Übergangsposition zum A-Ast ein. Der C-Ast mit den Unterarten vom Balkan und Italien, von der nördlichen *A m carnica* bis zur *A m sicula* (Abb 7), wird durch Faktor 2 charakterisiert (12% der Gesamtvariation). *A m sicula* zeigt sehr deutlich den Übergang zu den Rassen Nordafrikas an.

Es konnte gezeigt werden, daß bei Verwendung geeigneter Merkmale die Unterarten von *Apis mellifera* mit multivariaten statistischen Methoden entsprechend ihrer geographischen Herkunft voneinander getrennt werden können. Faktor 1 trennt die Unterarten mit kleinen Bienen aus den Tro-

pen von größeren, die in kühleren Klimagebieten leben. Faktor 2, berechnet aus mehreren Aderwinkeln im äußeren Anteil des Vorderflügels und aus der Haarlänge, trennt den C-Ast (mit *A m carnica*) von anderen Rassen der gemäßigten Zone. Mit Faktor 3 unterscheiden mehrere Aderwinkel hauptsächlich aus dem basalen Anteil des Vorderflügels, Breite der Filzbinden und Körperfarbe die Äste O und M. Die Mittelpunkte (Centroide) der äußersten Gruppen dieser drei Äste, *A m carnica*, *A m mellifera* und *A m caucasica* liegen beinahe im selben Abstand voneinander (Abb 3), das heißt, sie sind taxonomisch ähnlich gut voneinander getrennt. Dieses Ergebnis einer spezifischen geographischen Verteilung morphometrischer Merkmale wird durch eine große Anzahl weiterer Proben unterstützt, die in diese Untersuchung nicht einbezogen sind. Da morphometrische Unterschiede ebenso wie die spezifische geographische Verbreitung wesentliche Bestandteile der Definition einer Subspezies sind (Mayr 1963), müssen die Subspezies von *A mellifera* als gültige taxonomische Einheiten anerkannt werden.

***Apis mellifera* / Morphometrie / Microtaxonomie / Unterarten**

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