

Contribution to the knowledge of ecotones: colonisation of the banks of temporary environments in Eastern Morocco.

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Abstract. The banks of dayas (temporary pools) is a very interesting environment, characterised by species with extremely strict ecological requirements. Contrary to riparian communities of running water, which are present throughout the year, riparian populations of temporary stagnant environments only occur during the short period of impoundment. The colonisation of these environments depends on various parameters such as rainfall, temperature, and the size and depth of the water bodies. The impoundment of dayas of Sidi Bouhria is done after autumn and spring rains, if they are sufficiently abundant, and they dry up, in all cases, during the summer. This study aims to provide an overall synthesis about the colonisation of banks of dayas by riparian beetles. The samples were taken during the complete impoundment of each daya, from its appearance, after a rainfall, to its drying up. The fauna was collected every two days during one hour of sampling. The colonisation of the banks of the temporary environments studied takes place in three phases. The first phase is dominated by species of terrestrial origin from the vicinity of the dayas, the second phase is dominated by riparian and hygrophilous species that originate from the banks of more or less distant aquatic environments, and the third phase, which occurs with the drying of the environment, marks the return of terrestrial species. **Keywords:** ecotone, temporary environments, riparian community, colonisation, eastern of Morocco.

1 Introduction

The banks, which support the riparian community, represent a transition zone between the terrestrial and aquatic environments where representatives of these two major domains mixes [1-3]. They also constitute a biotope characterised by a population that is strictly dependent on it, in this case, strict riparian species [2,4-8]. The banks also serve as an extension of the aquatic domain and as a passage point for the colonisation of the terrestrial environment by amphibian organisms [9].

The species that make up banks communities can be divided into four elements: "true riparian" species, which are restricted to wet banks and cannot live in other environments; "riparian-tending" or "hydrophilic" species, which are attracted to this environment but occur in other wet biotopes; and "non-riparian" or "strict terrestrial" species, which are found accidentally on wet banks. In addition to these three categories, which are of terrestrial origin, there is a fourth element: species of "aquatic origin", which may occasionally be found at the water's edge [2,10]. Riparian communities are forced to follow the perpetual movement of the bank. The fauna is actively moving, with a qualitative and quantitative selection of populations according to the nature of the substrate through which the wet banks pass [11].

This work follows on from the one dealing with the impoundment of two dayas in the Sidi Bouhria region (Eastern Morocco), during the autumn of 1992, by carabid beetles [12]. It aims to deepen our knowledge of these environments, which are still very poorly studied [13,14] and to provide an overall synthesis of the colonisation of these dayas by riparian beetles, in the light of new data collected during three other sampling campaigns.

2 Materials and methods

The two dayas of Sidi Bouhria I (SBDI) and II (SBDII) are temporary environments that depend on rainfall. They are located in north-eastern Morocco, west of the town of Oujda (34°68'N - 02°13'W). They are located in a steppe zone, classified as an arid zone with a temperate winter. Both stations have a silty substrate with neutral pH and neutral freshwater. We were interested in all beetles and aquatic heteroptera found on banks. They were classified into three ecological categories: "aquatic", which includes species living in the aquatic environment, "terrestrial", which comes from the vicinity of banks and are not dependent on humidity, and "riparian", which include species dependent on soil humidity. The "true riparian" and the "hygrophilous" have been grouped. The latter are considered as riparians because in the region studied, they do not occur outside

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the banks of wetlands due to the high aridity. The fauna surveys carried out were semi-quantitative and were collected by “sight hunting” during a one-hour survey [4]. All the micro-environments were visited: shrinkage cracks, debris, and vegetation, and the underside of stones were lifted and the substrate was watered to draw out the fauna. Four sampling campaigns were carried out, with a total of 27 trips per daya. A follow-up, every two days, was carried out on the two dayas, from their impoundment to their complete drying up. Because of the severe droughts, all the campaigns took place in winter (December 1996, January/February 1997, January 1999, and January/February 1999). This is the only season in which there was sufficient rainfall to impound the dayas.

3 Results

3.1 Overall communities' structure

We collected 873 individuals and 89 taxa on the banks of the SBDI daya, including 42 terrestrial, 25 riparian, and 18 aquatic species. In terms of numbers, they represent 51%, 39%, and 10% respectively (Table 1). The total population of daya SBDII comprises 877 individuals, distributed among 62 taxa, including 27 terrestrial, 18 riparian, and 14 aquatic species. In terms of numbers, they represent 35%, 59%, and 6% respectively (Table 1).

Table 1. Richness (Rich.) and Abundance (Abund.) of taxa were recorded in the stations studied.

	SBDI		SBDII	
	Rich.	Abund.	Rich.	Abund.
Staphylinidae	14	257	11	449
Trechinae	11	79	7	57
Chrysomelidae	11	86	3	27
Scarabaeidae	8	75	4	58
Hydrophilidae	8	44	8	42
Curculionidae	7	13	6	12
Tenebrionidae	7	29	4	13
Dytiscidae	6	31	4	6
Pterostichinae	4	94	3	48
Lebiinae	4	145	5	149
Anthicidae	2	9	1	1
Corixidae	2	4	1	1
Nebriinae	1	2	1	2
Harpalinae	1	1	1	1
Elateridae	1	2	1	5
Hydraenidae	1	1	0	0
Heteroceridae	1	1	0	0
Licininae	0	0	1	1
Nepidae	0	0	1	5
Total	89	873	62	877

The families or sub-families Staphylinidae, Trechinae, and Lebiinae are the best represented in a number of taxa and numbers. They represent 32.6% of taxa and 59% of numbers in SBDI and respectively 37% and 74.7% in SBDII (Table 1).

The SBDI population is dominated by terrestrial species, both in terms of richness and abundance, whereas in SBDII they are dominant only in terms of richness, with riparian species being the most abundant. On the other hand, species of aquatic origin are fairly numerous but in relatively small numbers (Figure 1).

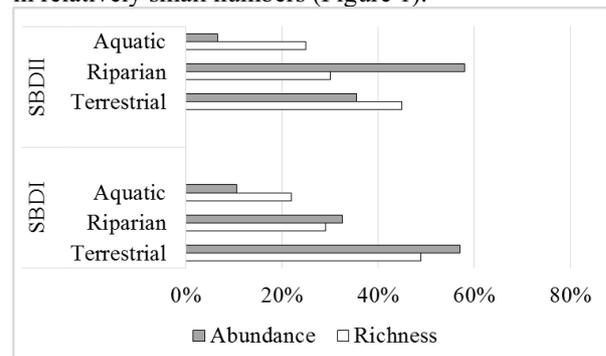


Fig. 1. Proportion of abundance and richness of different ecological groups on the banks of the Sidi Bouhria dayas (SBDI and SBDII).

Most of the species that inhabit dayas are sporadic. This category represents 53% of the taxa in SBDI (45 taxa) and 59% in SBDII (35 taxa). These species were encountered during only one of the four watering cycles (Table 2). On the other hand, for these two dayas, only 21% of the species for SBDI and 27% of the species for SBDII are constant and colonise the environment during at least three sampling campaigns. The majority of these species are either terrestrial in SBDI (9 species or 50% of taxa) or riparian in SBDII (9 species or 56% of taxa) (Table 2).

Table 2. Presence of species in the environment according to their ecological tendency (Riparian, Terrestrial, and Aquatic) during the sampling campaigns on the SBDI and SBDII dayas.

SBDI	R	T	A	
Constant (F ^a >50%)	7	9	2	18
Accessories (50% > F ^a >25%)	7	10	5	22
Sporadic (F ^a >25%)	11	23	11	45
SBDII	R	T	A	
Constant (F ^a >50%)	9	7	0	16
Accessories (50% > F ^a >25%)	2	6	0	8
Sporadic (F ^a >25%)	7	14	14	35

^a F = number of campaigns where the species is present compared to the total number of campaigns (4) in %.

The species that are regularly found on banks of the dayas during the same campaign represent only 10.6% of the taxa in SBDI (9 taxa) and 17% in SBDII (10 taxa). These are, among others, the carabids *Orthomus lacouri* and *Bembidion ambiguum* and the Staphylinidae *Aloconata gregaria* and *Platystethus cornutus*, these last

three species being riparian. As for the aquatic species, only *Agabus nebulosus* is regularly present on the banks.

3.2 Colonisation mode of SBDI and SBDII dayas

The riparian communities of SBDI and SBDII dayas generally evolves towards a more or less gradual decrease in abundance and richness, from the time of impoundment until complete drying (Figure 2). Indeed, abundance and richness are often at their maximum value at the beginning of the cycle and minimum

towards the end. Some of the taxa present at the time of the impoundment, especially terrestrial species, are probably displaced by runoff to the dayas. Indeed, many individuals of the genus *Microlestes*, of terrestrial origin, were only collected at the beginning of the cycle under plant debris.

In addition, the arrival of new rainfall during the impoundment of dayas can lead to an increase in richness and abundance, which was almost zero (Campaign I), or to a resumption of colonisation of the environment (Campaign IV).

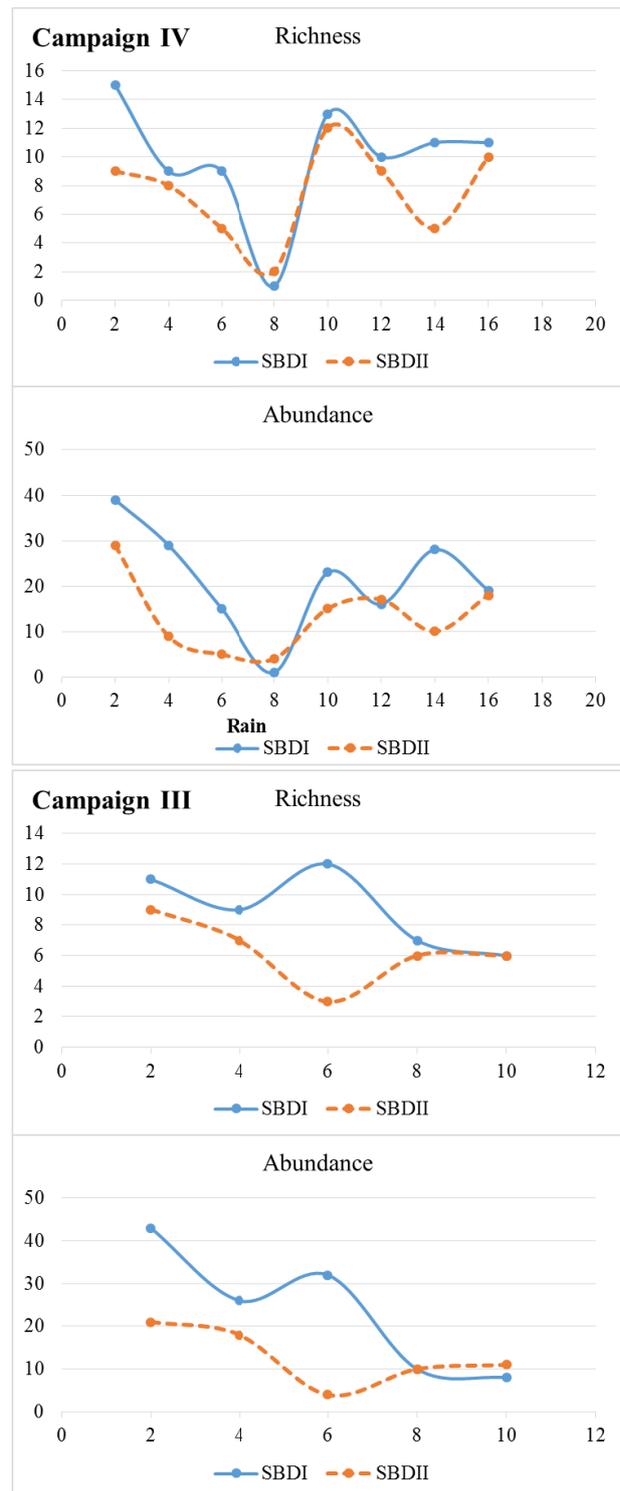
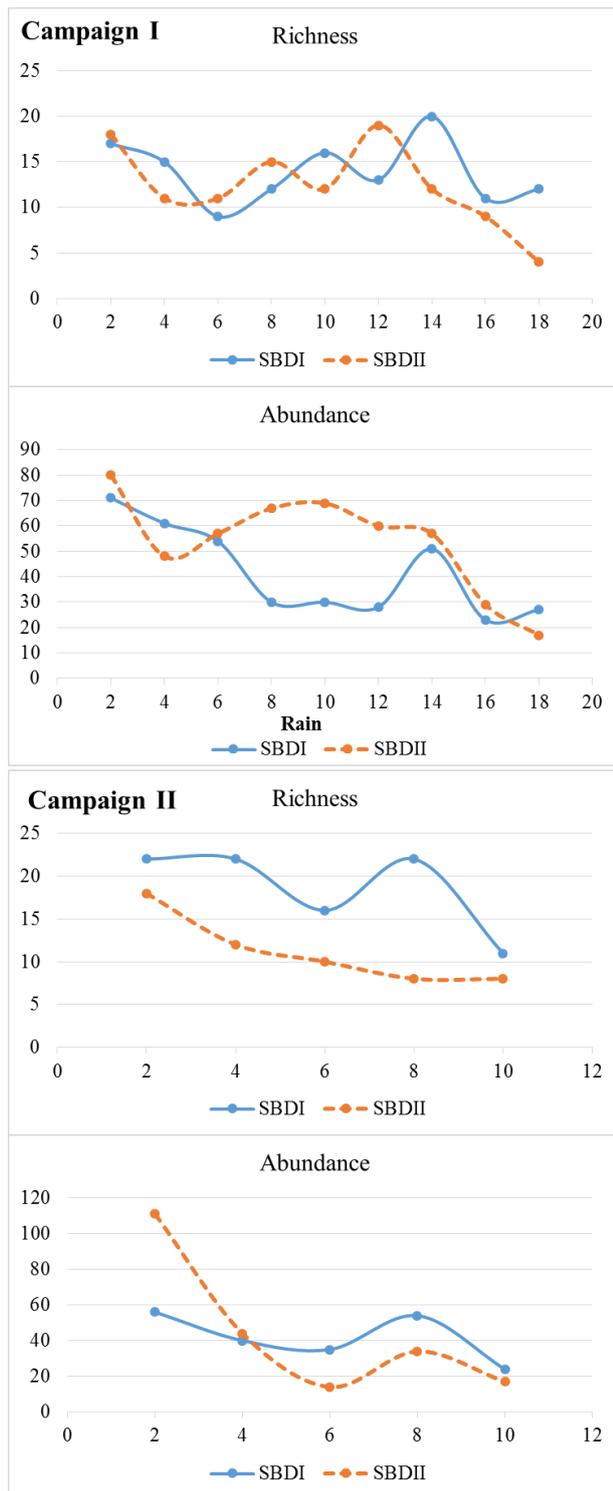


Fig. 2. Variation in overall population richness and abundance of SBDI and SBDII dayas during surveys I, II, III, and IV.

In order to study the colonisation of temporary riparian environments by the different ecological groups, we monitored fluctuations in the richness and abundance of riparian, terrestrial, and aquatic species over time and for each impoundment cycle (Figure 3). If we consider the evolution of terrestrial species about that of riparian species, we generally observe a decrease in the number

of terrestrial species and their abundance in the middle of the impoundment cycle and an increase in these parameters in riparian species. At the end of the cycle, the richness and abundance of riparian species decrease, while these parameters increase in terrestrial species. This situation is generally repeated on both dayas and for all watering cycles.

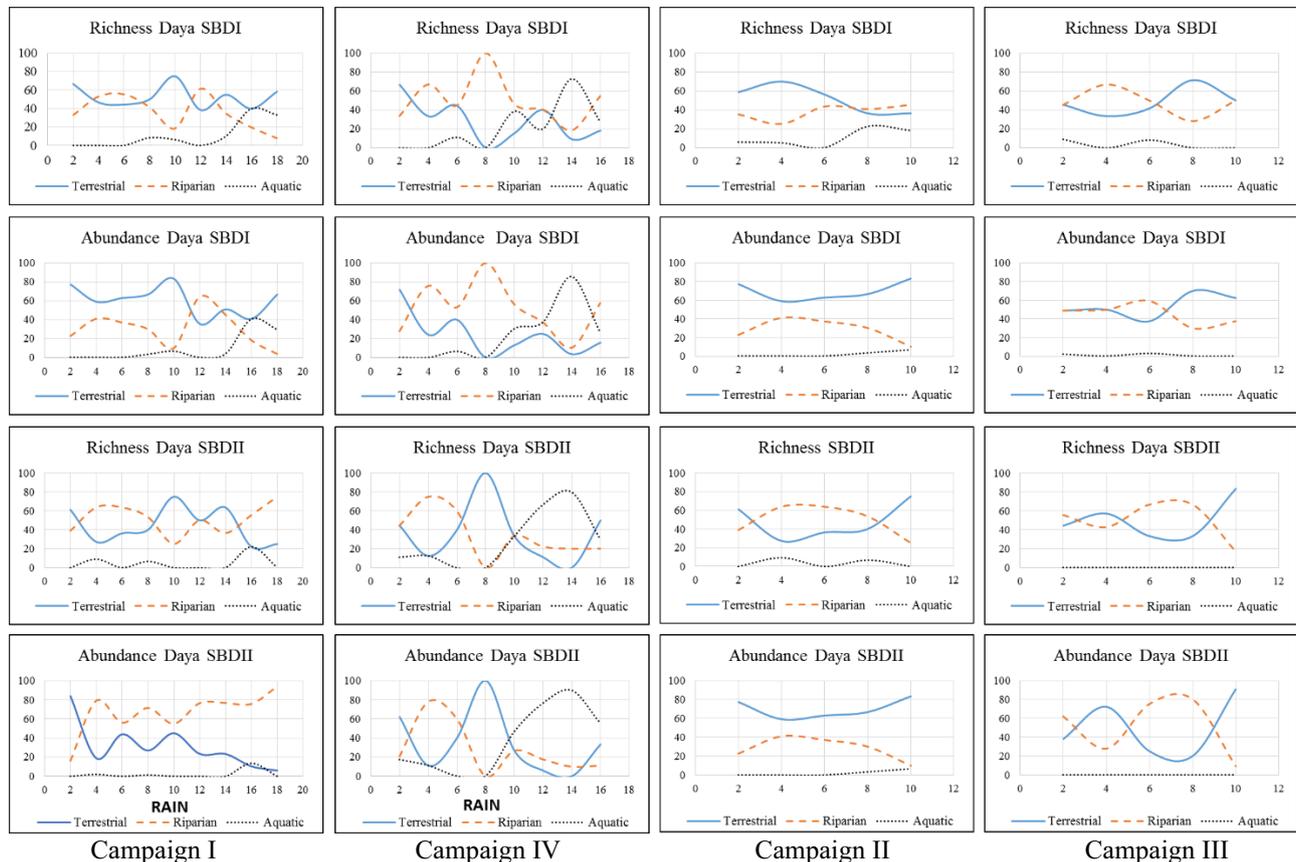


Fig. 3. Changes in richness and abundance of beetles of terrestrial, riparian and aquatic origin and aquatic

However, some variations can be observed, either due to the presence of rain during the cycle, which maintains a certain humidity and keeps the riparian species in the environment (case of the SBDI daya during campaign IV) or due to the environment drying out too quickly (case of the SBDI daya during campaign II). In this case, we see a return of terrestrial species (case of the SBDI daya during campaign II). In addition, during campaigns, I and IV, SBDI and SBDII dayas experienced a second filling of the water body, due to heavy rainfall that occurred, respectively, on day 8th and day 10th. This caused the dayas to refill as they were beginning to dry up. It is as if, for each campaign, two cycles followed one another immediately.

On the other hand, when they are present on the banks, the aquatic species show an increase in richness and numbers at the end of the cycle, in parallel with the reduction in the water mass.

4 Discussion

The three-phase colonisation pattern of temporary dayas of Sidi Bouhria, highlighted in a previous study based on Carabidae [15], is confirmed despite the much shorter water levels and the extension of the study to other groups of beetles. The first phase is dominated by terrestrial species. It is composed from the indigenous population, which was present in the area before the impoundment or was transported by water runoff. The second phase is dominated by riparian species, which use the temporary dayas as a “stopover” during their movements. These dayas can be considered, for various species, as “bridges” serving as a relay between the various more permanent wetlands [16]. Finally, the third phase corresponds to a return to the dominance of terrestrial species after the departure of the riparian species due to the drying of the environment. Thus, whatever the duration of the impoundment and whatever the season [15], the three phases of colonisation, or at least two of them, are present. These phases can be spread over several days or, on the contrary, be very brief, or even occur in only one sample. They can also be very clear-cut, with a very clear dominance of one of the ecological groups, or they can be less marked, with

a simple growth of one of the groups going in parallel with a decrease of the other without recording a clear dominance ratio.

In the course of the watering cycles, quite a few species of aquatic origin come to a mix with the other ecological groups. They do not seem to feed on the banks, as some authors assume [17,18], but are mostly trapped in small puddles that dry out quickly or under stones.

Depending on the case, rainfall during the impoundment cycle can have different consequences for riparian fauna. In some cases, they can lead to a decrease in richness and abundance, either by reducing the movement of insects, which have difficulty moving in overcast conditions or by causing a spatial dispersion of the population, due to the large wetlands around the dayas that are available to individuals. In other cases, on the other hand, rainfall can cause an increase in abundance and richness, either by increasing the moisture content of a drying soil or by increasing the surface area of wet banks as a result of the increased water surface. This allows a greater number of individuals to settle, especially as rainfall is generally a factor in the emergence of imagos.

5 Conclusion

Temporary riparian environments with very short periods of watering, such as the dayas of Sidi Bouhria, are unstable in time and space, under the influence of very rigorous ecological conditions, and inhabited by mostly unstable and unbalanced populations. They are composed of a majority of species with low abundance, occurring on the banks accidentally and sporadically [13]. The riparian species seem to be only passing through [19], they are good flyers, very mobile, and able to leave the environment as soon as the conditions become unfavourable. The study identified three phases of colonisation. The first is characterised by the dominance of terrestrial species, the second by riparian species, and the third corresponds to a return to the dominance of terrestrial species, with a population similar to that of the initial phase. The rainfall that occurs during the watering cycles plays a significant role in the development of these colonisation phases.

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