HONEYBEE AGROBIODIVERSITY: A PROJECT IN CONSERVATION OF *APIS MELLIFERA SYRIACA* IN JORDAN

Balarısı Tarımsal-Biyoçeşitliliği: Ürdün'de *Apis mellifera syriaca* Arısının Korunması Projesi

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Abstract: The existence of the autochthonous honey bees of Syria, Lebanon, Palestinian Authority, Israel and Jordan, *Apis mellifera syriaca*, is endangered by persistent honey bee imports of commercial breeder lines into the region. We investigated 26 colonies from 12 locations in Jordan by morphometric methods in comparison to reference samples of 7 relevant subspecies. Results showed, that samples from Jordan were, on average, not identical but more similar to reference samples of *A. m. syriaca* collected in 1952 than to any of the other subspecies. We determined sample locations of highest similarity to serve as source populations for a project in agrobiodiversity conservation.

Key words: *A. m. syriaca*, Jordan, morphometry, agrobiodiversity, conservation

Özet: Suriye, Lübnan, Filistin Yönetimi, İsrail, Ürdün yerli arısı *Apis mellifera syriaca* ithal edilen ticari damızlık arıların sürekli olarak bölgeye getirilmesi ile yok olma tehlikesi ile karşı karşıyadır. Biz Ürdün'de 12 istasyondan 26 koloniyi 7 referans ile karşılaştırarak moporfometrik analiz yöntemleri ile araştırdık. Sonuçlara bakıldığında Ürdün'den alınan numuneler ortalama olarak diğer ırklara değilde 1952 yılında toplanan referans numunelerine tam aynısı olmasa bile daha çok benzerlik göstermiştir. En fazla benzerlik gösteren numuneleri kaynak populasyonu olarak saptayıp tarımsal biyo-çeşitliliğin korunması projesi için belirledik.

Anahtar kelimeler: *A. m. syriaca*, Ürdün, morfometri, tarımsal biyo-çeşitlilik, koruma

INTRODUCTION

The honey bee of the eastern Mediterranean, *A. mellifera syriaca*, is found in the regions of Syria, Lebanon, Israel and Jordan. First detailed descriptions were given by Buttel-Reepen (1906), and its racial status was later confirmed by Ruttner (1988) based on samples collected by Brother Adam in 1952 (Brother Adam 1954). This smallest of the Near East bees is characterized by a pointed abdomen and yellow coloration of the first three dorsal segments and a bright yellow scutellum. Being the most south-western of the near-east honey bee races, it neighbors *A. m. meda* in the north (Ftayeh et al. 1994), and the next bees *A. m. lamarckii* and *A. m. yemenitica* in the south western direction, isolated by desert areas, already belong to the African races. *A. m. syriaca* thus occupies an interesting place in the biogeography of the species, which is emphasized by its morphological position where it is placed close to the origin of the four main phylogenetic branches recognized in principal component analysis on the honey bee infraspecific variability (Ruttner 1988).

However, due to persistent importations of commercial breeder lines and their establishment in honey production, the original autochthonous bee subspecies is bound disappear over time. Already in 1952 Brother Adam noted frequent importation of *A. m. ligustica* into Israel and remarked that it might be difficult to find pure *A. m. syriaca* there. This tendency has increased and was complemented by introducing other successful breeder lines including strains of Carniolan, Buckfast or

Caucasian origin (Slabezki *et al*. 2000; Hussein, 2000, Blum 1956). In combination with the increased transportation of colonies, which is part of modern beekeeping, cross-mating is bound to result in local populations with various degrees of blending of the original bee with commercial strains of diverse characteristics.

In particular for commercial beekeepers there seem to be good practical reasons for replacing *A. m. syriaca* by more suitable strains. Most notably, *A. m. syriaca* is a nervous bee, which is notorious for high defensiveness (Brother Adam 1954, Ruttner 1988), but also for frequent swarming (Blum 1956) and absconding, while commercial strains have been selected for easy handling and maintenance. However, this subspecies also has pronounced advantages. As a bee of the dry-hot regions, it is much better adapted to survive extreme summers temperatures without any honey flow, and adjusts its brood pattern showing a depression between the spring and autumn maxima (Zaitoun et al. 2000, Al Ghzawi *et al*., 2001 a). It has a superior ability to adapt egg laying to pollen availability and honeyflow (Bodenheimer and Ben-Nerya, 1937). Due to excessive production of swarm cells and, in particular, survival of virgin queens in the colonies until a mated queen has returned they avoid the risks of queen loss (Ruttner 1988). It is also better adapted to withstand attacks from *Vespa orientalis*, commencing flight activity when colonies are besieged (Blum 1956, Kalman 1973). Other traits might be present, in particular in respect to disease resistance, but investigations have only started (Al Ghzawi 2001 *et al*. b, c; Zaitoun *et al*. 2001). An advantage over pure imported bee strains is obvious**,** as these do not seem to thrive without extensive care, particularly outside the rift valley with its more favorite climate. By this, maintaining A. *m. syriaca* does confer distinct advantages in particular to the small-scale local beekeepers.

Only few systematic investigations on the specific traits of *A. m. syriaca* have so far been conducted to verify the potential traits. A basic requirement to conduct repeatable studies is to identify strains of original *A. m. syriaca* and to isolate these against uncontrolled inter-mating with bees of other origins. These then can serve as reference strains to which the obtained results refer. The obtained results might prove useful for potential breeding efforts, either by improving the local strains, which still appear to be more easily managed by small-scale beekeepers due to their adaptation to local conditions. Alternatively, specific advantageous traits could be crossed into imported strains to strengthen their endurance of harsh local conditions. Thus, as in other fields, maintenance of agro-biodiversity requires identification and conservation of defined natural subspecies**,** which then can serve as reservoir gene pool for future research and breeding.

Though more than half a century of foreign bee import has passed, it might not be too late to find pure or almost pure *A. m. syriaca*. In particular, the elevated regions of Jordan, climatically unfavorable for imported commercial strains, appear an appropriate region. Still in 1979, more than 80% of the hives were kept in traditional clay hives (Robinson 1981). Haddad et al. 2002, has reported that more than 98% are kept in modern Langstroth type, while 2% are still following traditional ways. According to the Ministry of Agricultural Statistics Reports (2003), 65% of the total number of the hives are located in the northern parts, and 25% in the central parts and the rest (10%) in the southern parts of Jordan.

We thus have set out an investigation of local populations in Jordan with the aim to determine the status general subspecies status of *A. mellifera* in Jordan and the identification of locations where bees can be regarded as sufficiently close to *A. m. syriaca* in its pure form, to serve as origin for further investigations and preservation in an research apiary.

METHODS

Twenty-one samples of worker bees were collected from 9 locations in the northern part of Jordan, two samples were collected from two locations in the central part, and three samples were collected from one location in the southern part.

Table I. Sampling locations and numbers of colonies sampled

Location	N	Latitude	longitude
Abu Zead Valley	3	32°30'N	35°41'E
Aen Alsaed	1	32°42'N	35°48'E
AenTrab	1	32°41'N	35°48'E
Albagyra	2	32°39'N	35°35'E
Almazar	1	32°28'N	35°47'E
Ramtha	1	32°34'N	36°00'E
Baqa'	1	31°55'N	35°41'E
Huwara	2	32°32'N	35°52'E
Kufur Awan	1	32°29'N	35°39'E
Madaba	1	31°42'N	35°46'E
Maro	9	32°35'N	35°52'E
Wadi Benhammad	3	31°18'N	35°38'E

The locations (Table I) were chosen to include apiaries maintained stationary and isolated over the last years in order to minimize influence of imported bee strains. In particular, some locations were sampled in which bees were kept in traditional box or clay hives. However, some locations also were included which were known to have imported bees. A total of 26 samples were collected. In each locality, between one and nine colonies were sampled. Each sample contained at least 30 worker bees, which were killed and preserved in 75% ethanol. Samples were split and one half was deposited in the Maro Bee Research Unit of NCARTT, the other half in the bee collection of the Institute für Bienenkunde, Oberursel.

All 26 colony samples were analysed at the Institut für Bienenkunde. From each sample ten worker bees were dissected for morphometric analysis and measured according to the methods described by Ruttner *et al*. (1978) and Ruttner (1988). Of the 41 morphometric characters listed in Ruttner *et al*. (1978) 37 were measured, excluding length of proboscis (No. 5) and cubital veins of the left wing (No. 29 and 30), resulting in 16 size characters, 11 wing angles, 7 colour characters and 3 hair characters. Measurements and colour scaling were performed using a stereomicroscope and a computer-aided measuring system based on a video system and measuring program (Meixner 1994).

Colony sample means, standard deviation, and standard error were computed for each character, thus representing estimates for the colony. Colony means were combined with data of *A. m. syriaca* (9) *A. m. meda* (9), *A. m. anatoliaca* (7), *A. m. ligustica* (10), *A. m. lamarckii* (26) and *A. m. yemenitica* (57) taken from the data bank in Oberursel, Germany. Samples of *A. m. syriaca* had been collected by Brother Adam (1952) in Palestine and Jordan, thus representing the closest approximation to the historical population available. The data were submitted to factor analysis and sample scores were plotted on principal component (PC) co-ordinates for visualisation. Subsequently, morphometric similarities were investigated by discriminant analysis, and by calculating Euclidian distances. Calculations were performed using the SPSS for Windows 10.00 statistical package.

RESULTS

General status of Jordan samples

Factor analysis of the 37 morphometric characters performed on the 156 sample means yielded 3 factors with high eigenvalues (>2.5) accounting for 58.7% of the total variation in the data. The first factor explained 41.7% of the total variation in the data and was positively associated with most size measures, but also some wing angles. The second factor accounted for 10.2% of the variation and was positively associated with characters of pigmentation and negatively with wing width, while the third factor accounted for 6.78% of the variation and was associated with the 4 wing venation angles.

Plotting colony sample scores on principal component axis 1 and 2 showed that the samples from Jordan were fairly inhomogeneous. The graph clearly demonstrates an overlap of the Jordan samples with the area occupied by the reference samples of *A. m. syriaca* (Fig. 1 a)

Fig. 1 a

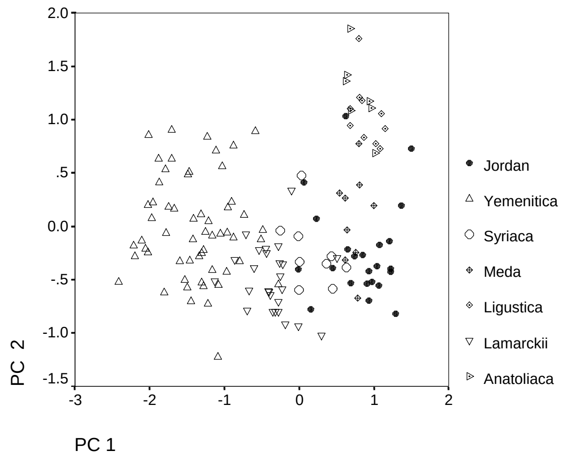
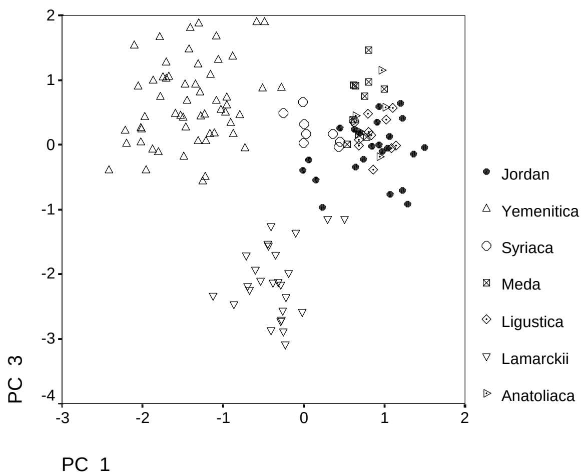


Figure 1. Sample scores on principal component axes derived by factor analysis of 26 samples from Jordan, and reference samples of Apis mellifera subspecies. Abscissa: PC1; Ordinate: PC2 (Fig. 1a) or PC2 (Fig. 1b)

Fig. 1 b



However, mean position of samples from Jordan were displaced to higher PCA1 values, indicating a shift to larger average size. In PCA2 values, they were in the identical range occupied by *A. m. syriaca*, while *A. m. anatoliaca, A. m. ligustica* and *A. m. yemenitica* differed clearly. *A. m. lamarckii* were predominantly smaller in PCA1 values but showed a with a slight overlap. *A. m. meda*, though predominantly placed at higher PCA2 values, showed some overlap with both the Jordan samples as well as the *A. m. syriaca* reference samples. Plotting PCA1 and PCA3 (Fig. 1 b) emphasized the distinction between the Jordan samples and *A. m. lamarckii*, *A. m. anatoliaca* or *A. m. ligustica*, and a partial overlap with the *A. m. syriaca* samples, but again showed some overlap with *A. m. meda samples*. By calculating Euclidian distances between sample centroids on the PCA axis, Jordan samples were closest to *A. m. syriaca*, followed by *A. m. meda*, *A. m. ligustica*, *A. m. anatoliaca*, *A. m. lamarckii* and *A. m. yemenitica* (0.74, 0.89, 1.37, 1.44, 2.22 and 2.25, respectively).

A discriminant analysis reallocated all samples into their respective groups with post-hoc probabilities of P>0.99.

Determining A. m. syriaca source locations

Morphological relation of samples to *A. m. syriaca* was determined by discriminant analysis, in which samples of Jordan were forced to be allocated into one of the subspecies used for comparison. All reference samples were allocated to their own groups with post-hoc probabilities of P>0.999. Of the 26 ungrouped samples 18 were allocated either to *A. m. syriaca* (9) or *A. m. meda* (9). Four of the remaining 8 were allocated to *A. m. anatoliaca*, 1 to *A. m. lamarckii*, and 3 to *A. m. ligustica*. In a restricted choice between *A. m. syriaca* and *A. m. meda*, 20 were allocated to *A. m syriaca* and 6 to *A. m. meda*, of which 5 were from Maro. In a choice situation restricted to *A. m. syriaca* and *A. m. ligustica*, 13 of the 26 samples were allocated to *A. m. ligustica*, 7 of which from Maro, and 13 were allocated to *A. m. syriaca*, 6 of which were from Wadi Belmhamad and Abu Zead valley.

The degree of similarity was assessed by calculating the Euclidian distances of each Jordan samples to the centroids of the reference groups, using positions in either the Factor Analysis PC space or the normalized character space of the original measures. In the PC space, 16 of the 26 samples were closest to the *A. m. syriaca* centroid. Eight were closest to the *A. m. meda* centroid, in all of these the second-closest centroid was that of *A. m. syriaca*. Two samples were closest to the *A. m. ligustica* centroid. With distances calculated on normalized sample scores in character space, 6 of the 26 samples were closest to the *A. m. syriaca* centroid and 12 to the *A. m. meda centroid*, in 5 of these the next-closest centroid was *A. m. syriaca* and in 7 it was that of *A. m. ligustica*. In 6 further samples the nearest centroid was that of *A. m. ligustica*, in two further it was *A. m. lamarckii*. In both of these cases the difference in distance to *A. m. syriaca* was minimal.

Table II shows, for the different sampling locations, the numbers of samples allocated to *A. m. syriaca* by discriminant analysis, or of those with nearest distance to the *A. m. syriaca* centroid by the two methods described above.

Table II. Allocation of Jordan bee samples to reference *A. mellifera* subspecies. N=numbers of colonies sampled in the respective location. Cells give numbers of colonies allocated by discriminant analysis (first figure) to the subspecies, or with minimal Euclidian distance in PC (second figure) or normalized character space (third figure). Empty cells= 0/0/0.

Location	N	*A. m. syriaca*	*A. m. meda*	*A. m. anatoliaca*	*A. m. ligustica*	*A. m. lamarckii*	*A. m. yemenitica*
Abu Zead valley	3	2 / 3 / 2	1 / 0 / 0			0 / 0 / 1	
Aen Alsaed	1	0 / 1 / 0		1 / 0 / 0	0 / 0 / 1		
AenTrab	1				1 / 1 / 1		
Albagyra	2	2 / 1 / 0	0 / 1 / 2				
Almazar	1	0 / 1 / 0	1 / 0 / 1				
Ramtha	1	0 / 1 / 0	1 / 0 / 1				
Baqa’	1		0 / 1 / 1		1 / 0 / 0		
Huwara	2	1 / 2 / 1	0 / 0 / 1			1 / 0 / 0	
Kufur Awan	1	1 / 1 / 1					
Madaba	1	1 / 0 / 0	0 / 1 / 1				
Maro	9	0 / 3 / 0	5 / 5 / 5	3 / 0 / 0	1 / 1 / 4		
Wadi Benhammad	3	2 / 3 / 2	1 / 0 / 0			0 / 0 / 1	

Besides Kufur Awan, which was represented by only one colony, the most consistent allocation to *A. m. syriaca* was found in Wadi Benhammad, where 2 of the 3 samples were closest to *A. m. syriaca* in all three methods, and the remaining one by at least two of the methods.

DISCUSSION

The samples collected in Jordan showed a closer similarity *to A. m. syriaca*, as represented by reference samples collected in 1952 by Brother Adam in about the same region, than to any other subspecies. None of the samples is rejected if placed together with the reference samples in discriminant analysis. At the same time, they are clearly not identical and are sufficiently different to be separated by discriminant analysis if defined as an own group, suggesting that the bee population already may have undergone some change during the last half century. PC plots indicate, that the major shift is associated with an increase in size, but also wing venation angles show some impact. They are clearly set apart from the southern and south western subspecies *A. m. yemenitica* and *A. m. lamarckii*, from the bees of

Turkey, *A. m. anatoliaca*, but also from the principal imported bees subspecies, *A. m. ligustica*.

However, there is some overlap with the bees of Iran and Iraq, *A. m. meda*. This bee is closest in its characteristics, and shows a transition into the northern range of the area of distribution of *A. m. syriaca* in Syria (Ftayeh et a. 1994). Considering mean group centroid distances, it is evident that the bees of Jordan are on average closer to *A. m. syriaca* than to *A. m. meda*. It is nevertheless surprising that, in single evaluation of the samples by discriminant analysis as well as by investigating distances, depending on the kind of analysis a variable portion was allocated as *A. m. meda*. This bee was not found to occur in the southern parts of Syria, close to the Jordan border (Ftayeh et al. 1994). However, by force allocation in a dual choice between *A. m. syriaca* and *A. m. meda* most of the samples to be determined as *A. m. syriaca*, and decisions on distances for *A. m. meda* were mostly based on very slight differences to that of *A. m. syriaca*.

The change which has taken place in comparison to the reference samples of 1952 might well been due to importation of foreign bee strains. The predominant imported breeder lines are derived from *A. m. ligustica* (Slabezki *et al*. 2000; Hussein, 2000, Blum 1956). On average this subspecies is distinctly apart and only few Jordan samples were allocated to *A m. ligustica*, showing that pure imported lines readily get dissolved in the local population. However, in a forced choice between *A. m. syriaca* and *A. m. ligustica* half of the samples were allocated to *A. m. ligustica* which strongly supports that indeed the importation has left a distinct mark on the morphology of the bees. This average change might also be responsible for surprisingly numerous allocations into *A. m. meda*, which in some traits as coloration shows intermediary values between *A. m. syriaca* and *A. m. ligustica*, and takes intermediary position in PC plots.

The variation of the bees is locally structured. Some of the bee yards, as Maro, showed a particular strong influence of *A. m. ligustica*, while other locations were obviously still closer to the morphology type represented by the reference samples. This is particularly clear in bees which had been collected from traditional hives, which took closer positions in PC plots and were persistently allocated to *A. m. syriaca*. Interestingly, some of these samples were even close to *A. m. lamarckii*, indicating a possible transition. In two of theses places, Wadi Bel Hammad and Abu Zead valley, bees are kept in relative isolation and morphological similarity to the oldest reference samples available suggests these might have also preserved other traits of *A. m. syriaca*, and thus can be considered source populations for conservation of the subspecies. For this purpose, 26 colonies were purchased to serve as a core to be maintained under controlled mating conditions at Maro Bee Station in Jordan to serve as reference strain for future investigations on the performance and behavior of the indigenous of Jordan, *A. m. syriaca*.

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