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Bees, honey, larvae and pollen in biomonitoring of atmospheric pollution

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SUMMARY. The value relations of lead, chromium, nickel and cadmium as detected by automatic monitoring devices and recoderd by chemical analysis from monthly samples of the honey, pollen and larvae of honey bees are reported and discussed. The experiment was conducted at Modena in 1989 using five monitoring stations deployed around the city, each consisting of two hives. No positive correlation between the values for the biological matrices and for the abiological data was found, although there appears to be a certain latency of the pollutant in the former as compared to the latter. In most cases the plotted trends of the data, especially for lead in honey, are overlapping.

Key words: cadmium, chrome, honey bees, lead, nikel, pollution.

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INTRODUCTION

The biggest problem of the large metropolis is also precisely what makes it a city-very high population density within relatively small confines. Having arisen for reasons of defense, the city has developed in the course of time into an important economic and trade centre, taking on despite itself a strategic role in terms of logistics. By the end of the last century the emergent forces shaping the destinies of the great metropolitan areas like London and Paris had even dictated the construction of underground systems of mass transport.

By contrast, the cities of Italy, which had developed around an historical core that was anything but amenable to motor traffic, suffered, so to speak, at the hands of economic development. *Vehicular traffic is today the leading cause of degradation in the nation's cities.* Currently, the monitoring of pollutants in the urban environment is more and more the task of expensive automatic networks, although several biological indicators are also being studied and, in some cases, even implemented.

The bee is one of these bioindicators. A number of researchers (Accorti and Persano Oddo, 1986; Celli *et al.*, 1987; Stein and Umland, 1987; Celli *et al.*, 1988) have become interested in it because of certain traits it possesses. Every honey bee gathers nectar and pollen from numerous flowers (about 1000 daily), honeydew from aphids and propolis from various plants; it consumes water in considerable quantities (up to a half-litre per day in warm climates), alights upon the ground and leaves, and has a hairy body that picks up airborne particles.

The present paper reports the results of a study conducted from 1987 to 1989 in the northern Italy city of Modena to compare the amounts of contaminating lead, chromium, nickel and cadmium found by chemical analysis in the honey, pollen and larvae of bees against the amounts of the same pollutants recorded by an automatic monitoring system. The aim of the experiment was to collect sufficient data to determine the set-points for the beehive as «monitoring instrument». The resulting values of the two systems — the biological and the abiological — are assumed to be different in that the monitoring devices collect air samples only, while the bees, as we have mentioned, provide more complex information. The initial working hypothesis was to collect enough data to upgrade the interpretation of the «message» so as to construct a model which would convert the biological values into an indicator of the average level of pollution within the territorial range of the bees.

MATERIALS AND METHODS

Several stations around the city were set up, each with one hive for the first two years and two hives in the last year of the study. The criteria for their deployment included the proximity to or distance from arteries of heavy traffic, the existence of gardens and parks for at least minimum survival of the bees, and the safety of residents, ie keeping them at a safe remove from the bees' pollinating routes so as to reduce any risk of aggression.

Once a month from April to September «young» honey (ie gathered and stored by the bees over the preceding fortnight as determined by measuring its water content as well as by the experience of the keepers), pollen (gathered throughout the month in special traps) and larvae (of varying age) were removed for chemical analysis. The honey was also subjected to melissopalinological analysis to determine pollen content and, hence, to establish the preferential routes followed by the bees each month. The automatic detectors, which were deployed near the hives, featured vacuum pumps (20 l/min) and a diaphragm filter of cellulose ester. Each sampling covered 24 hours, and the average data of the last two weeks of each month were used for comparison.

RESULTS AND DISCUSSION

The asymetrical distribution of the statistical data both from the automatic detecting system and from the biological products can be traced to a normal log with the occasional presence of outlier. The two-way analysis of variance (between months and between areas) showed better results after logarithmic transformation of the data, which improved the homoschedasticity.

For reasons of space, only the data for the last year, ie when two hives were operating at each station, are discussed. A comparative evaluation of the results of the chemical analyses made it possible to determine which of the three matrices — honey, pollen, larvae — was the most reproducible in detecting the amount of metals and, hence, the best monitoring indicator.

The graphs in Fig. 1 and 2 show the expected low correlation between the monthly values of lead, chromium, nickel and cadmium recorded by the automatic detectors and the matching ones found in honey, larvae and pollen. Note that at least for lead in honey, there appears to be a certain latency of the value registered via the biological as compared to the abiological system (anti-clockwise). The phenomenon deserves further study, especially in relation to the environmental pathways of these pollutants.

The overall patterns of the honey-data plots in Fig. 1 more or less overlap. The convergent or divergent tendencies shown at times by the curve-segments are assumed to depend on the different foraging areas of the two hives (Fig. 3). On the whole the segments show a close match especially for lead, whereas the readings for nickel, cadmium and chromium were not constant enough, showing occasional yet pronounced oscillations.

The pollen in comparison to the honey differences were considerable, a fact already reported by Celli *et al.* (1987). A somewhat similar pattern also held true for larvae: the accumulation of pollutants varied widely from month to month while registering an overall trend between that of honey and pollen.

These differences with respect to honey suggest several interpretations. One explanation

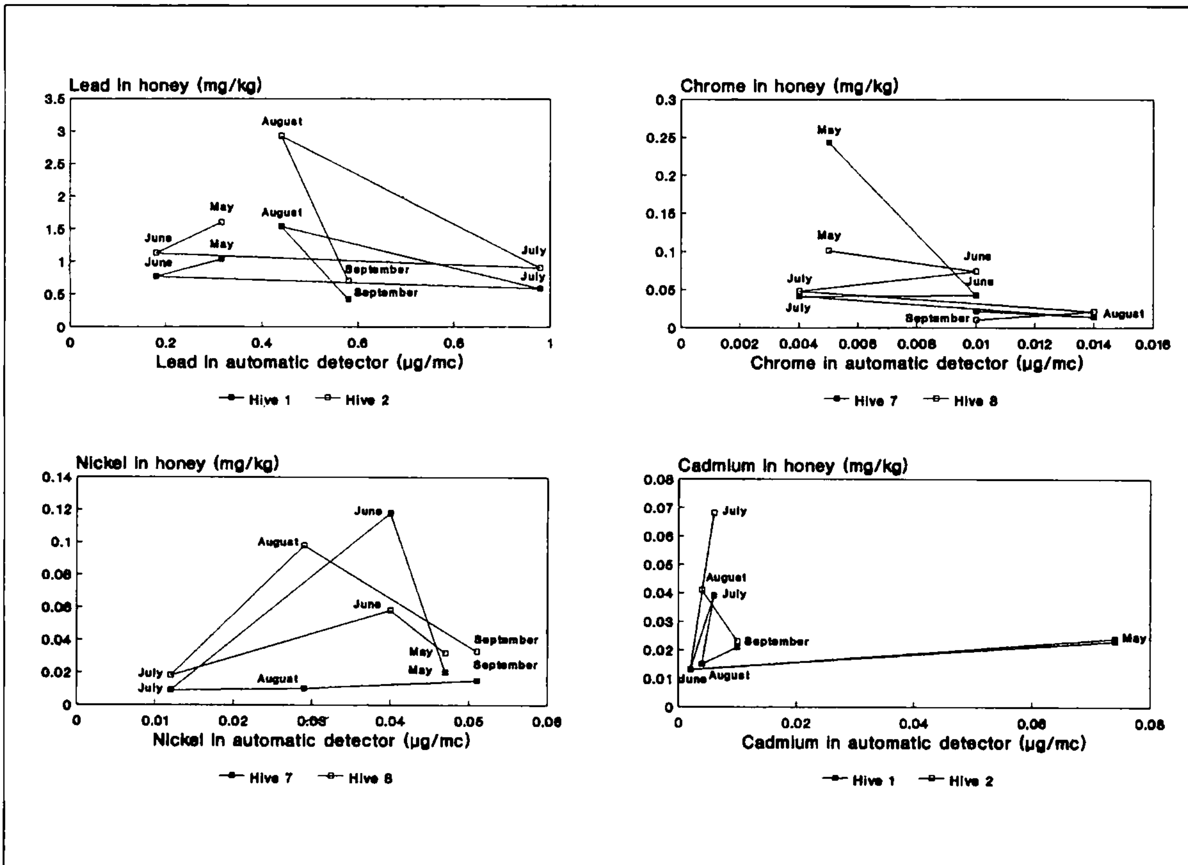

Figure 1. Lead, chromium, nickel cadmium: Trends detected in honey compared against those recorded by automatic detectors in pairs of hives deployed around the city of Modena in 1989.

might be that the bees, being insensitive to the presence of heavy metals, collected pollen (less protected than nectar in flower) from groups of flowers and plants that were exposed, for example, to very intense pollution from automobile exhaust. This assumption is highly plausible in that the larvae, which feed mainly on pollen and honey, are natural accumulators of those contaminants that the bee unwittingly collects and deposits in the hive. Thus the larvae that feed on such a diet will show strong traces of contaminants. The findings show that the proportion between overall median concentration (µg/m^3) registered by the automatic detector system and that in honey (µg/kg) can be estimated as to order of magnitude at about 1000/2000 for nickel and lead, 2000/4000 for chrome and 3000/5000 for cadmium. More precise estimates can be expected from a model that takes into account the latency of accumulation in honey.

Given its stability and reproducibility between hives, honey would appear from the results of the present study as the best biological indicator in a system designed to monitor toxic metals. It should be underscored too that the double-hive station seems to be indispensable to the reliability and to a better interpretation of the biological data.

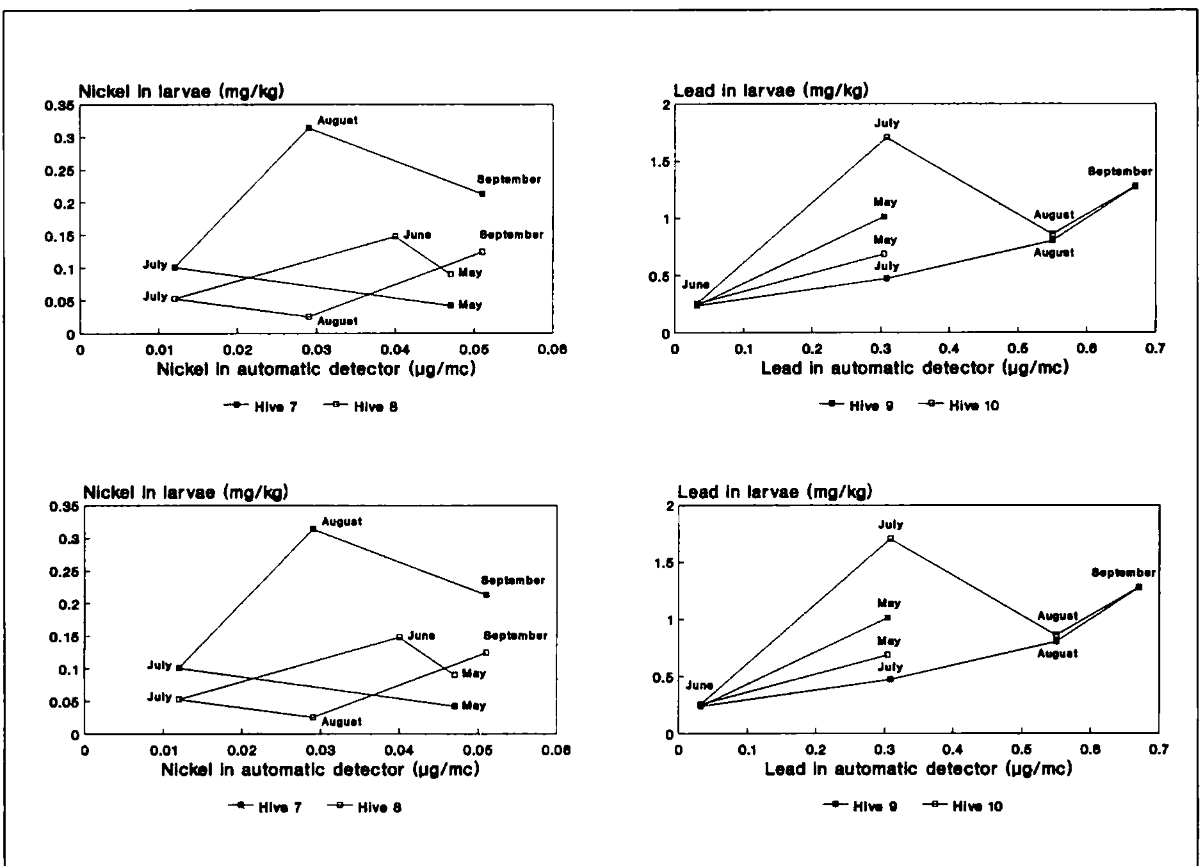

Figure 2. Lead and Nickel: Trends detected in larvae compared against those recorded by automatic detector in pairs of hives deployed around the city of Modena in 1989.

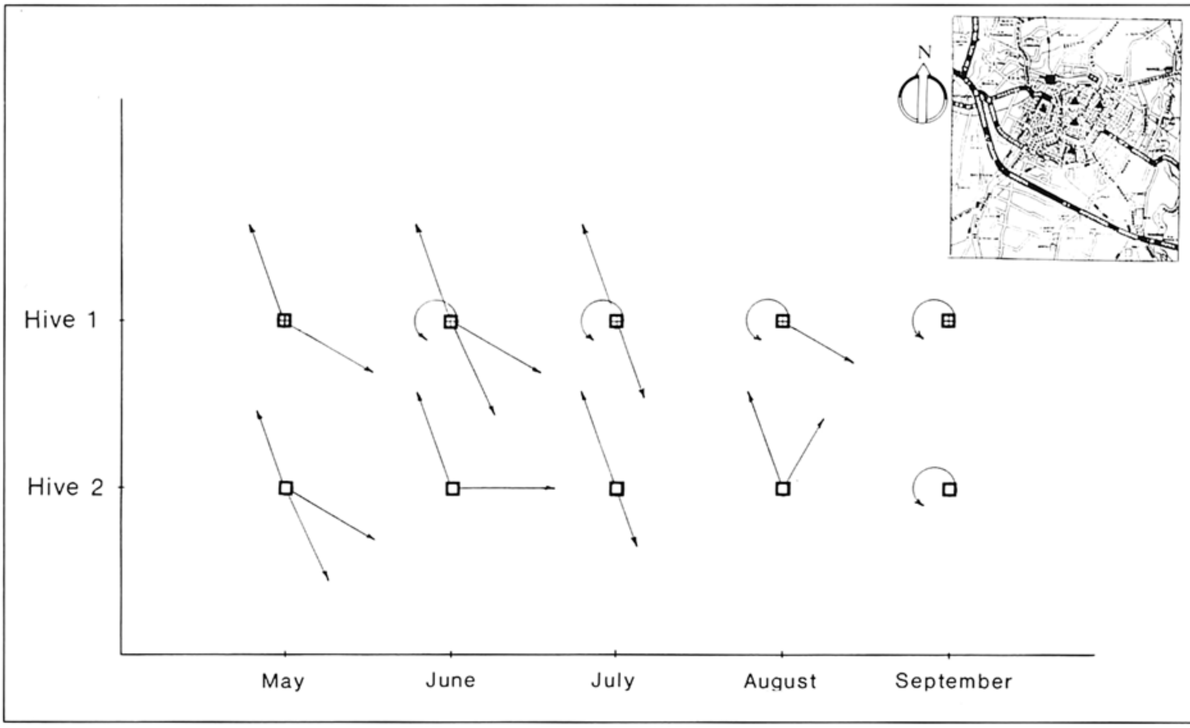

Figure 3. Foraging routes of bees from hives 1 and 2 at the city's northernmost monitoring station.

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