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TEMPORAL VARIATION OF AN ODONATA SPECIES ASSEMBLAGE (ROME, ITALY)

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The Castel Porziano estate is a well preserved coastal Mediterranean woodland, rich in still bodies of water, where odonatological studies have been taking place since the '50s. Adult Odon. were recorded for the entire estate in 1997 and 1998 (March-Nov.; 2 checks each month). 1,838 adults (22 spp.) were marked, to assess their movements. The results showed that in 1997-1998 a total of 31 spp. were present. This number is very close to the number (29) recorded up to 1976. Variation in species assemblage in 16 ponds was observed from 1997 to 1998. Although the overall species similarity was preserved, the number of spp. for each pond and the number of ponds inhabited by each sp. significantly increased from 1997 to 1998. In regard to the adult movements, 251 marked individuals of 13 spp. were re-sighted only at the same ponds where they had been marked and 30 individuals of 6 spp. were sighted at different ponds. Among the latter, the majority moved within a range of a few hundred metres, but some individuals were able to fly quite far, e.g. 2.7 km (*Coenagrion puella*) and 5.8 km (*Libellula depressa*). It is concluded that the assemblage variation for the entire estate was small, varying more on a decennial than on an annual scale, but for a single pond variation is wider on both time scales. The quick recolonization among ponds, due to the adult's movements, appears to be the cause of greater stability at mesoscale rather than at local scale.

INTRODUCTION

There is an increasing interest in evaluating the variation in time of diversity, in order to understand if it is linked with a general modification of the environment, due or not to human activity. However, if we want to use diversity variation as a biological indicator of environmental variation, it is necessary to distinguish between the variation due to intrinsic ecological characteristics of the taxa and that, if any, due to its responses to the changing environment. Also, it is interesting to understand what is the correct temporal and spatial scale from which to observe significant variation. Species diversity of the Odonata is beginning to be used as an environmental indicator (e.g.

CLARK & SAMWAYS, 1996), but often the species presence is assessed from short term observations, some times over a flight season, rarely over a year and very rarely over a longer time span. However, it is well known that Odonata have a different capacity and a different propensity regarding dispersal, so that some species are classified as "wanderer" (SCHMIDT, 1978) or as obligate or facultative migrants (CORBET, 1999). Furthermore, they often inhabit unstable small bodies of water. Consequently, the Odonata fauna of a biotope may change from year to year, both through extinction and colonization events. The best way to clarify this problem is by long-term study, unfortunately very rare in scientific literature. In fact, MOORE (1991) cited only six long-term studies on dragonfly populations in European still bodies of water, of which some were newly created so that the variation of the Odonata assemblage was also determined by the ecological succession.

The aim of this study is to elucidate the variations of the Odonata assemblages both during long and short time spans in several biotopes in a stable environment. To achieve this goal we chose the presidential estate of Castel Porziano, which retains some of the natural characteristics once common in Mediterranean coastal areas. Here we recorded for two years the species presence in several ponds. Since these ponds are hydrologically isolated, we also assessed the possibility of adult displacement. At Castel Porziano, a series of odonatological observations have been made since the early fifties, starting with the pioneer studies of O. Castellani, and continuing with C. Consiglio's works and those of his pupils. So, even if there was no prearranged long-term monitoring program, data on the Odonata assemblages from the last decades and from two recent years were available for comparison.

STUDY AREA

The Castel Porziano estate ranges from the outskirts of Rome to the Tyrrhenian coast, in a typical Mediterranean climatic zone. The estate area (60 square km) is covered mainly by pristine Mediterranean woodland. There are more than one hundred small bodies of still water (ZARATTINI et al., 1999), while the running waters are limited to two tiny rivulets on the northern boundary, and a stretch of a concrete ditch coming from a nearby urbanized area. These were not considered in our study. Nearly all the ponds are fed only by direct rainfalls (FRICANO et al., 1999), but from spring to autumn there is a long dry season, typical of a Mediterranean climate. Consequently, the ponds are subject to strong water level variation, and several are temporary (autumnal type, sensu WARD, 1992). Almost half of the ponds are ephemeral and unsuitable for Odonata. The studied ponds were more or less elliptical and relatively small (mean surface and its S.E. were 1390 and 275 square metres, respectively). A more complete description of estate and pond features is given in CARCHINI et al. (2003).

METHODS

ASSESSING OF ODONATA ASSEMBLAGE. — The records are based on the presence of adults, even when only a single specimen was sighted. During 1997, 16 ponds were surveyed from mid-March to October. During 1998 the ponds were increased to 23, and, due to climatic variations, the observation period was from mid April to late November. In both years, the observations started in spring before the first sighting of adult specimens, and lasted until autumn when only rare individuals were still on wings. Each pond was checked fortnightly by two of the authors walking along the banks. The checking started about 10.30 and ended at about 16.30, and no checks were made when there was cloudy or windy weather. In August, because of the estate rules, entrance was forbidden for the last three weeks, so the checks were limited to one visit for each pond. Although we chose the ponds among those presumably permanent, seven out of 16 dried out in late summer of 1997. On the other hand 1998 was rainier and six of the ponds which had dried out in 1997 retained the water during the summer. To assess whether the overall Odonata assemblage varied at short term, we compared the species distribution in 16 ponds checked both in 1997 and in 1998.

The species identifications were made by sighting or, when necessary, specimens were collected and the key of CONCI & NIELSEN (1956) was used. At Castel Porziano both *Chalcolestes v. viridis* (Vander L.) and *C. viridis parvidens* (Artobolevski) are present. According to COBOLLI et al. (1994), these should be considered separate species. Because they are hard to distinguish in the field, in our study we considered only the occurrence of the genus.

The species' presence for the entire estate from the 1950s to 1976 was taken from UTZERI et al. (1977). This paper does not report indications as to which pond the specimens were collected from, and considers all *Chalcolestes* specimens as *Lestes viridis*.

MARKING AND RE-SIGHTING OF ODONATA. – The Odonata were marked and re-sighted in all the 16 ponds checked in 1997. It is necessary to note that the individuals were not marked when teneral, so maiden flights were excluded in our data. The specimens, caught with an entomological net, were marked immediately on the ponds. One or two small spots were painted with a very fine brush, on the inferior surface of the left posterior wing for the Zygoptera, and on the right wing for the Anisoptera. The paint was acrylic, with water as solvent, but water-resistant after drying for a few minutes. The colour combinations allowed us to single out the pond where the specimen was marked. A progressive number was also painted on the left wing of the Anisoptera, with a non-toxic permanent pencil. The marked Odonata were allowed to fly away, and those specimens that were not able to fly were eliminated. Because our goal was to assess the possibility of dispersal on the whole estate, and this is too large to allow simultaneous checks in all ponds, we only recorded the marked specimens during fortnightly pond checks described above, using short-focus binoculars to check spots and numbers.

DATA ANALYSIS. – The presence/absence of each species for each pond and for the entire estate was noted. We used the Wilcoxon Matched Pair Test and the Mann-Whitney U test to compare the variations in species number or pond number, and the Jaccard index to evaluate the similarity between the assemblages of different ponds or different periods. To test similarity matrices we used the Mantel test, via the Monte Carlo iterative method by PC-ORD software package, version 3.09 (Mc CUNE & MEFFORD, 1997). The data on marked individuals were the site of marking, the site of re-sighting and, for the Anisoptera only, the time between marking and re-sighting. Differences in re-sighting between groups were tested by Pearson Chi-square statistics. All tests were two tailed with acceptance level at probability 0.05.

OBSERVATIONS

The species recorded by us for the entire estate are reported in Table I. Comparing the latter with the inventory given by UTZERI et al. (1977), the total number of species increased from 29 to 31 (26 same, 5 new and 3 unrecorded), resulting in a Jaccard index of 0.76. It was possible only for the P1 pond to compare the 1969-1971 species assemblage, as reported by CONSIGLIO et al. (1974), with that of 1997-1998. The number of species in this pond decreased from 19 to 12, with only 11 unvaried species, 8 missing and 1 new, resulting in a Jaccard index of 0.55.

The species recorded in the same 16 ponds in 1997 and 1998 are reported in Table II. A total of 24 species were recorded, being 21 unvaried, two new and one missing, with a Jaccard index of 0.87. This value is much higher than the average pond value, 0.57, ranging from 1 (P5 pond) to 0.33 (T49 pond). In six ponds the number of species in 1998 was 1/3 larger (or even more) than in 1997, with a maximum variation for the pond T49 from 4 to 12 species. In fact, the number of species present at each pond increased significantly from 1997 to 1998 (Wilcoxon Matched Pairs test: N = 16, T = 23, Z = 2.100, P = 0.035). Also the number of ponds inhabited by each species significantly increased from 1997 to 1998 (Wilcoxon Matched Pairs test: N = 24, T = 19, Z = 2.896,

Table I
List of the Odonata taxa recorded at Castel Porziano

Species		Whole estate		P1 pond	
	Source	UTZERI et al., 1977	This paper	CONSIGLIO et al., 1974	This paper
	Period	1969-1976	1997-1998	1969-1971	1997-1998
Calopteryx haemorrhoidalis (Vander L.)		+	+	-	-
Calopteryx splendens (Harr.)		+	+	-	-
Chalcolestes sp.		+	+	+	+
Lestes barbarus (Fabr.)		+	+	+	-
Lestes virens (Charp.)		+	+	+	+
Sympecma fusca (Vander L.)		-	+	-	-
Erythromma viridulum (Charp.)		+	+	+	-
Ceriagrion tenellum (de Vill.)		+	+	+	-
Ischnura elegans (Vander L.)		+	+	+	+
Ischnura pumilio (Charp.)		+	-	-	-
Cercion lindeni (Sél.)		+	+	+	+
Coenagrion puella (L.)		+	+	+	+
Coenagrion pulchellum (Vander L.)		-	+	-	-
Coenagrion mercuriale (Charp.)		-	+	-	-
Coenagrion scitulum (Ramb.)		+	+	+	+
Anax imperator Leach		+	+	+	+
Anax parthenope (Sél.)		+	+	+	-
Aeshna cyanea (Müll.)		+	-	+	-
Aeshna mixta (Latr.)		+	+	+	-
Aesna affinis (Vander L.)		+	+	-	+
Aeshna isosceles (Müll.)		+	+	-	-
Brachytron pratense (Müll.)		+	+	-	-
Libellula depressa L.		+	+	+	+
Libellula quadrimaculata L.		+	-	-	-
Orthetrum cancellatum (L.)		+	+	+	+
Orthetrum coerulescens (Fabr.)		+	+	-	-
Orthetrum brunneum (Fonsc.)		+	+	-	-
Crocothemis erythraea (Brullé)		+	+	+	+
Trithemis annulata (P. de Beauv)		-	+	-	-
Sympetrum striolatum (Charp.)		+	+	+	+
Sympetrum fonscolombei (Sél.)		+	+	+	-
Sympetrum sanguineum (Müll.)		+	+	-	-
Sympetrum meridionale (Sél.)		+	+	+	-
Sympetrum depressiusculum (Sél.)		-	+	-	-

P = 0.004). However, the Mantel test between the 1997 and 1998 matrices of all possible Jaccard distances between pairs from the 16 ponds rejected the null hypothesis of independence (Z = 0.5, P < 0.01). This means that the Odonata assemblage of the whole set of 16 ponds was not strongly altered between 1997 and 1998.

We tested the differences between the ponds dried out or not in 1997 in regard to the number of species in 1997, and in 1998. No test was significant (Mann-Whitney U test: N = 16 for all tests, Z = 1.011, 1.176, P = 0.311, 0.239, respectively). Comparing the number of species in 1997 and 1998 only in the set of six ponds that were dry in 1997 and wet in 1998 we found no significant differences either (Wilcoxon Matched Pairs test, N = 7, T = 8, Z = 1.014, P = 0.310).

The results of the marking and re-sighting are shown in Table III. There was a clear positive correlation between the number of marked and re-sighted individuals (linear correlation: N = 25, r = 0.791, P < 0.001). However *Crocothemis erythraea* was an outlier, showing a higher re-sighted/marked ratio. There was no significant difference in the percentages of the re-sighted specimens between Zygoptera and Anisoptera either in all species or on species for which at least one specimen was re-sighted (Mann-Whitney U test: N = 25, U = 66.5, P = 0.53, and N = 15, U = 16.0, P = 0.19 respectively). On the contrary, the frequencies of the re-sighted specimens were significantly lower for the females than for males, for both the Zygoptera (6% versus 14%) and the Anisoptera (2% versus 24%) (Pearson chi-square test on counts: $\chi^2 = 11.65$, df = 1, P = 0.001 and $\chi^2 = 35.26$, df = 1, P < 0.001, respectively). Despite the fact that the re-sighting was done at several ponds, all species showed a higher frequency of re-sighting at the pond where the specimens were marked, with the exception of *Aeshna affinis* of which only two individuals were re-sighted, one at the marking pond and the other at a different pond. Out of a total of 30 specimens re-sighted far from the marking pond, the distance between the marking pond and the re-sighting pond was 100 m (the smallest distance between the observed ponds) for three *Cercion lindeni*, one *A. affinis*, five *Libellula depressa*, one *Orthetrum cancellatum* and 14 *C. erythraea*; 300 m for two *O. cancellatum* and much more for a few other specimens: 1.5 km for one *O. cancellatum*, 1.9 km for one *C. erythraea*, 2.7 km for one *Coenagrion puella* and 5.8 km (in only one day!) for one *L. depressa*. Some *C. erythraea* were re-sighted first in another pond and later in the pond where they have been marked.

For the Anisoptera, which were marked individually, we also had some information about the longevity of the specimens of some species: *L. depressa* mean 10.9 days, maximum 36 (N = 30); *C. erythraea* mean 20.8, maximum 44 (N = 29); *O. cancellatum* mean 21.9 days, maximum 50 (N = 7); *Sympetrum sanguineum* 34 days (N = 1); *S. meridionale* 22 days (N = 1).

DISCUSSION

RELIABILITY OF THE DATA – The major concern about the data is that they are from the sightings of adults. A simple sighting may not enable the observer to distinguish between resident breeding specimens and non breeding visitor specimens. However, even the evidence of adult reproductive activity may not yield

Table II
List of the Odonata species recorded at 16 ponds in Castel Porziano on two subsequent years

Species / Ponds	A1		P1		P3		P4		P5		P6		P9		P10		P11		T1		T17a		T17b		T19		T22		T35		T49	
Years	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98	97	98
Chalcolestes sp			+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+				+		+		+		+
L. barbarus			+	+							+				+	+					+	+			+				+	+	+	+
L. virens			+			+	+	+			+	+			+	+	+	+		+		+				+	+	+				+
S. fusca																				+								+		+		
E. viridulum							+	+				+			+																	
I. elegans		+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+
C. lindeni			+						+	+									+	+								+				
C. puella		+	+	+			+		+	+					+	+	+	+	+	+	+	+						+				
C. pulchellum												+	+			+							+			+						
C. scitulum			+	+			+				+			+	+	+		+	+	+		+			+	+		+		+		+
A. imperator		+	+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+		+
A. parthenope												+						+									+	+				
A. mixta											+	+						+	+								+	+				
A. affinis	+	+		+		+	+	+	+	+	+	+			+	+	+	+	+	+				+	+	+	+	+				
L. depressa	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
O. cancellatum		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+			+	+	+	+	+	+		+
O. coerulescens																															+	
O. brunneum															+																	+
C. erythraea	+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+		+	+		+		+
S. striolatum			+	+		+		+			+	+	+		+	+	+	+		+		+					+	+				
S. fonscolombei											+	+						+		+		+					+	+	+	+	+	+
S. sanguineum											+					+	+	+									+	+	+			
S. meridionale											+				+	+		+									+	+		+		+
S. depressiusculum																											+					

a population able to complete the life cycle. The collection of larvae or exuviae would be a better way of assessing the real presence of a population, but these data are almost non-existent in the past, so that no comparison would have been possible with the present status. Therefore, we used the data of the simple presence of the adults, supported also by the consideration that our goal was to make comparisons between pairs of situations, each affected by the same bias.

LONG TERM VARIATION

The Castel Porziano Odonata fauna censuses cover a period of about 50 years. In fact, the UTZERI et al. (1977) data were mainly from hundreds of collections made in the 1969-1975 period, but discussed also data from previous literature (CASTELLANI, 1951). A detailed analysis of the species collected by us or reported by UTZERI et al. (1977) gives a smaller variation than that reported above. In fact, the two *Calopteryx* species are restricted to running water, and at Castel Porziano were always found as single specimens (only one for each species in our data) and considered "occasional" by UTZERI et al. (1977). Only one specimen was reported by UTZERI et al. (1977) for *I. pumilio, A. isosceles* and *L. quadrimaculata*, while we recorded just one specimen of *A. isosceles*. Only two *B. pratense* specimens were reported by UTZERI et al. (1977), and we found only one specimen. Only a single specimen of *T. annulata* was found by us, while none by UTZERI et al. (1977). These seven species cannot be considered as truly resident in Castel Porziano, but only occasional visitors.

On the contrary, *C. mercuriale* is confined to two small rivulets near the northern boundary of the estate, neglected by collectors until 1977 and consequently not included in the UTZERI et al. (1977) list. However, *C. mercuriale* had already been collected in the surroundings of the estate in 1946 (CASTELLANI, 1950), therefore we can assume its presence on the estate even before the first collecting after 1977.

Excluding the above mentioned seven species as occasional, and including *C. mercuriale* in both lists, the total number of species was 24 until 1977 and 26 in our data, the unvaried species being 23, the new 3 and the unrecorded 1, resulting in a Jaccard index of 0.88 instead of 0.76.

Only three species were real additions to the local fauna: *C. pulchellum*, which is widespread in Italy, even if less abundant in central and southern Italy than in northern Italy; *S. fusca*, which is equally widespread throughout Italy, and *S. depressiusculum*, known as migrant and often associated with artificial marshes such as rice-fields, which is more abundant in northern Italy, and occurs also in central Italy (CARCHINI et al., 1985), and in southern Italy (D'ANTONIO & De FILIPPO, 1985; D'ANTONIO, 1996). The missing species, *A. cyanea*, is known all over Italy, although not at sea level in southern Italy (CARCHINI & ROTA, 1986).

In regard to the cause of this long term variation, we can exclude a direct modification of the environment by man. The estate, which has been mainly woodland for centuries and since 1872 a game reserve of the Italian head of state, is surrounded by a high wall and entry is strictly regulated. The woodlands are not exploited for timber, and the management of the estate remained unchanged over the last fifty years. The ponds have

Table III
Result of the marking and re-sighting. For the Lestidae: * = individuals marked at emergence; ** = individuals marked at the start of the reproductive season (September). The percentages, approximated at the integer, refer to the marked specimens

Species	Number of individuals Marked	Re-sighted at same pond	other pond
Chalcolestes sp *	32	0	0
Chalcolestes sp **	476	57(12%)	0
L. barbarus *	26	1(4%)	0
L. barbarus **	23	1(4%)	0
L. virens *	30	1(3%)	0
L. virens **	138	16(12%)	0
E. viridulum	2	0	0
I. elegans	91	5(5%)	0
C. lindeni	160	36(23%)	3(2%)
C. puella	89	17(19%)	1(1%)
C. pulchellum	9	0	0
C. scitulum	83	10(12%)	0
A. imperator	17	0	0
A. parthenope	2	0	0
A. mixta	12	0	0
A. affinis	13	1(8%)	1(8%)
L. depressa	276	30(11%)	6(2%)
O. cancellatum	116	11(9%)	4(3%)
O. brunneum	1	0	0
C. erythraea	153	63(41%)	15(10%)
S. striolatum	24	0	0
S. fonscolombei	18	0	0
S. sanguineum	8	1(12%)	0
S. meridionale	27	1(4%)	0
S. depressiusculum	11	0	0

been, in general, left to natural evolution, with the exception of a few that were artificially deepened or newly excavated (in our set only the T1 and C2 ponds respectively, about twenty years ago) to increase the number of watering places for game. MOORE (2001) stated that the ecological succession in newly excavated ponds could lead even to the extinction of all Odonata populations in forty years, mainly because of shade due to growth of high scrubs around the ponds. The Castel Porziano ponds, usually much older than forty years, really have very few scrubs on the edges. This is probably due to the presence of abundant populations of *Dama dama* and *Sus scrofa* which trample on the banks during watering. Actually, a parallel study on the variables influencing the number of Odonata species in the Castel Porziano ponds, showed that the presence of riparian vegetation was one of the variables positively correlated with the number of species (CARCHINI et al., 2003). Excluding a variation of the environmental condition inside the estate, there remains the possibility of regional variation, such as climatic variation towards warmer and dryer conditions, often invoked as the cause of faunistic changes. At Castel Porziano in the last thirty years several ponds have shifted from permanent to temporary, but some also from temporary to permanent, so that it is difficult to establish if there has been an overall modification of the permanence of the water on the estate. Examining the ranges of the changed species, the three new species occur throughout Italy or even more abundantly in the North. The absence of *A. cyanea*, and *L. quadrimaculata*, present in southern Italy only at some elevations (CARCHINI & ROTA, 1986), coupled with the appearance of the southern *T. annulata* which has its northern limit in Tuscany (TERZANI, 1991), might be interpreted as a northward shift, due to warmer climatic conditions. Therefore, taking also into consideration that the latter two species were occasional at Castel Porziano, there is little evidence that the faunistic changes at Castel Porziano are due to a single environmental factor, such as the supposed global warming with consequent substitution of northern with southern species.

In regard to the fauna of single ponds, it was possible to compare the 1965-1971 assemblage with that of 1997-1998 for the P1 pond only. In this pond the variation was largely decreasing, in disagreement with the conclusion for the whole estate.

SHORT TERM VARIATIONS

The results of the comparison between the 16 ponds checked in 1997 and 1998 showed that the number of species increased in almost all the ponds. Accordingly, also the distribution of the species increased, even if not as much. On the the other hand, no significant difference was found between odonate fauna of ponds that did, or did not dry out in 1997. It seems, that the adults were insensitive to the drying out in 1997. The drying out of ponds occurred in late summer, when most of the species had already passed their reproductive period. No information is available on the fate of the larval populations in the dried out ponds. Some species can have a diapause at the egg stage, the egg being able to survive the drying out. This is the case in *A.mixta, L. barbarus, L. virens, Chalcolestes, S. striolatum, S. depressiusculum, S. sanguineum* (see CORBET, 1999, tab. A.3.5) and probably also in *S. meridionale*. For the remaining species we should expect the death of the larvae, but recent observations suggest that some non-diapausing species might be able to survive the drought, as eggs or larvae, for some weeks: viz. *I. elegans* (MOORE, 1991), and *L. depressa* (cited by several authors), and perhaps *C. puella* (see CORBET, 1999, tab. A.6.5 and p. 191). In any case, the drought should have caused a decrease in the number of species in the following year. However, in 1998 this was not the case. We can conclude, therefore, that there were several re-colonization events, in agreement with the observed species increase in the ponds studied, and that the majority of the Castel Porziano species at adult stage are unable to assess whether a pond had dried out in the previous year, or they are unaware of the fact.

ADULT DISPLACEMENT AND LONGEVITY

The re-sightings show great differences among the species, but in general the re-sighting frequencies are lower than those reported by UTZERI et al. (1976, 1984, 1988) for Castel Porziano populations of *L. barbarus* and *L. virens*, and by CONRAD et al. (1999) for several Zygoptera and Anisoptera species. An escape reaction, due to marking stress, which might have induced some individuals to fly out of the estate, cannot be excluded. This might be the case in the Aeshnidae, of which only two *A. affinis* were re-sighted out of 44 marked specimens of four species. The marked aeshnid specimens quickly flew into the sky, out of sight, immediately after release. Another factor reducing the re-sighting may be the check routine. Each marking pond was checked after two weeks, so that the marked specimens were subject to a certain mortality rate before the next check in the same pond. Since, based on our evidence and on literature data (CONRAD et al., 1999), it seems that the most inidividuals did not move from the marking pond, these two factors reduced the number of re-sighted specimens, especially if compared with the studies in which also the marking ponds were checked continuously after the marking. This fact should be particularly important in the Coenagrionidae, whose individual reproductive period lasts about one week on average (see CORBET, 1999, tab. 8.12). It is also probable that our dispersal rates would have been larger if we had also been able to assess the maiden flight or the pre-reproductive period movements. CONRAD et al. (1999) showed similar dispersal rates between teneral and mature individuals.

The majority of the specimens re-sighted out of the marking pond were re-sighted in ponds which were about 100 m away. This distance is within the range of the commuting movement of several species. However, the Odonata appear to be able to return to the same spot, if they "want" (see the examples in CORBET, 1999). Consequently, the observed displacements should be considered migration flights even where the distances covered were short. A high dispersal at small distances is in agreement with an exponential negative correlation between distance and dispersal rate, as reported by CONRAD et al. (1999). However, our data show longer displacements than those reported in that paper (max. 1.2 km in *S. sangineum*) even in *C. puella* for which the previous record was 800 m (BANKS & THOMPSON, 1985). In all species, we observed a lower overall re-sighting ratio in the females, which would be in agreement with a higher female dispersal tendency. Unfortunately, the number of specimens re-sighted out of the marking pond was so small that a test on the differences between male/female frequencies was not possible.

The philopatry of the Lestidae, highlighted already by UTZERI et al. (1976, 1984, 1988), appears confirmed by our data. This applies also to *Chalcolestes*, which was not studied previously.

Finally, our data on the Anisoptera longevity in the field appear to exceed the mean value (11.5 days) reported by CORBET (1999, tab. 8.12), with the exception of *C. erythraea* which had an almost identical value.

CONCLUSIONS

Our observations indicate that the Odonata assemblages variation in time depends on the spatial scale from which it was investigated. On the scale of the entire estate, which can be defined as the mesoscale, variation over a short term (year) was very low, both for the number of changing species (as shown by Jaccard values) and for their overall distribution among the ponds (as shown by Mantel test). Also over a long term (several decades) the variation was small, although higher than over a short term. On the scale of a single pond, which can be defined as the local scale, the variation was much higher both over long periods (as shown by the comparison of the P1 assemblages), and over short periods (as shown by the Jaccard values and by the significant increase of species number per pond and number of ponds per species in a year.

The lower temporal stability of the assemblage at the mesoscale as compared with the local scale could be interpreted as a consequence of a metapopulation effect. The four features, highlighted by HANSKI (1997), characterizing a classical metapopulation, are all encountered at Castel Porziano. However, the requirement of the local extinction persisting for several generations (HARRISON & ANDREW, 1997) is not met in our case, where rapid re-colonization of ponds, from one year to the other, is taking place. Because of the hydrological isolation of the ponds, which prevents the exchanges of larvae, only the adult displacements can achieve the dispersal. In this respect, there is much variation between the species. The extremes are the Lestidae with no dispersed specimens (out of 725 marked), and *C. erythraea* with 23.8% dispersed specimens and with some individuals spending their reproductive period in more than one pond. The results of CONRAD et al. (1999) also show dispersal rates considerably higher (> 10%) than those observed in classical metapopulation cases, both for Zygoptera (from 10.3 % in *I. elegans*, to 28.6 % in *P. nymphula*) and for the only reported Anisoptera (46.9 % in *S. sanguineum*). In addition, some of their specimens, pertaining to several species, were re-sighted in more than one pond. In view of high dispersal rates and the reproduction of the same individual in several ponds, the populations should be considered as "patchy" rather than "classical" metapopulations (HARRISON & ANDREW, 1997). Surely more data on dispersal are required to characterize odonate metapopulation features. In any case, our results highlight the importance of maintaining or construing systems of ponds at distances not exceeding one km from each other in order to assure a better conservation of the Odonata diversity.

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