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Small-scale spatial genetic structure of *Populus nigra* L. seedlings on a new sandy-gravelly bar appeared after maintenance operations in the Loire River (France)

Etude de la composition génétique et de la microstructuration spatiale de semis de *Populus nigra*, installés sur une nouvelle barre sédimentaire de Loire (France)

Sara Marin[1], Véronique Jorge[2], Vanina Guérin[2], Coraline Wintenberger[3], Marc Villar[2]

[1]Université Toulouse 3 Paul Sabatier, CNRS, ENFA ; UMR 5174 EDB, 118 route de Narbonne F-31062 Toulouse, France ; [2]INRA, UR588 Amélioration, Génétique et Physiologie Forestières (AGPF), Centre de Recherche d'Orléans, CS 40001 Ardon, F-45075 Orléans, France (corresponding author : marc.villar@orleans.inra.fr)
[3]Université François Rabelais de Tours, E.A 6293, GéoHydrosytèmes Continentaux, UFR Sciences et techniques, Parc de Grandmont, 37200 Tours, France

RÉSUMÉ

Le peuplier noir (*Populus nigra* L.) est une espèce clef de l'écosystème riverain ligérien et représente un marqueur biologique de la dynamique morphosédimentaire du fleuve. Cette espèce est menacée par les activités anthropiques. L'objectif de cette étude est de rechercher une éventuelle structuration génétique spatiale de semis de *P. nigra,* qui sont apparus sur une barre sédimentaire nouvelle à la suite de travaux d'entretien du lit de la Loire. Cette étude a été réalisée au sein de la mosaïque de cinq ilots de Mareau-aux-prés (13 hectares, inclus dans l'Unité Conservatoire des ressources génétiques de *P. nigra*, Loiret, France). En septembre 2012, la végétation de l'ilot central a été détruite, les souches ont été extraites et l'ilot a été arasé. Pendant le printemps et l'été 2013, une nouvelle barre sédimentaire est apparue et a été explorée régulièrement pour répertorier les zones de germination de semis de *P. nigra*. En septembre 2013, 1550 jeunes plantules (31 x 50 zones) ont été collectées pour des analyses génétiques via 11 marqueurs ADN microsatellites. La diversité génétique a été estimée via le taux de polymorphisme, la richesse allélique, l'hétérozygotie observée et attendue et la différenciation génétique neutre (F_{st}). Bien que significativement différent de zéro, le F_{st} des 50 zones est faible, et le niveau de diversité est comparable aux populations parentales des berges. Ces résultats sont discutés en termes de microtopographie de la barre, de la fluctuation de la nappe, de la période de libération des graines et de la texture sédimentaire.

ABSTRACT

Black poplar (*Populus nigra* L.) is a key species of the Loire riverine ecosystem and represents one biological marker of the sediment morphodynamics and fluvial metamorphosis of the river. This species is threatened by human impacts. The main objective of this work is to study small-scale spatial genetic structure of *P. nigra* seedlings on a new sandy-gravelly bar appeared after fluvial maintenance operations in a mosaic of five islands (13 hectares, included in the Conservation Unit of genetic resources of *P. nigra*, Loire River, Loiret, France). In September 2012, the vegetation of the central island was uprooted and the level lowered in order to maintain the flow capacity of the river. During 2013 spring and summer, the fresh sediments of the new bar were regularly surveyed to identify and geocode successive regeneration zones. In September 2013, 1550 seedlings (31 seedlings x 50 zones) were collected for genetic analysis using 11 microsatellites DNA markers. Genetic diversity was expressed in terms of percentage of polymorphic loci, observed and effective number of alleles, observed and expected heterozygosity and genetic differentiation (F_{st}). Although significantly different from zero, F_{st} within the 50 regeneration zones is very low and level of genetic diversity is comparable to parental populations (mature trees on the river banks). These results are discussed in terms of microtopography, water level fluctuation, phenology of seed dehiscence and sediment texture.

KEYWORDS

Genetic diversity, fluvial management, *Populus nigra*, spatial structure

1 INTRODUCTION

The main objective of this work was to study small-scale spatial genetic structure of *P. nigra* seedlings on a new sandy-gravelly bar appeared after fluvial maintenance work (FMW) in a mosaic of five islands of Mareau-aux-prés (13 hectares, Loire River, Loiret, France). In september 2012, the vegetation of the central island was uprooted and the level lowered in order to maintain the flow capacity of the river. The study of the impact of such FMW on several components of biodiversity is the core of the research project 'BioMareau' (2012-2015), entitled « Consequences of fluvial maintenance operations in the Loire river on some components of biodiversity in the mosaic of Mareau-aux-Prés islands ». During 2013 spring and summer, the fresh sediments of the new bar (code : ecotope 2058) were regularly surveyed to identify and geocode successive regeneration spots. In September 2013, 1550 seedlings (31 seedlings x 50 spots) were collected for genetic analysis using 11 microsatellites DNA markers, including seedlings from spots from other ecotopes, upstream and downstream the new bar.

2 RESULTS

2.1 *In situ* measurements

The elevation of the spots ranges from 83.60 m to 86.50 m high. The height of the seedlings ranges from 23.5 mm to 201 mm, with a mean of 47 mm. Density per spot ranges from 2.2 seddlings/m^2 to 412/m^2 with a mean of 56.7/m^2 .

2.2 Genetic analysis

All microsatellite markers were highly polymorphic, revealing from 9 (PMGC2156) to 23 alleles (WPMS05). F_{is} values for single loci reflected a deficit of heterozygosity for two loci (PMGC2156 and PMGC2235). Overall F_{st} among the spots was 0.032, with F_{st} between pairs of spots varying between 0.062 and 0.007. The STRUCTURE analysis distinguished no cluster among the 50 spots and the 1550 seedlings. Based on F_{st} values, the highest differentiation is from seedlings from ecotope 2057, a distinct zone upstream from the 2058 ecotope. Such higher differenciation has also been revealed in a old seedling spot (three years old) in the downstream ecotope 2061. No correlation has been detected between genetic diversity and elevation of the spot. Furthermore, no significant genetic difference between 2013 seedlings (after FMW) and 2008 seedlings (before FMW) has been detected.

3 DISCUSSION AND CONCLUSIONS

The genetic analysis of 1550 seedlings from 50 regeneration events revealed very low genetic differentiation in between spots and ecotopes. Main conclusion is that we found no evidence for spatial genetic structure of the 2013 seedlings in this area. These results must be linked with the hydrogramme of the Loire river in 2013 (Fig. 1), basis of the model of the recruitment box from Mahoney and Rood (1998). Important and unusual flooding period in May and beginning June induced late emergence of the bar (approx. 17th June). This period corresponds to release of seeds only from late mature mother trees, thus reducing the potential genetic diversity from the whole parental genotypes of the area. Furthemore, two micro floods in August could have uprooted or buried the young seedlings, thus eliminating the smallest ones and their genetic diversity. These summer unusual events could also explain higher differentiation of the 2011 seedlings in the dowstream ecotope 2061 (taller and with a stronger root system) and spots from the upstream 2057 ecotope, located at higher elevation. Further study will search for SGS of the mature adult *Populus nigra* from the five islands combined with paternity studies of the 2013 seedlings.

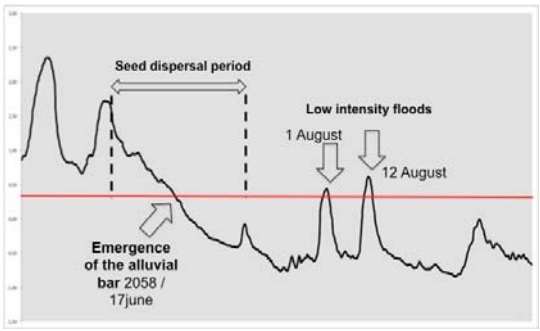


Fig. 1. Hydrological regime variation of the Loire river measured 10kms upstream the study zone. Data from Hydro DREAL Centre from May to September 2013

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