Geometric morphometrics analysis of honey bee populations from Greece

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Introduction

Geometric morphometrics using homologous landmarks (Bookstein, 1991) has been shown in many occasions (Rohlf and Marcus, 1993; Debat *et al.*, 2002) to be very powerful tool in evolutionary studies to explore intraspecific variation at the population level.

According to Ruttner (1988) morphometrics analysis, four distinct honey bee races should exist in Greece: *A.m. macedonica* in Macedonia and Thrace regions, *A.m.cecropia* in Thessalia, Peloponnese and Kyklades islands, and *A.m.adami* in Crete. Bees of Ionian islands were assigned to *A.m.carnica* race, while nothing was mentioned about the rest of Aegean islands. However, in a preliminary study of ours (Hatjina *et al.*, 2002) using geometric morphometrics it was shown that only honey bees from some Aegean islands were completely differentiated from the rest of the populations studied.

The aim of this study was to investigate the existence of variability in between and among honey bee populations from 28 large different areas of Greece. Honey bee samples from several apiaries were grouped together to form the population for each of the 28 large areas.

Methodology

A geometric morphometrics analysis using the coordinates of 19 landmarks located at vein intersections of the left wings was contacted on a sample of 578 honey bees collected from 28 different areas of Greece. Landmark coordinates were processed, using MS Excel and NTSYS (Rohlf 1990) program packages. The phylogenetic tree was constructed according to UPGMA method (Sneath & Sokal 1973).

Results

- Low intrapopulation variability was detected in populations from Xanthi, Rodopi (Fig. 1), Lakonia, Messinia, Korinthos (Fig. 2), Lefkada, Ithaki, Kerkyra (Fig. 4), while high variability was detected in populations from Evros, Chalkidiki (Fig. 1), Kythira (Fig. 2), Rethimno (Fig. 3), Kos (Fig. 5).
- The data indicate that Greek honey bee populations are characterized of high hybridization (Fig. 6).
- The topology of the UPGMA phylogenetic tree confirms that the populations studied are mixed (Fig. 7).

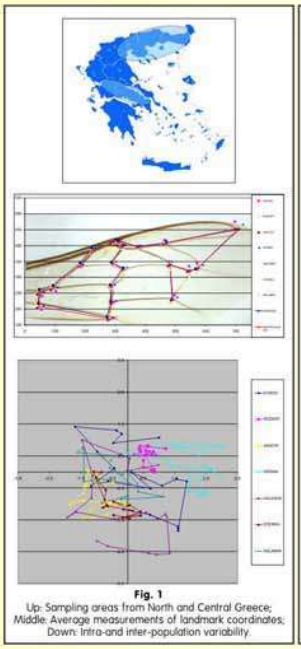

Fig. 1 Up: Sampling areas from North and Central Greece; Middle: Average measurements of landmark coordinates; Down: Intra-and inter-population variability.

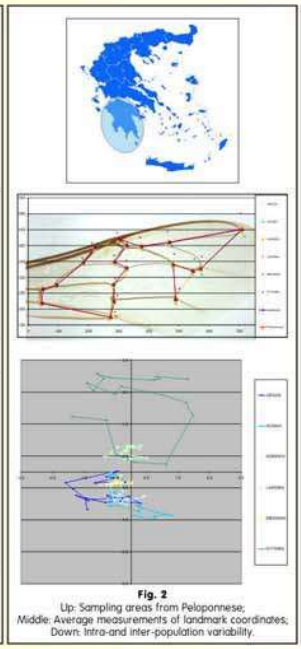

Fig. 2 Up: Sampling areas from Peloponnese; Middle: Average measurements of landmark coordinates; Down: Intra-and inter-population variability.

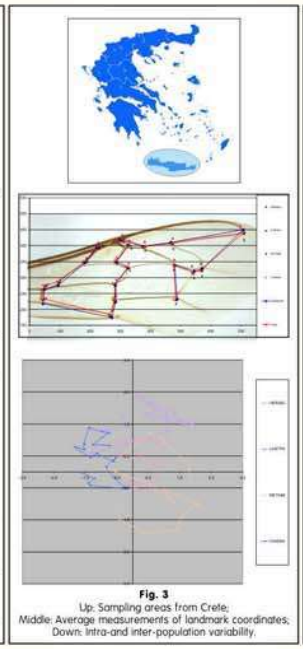

Fig. 3 Up: Sampling areas from Crete; Middle: Average measurements of landmark coordinates; Down: Intra-and inter-population variability.

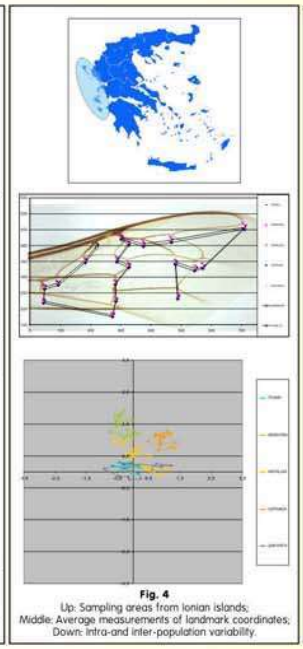

Fig. 4 Up: Sampling areas from Ionian islands; Middle: Average measurements of landmark coordinates; Down: Intra-and inter-population variability.

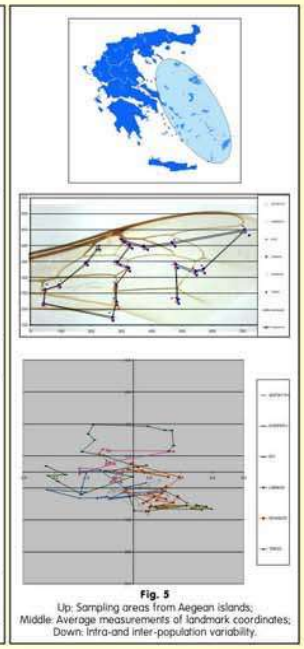

Fig. 5 Up: Sampling areas from Aegean islands; Middle: Average measurements of landmark coordinates; Down: Intra-and inter-population variability.

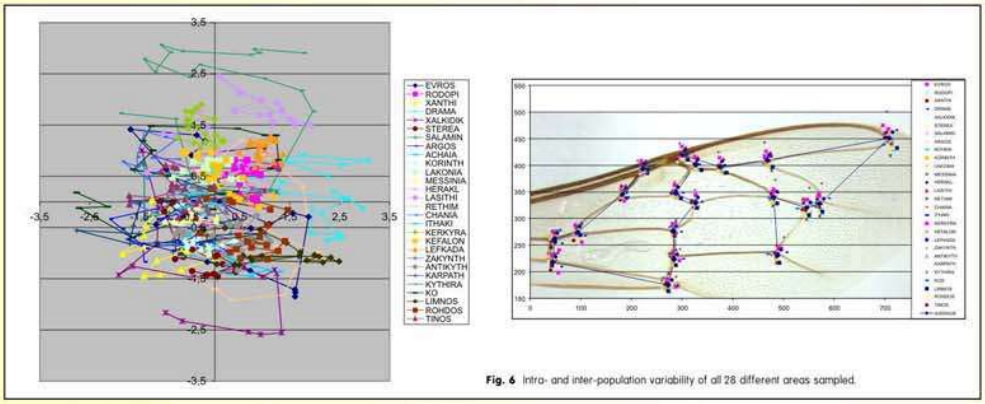

Fig. 6 Intra- and inter-population variability of all 28 different areas sampled.

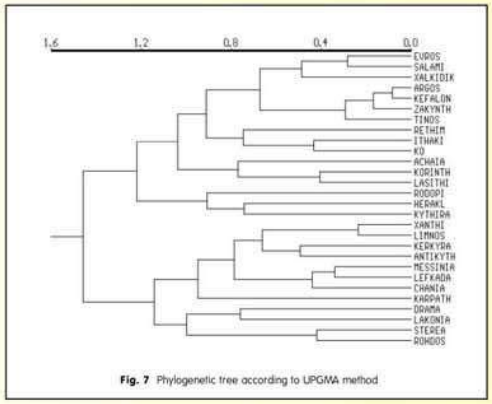

Fig. 7 Phylogenetic tree according to UPGMA method

Conclusions

- The present study clearly shows that extended hybridizations has taken place in honey bee populations from Greece, even in Ionian and Aegean islands, probably due to beekeeping manipulations (migratory beekeeping and commercial breeding).
- These results are confirmed in the UPGMA phylogenetic tree where populations from N. Greece are mixed with those of Peloponnese (S. Greece), Crete and the rest of the islands. It is interesting to note that the 'average' pattern revealed in populations from areas of Peloponnese fit exactly the 'average' pattern of the whole Greece.
- The low intrapopulation variability detected in some of the areas might show a lower level of hybridization in these areas compared with the ones showing high intrapopulation variability.
- The above results are partly in disaggrement with a preliminary study of ours concerning populations of the mainlad and Aegean islands (Hatjina *et al.*, 2002) where we detected a 'Macedonia like group' in the mainland and part of Crete while the populations from Rodos, Astypalaia and Ikaria (Aegean islands) were clearly differentiated from the rest ones and formed a distant group.
- Further studies are needed to conclude the above work, and to detect any distant populations with low variability, which could present what has been left from the distinct honey bee races mentiond by Ruttner (1988) in Greece.

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