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TEMPORAL SUCCESSION OF THE MACROINVERTEBRATE FAUNA IN A CORSICAN TEMPORARY POND

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TEMPORARY POND
PHENOLOGY
MACROINVERTEBRATES
FAUNISTIC COMPOSITION
TROPHIC ORGANIZATION
HYDROPERIOD

ABSTRACT. – During the years 2001-2002, macroinvertebrate fauna of a temporary pond of Corsica has been studied from the filling to the drying of the pond. Approximately 1400 individuals belonging to 40 taxa were recorded during the study. Insects counted 35 taxa including 16 Coleoptera ones. *Bothromesostoma personatum* and *Castrada cristatispina* (Rhabdocoela) were recorded for the first time in Corsica. The numbers of taxa were lowest during both the filling and just before the drought of the pond, whereas the greatest numbers of taxa were recorded after fall and spring rains. Five ecological phases, with contrasting fauna structure, composition, trophic organization and abiotic features, were identified during the pond life. Detritivores and organisms belonging to the group 1 of Wiggins characterized the immature pond. Conductivity and TDS exhibited low values. Fauna and abiotic features of the filling phase and these occurring after spring rains exhibited a certain similarity, revealing a rejuvenation of the pond. In a more mature pond, predators and organisms belonging to the groups 3 and 4 of Wiggins prevailed, but the aquatic macroinvertebrate community differs in relation to season. TDS and conductivity increased with the loss of water.

INTRODUCTION

Temporary ponds are widespread in the world, and their occurrence can be significant in arid or tropical areas. The Mediterranean area, whose climate is characterized by the existence of an estival dry period often lasting more than three months, exhibits many lotic temporary habitats, which are less known than other freshwater ecosystems. The cyclic drying habitat is responsible for various adaptive strategies of organisms and generates an original fauna, distinct from the fauna of permanent ecosystems (see Wiggins *et al.* 1980, Williams 1987, 1996 and references therein).

Studies of entire communities in temporary ponds remain scarce (Kenk 1949, Barclay 1966, Wiggins *et al.* 1980, Williams 1983, Lake *et al.* 1989, Bazzanti *et al.* 1996, Giudicelli & Thiéry 1998, Boix *et al.* 2001, 2004). In Corsica particularly, only few studies concerning specific groups were realized (Champeau 1970, Champeau & Thiéry 1990).

Our study, carried out from November 2001 to May 2002 in the Chevanu pond, provides an inventory of the invertebrate species in order to enhance the knowledge of Corsican temporary pond fauna. The present paper deals in particular with the faunistic succession of the communities and allows to recognize distinctive ecological phases of the pond life.

STUDY AREA

The temporary pond is located in the extreme southern of Corsica (locality of Pianottoli-Caldarello), in the west of the Chevanu handle (long 41°28.31'N, lat 08°61.98'E). The pond has a natural origin and comes from an old littoral platform. Lorenzoni & Paradis (1997) provide some geological data and floristic characteristics.

The observations carried out during several years indicate the pond fills in November and the dryness occurs in early June. From observations relating from several years, the pond, irregular in shape, has a maximum length of 75 m, a maximum depth of 42 cm and a maximum surface of 1000 m^2. In the center of the pond, a small island of shrubs is present. A layer of characteristic bush and holm oaks (*Quercus ilex*) surrounds the pond.

MATERIAL AND METHODS

Samples were collected in early afternoon (about 13.00 pm). Eleven faunistic samples were carried out approximately every fifteen days from November 2001 to the end of May 2002. Abiotic data (18 sampling days) were recorded roughly every week. Temperature, conductivity, TDS and pH values were measured at various depths on each sample by means of field meters and the maximum depth of the pond was determined.

The macrofauna was captured using a pond net (mesh opening: 0.2 mm) trailed above and inside the water from the periphery of the pond towards its center. The material is fixed in 10% formalin. Invertebrates are counted and identified to the lowest possible taxonomic level. Organisms are classified according to their diet following Merritt & Cummins (1995) and Cummins & Wilzbach (1985), and arranged into the four groups of Wiggins *et al.* (1980) according to their strategy toward the dryness. The structural and functional analysis of the invertebrate community is studied by the determination of the Shannon-Wiener diversity (Magurran 1988) and evenness (Pielou 1969). The biotic and abiotic parameters are correlated using Pearson's coefficient (r). Correspondence Analysis (CA), performed on numerical abundances and frequently used in studies on freshwater benthic communities, was chosen to elucidate successional phases of the pond.

RESULTS

Physicochemical data

During the year of study, the pond of Chevanu filled in November 2001 and dried up in late May 2002. The variations of the maximum depth during the study coincided with the rain fall (Fig. 1). The filling of the pond, only imputed to precipitations, results from autumnal rainfalls, characteristic of the Mediterranean climate. The second peak of depth corresponds to the spring rainfalls. From mid-May, the level of the water declines gradually until the pond dried up in May, after 160 days of flooding. Measurements of the pH values vary from slightly acid to basic (Table I). The lower pH values (6) are obtained when the level of the water is lowest. A positive correlation exists between pH and maximum depth ($r = 0.69$, $p < 0.01$). A very strong negative correlation exists between the maximum depth of the pond and both conductivity and TDS (respectively $r = -0.825$, $p < 0.0001$ and $r = -0.816$, $p < 0.0001$). The pond is always very turbid because of the high proportion of silt and clay in the sediments (36 %).

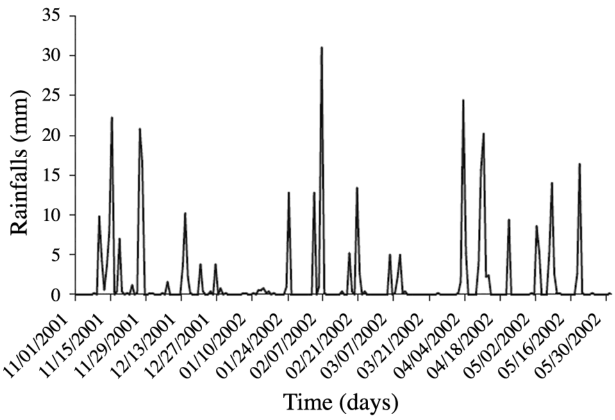

Fig. 1. – Weekly rainfalls in the Chevanu pond during the study.

Table I. – Physicochemical characteristics of the Chevanu pond.

Date	Wet phase duration	Depth (cm)	pH	Water temperature (°C)	Conductivity (μs.cm^{-1})	TDS (mg.l^{-1})
11/19/2001	3	9	-	-	-	-
12/02/2001	13	15	8,1	15,7	114,5	53,5
12/30/2001	41	14	7,66	15,6	217	101,9
01/27/2002	69	12,5	6,99	11,8	182,7	84,5
02/08/2002	81	21	8,3	15,9	130,9	61,3
02/17/2002	90	15	8,09	18,5	213	101
03/03/2002	104	9	6,89	20	407	195,2
03/10/2002	111	12	7,92	23,8	285	136,8
03/17/2002	118	8,5	7,4	20,8	485	204
03/23/2002	124	6,5	6	13,7	864	421
04/07/2002	139	15	8,08	23,2	102,1	48,4
04/13/2002	145	19,5	8,73	14,7	106,3	49,4
04/21/2002	153	14	8,62	26,5	213	102,2
04/28/2002	160	11	8,14	25,3	289	138,7
05/05/2002	167	12	6,9	26,3	202	96,9
05/12/2002	174	15	6,43	25,9	130,9	62,4
05/19/2002	181	12	6,42	22	268	128,3
05/26/2002	188	7	6	27,4	547	265

Composition, structure and trophic organization of the macroinvertebrates communities

A total of approximately 1400 organisms belonging to 40 taxa (including 22 species and 7 genera) was collected and identified in the Chevanu pond from November 2001 to May 2002 (Table II). Rhabdocoela (*Bothromestoma personatum* and *Castrada cristatispina*) are regularly observed in the pond but hardly numbered once formol fixation was realized and then they were eliminated from the counts.

The insects (35 taxa) are qualitatively the more abundant. Among them, Coleoptera provides the greater number of taxa (16 taxa). Anostraca only provide one species, *Tanymastix stagnalis*. However Anostraca (and Coleoptera) show the highest percentages on the total fauna (Fig. 2).

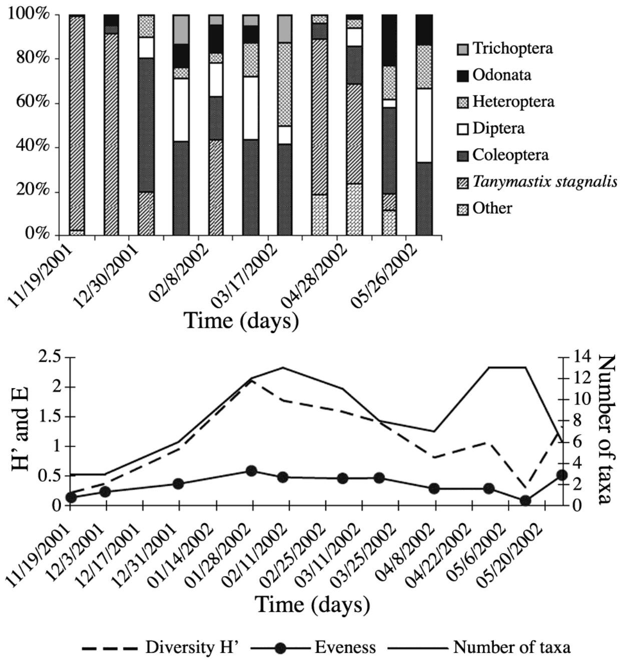

Fig. 2. – Top, Relative abundance of macroinvertebrate zoological groups in the Chevanu pond during the study. Bottom, Number of taxa, diversity (H') and eveness (E) of the macroinvertebrate community in Chevanu pond.

Table II. – Faunal inventory in Chevanu pond during the study period (+ = presence, ad = adults, l = larvae).

	11/19/01	12/02/01	12/30/01	01/27/02	02/08/02	03/03/02	03/17/02	04/07/02	04/28/02	05/12/02	05/26/02
Platyhelminthes											
Bothromesostoma personatum Schmidt, 1848	+	+	+	+	+	+	+	+	+	+	+
Castrada cristatispina Papi, 1951	+	+	+	+	+	+	+	+	+	+	+
Annelida											
Oligochaeta											
Eiseniella tetraedra Savigny, 1826	+							+			
Arthropoda											
Hydracarini										+	
Crustacea											
Anostraca											+
Tanymastix stagnalis Daday, 1913	+	+	+		+			+	+	+	
Insecta											
Coleoptera											
Dytiscidae											
Agabus bipustulatus (l) Linnaeus, 1767			+	+		+	+				
Agabus nebulosus (ad) Forster, 1771				+							
Copelatus haemorroidalis (l) Fabricius, 1787								+			
Bidessus minutissimus (l) Germar, 1824									+		
Bidessus unistriatus (ad) Goeze, 1777										+	
Guignotus pusillus (ad) Fabricius, 1781										+	
Dytiscus circumflexus (l) Fabricius, 1801									+		
Hydroporus sp. (l)				+	+				+		
Hydrovatus clypealis (ad) Sharp, 1876			+	+	+	+	+				
Laccophilus minutus (l) Linnaeus, 1758			+		+						+
Laccophilus minutus (ad) Linnaeus, 1758						+					
Ilybius sp. (l)										+	
Hydroporinae indet											+
Haliplidae											
Haliplus guttatus (ad) Aubé, 1836		+			+						
Helophoridae											
Helophorus brevipalpis (ad) Bedel, 1881									+	+	
Hydrophilidae											
Berosus signaticollis (ad) Charpentier, 1825								+			
Enochrus sp. (ad)									+	+	
Diptera											
Chironomidae											
Chironomini				+					+		
Orthocladiinae				+	+						
Tanypodinae	+			+	+	+					
Tanytarsini			+	+	+		+			+	
Culicidae											
Culex hortensis Ficalbi, 1889									+		+
Limoniidae											
Phylidorea sp.						+					
Heteroptera											
Corixidae											
Corixidae (l)				+	+		+	+			+
Corixa punctata (ad) Illiger, 1807			+			+	+		+	+	+
Parasigara sp. (ad)						+					
Sigara sp. (ad)					+						
Notonectidae											
Nychia marshalli (ad) Cameron, 1875				+							
Notonectidae (l)						+	+			+	
Gerridae											
Gerris gibbifer Schummel, 1832							+		+	+	
Lepidoptera								+	+	+	
Odonata											
Lestes barbarus Fabricius, 1798		+		+	+	+			+	+	+
Libellula fulva Müller, 1764					+						
Trichoptera											
Limnephilini					+	+	+				
Notidobia sp.				+							
Collembola									+		

The number of taxa (Fig. 2) is very low when the pond fills (3 taxa). It quickly increases from December to February and regularly decreases until early April when a second fast increase appears. The number of taxa remains constant until mid-May and a rapid reduction is registered just before the pond drying. Diversity (H') variation follows the number of taxa, except for the two last samples (Fig. 2). During the last sampling, the great evenness (E)

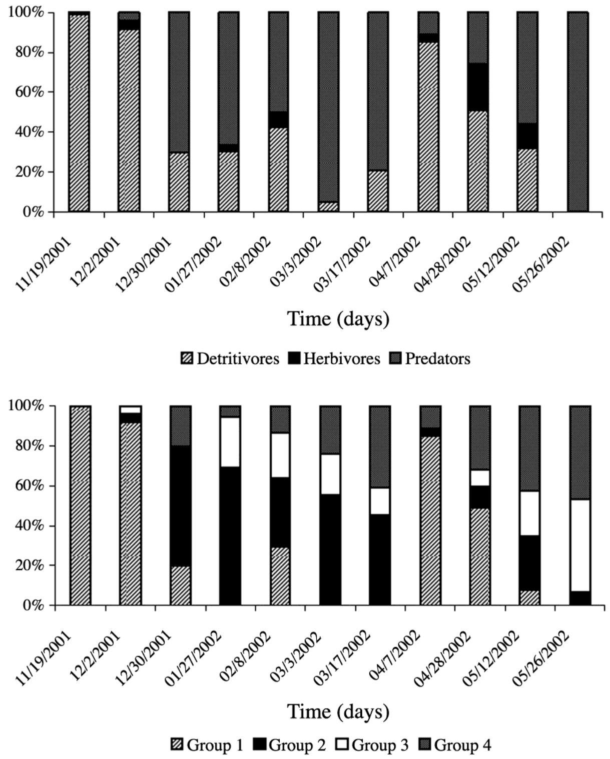

Fig. 3. – Top, Trophic organization of the macroinvertebrate community in the Chevanu pond (proportions are number of individuals). Bottom, Relative abundance (in number of individuals) of Wiggins *et al.* (1980) groups in the Chevanu pond during the study.

increases the diversity values (relation between these two parameters: $r = 0.94$, $p < 0.0001$).

During the study, the macroinvertebrate community shows a significant turnover of species (Table II). Abiotic characteristics allow us to recognize two major stages in the pond life. The former (November to March) corresponds to the filling phase: the flooding duration is positively correlated conductivity and TDS (respectively $r = 0.70$, $p < 0.05$ and $r = 0.68$, $p < 0.05$). The latter stage (April to May) correspond to a "re-starting" of the pond appear after spring rains. During this stage, the flooding duration is positively correlated to conductivity and TDS ($r = 0.72$, $p < 0.01$ for both). On the contrary, flooding duration and pH are correlated in a negative way during this stage ($r = -0.91$, $p < 0.01$). On the other hand, pH and maximum depth are positively correlated during the entire hydrological cycle of the pond ($r = 0.69$, $p < 0.01$).

The trophic organization (Fig. 3 top) indicates a clear dominance of predators and detritivores. Herbivores seem limited because of the high water turbidity. Detritivores are negatively correlated with the flooding duration for the two stages previously described (respectively $r = -0.88$, $p < 0.01$ and $r = -0.99$, $p < 0.05$) whereas predators show a positive correlation with the flooding duration ($r = 0.87$, $p < 0.02$ and $r = 0.95$, $p < 0.05$). On the contrary, no correlation has been observed between predators and maximum depth. Concerning the predators, it is significant to note the presence of small ones at the beginning of the hydrological cycle whereas larger predators occur at the end of the pond draining.

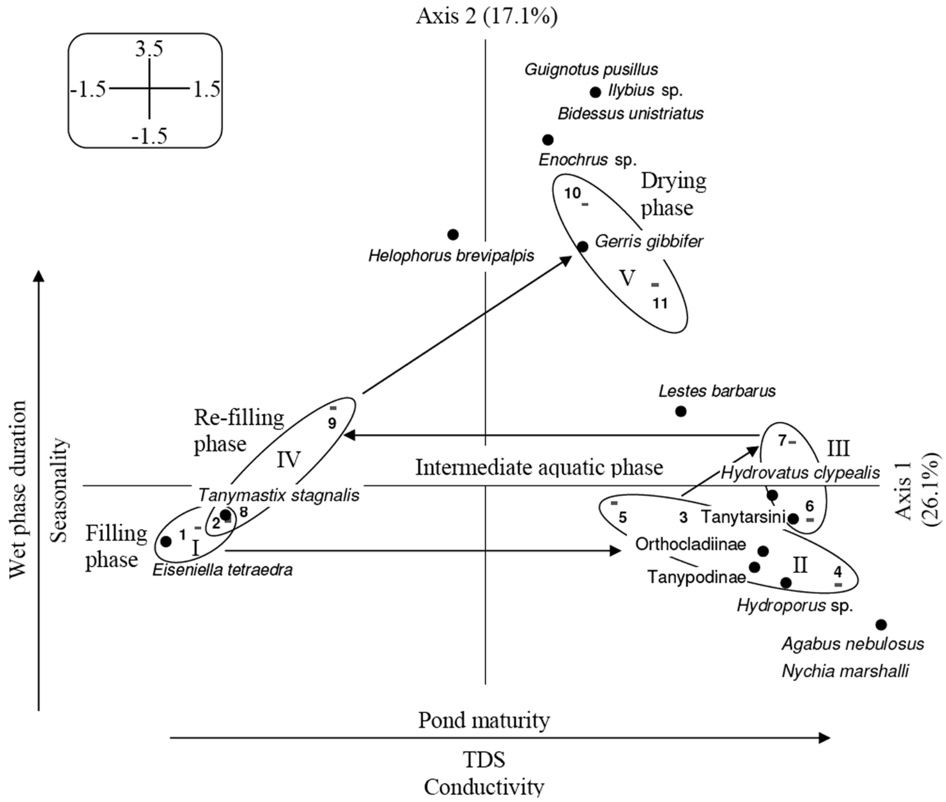

Fig. 4. – First two axes of CA analysis. Numbers refer to sampling occasions in a temporal order and species mentioned are the most contributive (relative contribution > 30%). The five ecological phases recognized (I, II, III, IV, and V) are linked in chronological order by arrows.

The classification of the invertebrates into the groups of Wiggins *et al.* (1980) shows (Fig. 3 bottom) the greatest percentages for the organisms belonging to group 1 when the pond fills (first two samples) and a new recruitment in April. On the contrary, the individuals belonging to the group 4 completely lack in the first samples and reach their maximum at the end of the pond life. Percentages of group 4 species are strongly correlated in a positive way to the flooding duration ($r = 0.83$, $p < 0.01$). The decrease of organisms belonging to the group 1 during the hydrological cycle allows the development of individuals belonging to groups 2 and 3 of Wiggins.

According to different taxa present in each sample, a CA plot allows us to recognize five phases in the pond (Fig. 4). The first axis mainly distinguished samples containing taxa occurring in an immature pond (filling and re-filling phases) from samples with taxa characterizing a more mature pond (including the drying phase) as *Lestes barbarus, Gerris gibbifer, Nychia marshalli, Bidessus unistriatus* or *Hydrovatus clypealis*. The second axis, distinguishing the last two samples from the other ones, reveals the wet phase duration, in relation to the season. It is interesting to note the similarity between the filling and the re-filling phases (samples 1-2 and 8-9) mainly characterized by Anostraca and Oligochaeta.

DISCUSSION

This study is the first concerning the entire macroinvertebrate community of a temporary pond in Corsica. As far as we know, only some specific zoological groups as Entomostraca (Champeau & Thiéry 1990) had been studied. Some species occurring in the Chevanu pond are exclusively known in temporary habitats. It is namely the case of the Anostraca *Tanymastix stagnalis*. Other species are largely widespread in temporary waters (*Berosus signaticollis*, *Helophorus brevipalpis*, *Agabus nebulosus*). In particular, *B. signaticollis* and *H. brevipalpis* can hide and finish their development (larval or adult stages) in the sediment (Thiéry 1979, Barbero *et al.* 1982). Turbellaria also constitute a taxon usually found in temporary ponds. In Chevanu, two species of Rhabdocoela were recorded for the first time in Corsica, *Bothromesostoma personatum* and *Castrada cristatispina*. The other taxa are largely widespread in all types of lentic waters.

Macroinvertebrate communities of the pond showed a rather low taxonomic richness, probably in relation to the short flooding period (188 days). Moreover, several groups (as the Chironomidae) were identified in a low taxonomic level. A similar taxonomic richness was recorded in temporary ponds of Morocco (Boutin *et al.* 1982, Metge 1986) including respectively 25 and 45 macroinvertebrate taxa. In the same way, in France, the ponds of Catchéou 1 and 3 (Provence) have a total richness (Insects and Crustacea) of respectively 59 and 53 taxa (Giudicelli & Thiéry 1998).

The minimal numbers of taxa in the pond correspond to both the initial and the final stages of the hydrological cycle, when the depth is lowest. The maximum number of taxa is reached twice: in February (after 81 days of flooding), when the pond exhibited its maximum depth, and in spring (160 and 174 days of flooding), just before the pond dry. The lowest numbers of taxa occur at both the beginning and the end of the hydrological cycle, as also observed in a Canadian pond (Williams 1983) and in a New Zealand pond (Barclay 1966). This pattern is somewhat similar to that observed in Italy (Bazzanti *et al.* 1996) but marked differences exist in the absence of a maximum number of taxa in the last sample. In Australia (Lake *et al.* 1989), after a maximum quickly reached after filling, the number of taxa remains fairly constant until the drought.

A decrease of conductivity with reduction of maximum depth (Schneider & Frost 1996, Arle 2002) is not observed in the pond investigated. Moore (1970), Lake *et al.* (1989) and Lahr *et al.* (1999) also found increase in conductivity as the pond dried out. This could show that water loss is dominated by evaporation rather than seepage. TDS values follow the same trend. Investigations on the seasonal variations of the hydrogen ion concentration are present to small extent. Our results confirm the study of Bazzanti *et al.* (1996) who record a positive correlation between pH and maximum depth.

The invertebrate succession during the hydrological cycle was already used in order to distinguish the existence of various ecological phases in temporary ponds (Kenk 1949, Barclay 1966, Lake *et al.* 1989, Bazzanti *et al.* 1996, Boix *et al.* 2004). Thus, Lake *et al.* (1989) identified three main phases (filling, intermediate and drying phases). Our study recognizes five ecological phases in the pond phenology with distinctive biotic and abiotic features.

The filling phase (samples 1-2) is short and characterized by low depth and temperature. Diversity and taxonomic richness are reduced. Our study corroborates low values of TDS and conductivity are indicative this stage (Williams 1983, Lake *et al.* 1989, Lahr *et al.* 1999). Organisms belonging to the group 1 of Wiggins dominate the fauna and the species present are mainly detritivores. It is a characteristic of many temporary ponds (Mozley 1944, Wiggins *et al.* 1980, Lake *et al.* 1989, Bazzanti *et al.* 1996) and is mainly related to the great availability of organic matter and to its great nutritional value in temporary ponds (Bärlocher *et al.* 1978). The winter phase (samples 3-5) was characterized by an increase of depth and temperatures. Taxonomic richness and diversity increase quickly during this phase until reaching a first maximum value. Both conductivity and TDS increased during this stage. The number of organisms belonging to Wiggins group 1 decreases for the advantage of organisms belonging to groups 2 and 3. From a trophic viewpoint, predators dominate the community. During the early spring phase (samples 6-7), temperature increased again whereas a significant reduction in the level of water is observed. This stage is marked by an increase of conductivity and TDS, whereas pH decreases until reach its minimal value. A reduction of both diversity and taxonomic richness is also recorded. Predators still dominate the community and the individuals are mainly distributed into Wiggins groups 2 and 4. Individuals belonging to the group 1 as *T. stagnalis* disappear. Late appearance of large predators in the pond coincides with preys' number (Grillet *et al.* 2002). The next phase (samples 8-9), occurs after spring rainfalls. Diversity and specific richness reach their second highest values. Abiotic factors reveal a significant decrease of conductivity and TDS whereas pH exhibits its most basic values. The community was again dominated by detritivores and a new recruitment of species belonging to group 1 appears. Both the fauna and the abiotic characteristics of this stage present a great similarity with the filling phase and seem corresponding to a rejuvenation of the pond. Pioneer species are the same in the two phases (mainly Anostraca and Oligochaeta). The proportion of predators rapidly raised. Indeed, the increase of the water level involved new laying quickly followed by hatchings. The last phase, the drying phase (samples 10-11) was characterized by water level and taxonomic richness fast reduction, while pH reached its most acid values. On the contrary, conductivity and TDS increased. Most of the insects, namely Odonata and most of the Coleoptera left the pond. The invertebrate community was dominated by large predators and both the groups 3 and 4 of Wiggins reached their highest proportions.

Migrant species colonize the biotope according to the season. Particularly, taxa such as *Hydroporus* sp., *Hydrovatus clypealis, Agabus nebulosus* and Trichoptera seem occur rather in late winter. Preference for winter of the genera *Agabus* and *Hydroporus* is corroborated by Boix *et al.* (2001). On the contrary, *Helophorus brevipalpis, Guignotus pusillus, Bidessus unistriatus, Gerris gibbifer* and *Hydroporinae larvae* seem more adapted to warmer periods.

On the other hand, *Lestes barbarus* is a migrant species occurring lately in the pond (Eyre *et al.* 1992) without preference for the season.

The phenology of the Chevanu pond stacks in fact two times: the former corresponds to the filling and the latter to rejuvenation. The pioneer species are the same and belong to the group 1 of Wiggins. The colonizing species differ according to the season. In the present study, filling and rejuvenation are characterized by low conductivity and TDS. These values increase until the drought.

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