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Colour change and habitat preferences in *Mantis religiosa*

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Abstract

A population of praying mantids *Mantis religiosa* L. was studied in a submontane habitat near Vicenza in Northern Italy. Sixty-three mantids were observed and studied in the field with the mark and recapture method to obtain ecological information about the coloration patterns, habitat preferences and strategies of this species. Additionally, a population of mantids was housed in artificial conditions to estimate the presence of colour changes in adults. A regular distribution of the coloration of the insects was found in the field during the changing of the season, and partial colour changes not linked to the substrate or the moult process were observed in artificial conditions. The basic structure of the preferred habitat of *M. religiosa* is described as a pattern of grassland and thorny bushes of the Rosaceae family.

Key words: Mantodea, *Mantis religiosa*, colour, habitat, ecology.

Introduction

Mantis religiosa L. is a large insect, a predator with a worldwide distribution. It cannot be found easily, because of its extraordinary mimetic abilities with its cryptic shape, coloration and behaviour. *M. religiosa* is probably the commonest and most widespread mantis in Europe, with one of the widest distribution among the taxa of Mantodea: it is present also in Africa and Asia and has been introduced in recent times in Australia and North America.

M. religiosa can often be found in fields with two main different colorations: grass-green and brown shades from yellow-ochre to brown-sepia. Some studies exist on the colour change in *M. religiosa*, the ability of this insect to change its colour from green to brown or vice versa just after a moult. Older studies (James, 1944 and Ergene, 1952 in: Grassè, 1975) relate this change to the colour of the substrate where the moult occurs, whereas more recent ones (Jovancic, 1960; Grassè, 1975; Lopez, 1998) relate it to humidity, air temperature and light intensity. The colour changes are reported, however, only for juvenile stages or strictly in relation to the moult. Very little is known about the colour in the adults. The distribution of the colours that characterise a population of mantids has been related here to the substrate and season and the presence of colour changes in the adult stage have been investigated.

The widespread distribution and the wide range of colorations of this insect suggest an extraordinary adaptive ability in many different kinds of microhabitats and plasticity in their colonisation. In this work we tried to estimate if habitat preferences exist that are compatible with the insect's ability and how they can suggest the directions of future dispersal of this insect.

Materials and methods

The area of the study was located in Italy, near Vicenza, on the SSW slopes of the Mount Grappa complex (45°48'09"N 11°44'34"E), at about 573 m above sea level, with an extension of 1176 m^2 and an inclination of 35%. The vegetation is typically meso-xerophilous, composed of grandniece grass interspaced with brush groups of *Cornus sanguinea* L., *Rosa canina* L., *Fraxinus ornus* L., *Prunus domestica* L., *Rubus* sp. and surrounded by a compact oak forest that isolates the area from other similar ones. Nine samplings of the population, in nine subsequent weeks, were performed with the mark and recapture method (Begon, 1979) between August and October 2003. The whole area was carefully investigated at every level of vegetation to find and capture mantids. Adult mantids were marked with a progressive number as a unique ID mark, painted with an alcohol waterproof pen on the tegmina, under the lower face of the abdomen and when necessary also on the pronotum. For every encounter the following were recorded: sex, number, colour and position of the mantids on a map of the area, divided for study purposes into 10 × 10 m sectors. In the statistical analysis Student's t-test was used at significance level 0.05 to compare mean movements of males and females, combining all the data of the different samplings, and to compare the quantity of mantids of a certain colour captured in male or female populations in the search for a link between sex and coloration. Climatic data were obtained from a meteorological station located in Romano d'Ezzelino, about 1.5 km from the study area, with the same sun exposition. The percentage of brown mantids (both males and females) in the total population captured, each week was compared with mean weekly temperatures recorded, to evaluate the presence of a correlation between them.

In order to investigate the kind of resources and habitat character that this mantis would prefer, we considered the typology and structure of the vegetation in the study area in terms of what was necessary and desirable for a mantis: a coloured background to mimic, a place to move, to hide and to hunt. A Chi-square test with Yates's correction was used to test the existence of a correlation between the vegetation pattern and mantid distribution on the field, using the distribution of plants as expected values for mantid distribution.

Thirty immature mantids (fifteen males and fifteen females, last nymphal stage) were captured in the fields of Torreselle, Mossano, Campanella, near the town of Vicenza (North Italy) and when reared were used to observe the colour changes in adult stage in artificial conditions from their last moult between July and August to their death between October and November. All the specimens were kept in separate cages (10 × 11 × 12 cm, with transparent plastic walls and opaque roof; we chose colours usually rare in a field, i.e. pink for females, blue for males), in the same room and ambient conditions (temperature 20 to 23 °C, humidity 60 to 80%), near a window, under normal daylight illumination. All the mantids were fed with brown specimens of *Calliptamus italicus* (L.).

Results and discussion

Colour

In the field, the total population of the area was estimated with the mark between 70 and 80 individuals (max. density = 0.07 mantids/m^2), and 63 of them were marked during the period of the study.

From August to October, in the field, a regular distribution of the two main colorations was found (figures 1, 2, 3). Both in males and in females, brown specimens were more often encountered in the early part of the season whereas with progression of the summer and the coming of autumn green ones were more abundant. Mantids were never observed on a tree or on the top of a very high bush, but the variability of the colour of the other levels of the vegetation should allow even the smaller percentage of brown mantids to find a suitable habitat throughout the season, maintaining the variability of the population. A t-student test confirmed (t = 0.14 with 11 d.f.) that the quantitative differences between male and female populations of brown mantis captured are owed to random factors and not to the different sex.

If we compare this colour trend (figure 1) with the climatic trend (figure 4) we can see some analogies between the decrease of brown individuals in the area and the decrease of temperatures (also proportional to light intensity) and a less evident increase of humidity, which can be represented by a linear regression (figure 5) From this perspective our results in the field seem to show a link between the colour of the adults and both climatic conditions and the substrate colour.

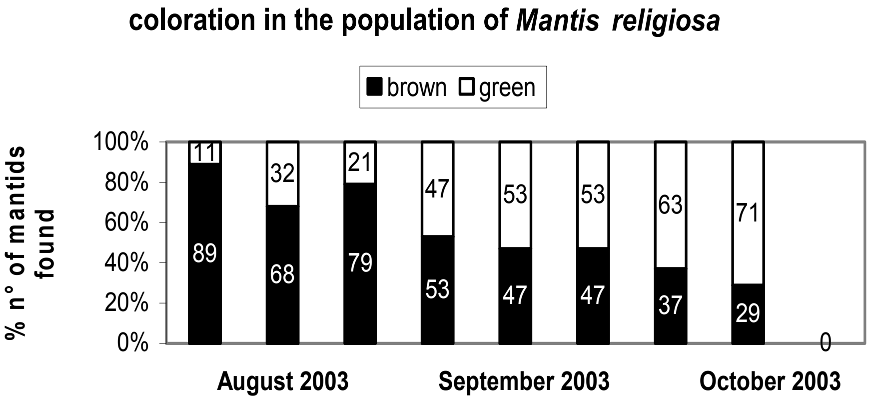
coloration in the population of *Mantis religiosa*

Figure 1. Percentage of mantids found in every sampling grouped by colour.

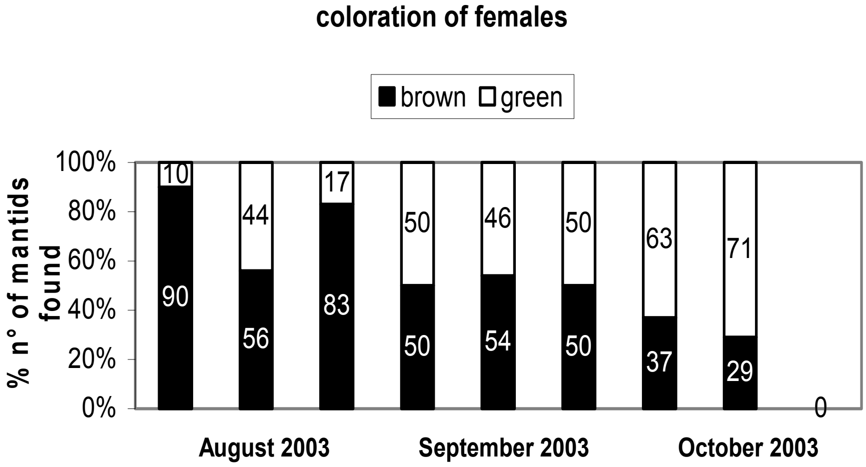
coloration of females

Figure 2. Percentage of females found in every sampling grouped by colour.

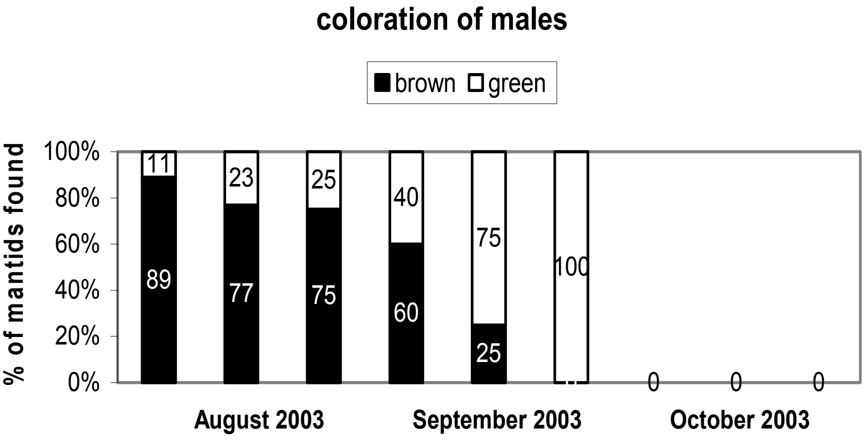

Figure 3. Percentage of males found in every sampling grouped by colour.

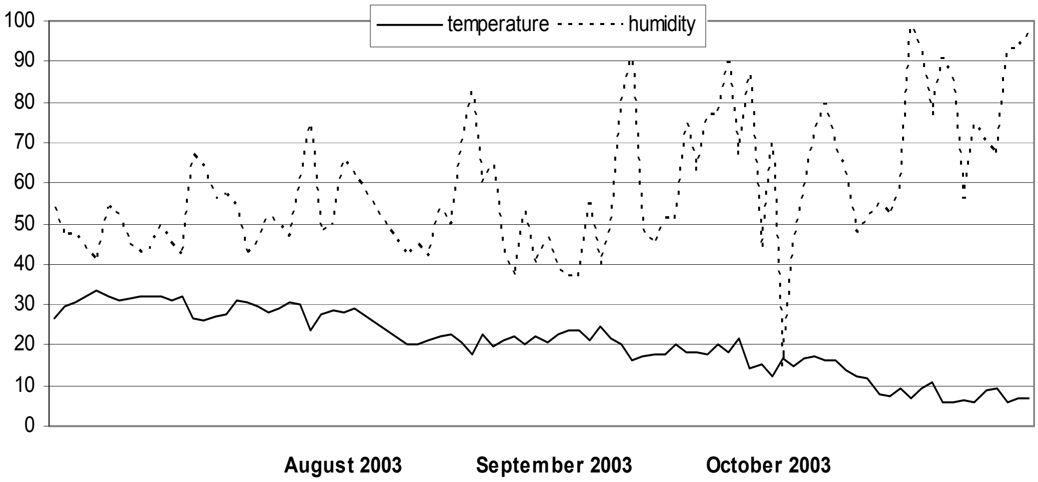

Figure 4. Humidity (%) and mean temperatures (°C) recorded from August to October 2003.

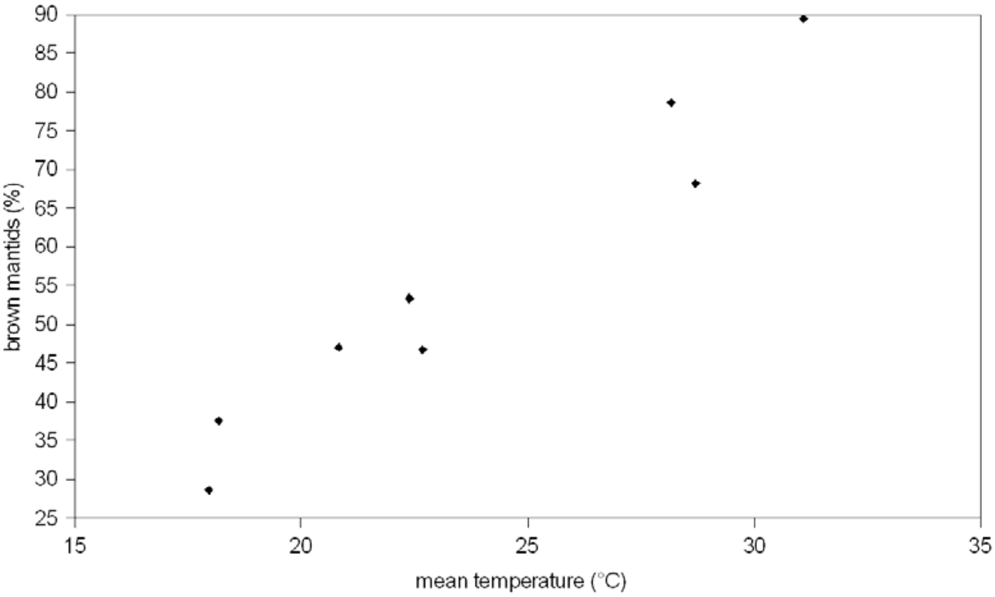

Figure 5. Comparison between weekly mean temperatures and percentage of brown mantids recorded in every sampling from August to October 2003.

In artificial conditions, four of the five brown females housed in cages, which survived after the end of the summer, showed an incomplete but clearly visible variation in green tones in body parts rich in living cells, such as the head, limbs, and lower face of thorax and abdomen, with a progressive intensification towards late autumn, when only the tegmina and part of the pronotum remained brown (figure 6). Their cages were filled with an earthy soil and some dry twigs, but no green components were present.

This should show the ability of this insect to change colour even in the adult stage and without using the renovation processes of the moult.

The change was in this case much slower and incomplete; it was recognisable only after several days and not in a few hours, and it did not involve all the body. Even in artificial conditions the substrate colour seems to have no influence on it, but the process was probably activated by the climate conditions, mostly by the reduction of daylight intensity that occurs at the end of the season.

Figure 6. A brown mantis changing colour to green in late autumn.
(In colour at www.bulletinofinsectology.org)

Habitat

The different kinds and distribution of the various plants species in the study area were compared with the distribution of the mantids (figure 7). Whereas about 2/3 (70.55%) of the area were covered with grass and 1/3 (29.45%) with bushes, more than half (59.81%) of the mantids were encountered on or near (less than 1m away) bushes, showing a large preference for the intricate and thorny genus *Rubus*. A Chi-square test confirmed that the differences between vegetation and mantid distribution (χ^2 = 56.39, with 5 d.f.) are not owed to random factors and a mantis probably chooses a plant to live on regardless of its abundance.

Average mobility seems to confirm this preference with wider average movements in open spaces (males: 18.04 m/week; females: 7.68 m/week) than nearby bushes (males: 3.46 m/week; females: 2.99 m/week), with an insignificant difference between the two sexes (t = 1.02, with 38 d.f.). Small bushes seem to be the best place to spend most of the time, probably hunting and hiding, and the grass on the ground the best and fastest way to reach another bush unnoticed by predators.

The direction of movements has shown another interesting clue. Out of nine mantids recaptured at least three times, from the beginning to the end of the season, only one returned to the starting-point; the others moved on average 13 m to North North-East, in conformity with the obstacles on the ground.

Conclusions

As observed by Lopez (1998) the distribution of the two main colorations in males and females seems to confirm the absence of a link between sex and coloration, and probably the relationship with the main colour of the

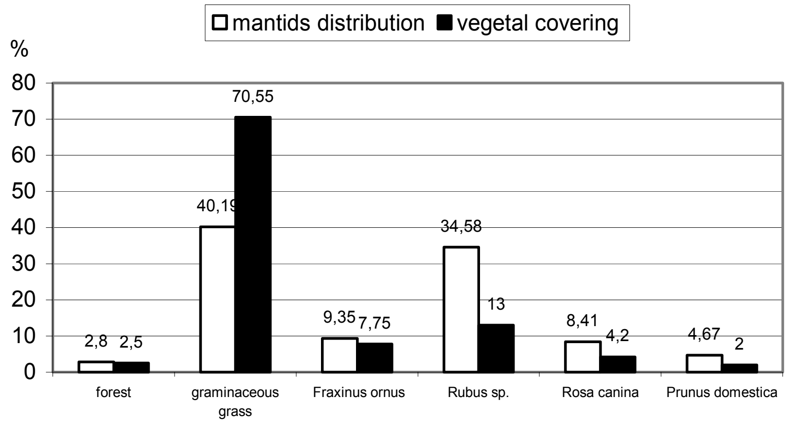

Figure 7. Comparison between mantid distribution and vegetal covering in the study area. All numbers are expressed in percentages.

lower levels of the vegetation, namely yellowish-ochre grass and thorny brown bushes covering the field under the burning sunlight of the hot summer days, and greenish leaves taking their place after the first autumnal rain, when the light is gloomy and the shadows stretched. This distribution of colours is possibly related to the places where the species should live to be most well-hidden: this change of colour occurred only on the lowest levels of the vegetation such as grass or small bushes. In the upper levels, such as high bushes or trees, the brown of the cortex in autumn took the place of green, fallen leaves and the direction of the change was opposite and probably disadvantageous for most of the mantids. Comparing the data obtained from the field study with those from indoor housing, we see that the hot sun, low humidity and intense light of summer promote the production of brown ground vegetation and brown mantids, more moderate temperatures promote higher humidity and low light intensity promotes green vegetation and mantids. But probably two other factors explain this colour distribution: predators detect and eat mantids that do not match the changing environmental colour and the mantids possibly actively prefer microhabitats that match their own coloration.

The colour of the substrate in the field should be considered as a co-factor of the success of this strategy of *M. religiosa* but not its main direct cause.

M. religiosa is revealed to be a sedentary insect not needing wide spaces, but its wide distribution suggests a slow but efficient dispersal ability to colonise new places. This is evident even in juvenile stages (Hurd and Eisemberg, 1984) which disperse to reduce the density of the population, as well as the occurrence of competition and cannibalism.

The preferences recorded by Lopez (1998) for *Rosa* sp. evidence the suitability of the Rosaceae family for *M. religiosa*, possibly dependent on the particular structure of this plant, which offers intricate and rich hiding places and thorns, protecting the insect against large predators, is easy to climb, and attractive to most phytophagous insects and natural prey of *M. religiosa.* The choice of a habitat with a vegetation pattern composed of grass and thorny bushes suggests that many fields of temperate-dry zones are suitable for *M. religiosa* as possible colonisation areas and seems to explain the success of this species in its native continents (Asia and Africa) as well as the recent anthroporic diffusion in Northern America and Australia, whereas the tropical forests of South America seem to remain a solid barrier.

In northernmost regions an optimisation of movements is probably used to maximise the sunlight exposition during the coldest days, related to the field exposition, as supposed also by LOPEZ (1998). This behaviour also shows an apparent absence of territorialism, such as the control of a circumscripted area for a long time.

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References

BEGON M., 1979.- *Investigating on animal abundance: capture-recapture for biologists*.- Edward Arnold, London, UK.

GRASSÉ P., 1975.- Pigments des insectes, pp. 163-167. In: *Traité de Zoologie, Anatomie, Systématique, Biologie* (Grassé P., Ed.) Vol. 8.- Masson, Paris, France.

HURD L. E., EISEMBERG R. M., 1984.- Experimental density manipulations of the predator *Tenodera sinensis* (Orthoptera: Mantidae) in an old-field community. I. Mortality, development and dispersal of juvenile mantids.- *Journal of Animal Ecology*, 53: 269-281.

JOVANCIC L., 1960.- Genese des pigments tegumentaries et leur rôle physiologique chez la mante religieuse et chez d'autre espèces animales.- *Museum d'Histoire Naturelle Beograd*, 29: 1-114.

LOPEZ A. I., 1998.- *Un insecto de leyenda en Leon:* Mantis religiosa.- Universidad de León, León, Spain.

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