¡Muchas gracias por compartir con la comunidad fluvial tus experiencias y resultados!

Para facilitarte la tarea de escribir tu comunicación, te proporcionamos:

⇨Plantilla con los formatos para preparar tu comunicación.

⇨Recomendaciones para los contenidos.

⇨Instrucciones para el envío.

Léelas con atención y síguelas: fácil para tí, fácil para nosotros.

¡NOS VEMOS EN MURCIA!

LIFE+ RIPISILVANATURA: Preliminary assessment of the effect of riparian restoration actions on aquatic and terrestrial biodiversity

Bruno, Daniel[a]*; Zapata, Víctor[b]; Guareschi, Simone[c]; Dettori, Ettore[b]; Picazo[b], Félix; Millán, Andrés[b]; Velasco, Josefa[b]; Robledano, Francisco[b]

[a]Instituto Pirenaico de Ecología (IPE-CSIC), Dpto. de Conservación de la Biodiversidad y Restauración de Ecosistemas. [b]Universidad de Murcia, Dpto. de Ecología e Hidrología. [c]Loughborough University, Geography and Environment.

*Autor para contacto: dbrunocollados@um.es

Resumen

Las especies invasoras están entre las cinco causas más importantes de pérdida de biodiversidad. En concreto, la caña común (*Arundo donax*) ha colonizado las riberas fluviales de numerosos ríos mediterráneos con efectos negativos sobre la biodiversidad riparia y acuática. Los métodos para su control varían en función de las condiciones ambientales, económicas y sociales. En el marco del proyecto RIPISILVANATURA LIFE13BIO/ES/001407, evaluamos el efecto de las cortas reiteradas de caña (2 tratamientos: suave – corta cuatrimestral *versus* duro – mensual) combinadas con la plantación de especies nativas, sobre la diversidad taxonómica y la calidad de las comunidades riparias (vegetación y aves) y de las comunidades de macroinvertebrados acuáticos. En concreto, se evaluó si hubo una evolución positiva y si los tratamientos tuvieron efectos diferentes aplicando modelos mixtos sobre los datos obtenidos de los muestreos anuales (2015-2018). Los modelos mixtos también fueron utilizados para testar la relación entre las variables riparias y las comunidades de aves y macroinvertebrados acuáticos. Aplicamos NMDS, PERMANOVA e IndVal para explorar si existen diferencias temporales en la composición taxonómica de las comunidades biológicas. En esta evaluación preliminar, encontramos cambios significativos en los patrones de composición de vegetación y macroinvertebrados acuáticos. La calidad (RQI y IBMWP) y riqueza de las comunidades riparias y acuáticas se vio incrementada mientras que la altura y cobertura de *A. donax* se redujo significativamente, sin diferencias entre tratamientos. Finalmente, el control suave produjo un efecto positivo sobre la riqueza, densidad y abundancia de aves mientras que el tratamiento duro tuvo un efecto ligeramente negativo.

Palabras clave*: Arundo donax, Restauración Ecológica, Macroinvertebrados acuáticos, Aves.*

Abstract

Invasive species are among the top five causes of biodiversity loss. Particularly, giant reed (*Arundo donax*) has progressively colonized the riparian zones of Mediterranean rivers with detrimental effects on riparian and aquatic biodiversity. Different methods have been traditionally used to control it and restore native riparian vegetation depending on the environmental, economic and social context. We assess the effect of repeated pruning of giant reed (testing 2 treatments: soft-quarterly pruning and hard-monthly pruning) combined with the plantation of native species, on aquatic and terrestrial communities in the context of the project LIFE13BIO/ES/001407 RIPISILVANATURA. Specifically, we evaluate if riparian vegetation, birds and aquatic macroinvertebrates show significant responses throughout time and between treatments based on annual biomonitoring data (2015 -2018). Changes in taxa diversity and ecological quality indices for the different biological communities were tested using mixed-effect models (LMEs). LMEs were also applied to assess how riparian variables were related to bird and aquatic macroinvertebrate indices. Non-metric Multidimensional Scaling (NMDS), Permutational Multivariate Analysis of Variance (PERMANOVA) and Indicator Value analysis (IndVal) were performed to detect significant temporal differences in taxa composition. During this preliminary assessment, we documented significant changes in riparian and aquatic macroinvertebrate composition patterns. We also found increases in riparian and aquatic macroinvertebrate richness and quality indices (RQI and IBMWP), and a significant decrease in *A. donax* height and cover, without significant differences between treatments. Finally, differential effects between soft (positive-neutral effect) and hard treatments (neutral-negative effect) were found for bird richness, density and abundance.

Keywords*: Arundo donax; Ecological Restoration; Aquatic macroinvertebrates; Birds*

1. Introduction

Invasive species are among the top five causes of biodiversity loss. Particularly, giant reed (*Arundo donax* L., Poaceae) has colonized progressively the Mediterranean Basin from the Middle East in Asia towards the West (Hardion et al., 2014), being one the 100 most dangerous invasive species worldwide (Lowe et al., 2000). In Spain, the giant reed is widely spread disturbing the native riparian habitats through the impoverishment of riparian native flora and terrestrial and aquatic fauna as well as causing changes in riparian food webs which benefit its own growth and continued spread (Maceda-Veiga et al., 2016). This graminoid is a tall (2-8 m), erect, robust, fast-growing (2-10 cm/day) and perennial hydrophyte with vegetative reproduction usually forming monospecific clumps (Perdue, 1958). It spreads from thick rhizomes or stem nodes carried downstream that once rooted and established, tends to form large, continuous, clonal root masses (up to 1 m thick; Bell, 1997). It is well adapted for establishment and spread in riparian areas of regulated rivers (dams), altered hydrologic regimes or disturbed riparian vegetation (Dudley, 2000).

A. donax dominance is a direct consequence of previous fragmentation and deforestation to develop anthropic land uses (agriculture, urban settlements, roads, etc.), which have weaken native riparian communities leaving empty niches for the rapid invasion of this invasive species (promoted by agricultural activities and fire; Coffman et al., 2010). This invasion has detrimental effects on different ecosystem services as the provisioning of material and energy, regulation and maintenance of the environment for humans and cultural services. In particular, in comparison with native riparian species, *A. donax* is related to a reduced water quality (less shadow to the river, increased temperature and decreased dissolved oxygen, Bell, 1997) and quantity (higher evapotranspiration rates and less aquifer recharge), less recreation and navigation opportunities (less water discharge and invaded banks), increased flood (it is related to vegetation encroachment, channel narrowing, faster runoff and higher sedimentation rates, Vilà & Holmes, 2017) and fire risk (this species is extremely flammable), bank instability and erosion (shallower root system combined with greater aerial biomass) which derives in potential bridge (and other hydraulic infrastructure) collapse (Deltoro-Torró et al., 2012).

Given the intensity and variety of ecological, economic and social impacts generated, different methods have been traditionally used to control giant reed: burning (which is a complete mistake due to its stronger post-fire resprouting; Coffman et al., 2014), chemical treatment (mainly the polemic glyphosate), plastic layering or coverage, flooding or weeding, among others (Deltoro-Torró et al., 2012). Most of these methods are valid for degraded areas where *A. donax* dominates completely but not for river reaches where this species coexists with native vegetation and/or in protected areas (with legal and ecological restrictions for the application of hard restoration methods), where less aggressive methods are required to avoid the disturbance of native communities and ecological succession. Previous eradication campaigns have usually been performed locally (especially in lower reaches where *A. donax* forms extensive monospecific clumps) and without any coordination or long-term planning resulting in high costs and poor results (Bruno et al., 2018). River restoration projects should lie in coordinated holistic measures planned at broad scale rather than on local disconnected actions, to develop more effective management strategies (Neeson et al., 2015).

In this context, LIFE13BIO/ES/001407 RIPISILVANATURA (2014-2019, coordinated by Confederación Hidrográfica del Segura) aims to control invasive alien species by strengthening riparian habitats (specially the 92A0 of European Directive 92/43/CEE) in moderately disturbed middle reaches of the Segura river, where both invasive species and remnants of riparian native vegetation coexist and there is a significant presence of protected areas. Therefore, this project aims to weaken *A. donax* while expanding native riparian cover, through coordinated soft-engineering techniques in order to enhance the competition exerted by native riparian species. Here, we aim to make a preliminary evaluation of the effectiveness of a previously non-evaluated strategy to face the invasion of *A. donax* in Mediterranean areas: repeated pruning with two different frequencies (monthly vs. quarterly) combined with the plantation of native riparian species. The rationale behind this restoration strategy is to exhaust the rhizome nutritional reserves since by forcing *A. donax* to replace constantly its stems at the same time we leave time to vegetation to develop and be able to successfully compete with this helophyte for the sunlight and the riparian space (Deltoro-Torró et al., 2012). We also assess if the taxonomic composition, condition and species richness of riparian vegetation, birds and aquatic macroinvertebrates are showing significant responses to these restoration actions. We expected a reduction in *A. donax* cover, height and stem density as well as a parallel increase in native riparian coverage, diversity and ecological status of riparian and aquatic communities.

2. Methods

1.1 Study area

The current study was developed in the Segura river basin, a semi-arid Mediterranean catchment located in the South-East of the Iberian Peninsula. In particular, riparian restorations took place in 57 Km of the middle reach of the Segura

River including the municipalities of Cieza, Calasparra and Moratalla. This area is geologically characterized by the dominance of limestone, sandstone, gypsum and loam substrates and climatically featured by a mean annual precipitation of 300 mm and annual mean temperature of 17ºC. Regarding anthropogenic impacts, the river reach is subjected to intense flow regulation and consequently spread hydro-morphological alterations whereas the main land use in the area is semi-natural (dominant shrubby landscape; >50% of the area) and agriculture (mainly rice fields, apricot and peach trees; <50%) being urban areas scarce (<2%). Finally, the preliminary assessment of riparian vegetation within the context of LIFE+ RIPISILVANATURA, pointed that this area was namely characterized by 92A0 and 92D0 habitats (Habitat Directive 92/43/CEE), showing a mixture of European and African flora (*Salix* spp., *Fraxinus angustifolia*, *Populus* spp., *Tamarix* spp., *Nerium oleander*), which constitute a distinctive occurrence in the Iberian Peninsula (Bruno et al., 2014). Nevertheless, native habitats have been progressively displaced by *A. donax*, which already occupies nearly a 40% of the whole river reach according to preliminary evaluation done to design the project.

1.2 Data collection

Restoration actions were developed in 52 river reaches where soft (quarterly) or hard (monthly pruning) maintenance has been applied aiming to reduce the competence exerted by *A. donax* and leave time to the vertical and lateral development of planted riparian species (slower growth than *A. donax*). Restoration was assessed through a BACI design (Before–After Control-Impact): >25% of restored river reaches have been annually (2015-2018) monitored (in spring) for riparian vegetation (16 transects and 80 plots) and birds (15 transects), half of them located in sections with monthly and quarterly pruning, respectively. Similarly, aquatic macroinvertebrates were sampled in 12 sites along the watercourse through a multihabitat standardised protocol to monitor changes in aquatic communities as consequence of restoration actions. Within this biomonitoring scheme, we recorded a set of ecological indicators for each sampling site and year: riparian vegetation richness, riparian quality index (González del Tánago & García de Jalón, 2011), density and height of *A. donax*, native and exotic vegetation cover, aquatic macroinvertebrate family richness, Coleoptera richness, Hemiptera richness, Iberian Biomonitoring Working Party (IBMWP, Alba-Tercedor et al., 2002), as well as species richness, density and kilometric abundance index (IKA) for birds.

1.3 Data analysis

Changes in riparian vegetation (species richness, quality-RQI, *A. donax* height and stem density, native and exotic cover), aquatic macroinvertebrate metrics (family richness, quality-IBMWP, Coleoptera and Hemiptera species richness) and birds (species richness, density and abundance-IKA) among years (2015, 2016, 2017 and 2018) and treatments (soft-monthly vs hard-quarterly pruning) were tested using linear mixed-effect models (LMEs), considering year and type of treatment as fixed factors and sites as random factors. Tukey post-hoc tests were applied when significant results were found. LMEs were also applied to find relationships between riparian variables, macroinvertebrate and bird indices. Non-metric Multidimensional Scaling (NMDS), Permutational Multivariate Analysis of Variance (PERMANOVA) and Indicator Value (IndVal) analysis were used to detect differences in the taxonomic composition of the different biological communities. All statistical analyses were performed using R statistical software (R Development Core Team, 2017).

3. Results

We observed a significant reduction of *A. donax* height and exotic cover, an improvement of the riparian quality (RQI) and an increase in riparian species richness throughout time, without significant differences between soft and hard treatments (Figure 1). No significant differences among years nor treatments were found for *A. donax* stem density and native cover. Regarding aquatic macroinvertebrates, we detected a significant increase in quality (IBMWP) and richness (family richness and Hemiptera species richness) after 2017. No significant differences among years were observed for Coleoptera richness. In the case of birds, at first glance LMEs did not show significant temporal differences between years for bird density, abundance (IKA) and species richness (Figure 3). Nevertheless, there was a significant interaction between date and treatment (Figure 4) pointing to differential effects between soft (positive effect) and hard treatments (neutral-negative effect) on bird community. Regarding the relationships between riparian vegetation and faunal communities, aquatic macroinvertebrates and birds were positively influenced by riparian species richness and quality (RIQ) but negatively by exotic cover and *A. donax* stem density (Figure 5).

NMDS and PERMANOVA results pointed to significant temporal taxonomic changes between 2015 (before the restoration actions) and 2018 for aquatic macroinvertebrates (P=0.016, R^2=0.08) and riparian vegetation (P=0.001, R^2=0.13). No significant taxonomic changes were detected for birds (P=0.18). Finally, although IndVal did not identify any indicator species for riparian vegetation before the beginning of restoration measures (2015), it did in 2018 selecting *Salix purpurea*, *Salix neotricha*, *Nerium oleander* and *Sambucus nigra* (P = 0.001) as the most significant riparian species. Regarding macroinvertebrates, Planorbidae was the unique indicator taxon (P=0.003) in 2015 whereas Tabanidae

(*P*=0.002), Platycnemididae (*P*=0.011), Melanopsidae (*P*=0.033) and Gerridae (*P*=0.04) were representative of the current aquatic community (2018). No significant indicator species was identified for birds in any of the periods (2015 or 2018).

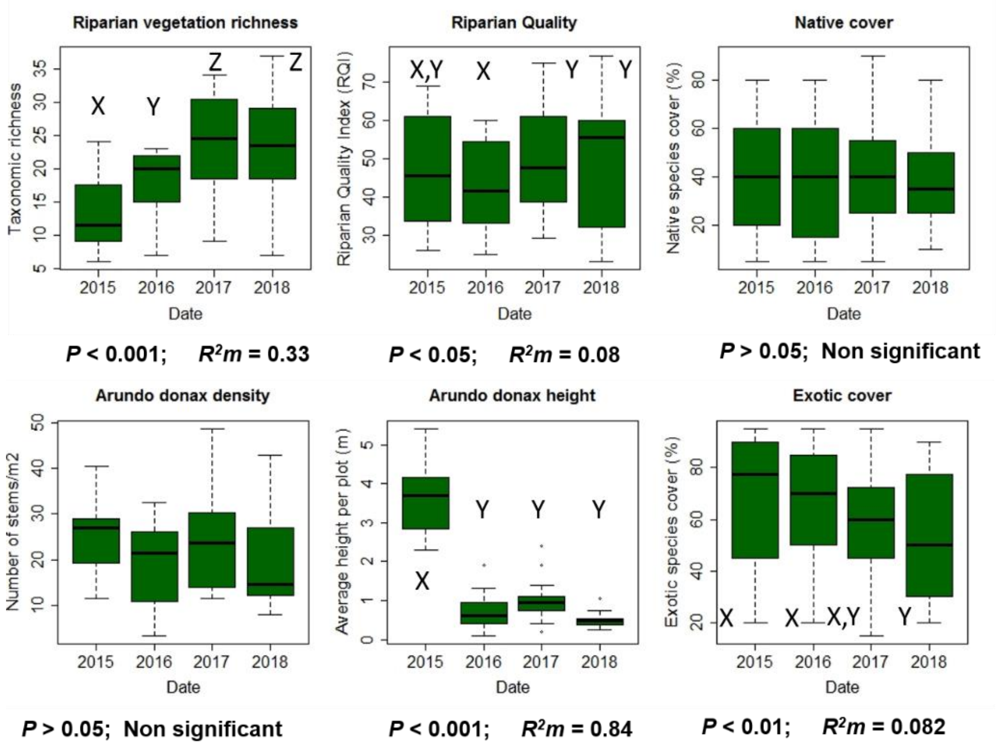


Figure 1. Results of mixed models and Tukey post-hoc test relative to the temporal evolution of the indicators of riparian vegetation. *Elaboración propia.*

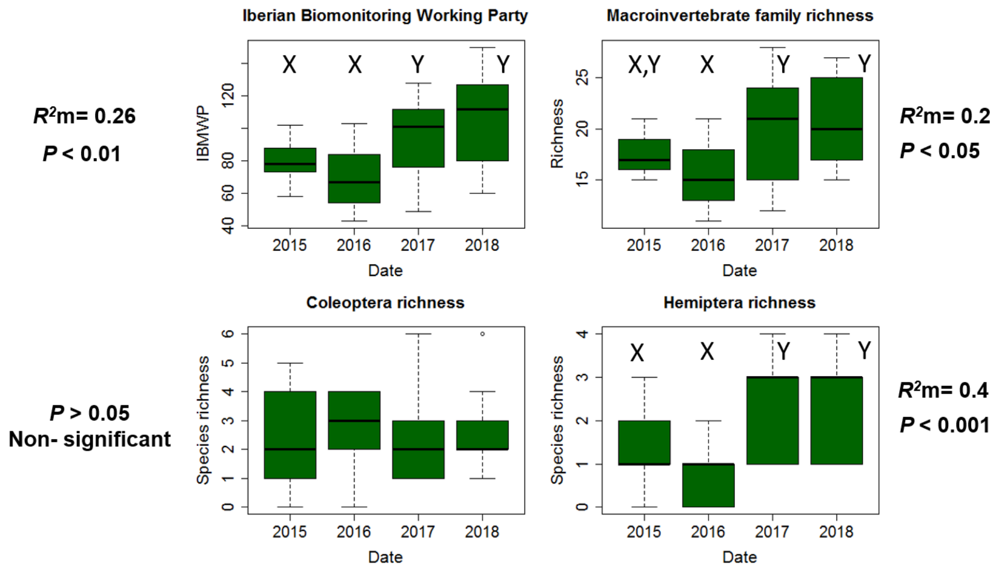
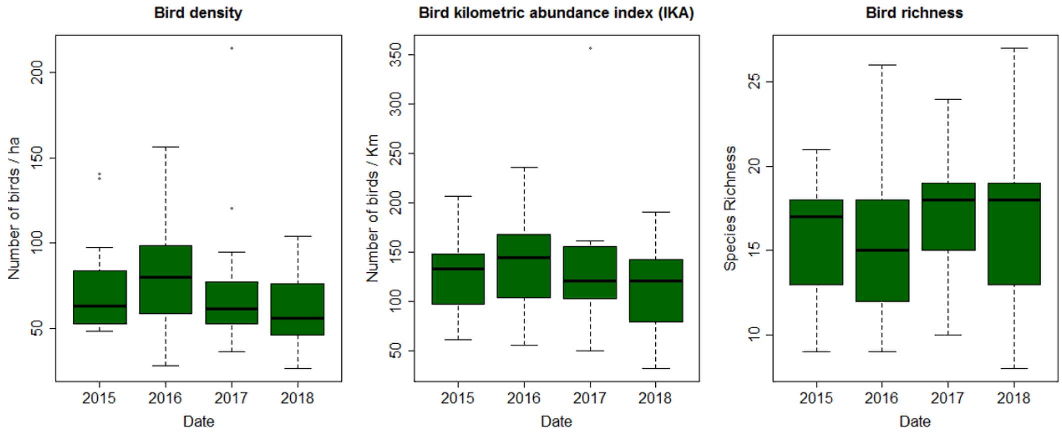


Figure 2. Results of mixed models and Tukey post-hoc test about the temporal evolution of aquatic macroinvertebrates quality (IBMWP) and richness indices (family richness, Coleoptera and Hemiptera species richness). *Elaboración propia.*



Date; P > 0.05; Non significant

Figure 3. Results of mixed models and Tukey post-hoc test relative to the temporal evolution of bird density, kilometric abundance (IKA) and species richness. *Elaboración propia*

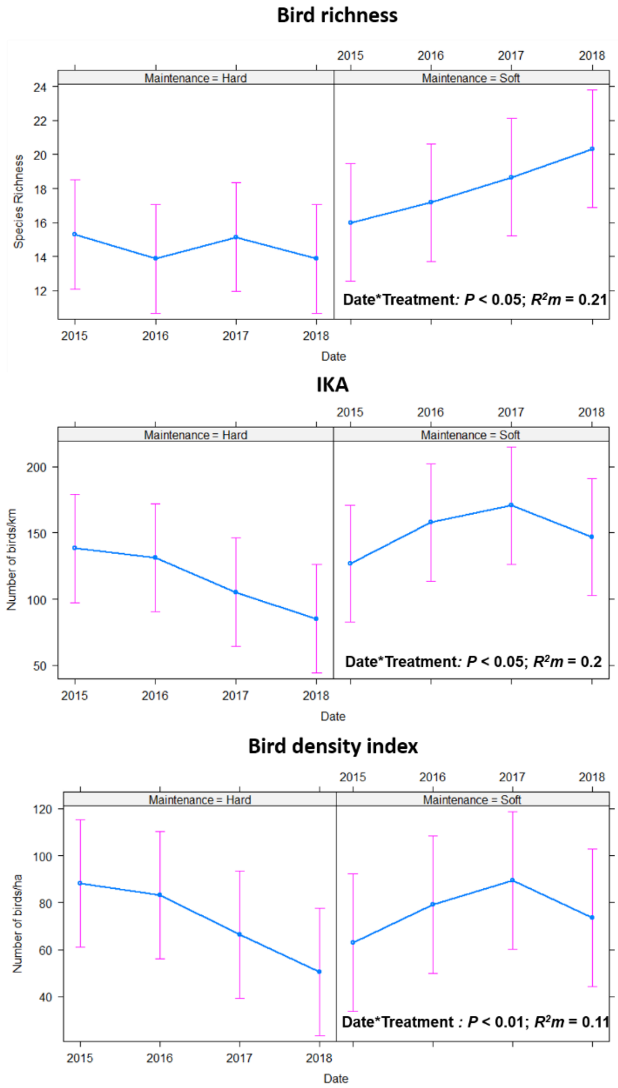


Figure 4. Significant interaction between date and treatment (i.e., pruning) on bird indicators (bird density, kilometric abundance-IKA and species richness) according to mixed models. *Elaboración propia.*

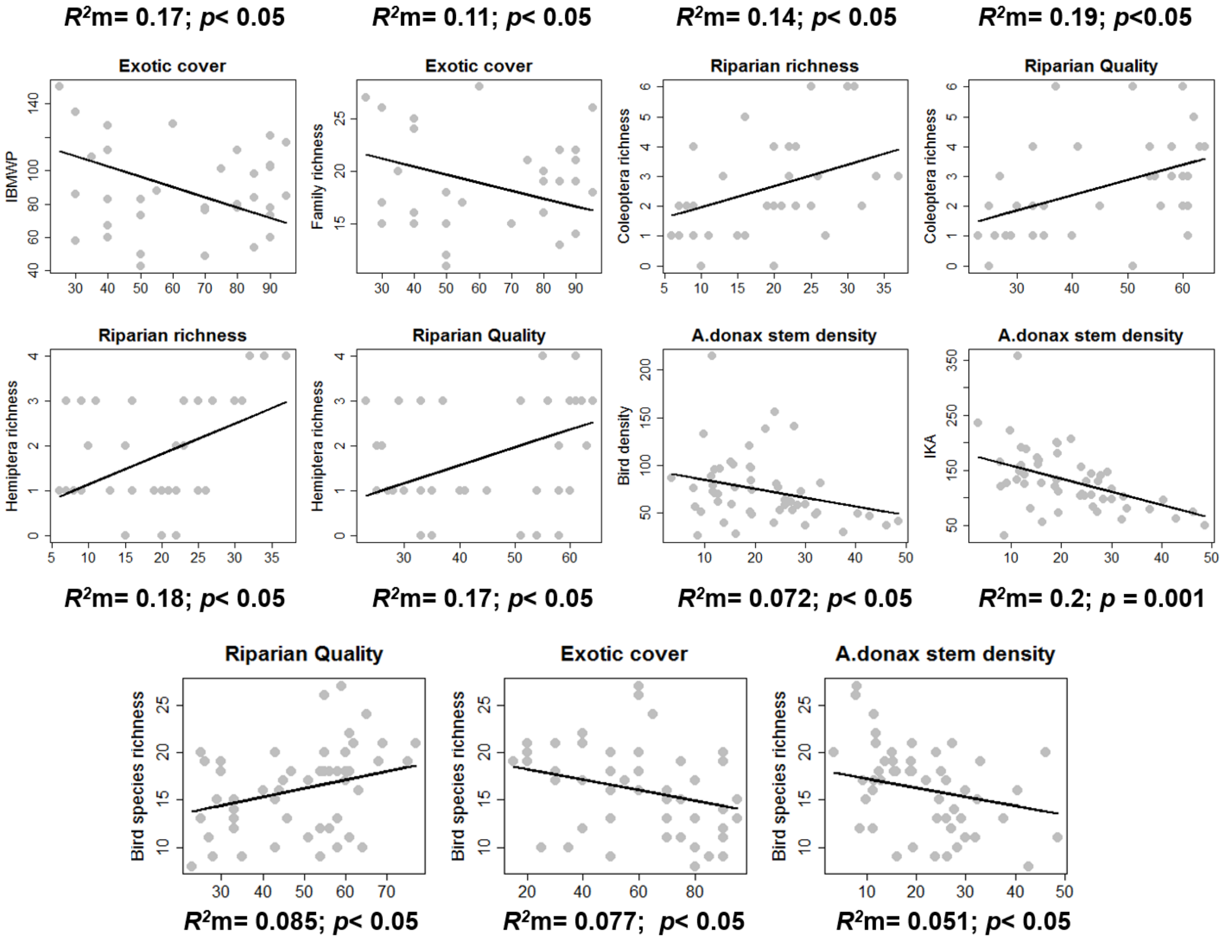


Figure 5. Significant relationships between riparian variables and aquatic macroinvertebrate and bird community indexes according to mixed model results. *Elaboración propia*

4. Discussion and conclusions

Repeated pruning in combination with the plantation of native riparian species has partially succeeded in the control of *A. donax* and the recovering of biological communities. Two years after starting *A. donax* control methods and riparian restoration actions, first changes in riparian vegetation, aquatic macroinvertebrates and birds were observed. Most seedlings are growing at good rate and in good condition, so the establishment and consolidation of planted species has increased riparian richness in all monitoring sites. This trend has been reinforced through methodological improvements in *A. donax* control operations by minimizing the accidental damage on seedlings and irrigation during summer. After riparian plantations, habitat 92A0 seem to be strengthened through the increase in richness and abundance of native riparian species, being *Populus alba*, *P. nigra*, *Nerium oleander, Fraxinus angustifolia*, and *Salix* spp. the more frequent riparian taxa in monitored reaches.

Although positive significant results have been obtained and a riparian general improvement has been observed (increase of riparian quality and species richness, reduction of *A. donax* height and cover, increase of richness of aquatic macroinvertebrates) only slight changes in birds have been observed. Thus, the values of the ecological indicators used are still far from reference values, especially for riparian vegetation and birds, whose results are closely related. At this moment, the plantation of woody native species needs more time to develop and outcompete *A. donax*, occupying progressively the riparian space and intercepting sunlight by closed canopies. Although riparian quality would benefit of an extension of *A. donax* control actions, some improvements have been already observed in the ecological status, longitudinal and vertical connectivity.

The best biomonitoring results were obtained for the aquatic macroinvertebrate community. Currently, the taxonomic groups with more family richness were Coleoptera, Diptera and Trichoptera (8) followed by Mollusca (7), Ephemeroptera (6) and Odonata (6). We have detected in 2018 the occurrence of species related to well-conserved riparian forests (e.g., *Potamophilus acuminatus,* Coleoptera) but also others associated to artificial watercourses (e.g., *Heliocorisa vermiculata,* Hemiptera*)*. In addition, the endemic mollusc *Melanopsis lorcana* (SE Iberian Peninsula), considered as vulnerable in the Spanish red book of invertebrates (Verdú et al., 2011), has been recurrently recorded during this project. Despite restored river reaches are affected by flow regulation driven by dams upstream, all sampling sites displayed good or very good ecological condition based on IBWMP index (except the Moratalla river mouth probably due to artificial flow intermittence i.e., Moratalla dam). This fact could be due to the improvement of the status of riparian areas and river banks as consequence of restoration actions, but especially to the good physico-chemical water parameters found along the study area (nitrates <5 mg/l, water conductivity <1000 µS/cm, total and volatile suspended solids <5 mg/l; measured at the same time than macroinvertebrates were collected), with the exception of local and punctual disturbances in sampling sites located near rice fields which worsened water quality occasionally. The good ecological quality of aquatic macroinvertebrates communities and water physico-chemical parameters in the middle reach of the Segura river is not surprising, since it is basically reflecting the notable reduction of organic pollution occurred in the last decades due to a better management of wastewater and the construction of many water treatment plants along the Segura river (Ródenas & Albacete, 2014).

Waterbirds and riparian bird community are highly influenced by climate (Guareschi et al., 2015), structural features of riparian vegetation and adjacent land use (Saab, 1999). Regarding the effect of restoration measures, planted riparian vegetation has not fully developed to modify associated bird communities substantially. Nevertheless, only birds were differentially affected by the frequency of repeated pruning. Thus, only soft treatment (quarterly pruning) should be extended in time to reduce exotic cover without detrimental effects on bird communities. At the moment, 54 bird species have been recorded through transects in the last sampling campaign (2018) but a total 71 species have been recorded during the project, an amount noticeably higher than other monitoring programs in forest habitats in the region (45-56 species; Vilar, 2015). Although we did not detect significant changes in the more frequent species, there was a negative trend in birds inhabiting open habitats (e.g. *Muscicapa striata*), and an increase of riparian and facultative birds with seed dispersal potential (e.g. *Turdus viscivorus*), which could benefit passive restoration in the long term (as it has been demonstrated in burned areas, Cavallero et al., 2014). The high cost of this restoration approach make repeated pruning in combination with the plantation species not extensively applicable, making it only recommendable to river reaches with special ecological interest (e.g., habitats of European interest, protected areas, threaten species, etc.) and not fully invaded by *A. donax*. Otherwise, there are promising strategies that could be successfully applied in riparian areas dominated by monospecific clumps of *A. donax*, such as plastic layering, a cost-effective, clean and sustainable technique that consist of covering with an opaque reusable material (preferentially of polyetilene) during several months to increase temperature above 60ºC and intercept sunlight completely exhausting so the reserves of the rhizome and producing the massive death of *A. donax* (Deltoro-Torró et al., 2012, Angosto, 2018). Given the advance state of *A. donax* invasion in the Segura river, it is not possible to remove this invasive species and recover native riparian communities successfully without reverting or at least mitigating the negative effect of the human activities which originally enabled the invasion, as partially addressed by LIFE+ RIPISILVANATURA through the implementation of complementary actions to restoration measures (e.g., removal of unnecessary river embankments, delineation of public waters and riparian area, support and promotion of sustainable agricultural practices, fire prevention, creation of land stewardship network).

The observed trends arise from a preliminary assessment of the success of ongoing restoration actions. Final evaluation at the end of the project (2019-2020) will allow to identify the real key factors behind success, or fails (treatments, planted species combination, initial status, etc.), in order to be able to extract more robust conclusions to be applied in further riparian restoration projects. Moreover, long-term biomonitoring is recommended to have a complete view of the processes, effects and durability of the applied measures (Buchanan et al., 2014). This biomonitoring and assessment helps to incorporate adaptive management to restoration projects, which enables to extrapolate successful actions and discard failed ones to improve the cost-benefit ratio of further management actions. If this biomonitoring is maintained, further hot research topics could be focused on how riparian restoration actions modify the functional features of aquatic and terrestrial species and how these traits interact between associated biological communities.

5. References

Alba Tercedor J, Jáimez-Cuéllar P, Álvarez M, Avilés J, Bonada i Caparrós N, Casas J, et al. 2002. Caracterización del estado ecológico de ríos mediterráneos ibéricos mediante el índice IBMWP (antes BMWP'). Limnetica 21: 175-185.

Angosto I. 2018. Evaluación del método de cubrimiento para el control de caña (*Arundo donax*) en el marco de actuaciones de restauración de riberas. Trabajo Fin de Grado, Ciencias Ambientales, Facultad de Biología, Universidad de Murcia.

Bell GP. 1997. Ecology and management of Arundo donax and approaches to riparian habitat restoration in southern California. In: Plant invasions: studies from North America and Europe (JH. Brock, M. Wade, P. Pysek, D. Green, eds). Backhuys Publishers: 110-113.

Bruno D, Belmar O, Sánchez-Fernández D, Velasco J. 2014. Environmental determinants of woody and herbaceous riparian vegetation patterns in a semi-arid mediterranean basin. Hydrobiologia 730(1): 45-57.

Bruno D, Zapata V, Conesa A, Guareschi S, Picazo F, Dettori, E., et al. 2018. LIFE+ RIPISILVANATURA: Biomonitoring and short-term assessment of restoration measures to control invasive alien species in the Segura River (Spain). IS RIVERS.

Buchanan BP, Nagle GN, Walter MT. 2014. Long ‐ term monitoring and assessment of a stream restoration project in central New York. River research and applications 30(2): 245-258.

Cavallero L, Raffaele E, Aizen MA. 2013. Birds as mediators of passive restoration during early post-fire recovery. Biological Conservation 158: 342-350.

Coffman GC, Ambrose RF, Rundel PW. 2010. Wildfire promotes dominance of invasive giant reed (Arundo donax) in riparian ecosystems. Biological invasions 12(8): 2723-2734.

Deltoro-Torró V, Jimenez-Ruiz J, Vilan-Fragueiro XM. 2012. Bases para el manejo y control de Arundo donax L. (Caña común). Coleccion Manuales Tecnicos de Biodiversidad, 4. Conselleria d'Infraestructures, Territori i Medi Ambient. Generalitat Valenciana. Valencia.

Dudley TL. 2000. Arundo donax L. In: Invasive plants of California's wildlands (CC. Bossard, JM. Randall, MC. Hoshovsky, eds). University of California Press: 53-58.

Gonzalez del Tanago M, Garcia de Jalon D. 2011. Riparian Quality Index (RQI): A methodology for characterising and assessing the environmental conditions of riparian zones. Limnetica 30(2): 0235-254.

Guareschi S, Abellán P, Laini A, Green AJ, Sánchez-Zapata JA, Velasco J, Millán A.2015. Cross-taxon congruence in wetlands: assessing the value of waterbirds as surrogates of macroinvertebrate biodiversity in Mediterranean Ramsar sites." Ecological Indicators 49: 204-215.

Hardion L, Verlaque R, Saltonstall K, Leriche A, Vila B. 2014. Origin of the invasive Arundo donax (Poaceae): a trans-Asian expedition in herbaria. Annals of botany 114(3): 455-462.

Lowe S, Browne M, Boudjelas S, De Poorter M. 2000. 100 of the world's worst invasive alien species: a selection from the global invasive species database (Vol. 12). Auckland: Invasive Species Specialist Group.

Maceda-Veiga A, Basas H, Lanzaco G, Sala M, de Sostoa A, Serra A. 2016. Impacts of the invader giant reed (Arundo donax) on riparian habitats and ground arthropod communities. Biological invasions 18(3): 731-749.

Neeson TM, Ferris MC, Diebel MW, Doran PJ, O'Hanley JR, McIntyre PB. 2015. Enhancing ecosystem restoration efficiency through spatial and temporal coordination. Proceedings of the National Academy of Sciences 112: 6236-6241.

Perdue RE. 1958. Arundo donax—source of musical reeds and industrial cellulose. Economic Botany 12(4): 368-404.

R Development Core Team. 2017. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. http://www.R-project.org/.

Ródenas MA, Albacete M. 2014. The River Segura: reclaimed water, recovered river. Journal of Water Reuse and Desalination 4(1): 50-57.

Saab V. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. Ecological applications 9(1): 135-151.

Verdú JR, Numa C, Galante E. 2011. Atlas y libro rojo de los invertebrados amenazados de España (especies vulnerables). Dirección General de Medio Natural y Política Forestal, Ministerio de Medio Ambiente, Medio Rural y Marino, Madrid.

Vilà M., & Hulme, P. E. (Eds.). (2017). Impact of biological invasions on ecosystem services (Vol. 12). Cham: Springer.

Vilar CM. 2015. Respuesta de la biodiversidad ante el cambio global: caracterización de las comunidades de aves de ribera como indicadores de degradación y restauración. Trabajo Fin de Grado, Universidad de Murcia, España.