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Biodiversity in riverbank techniques for erosion control: assessment of animal and plant species diversity along a natural gradient.

Paul Cavaillé [1*], Nathan Daumergue [1], Sébastien De Danieli [1] and André Evette [1].

1 Cemagref, UR EMGR, 2 rue de la papeterie BP 76, 38402 Saint-Martin-d'Hères, France

* Corresponding author: paul.cavaille@cemagref.fr

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Extended abstract:

Riverbanks are characterised by high levels of both species-richness and anthropic pressure (Decamps 2003; Schnitzler-Lenoble 2007). Erosion controls on riverbanks often involve installations to protect human investments (i.e. buildings, public amenities etc.). However, whether such installations can accommodate natural biodiversity has not been well assessed and is consequently seldom taken into account in the choice of technique. Furthermore, specific work must be done on exotic species and their negative effect on biodiversity in such environment. Indeed, the development of invasive species is of considerable importance as it represents the fourth threat in terms of biodiversity loss (Thuiller 2007). Riparian ecosystems are particularly impacted by this invasion phenomenon since they are considered as being rich and strongly perturbed area (PlantyTabacchi, Tabacchi et al. 1996; Vitousek, Dantonio et al. 1997; Alpert, Bone et al. 2000).

This study aims to assess animal and plant taxonomic diversity on a naturalness gradient of various riverbank protection systems. This is done by comparing biodiversity of riverbank construction from entirely stone riprap, through combined constructions (mixing riprap and bioengineering), to purely vegetative bioengineering structures. We also seek to highlight bioengineering effects on exotic species development.

Three types of riverbank protections were chosen:

- Entirely mineral protections: made up of rough riprap.
- Mixed protections: composed of rough riprap for the lower part of the riverbank and plant seedings and cuttings on the upper part.
- Vegetative bioengineering protections: made up of willow fascines, brush layers, cuttings and seeding.

These three types of riverbank protections are respectively called “Mineral”, “Mixed” and “Vegetal” (fiugure1).

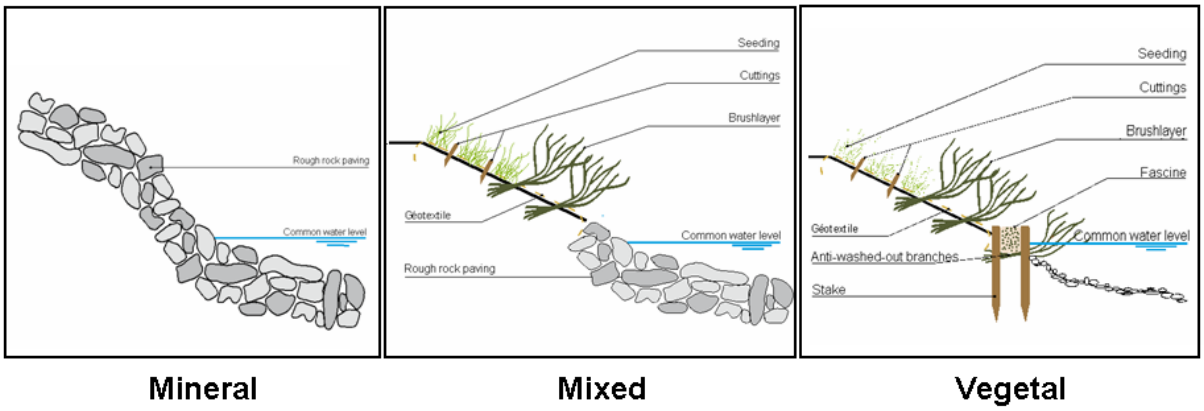

Figure 1: Schemes of the three types of riverbank protection.

In order to compare the species diversity of these three types of riverbank protection, environmental factors and local topographic profile need to be priorly studied. First, all protection sites are located between 250 and 500 meters high in order to minimize the altitude influence on vegetation structure. The ages of riverbank protections are also considered as a determining factor especially to take into account the progression of species colonisation and ecological succession processes.

We compared plant species diversity and animal taxonomic diversity above ground (beetles) on five sites for each type of riverbank protection. Analyses were also made on the average number and frequency of exotic plant species for each type of riverbank protection. Vegetation was sampled along three longitudinal transects using the point contact method. Coleoptera genuses were sampled in the air by trapping (yellow Flora® bowl trap). The fifteen sites sampled were located in the Rhône-Alpes region (South East France).

As a result, 148 plant species and 78 beetle genera were recorded. We found significantly lower plant diversity on riprap constructions ("Mineral") than on both other types. Surprisingly, plants diversity was higher, even if not significantly, in combined works ("Mixed") than in purely vegetative ones ("Vegetal")(figure2). Coleoptera genius diversity was clearly linked to the type of riverbank protection. Thus we counted an average number of 12.2 coleoptera genus for the "Vegetal" type, 7.2 for the "Mixed" category and only 3 genuses for the "Mineral" type (figure 3).

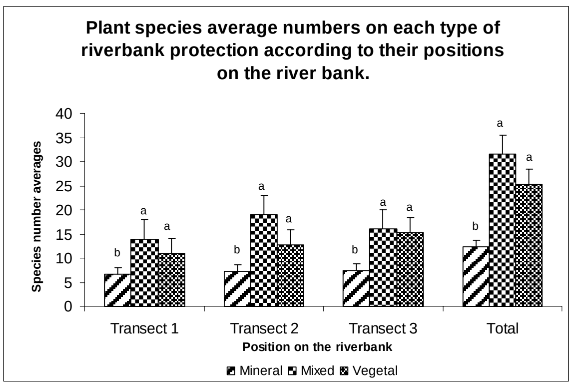

Figure 2: Bar chart of plant species average number on each type of riverbank protection according to their positions on the river bank.

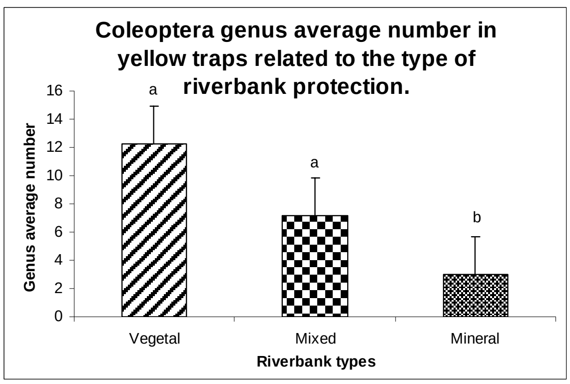

Figure 3: Bar chart of coleoptera genus average number in yellow traps related to the type of riverbank protection.

We found out that riprap techniques were more subjected to exotic invasions than techniques using bioengineering. Indeed, the number of exotic species (figure 4) is almost the same between the three types but the frequency (figure 5) is clearly higher for the "Mineral" type.

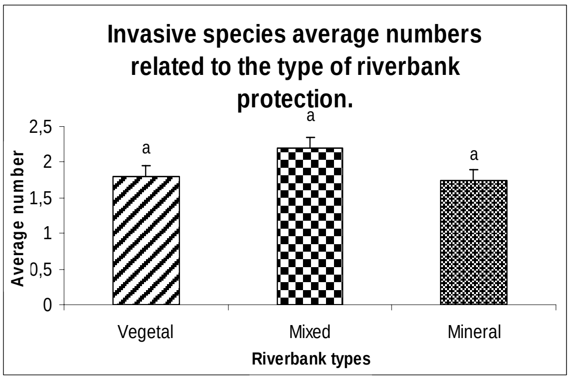

Figure 4: Bar chart of invasive species average numbers related to the type of riverbank protection.

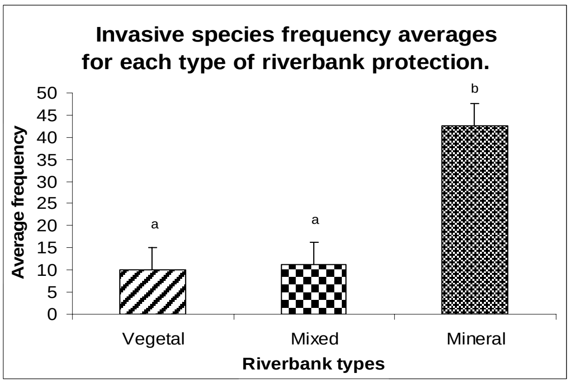

Figure 5: Bar chart of invasive species frequency averages for each type of riverbank protection.

This study highlights many differences between the three types of riverbank protections. Indeed, plants diversity is clearly lower on the "Mineral" type. This phenomenon may be related to the substratum composition which is not conducive to plant colonisation. We found that plants diversity was higher, even if not significantly, on combined works ("Mixed") than on purely vegetative ones ("Vegetal"). This result can be explained by the presence of rough riprap on the lower part of the riverbank. It forms a second colonisation front (following the one at the top of the riverbank) which particularly enables helophytic plant colonisation. Moreover, willows used for fascines are generally fast growing trees (Newsholme 2003; Adam 2008). Consequently, they inhibit plant species colonisation by reducing light and space availability.

Likewise, a major result is the relationship between the average number of coleoptera genus in yellow traps and the type of riverbank protection. The coleopteran diversity is significantly lower on "Mineral" protection type. This result is consistent with previous studies (Lecomte and Pouzat 1986; Pham-Delegue and Besson 1992). It can be explained by the lack of vegetation which plays a key role in habitats formation by providing shelters and a source of food for animals. The results of coleoptera diversity on "Mixed" and "Vegetal" types moderate the previous observations on flora diversity. Thus, we took a census that was substantially higher on "Vegetal" protection type than on "Mixed" type. This result confirm that Salix genus is a important habitat for insects (Sommerville 1991) as it provides a very early and abundant source of food (Newsholme 2003).

The analyses conducted on exotic species (including *Fallopia japonica*, *Budleia davidii* and *Solidago Canadensis*) show that the number of invasive species is nearly the same on every type of riverbank protection. By contrast, their frequency is greatly superior on the mineral type. The invasion is not a problem in itself. However, since the invasive species become abundant, the threat to natural or restored systems becomes significant (Siemens and Blossey 2007). This result demonstrates the capacity of riverbank bioengineering to limit invasive species development. It underlines an inter-species competition between invasive species and plants used for bioengineering.

To conclude, this study gives new insights into animal and plant biodiversity of riverbank protections against erosion, ranging from entirely mineral to purely vegetative constructions. It also provides useful information to practitioners by providing them with useful data to choose techniques in relation to their future impact on biodiversity. However, our results should be complemented with: (i) studies on other techniques of riverbank protection as well as on natural riverbanks to set a reference; (ii) hydrobiological surveys to evaluate the influence of the riverbank protection type on aquatic macro invertebrate diversity; (iii) a diachronic approach in order to figure out the evolution of biodiversity; (iv) studies on functional diversity to assess the ecological functions of these restored ecosystems.

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