The dragonfly fauna of the Vienna Lobau – a survey from 2017–2020

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In this study, the ecological status of the water bodies in the Viennese part of the Danube Floodplain National Park, the Viennese Lobau, was assessed from a dragonfly ecology perspective. The surveys for this were conducted in 2017, 2018 and 2020. The assessment was based on the comparison of the status quo with the water body type-specific reference coenosis, based on a classification of the Lobau waters using the Lorenzo map (surveyed 1816–1817). The reference coenosis was dominated by rheophilous species and dragonfly species that depend on dynamic waters with fluctuating water levels. Due to the low abundance of stillwater habitats, limnophilic species played only a minor role in the reference situation. The dragonfly fauna recorded during the study – 43 dragonfly species, with 39 of them autochthonous – consists for the most part (74 %) of species with a distribution focus in the limnophilic range. Rheophilic species and species adapted to strongly fluctuating water levels made up only a small part of the species spectrum and also occurred (especially in the Upper Lobau) only to a very limited extent. Due to this, the dragonfly ecological status of the waters in the Lobau was assessed as "poor".

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In der vorliegenden Studie wurde der ökologische Zustand der Gewässer im Wiener Teil des Nationalparks Donau-Auen, der Wiener Lobau, aus libellenkundlicher Sicht bewertet. Die Erhebungen dazu fanden in den Jahren 2017, 2018 und 2020 statt. Die Bewertung basierte auf dem Vergleich des Ist-Zustandes mit dem gewässertyp-spezifischen Referenzzustand basierend auf einer Einteilung der Lobaugewässer anhand der Lorenzo-Karte (vermessen 1816–1817). Das Referenzartenspektrum war geprägt von rheophilen Spezies und Libellenarten, welche auf dynamische Gewässer mit schwankendem Wasserstand angewiesen sind. Aufgrund der geringen Ausprägung von Ruhigwasserhabitaten spielten limnophile Spezies nur eine untergeordnete Rolle in der Referenzsituation. Die im Rahmen der Studie festgestellte Libellenfauna – 43 Libellenarten, 39 davon bodenständig – besteht zum Großteil (zu 74 %) aus Arten mit Verbreitungsschwerpunkt im limnophilen Bereich. Rheophile Arten und Spezies mit Anpassung an stark schwankende Wasserstände machten nur einen geringen Teil des Artenspektrums aus und traten ebenfalls (insbesondere in der Oberen Lobau) nur sehr eingeschränkt auf. Auf Grundlage der vorliegenden Fundsituation wurde der libellenökologische Zustand der Gewässer in der Lobau als „unbefriedigend" bewertet.

Keywords: Lobau, dragonflies, bioindicators, assessment, ecological status, Water Framework Directive.

Introduction

Riverine floodplain systems represent the original habitats of a large proportion of Central European Odonata (Schorr 1996; Laister 1998; Chovanec & Waringer 2001; Lohr 2010; Chovanec 2017). Amoros et al. (1987) and Amoros & Roux (1988) classified the aquatic compartments of anthropogenically uninfluenced floodplain systems according to hydrological connectivity to the main stream into (1) waters of the dynamic eu- and parapotamon, (2) waters with terrestrialization processes (plesio- and palaeopotamon), and (3) into astatic wetlands (see also Castella et al. 1991; Ward & Stanford 1995; Ward et al. 1999, 2002). Dragonflies colonize nearly all aquatic and semiaquatic habitats of

these systems. Therefore, assessment of floodplains through bioindication based on dragonfly surveys allows typological characterizations and assessments that include all lotic and lentic, perennial and temporary habitats. The total number of species as well as the inventory of autochthonous species and the characteristics of ecological guilds allow the assessment of structural diversity, niche richness, and functional relationships in the ecosystem (Waringer 1989; Chovanec & Waringer 2001; Chovanec et al. 2004; Chovanec 2017).

Imagines are easily identifiable in the field, there is extensive information on species distribution and biology, their rapid response to positive or negative habitat changes, and the existence of established methods for survey and assessment are further advantages pointing at the suitability of dragonflies as indicators of status, value, and targets (Chovanec 2019; see also, e.g., Oertli 2008).

Floodplain areas are a key element of the Austrian landscape: along the 53 largest watercourses, these floodplains occupy an area of nearly 4,750 km^2. Today, only 24 % of this area has forest cover, and only 15 % is riparian forest in the narrower sense with regular flooding (Haidvogl et al. 2009). The systematic river regulation and extensive drainage of the 19th and 20th centuries for the purpose of flood protection and the acquisition of agriculturally usable areas are responsible for the loss of the largest areas. According to the current floodplain inventory, 961 km^2 of floodplains exist in Austria, distributed over about 850 "floodplain objects" with a minimum size of 3 ha. The Lobau is the largest of nine floodplain systems in Vienna and has an area of 23.28 km^2 (Lazowski & Schwarz 2014). For the assessment according to the Austrian Water Act and the Water Framework Directive (WFD), floodplains also play a major role in the definition of the "good ecological potential" of "heavily modified water bodies". The network of those watercourses with a catchment area size >10 km^2 – i.e., the river network covered by the WFD – comprises 32.101 km in Austria; of these, 12,3 % are "heavily modified". Of these 3.947 km, 30 % have been significantly modified by flood control measures and 65 % by hydropower (BMLRT 2022). Given appropriate conditions (in the case of ecologically effective integration and connectivity with the main water body), floodplain areas may provide valuable refugial habitats for waterbody-type-specific fauna and flora and thus represent sources for colonization processes. Moreover, they fulfil essential ecological functions related to longitudinal and lateral connectivity (e.g., Godreau et al. 1999; Ward et al. 2002). The use of an appropriate implementation-oriented assessment system is essential for defining and describing the categories of the "ecological potential," for planning and implementing measures, and for monitoring their success (see, e.g., Chovanec et al. 2005; Waringer et al. 2005; Dziock et al. 2006; Roni et al. 2019; Seidel et al. 2019).

Riverine floodplains thus also represent an intersection in legal and jurisdictional terms: They are to be covered by water management planning and implementation, as they are part of river type-specific characteristics according to the Water Framework Directive. In addition, riverine floodplains play an essential role as retention areas in flood control and they are also covered by nature conservation regulations (see e.g., Korn et al. 2005; Brückmann 2010; Weigelhofer et al. 2020).

The protection and conservation of the few ecologically intact floodplains as well as the improvement of ecologically degraded areas are main objectives in the Floodplain Strategies for Austria 2020+ and 2030+ (BMLFUW 2015; BMLFRW 2022). Thus, the assess-

ment of floodplains represents an essential basis of both the evaluation of their status and the success of rehabilitation measures.

As documented in national and international literature, dragonflies have proven to be a sensitive indicator group for this purpose for decades: e.g., Castella (1987), Chwala & Waringer (1996), Schorr (1996), Schorr & Götz (1996), Laister (1998, 2008), Waringer (1989), Wassermann (1999), Chovanec & Waringer (2001), Schultz et al. (2003), Chovanec et al. (2004), Raab (2004), Lohr (2010), Graf et al. (2013), Graf & Chovanec (2016), Chovanec (2017), Januschke et al. (2018).

In this paper, the results of the 2017–2020 survey of the dragonfly fauna in the Lobau are presented, they are compared with data from previous years and interpreted in terms of water management and conservation.

Material and Methods

Investigated Area – the Viennese Lobau

The Lobau is located north of the Danube and largely within, but also partly east of Vienna and is part of the Donau-Auen National Park that extends along the left bank of the Danube between Vienna and the mouth of the Morava River (border with Slovakia).

The Viennese Danube section can be classified as a braided river with high hydrological and morpho-dynamics, sediments predominantly consisting of micro- and mesolithal and a glacial hydrological regime

(Hohensinner et al. 2008a; Graf & Chovanec 2016). Today's Viennese Lobau is the remnant of an originally extensive dynamic floodplain on the left bank of the Danube. Regulation measures at the end of the 19th century led to the almost complete disconnection of the area from the main stream. The Schönauer slot at the downstream end of the Lobau, nowadays is the only connection to the Danube. Floodwaters can backwater here against the direction of flow of the Danube into the Lobau. The temporal and spatial dynamics in this floodplain system decreased drastically, and the previously balanced erosion and sedimentation processes no longer existed. Terrestrialization processes drastically increased and led to a loss of over 30 % of the water areas between 1938 and 2004 (Hohensinner et al. 2008b). Permanently flowing main and side arms have been replaced by unilaterally connected and isolated oxbow lakes, which are characterized by advanced succession (Hohensinner et al. 2011). Especially the aquatic landscape in the Upper Lobau is dominated by strong terrestrialization processes and extended reed beds (Reckendorfer et al. 2013).

With targeted water supply, an attempt is made to counteract or slow down the current negative development of the area and at the same time preserve all utilization interests (including urban areas, local recreation, drinking water production) (Weigelhofer et al. 2013). While the concepts for the Lower Lobau focus on dynamization and floodplain restoration (Weigelhofer et al. 2011), the approach chosen for the Upper Lobau was to maintain the current condition of the area through targeted water supply. For this reason, water from the New and Old Danube has been fed into the Upper Lobau via the Upper Mühlwasser since 2001 (water supply period March 1 to October 31). During the sampling period in 2017, 2018 and 2020 the mean daily water supply volume ranged from 164 to 226 l/s (pers. communication Thomas Ofenböck, Municipal Department 45 – Water Management).

Survey and sampling sites

The present study was conducted in 2017, 2018 and 2020 in the Lobau, Viennese part of the Donau-Auen National Park. The dragonfly fauna was surveyed at a total of 29 sampling sites (L1–L29 in Fig. 1) at 14 water bodies. Seventeen of the surveyed sampling sites are part of the Upper Lobau, that extends from the western end of the National Park to the Donau-Oder-Kanal (L01). The channel divides the Lobau into two areas, the Upper and Lower Lobau. Following the Donau-Oder-Kanal, the Lower Lobau, (where 12 sampling sites have been surveyed) extends to the Gänsehaufentraverse and thus to the border of Vienna.

The 29 sampling sites, with a few exceptions (see below), consisted of 100 m shoreline-stretches. They were selected to be representative of the respective water body (or section of the water body) in terms of their habitat characteristics. In addition, the FFH species *Leucorrhinia pectoralis* was specifically surveyed at the Seeschlachtgraben (L12). The location of the 29 stretches can be seen in Fig. 1 and in the Appendix.

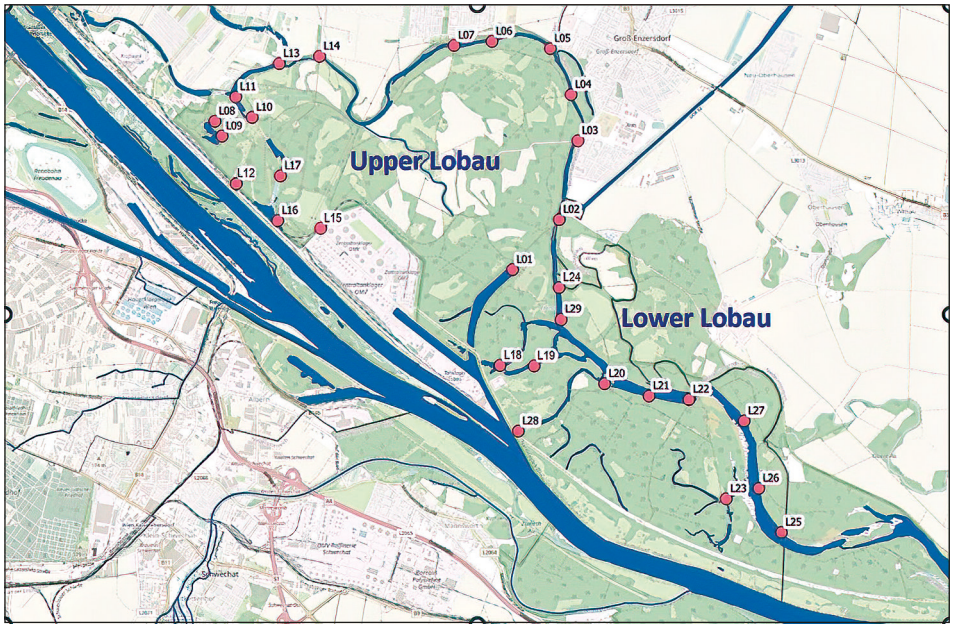

Fig. 1: Location of the study sections in the Lobau, Vienna. Upper Lobau: L1-L17, Lower Lobau L18-L29. – Abb. 1: Lage der untersuchten Standorte in der Lobau. Obere Lobau: L1-L17, Untere Lobau L18-L29.

At the sampling sites we recorded the species encountered, their abundance and autochthony. Exceptions were the sites L15, L18, L19, L24, L28 and L29. Due to the difficult accessibility of these sampling sites, only punctual surveys could be accomplished there: occurring species were noted, but no information about abundance was recorded.

The surveys of the sampling sites were carried out at least four times a year on sunny and windless or low-wind days, between 10:00 and 17:00 CEST (Central European Summer Time). This excludes the Seeschlachtgraben (L12), where surveys were conducted exclu-

sively during the flight season of *Leucorrhinia pectoralis* (May to July). Surveys focused on imagines, in addition, findings of exuviae were included as evidence of autochthony.

The number of individuals per species observed at a sampling site was transferred to abundance classes, considering family-specific spatial requirements (Tab. 1; Chovanec 2019). Species were assigned to the classes for each of the sampling sites based on the maximum abundance of individuals detected within one day during the study period.

Tab. 1: Assignment of individual numbers per sampling site to abundance classes (Chovanec 2019). – Tab. 1: Zuteilung der Individuenzahlen pro Standort zu den Abundanzklassen (Chovanec 2019).

	1 single	**2 rare**	**3 frequent**	**4 abundant**	**5 extremely abundant**
Zygoptera without Calopterygidae	1	2-10	11-25	26-50	>50
Calopterygidae and Libellulidae	1	2-5	6-10	11-25	>25
Anisoptera without Libellulidae	1	2	3-5	6-10	>11

The finding of freshly emerged individuals and/or exuviae was decisive for the classification of a species as certainly autochthonous at a site. A species was considered to be probably autochthonous, if reproductive behaviour (copula, oviposition, and tandem flight) was observed and/or imagines were detected at that locality in abundance classes 3, 4, or 5 (Tab. 1). A species was considered possibly autochthonous, if imagines in abundance class 1 or 2 occurred on at least two different survey dates at the same site. In the following, species that are certainly, probably, or possibly autochthonous are summarized as "autochthonous". If a species was found in two different water bodies, regardless of abundance and any evidence of autochthony, it was classified as autochthonous for the Lobau.

Assessment

The assessment method described here is based on the comparison of the river type-specific dragonfly fauna (derived from the conditions of the time before regulation measures, according to the Lorenzo map (surveyed from 1816 to 1817)) with the status quo. Any deviations are reflected in the five-level system of ecological status, with "very good status" corresponding to the reference status. The assessment of the ecological status of the Lobau waters is based on the WFD-compliant assessment system for floodplains of large rivers developed by Graf & Chovanec (2016) on the basis of macrozoobenthos (see also Hohensinner et al. 2011). Basis for the assessment system is a classification of floodplain waters into five habitat types, based on historical data according to the intensity of hydrological dynamics. The different habitat types correspond to the spectrum of water body types along a gradient of lateral connectivity in an uninfluenced floodplain, from dynamic eu- and parapotamon (H1, H2) to isolated and astatic (H5) (Tab. 2). Hydrologic dynamics include both surface waters corresponding to the natural hydrologic regime and fluctuations in groundwater levels (Fig. 2).

The indicator species for the different habitat types in a lateral connectivity gradient are determined as follows:

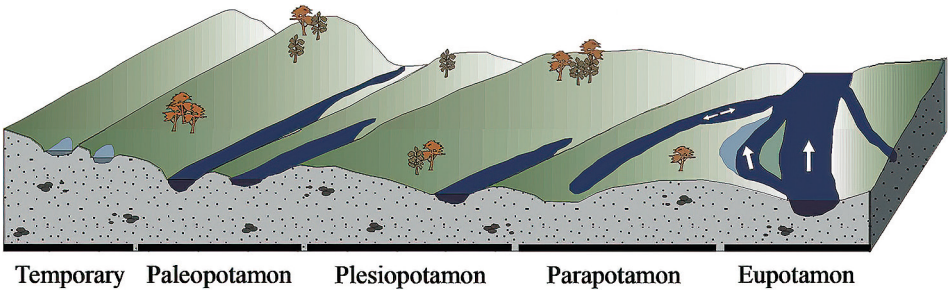

Fig. 2: Schematic representation of a hypothetical wetland landscape, according to Amoros et al. (1987) (Graphic: J. Waringer). – Abb. 2: Schematische Darstellung einer hypothetischen Auland-schaft, nach Amoros et al. (1987) (Grafik: J. Waringer).

(1) Calculation of habitat value (HV):

10 points are assigned for each dragonfly species according to its habitat preferences and based on the saprobity index, according to the species' occurrence in the 5 habitat types (Chovanec & Waringer 2001). Thus, H1–H5 represent species-specific habitat preferences (example in Tab. 2).

Finally, habitat values (HV) are calculated for each species:

$$HV = \frac{1*H1+2*H2+3*H3+4*H4+5*H5)}{10}$$

Habitat values of all species can be found in Waringer et al. (2005).

(2) Assignment of habitat values to habitat types:

Based on the calculated habitat values, the individual species were assigned to a corresponding habitat type according to the classification defined by Graf & Chovanec (2016) (Tab. 3).

(3) Reference species range:

The classification of the waters in the Lower Lobau into the five habitat types described above, based on the Lorenzo map (surveyed 1816–1817) by Graf & Chovanec (2016), served as the basis for the description of the reference coenosis. The reference coenosis con-

Tab. 2: Habitat type classification and calculated habitat values according to Sladecek (1964) on the example of five selected dragonfly species (Chovanec & Waringer 2001). – Tab. 2: Klassifizierung des Habitattyps und berechnete Habitatwerte nach Sladecek (1964) am Beispiel von fünf ausgewählten Libellenarten (Chovanec & Waringer 2001).

	H1	H2	H3	H4	H5	HW	habitat type according to HV
Calopteryx splendens	9	1	0	0	0	1,1	H1
Orthetrum cancellatum	1	7	1	1	0	2,2	H2
Anax imperator	1	1	5	3	0	3,0	H3
Sympetrum sanguineum	0	2	0	5	3	3,9	H4
Lestes barbarus	0	0	0	2	8	4,8	H5

Tab. 3: Assignment of habitat values to habitat types and description of the five habitat types according to Graf & Chovanec (2016). – Tab. 3: Zuordnung der Habitatwerte zu den Habitattypen und Beschreibung der fünf Habitattypen nach Graf & Chovanec (2016).

Habitat types and habitat values	Description of habitat types
H1: 1.0–1.8	Riparian areas of eupotamal, permanently flowing, flowed-through water bodies (main channel as well as permanently flowed-through side arms connected to the main channel); high hydrological dynamics; (almost) no siltation; open banks or phalaridetum stands and riparian woody vegetation; sediment: gravel and sand dominate.
H2: 1.9–2.6	Riparian areas of permanently watered, mostly non-flowing parapotamal waters (open oxbow lakes connected to the main stream) or plesiopotamal waters (closed oxbow lakes) as well as riparian areas of gravel pits located in the floodplains; reduced hydrological dynamics; siltation intensity low; banks open; macrophyte stands weakly developed; riparian woody plants; sediment: high proportion of gravel and sand.
H3: 2.7–3.4	Open water areas of permanent plesiopotamal and palaeopotamal stream-free floodplain waters and gravel pits with floating leafy plants and/or floating macrophytes; significantly reduced hydrologic dynamics; high siltation intensity.
H4: 3.5–4.2	Riparian areas of permanently plesio- and palaeopotamal waters with dense reed beds; significantly reduced hydrologic dynamics; very high siltation intensity and sedimentation; muddy substrates predominate.
H5: 4.3 - 5.0	Temporary (mostly smaller) water bodies with at least one dry phase during the year (mostly in late summer, fall).

tained those species whose habitat values are assigned to the habitat types that were present before regulation measures and thus preferentially occur at waters of these habitat types.

According to Graf & Chovanec (2016), flowing side arms (eupotamon B) and dynamic oxbows of type H1 (incl. parapotamon A = transitional type H1–H2) covered the largest area in the Lower Lobau with about 86 %. The pronounced hydrological dynamics produced habitats poor in vegetation, characterized by open sand and gravel areas, which dried out during low water, promoting habitat type 5 species.

In contrast to permanently flowing water bodies, unilaterally connected oxbow lakes (parapotamon B, habitat type 2) and isolated oxbow lakes (dead arms, plesio- /palaeopotamon), representing habitat types 3 and 4, occupied much smaller areas, accounting for about 13.6 %.

Hence the uninfluenced Danube system in the Lower Lobau had a primarily lotic (eupotamal) character and favoured rheophilic coenoses. The reference species spectrum is therefore dominated by rheophilic species, i.e., species of habitat types 1 and 2. Due to the high hydrological dynamics in the area of surface water and in groundwater, species of habitat type 5 were included in the reference species spectrum. Species of habitat types 3 and 4 play a minor role in the reference species spectrum of the Lower Lobau due to the low number of standing water habitats in the reference situation.

Although the water body classification described by Graf & Chovanec (2016) refers to the Lower Lobau, the ratio in which the individual habitat types were expressed is – due to the similar situation – also transferable to the Upper Lobau and consequently was adopted for the entire area.

Evaluation

For a "very good" dragonfly ecological status, at least 10 species from habitat types 1, 2 and 5 must occur and they have to be autochthonous at >75 % of the sampling sites in the study area. At least two or one of these 10 species should have their main occurrence at waters of habitat type 5. If this is not the case, the assessment of the dragonfly ecological status is downgraded one level. A "bad" dragonfly ecological status is assigned if either more than 5 species from habitat types H1, H2 or H5 occur, but they are distributed at less than 10 % of the sites, or less than 5 species from these habitat types occur. In the latter case, distribution does not matter because of the extremely reduced number of species.

Tab 4: Scheme for assessing the ecological status of water bodies in the Lobau, according to the occurring dragonfly fauna and based on the 5 habitat types according to Graf & Chovanec (2016). – Tab. 4: Schema zur Bewertung des ökologischen Zustands der Gewässer in der Lobau, nach der vorkommenden Libellenfauna und basierend auf den 5 Habitiattypen nach Graf & Chovanec (2016).

Dragonfly ecological status class	**I very good**	**II good**	**III moderate**	**IV poor**	**V bad**
H1 + H2 Species with habitat value 1–2.6: dynamics surface waters **H5** Species with habitat value ≥ 4.3: groundwater dynamics	at least 10 species are autochthonous at >75 % of the sites, whereby at least two H5 species must be present (if this is not the case, only status "good" is achieved)	at least 10 species are autochthonous at >50 % of the sites, whereby at least two H5 species must be present (if this is not the case, only status "moderate" is achieved)	At least 8 species occur autochthonous at >25 % of the sites, whereby at least one H5 species must be present (if this is not the case, only status "unsatisfactory" is reached)	at least 5 species are autochthonous at >10 % of the sites	>5 species are autochthonous at <10 % of sites or <5 species occur independently of autochthony and distribution

Results

General description

A total of 43 species were detected at the study area in the years 2017, 2018 and 2020. The detected species spectrum thus corresponds to 56 % of the Austrian odonate fauna. Thirty-nine of the occurring species could be classified as possibly, probably or certainly autochthonous in the study area. Fourteen species belong to the suborder Zygoptera and come from four families (Calopterygidae, Lestidae, Coenagrionidae and Platycnemididae). The other 29 species belonged to the suborder Anisoptera and represent the families Aeshnidae, Gomphidae, Corduliidae and Libellulidae, whereby the family Gomphidae was represented only by the detection of two non-autochthonous individuals (one *Gomphus vulgatissimus* and one *Onychogomphus forcipatus*).

The total number of species detected at each water body varied from 17 (OMV pond – L15 & Küniglwasser – L23) to 33 species (Großenzersdorfer Arm – L02–L06).

Approximately 50 % of the detected species are listed in endangerment categories of the Austrian Red List (NT-CR). Particularly remarkable are the three "critically endangered" *Leucorrhinia* species (*L. pectoralis, L. caudalis* and *L. albifrons*). All three species are also listed in Annexes of the Habitats Directive (92/43/EEC) and could be classified as autochthonous at the Mühlwasser-Tischwasser-system (Fischer et al. 2018). *Leucorrhinia pectoralis* additionally occurred at two other water bodies (Seeschlachtgraben – L12 in Tab. 6 and Oberleitner Wasser – L07), although the occurrence at Oberleitner Wasser currently appears extinct. *Sympetrum meridionale* (also "critically endangered") was observed in low abundance at the Kühwörther Wasser and classified as autochthonous to the study area. *Somatochlora flavomaculata* and *Libellula fulva* were recorded as "endangered" species. Eleven other species are classified as "vulnerable" in the Austrian Red List (Raab 2006).

Tab. 5: Overview of dragonfly species detected in the Upper Lobau at the sampling sites (L01-L17; see Fig. 1) in 2017, 2018, and 2020, their abundance, autochthony (*) and corresponding habitat type (H1-5). – Tab. 5: Übersicht über die in der Oberen Lobau an den untersuchten Standorten (L01-L17; siehe Abb. 1) 2017, 2018 und 2020 nachgewiesenen Libellenarten, ihre Häufigkeit, Bodenständigkeit (*) und ihrem entsprechenden Habitattyp (H1-5).

		UPPER LOBAU						
Species	H	L01	L02-L06	L07	L08, L09	L11, L13, L14	L10, L16, L17	L15
Aeshna affinis Vander Linden, 1820	H4							
Aeshna cyanea (Müller, 1764)	H3		1	1	1	1	1	
Aeshna grandis (Linnaeus, 1758)	H3	1	1	1	1	1*	2	x
Aeshna isoceles (Müller, 1767)	H4	3*	2*	2*	2*	3*	4*	x
Aeshna mixta Latreille, 1805	H4	4*	3*	2	2*	4*	3*	x
Anax imperator Leach, 1815	H3	1*	2*	2	1*	3*	1*	x
Anax parthenope (Selys, 1839)	H4	2*	2*		3*	2*	3*	
Brachytron pratense (Müller, 1764)	H4		1*	2*		2*	2*	
Calopteryx splendens (Harris, 1782)	H1		2*			3*	1*	
Calopteryx virgo (Linnaeus, 1758)	H1		1*			1		
Chalcolestes viridis (Vander Linden, 1825)	H4		2*	3*		2*	3*	x
Coenagrion puella (Linnaeus, 1758)	H3	4*	5*	4*	5*	3*	4*	x
Coenagrion pulchellum (Vander Linden, 1825)	H4	1	2*	1	2*	3*	3*	x
Cordulia aenea (Linnaeus, 1758)	H3	1	4*	3*	1	5*	3*	x
Crocothemis erythraea (Brullé, 1823)	H3	2*	2*		2	2*	2*	x
Enallagma cyathigerum (Charpentier, 1840)	H3				1		1	
Erythromma najas (Hansemann, 1823)	H3	3*	3*		2*	3*	4*	
Erythromma viridulum (Charpentier, 1840)	H3	3*	4*	3*	3*	4*	5*	x
Gomphus vulgatissimus (Linnaeus, 1758)	H1		1					
Ischnura elegans (Vander Linden, 1820)	H3	2*	4*	2*	2*	2*	5*	x
Ischnura pumilio (Charpentier, 1825)	H5							
Lestes sponsa (Hansemann, 1823)	H4		1*	3*			3*	
Leucorrhinia albifrons (Burmeister, 1839)	H3					5*		
Leucorrhinia caudalis (Charpentier, 1840)	H3					5*		
Leucorrhinia pectoralis (Charpentier, 1825)	H4			4*		4*		
Libellula depressa Linnaeus, 1758	H3		2	2				

Species	H	UPPER LOBAU						
		L01	L02-L06	L07	L08, L09	L11, L13, L14	L10, L16, L17	L15
Libellula fulva Müller, 1764	H1	1	2*		2*	2*	2*	
Libellula quadrimaculata Linnaeus, 1758	H4	2	2*	2*	2*	4*	2*	x
Onychogomphus forcipatus (Linnaeus, 1758)	H1							
Orthetrum albistylum (Selys, 1848)	H2		2*				2*	
Orthetrum brunneum (Fonscolombe, 1837)	H1		1					
Orthetrum cancellatum (Linnaeus, 1758)	H2	1*	2*		2*	1	2*	
Orthetrum coerulescens (Fabricus, 1798)	H2		3*		2	4*	1*	
Platycnemis pennipes (Pallas, 1771)	H2		3*	1*	2*	4*	3*	x
Pyrrhosoma nymphula (Sulzer, 1776)	H3		2*	1				
Somatochlora flavomaculata (Vander Linden, 1825)	H4			3*		1	3*	
Somatochlora metallica (Vander Linden, 1825)	H3			1	1	1	1*	
Sympecma fusca (Vander Linden, 1820)	H3	1	4*		1	2*	4*	x
Sympetrum meridionale (Selys, 1841)	H5							
Sympetrum pedemontanum (Allioni, 1766)	H3		1			2*	2*	
Sympetrum sanguineum (Müller, 1764)	H4	2	3*	5*	2*	5*	4*	x
Sympetrum striolatum (Charpentier, 1840)	H3	2*	4*	2*	2*	3*	4*	x
Sympetrum vulgatum (Linnaeus, 1758)	H4	3*	3*	3*		3*	4*	x
species number/sampling site		19	33	23	23	31	31	17

Tab. 6: Overview of dragonfly species detected in the Lower Lobau at the sampling sites (L18-L29; see Fig. 1) in 2017, 2018, and 2020, their abundance, autochthony (*) and classification in the Red List of Austria (RLA); L12-Seeschlachtgraben. – Tab. 6: Übersicht der in der Unteren Lobau an den untersuchten Standorten (L18-L29; siehe Abb. 1) 2017, 2018 und 2020 nachgewiesenen Libellenarten, deren Abundanz, Bodenständigkeit (*) und Einstufung in der Roten Liste Österreichs (RLA); L12-Seeschlachtgraben.

Species	RLA	LOWER LOBAU								
		L20	L21	L22	L23	L25–L27	L28	L24, L29	L18, L19	additional records Lobau
Aeshna affinis	VU									x
Aeshna cyanea	LC	1								
Aeshna grandis	LC	1						x	x	
Aeshna isoceles	VU	1	3*	3*	x	1*	x	x	x	
Aeshna mixta	LC	1*	4*	5*	x	4*	x	x	x	
Anax imperator	LC		1*	1*	x	2*	x	x	x	
Anax parthenope	LC		2*	2*		3*	x		x	
Brachytron pratense	VU	2				2*	x	x	x	
Calopteryx splendens	NT	2		2		1*		x		
Calopteryx virgo	NT	2	1		x	1*				
Chalcolestes viridis	LC	2*	2	1	x			x	x	
Coenagrion puella	LC		2	2*	x	3*		x	x	
Coenagrion pulchellum	VU	2			x	1			x	
Cordulia aenea	LC		1	1	x		x			

Species		LOWER LOBAU								
	RLA	L20	L21	L22	L23	L25–L27	L28	L24, L29	L18, L19	additional records Lobau
Crocothemis erythraea	LC			1*	x	2*	x		x	
Enallagma cyathigerum	LC			2*						
Erythromma najas	NT		5*	4*	x	4*	x	x		
Erythromma viridulum	LC		2	2	x	5*	x	x	x	
Gomphus vulgatissimus	VU									
Ischnura elegans	LC	2*	4*	5*	x	5*	x	x	x	
Ischnura pumilio	NT					1*				
Lestes sponsa	LC	3*	2	3*	x	3*		x	x	
Leucorrhinia albifrons	CR									
Leucorrhinia caudalis	CR									
Leucorrhinia pectoralis	CR									(L12) 3*
Libellula depressa	LC									x
Libellula fulva	EN	1		1				x		
Libellula quadrimaculata	LC			2		1	x	x	x	
Onychogomphus forcipatus	VU			1						
Orthetrum albistylum	LC			1		4*	x			
Orthetrum brunneum	NT									
Orthetrum cancellatum	LC		3*	3*		2*	x	x	x	
Orthetrum coerulescens	VU	2		1						
Platycnemis pennipes	LC					3*	x		x	
Pyrrhosoma nymphula	LC									
Somatochlora flavomaculata	EN	2		3*	x			x	x	
Somatochlora metallica	LC		1							
Sympecma fusca	VU	2	2*	5*	x	5*	x	x	x	
Sympetrum meridionale	CR					2*				
Sympetrum pedemontanum	VU	2*	2	1		2*				
Sympetrum sanguineum	LC	2*	1	4*	x	4*	x	x	x	
Sympetrum striolatum	LC	1*	1*	4*	x	3*	x	x	x	
Sympetrum vulgatum	LC	2*	2	3*		2*	x	x	x	
species number/ sampling site		19	19	26	17	25	18	20	21	

Evaluation

The occurring dragonfly fauna was dominated by typical species of standing waters (parapotamon B, plesio- and palaeopotamon), with a distribution focus in habitat types 3 and 4. 74 % of the species inventory (29 species), correspond to these two habitat types and were distributed on average at about 40 % of the sites (Fig. 3a).

Rheophilic species of habitat types 1 and 2 or species with a main distribution in dynamic, temporary waters (H5) make up only about 26 % (10 species) of the autochthonous species spectrum of the Lobau. If we focus on species of habitat type 5, we can see that species of this habitat type occurred on average at only 5 % of the surveyed sites (Fig. 3b). Of the habitat types 1, 2 and 5 only two species, both originating from habitat type 2, occurred

at more than 25 % of sites. A total of six species from H1, H2, H5 were classified as native at >10 % of the sampling sites. The low proportion of rheophilic and dynamic species as well as their limited distribution indicates (according to the assessment scheme) the assessment of the Lobau with "poor dragonfly ecological status".

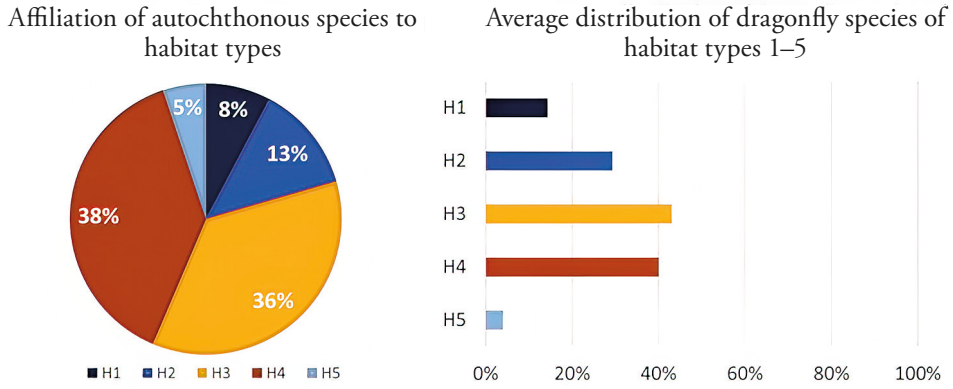

Fig. 3a and b: Affiliation of autochthonous species to habitat types & average distribution of dragonfly species of the respective habitat types at the sampling sites. – Abb. 3a und b: Zugehörigkeit der bodenständigen Arten zu den Lebensraumtypen & durchschnittliche Verbreitung der Libellenarten der jeweiligen Lebensraumtypen an den untersuchten Standorten.

Discussion

Despite high species diversity and a high proportion of endangered species, the occurring species community deviated strongly from the reference coenosis, whereby the dragonfly ecological status of the aquatic landscape Lobau was assessed as "poor".

Pristine river-floodplain systems are characterized by high lateral connectivity, strong hydrologic dynamics, and balanced erosion-sedimentation processes. They have a primarily lotic (eupotamal) character, with standing, permanent water bodies (para-, pleisio-, and paleopotamon) existing in the marginal areas (Amoros et al. 1987; Graf & Chovanec 2016). The resulting mosaic of diverse, semi-aquatic and aquatic habitats, often provides a refugium for species diversity.

The separation of the Lobau from the main stream during the "Great Danube Regulation" in the 19th century, has drastically reduced temporal and spatial dynamics in this floodplain system. Damming of numerous side arms caused a large-scale loss of habitat types characteristic for the floodplain. Permanently flowing main and side arms have been replaced by unilaterally connected and isolated oxbow lakes, which are characterized by strong succession (Hohensinner et al. 2011). The occurring dragonfly fauna reflects the changes in the aquatic landscape of the Lobau: the majority of the dragonfly fauna recorded in Lobau (74 %) nowadays consists of limnophilic species with a distribution focus in the palaeo- and plesiopotamal (H3 and H4), partly characteristic for habitats in far advanced stages of succession. Thus, the current dragonfly fauna deviates strongly from the reference coenosis, which originally consisted of eu- and parapotamal species (H1 and H2) and species with specialization on dynamic and temporary waters (H5). In the whole

Lobau, species of these habitat types make up only a small proportion of the occurring dragonfly fauna and are very restricted in their distribution.

This is particularly noticeable in the Upper Lobau: due to the loss of the direct connection to the Danube, in this area the waters are exposed to even stronger sedimentation processes and they are characterized by dense reed beds. Only 19 % of the occurring species are from the habitat types 1, 2 and 5. In the Lower Lobau, 31 % of the species spectrum could be assigned to these habitat types.

Even though the percentage of H1, 2 and 5 species is higher here than in the Upper Lobau, a comparison of the currently occurring dragonfly fauna with the data collected in earlier studies in the Lower Lobau clarifies a still ongoing terrestrialization process. In the years between 1998 and 2012, several dragonfly surveys were conducted at water bodies of the Lower Lobau, in order to survey the status quo and assess the dragonfly ecological status of the water bodies and measures taken for the revitalization of the Lower Lobau (Raab 2000; Chovanec et al. 2004; Schultz 2008; Schulze & Schneeweihs 2013). Based on the calculated mean value of the Odonata Habitat Index (OHI), the high species number and the proportion of sensitive species the dragonfly ecological status of the Lower Lobau was classified as "good" in 2007 and 2012 (Schultz 2008; Schulze & Schneeweihs 2013). However, the species range detected during these studies was dominated by limnophilic species, as it was between 2017 and 2020. Rheophilic species played only a minor role already in 2007 (Schultz 2008). For species that depend on dynamic water bodies and regularly flooded riparian areas a decline of species and their distribution has been observed. Species specializing in these water bodies (H5), are among the most endangered dragonfly species in Austria due to the strong decline of this habitat type. While six species of this habitat type were present in the lower part of the Lobau between 1998 and 2000, the number of species already decreased in the following decade (Schultz 2008; Schulze & Schneeweihs 2013). Between 2017 and 2020 only two H5-species were recorded in Lower Lobau. In the Upper Lobau, not a single species of this habitat type was present autochthonous.

Nevertheless, the number of species detected during the study was high, as well as the proportion of endangered species. Both illustrate that despite the loss of floodplain characteristic habitats, the Lobau plays an essential role in Vienna's dragonfly diversity and serves as a refugium for endangered species.

With a total of 43 species, the dragonfly fauna recorded in the Lobau comprises 55 % of the Austrian dragonfly fauna and, with around 70 %, the majority of the Viennese dragonfly fauna. If only data from more recent dragonfly surveys at Viennese water bodies (since 2014) are used, the proportion is 86 %.

Approximately 50 % of the species spectrum is listed in endangerment categories of the Austrian Red List (NT-CR) and three species in the Annexes of the Habitats Directive. A large part of the endangered species spectrum (72 %) including all three FFH species is assigned to habitat types 3 and 4. In 2017, all three FFH species from the genus *Leucorrhinia* were detected at the Mühlwasser-Tischwasser complex (Fischer et al. 2018). For *L. albifrons* this was the first detection for Vienna and *L. caudalis* was detected for the first time in Vienna at the Old Danube in 2015 (Fischer 2016). Occurrences of *L. pectoralis* were already known for the Lobau. It is likely that colonization of the two new *Leucorrhinia* species occurred only a few years ago as part of a dispersal event recognizable in Central Europe (from 2012) (Staufer & Pöchhacker-Florian 2018). The species occur in larger, stagnant,

perennial nutrient-poor waters with clear water, which are often surrounded by forest and show medium states of succession. Dense submerged vegetation reaching the water surface, at least at some patches, is important for both species. *L. albifrons* also prefers waters with distinct siltation zones and stands of reeds or sedges (Sternberg et al. 2000; Ott 2013). Thus, all three species benefited from the shift in habitat supply towards paleo- and plesiopotamal waters, but nevertheless are currently threatened by the strong siltation tendencies of the Upper Lobau. It should, however be emphasised that terrestrialisation is a general threat for most of the dragonfly species occurring in the Lobau.

Conclusion

While the species diversity and portion of endangered dragonfly species in the Lobau is still high, the assessment presented here evidenced a considerable deviation from the reference coenosis, originally consisting of species indicating habitat types H1, H2, and H5. Specifically, the decline of habitat type H5 caused the loss of species with specialization on temporary waters. The assessment of the Lobau with "poor dragonfly ecological status" should be seen as a remit to realize the commitment for protection of fluvial habitats. Hydrological and ecological deficits, reflected by the occurring dragonfly fauna call for sustainable restoration measures for the Lobau, which preserve the high natural value of the area, allow for stronger hydrological dynamics corresponding to the original character and at the same time secure existing utilization interests, such as flood protection and drinking water production.

Appendix

Appendix: Sampling sites with associated site code and coordinates. – Anhang: Probenahmestellen mit zugehörigem Standortcode und Koordinaten.

Water body	Site code	Longitude	Latitude
Donau-Oder-Kanal	L01	48,174987	16,529213
Großenzersdorfer Arm	L02	48,180811	16,537409
Großenzersdorfer Arm	L03	48,189888	16,540671
Großenzersdorfer Arm	L04	48,195241	16,539480
Großenzersdorfer Arm	L05	48,200587	16,535849
Großenzersdorfer Arm	L06	48,201416	16,525611
Großenzersdorfer Arm	L07	48,200948	16,519074
Dechantlacke	L08	48,192149	16,477119
Dechantlacke	L09	48,190432	16,478376
Panozzalacke	L10	48,192606	16,483660
Mühlwasser	L11	48,194976	16,480805
Seeschlachtgraben	L12	48.184884	16.480777
Mühlwasser	L13	48,198842	16,488424
Mühlwasser	L14	48,199685	16,495481
OMV-Teich	L15	48,179804	16,495688
Panozzalacke	L16	48,180694	16,488157
Panozzalacke	L17	48,185875	16,488627
Lausgrundwasser	L18	48,163954	16,527012
Lausgrundwasser	L19	48,163893	16,533

Water body	Site code	Longitude	Latitude
Kreuzgrund-Traverse	L20	48,161829	16,545364
Mittelwasser	L21	48,160406	16,553157
Kühwörterwasser/Mittelwasser	L22	48,160005	16,560135
Küniglwasser	L23	48,148464	16,566694
Eberschüttwasser	L24	48,172919	16,53739
Kühwörterwasser	L25	48,144562	16,576352
Kühwörterwasser	L26	48,149674	16,572393
Kühwörterwasser	L27	48,157505	16,569821
Schwarzes Loch	L28	48,156323	16,530225
Eberschüttwasser	L29	48,169248	16,537723

Literature

Amoros C, Roux AL (1988) Interaction between water bodies within the floodplains of large rivers: function and development of connectivity. Münstersche Geographische Arbeiten 29, 125–130

Amoros C, Roux A L, Reygrobellet J L, Bravard J P, Pautou G (1987) A method for applied ecological studies of fluvial hydrosystems. Regulated Rivers: Research and Management 1, 17–36

BMLFUW (2015) Auenstrategie für Österreich 2020+. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien, 22p

BMLFRW (2022) Auenstrategie für Österreich 2030+. Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft Wien, in Druck

BMLRT (2022) Nationaler Gewässerbewirtschaftungsplan. Bundesministerium für Landwirtschaft, Regionen und Tourismus, Wien, 341p

Brückmann Y (2010) Flussauen zwischen FFH-Richtlinie und Wasserrahmenrichtlinie: Ein Vergleich der naturschutzfachlichen und wasserwirtschaftlichen Ziele am Beispiel des FFH-Gebietes „Elbaue Beuster-Wahrenberg". VDM Verlag, Saarbrücken, 128p

Castella E (1987) Larval Odonata distribution as a describer of fluvial ecosystems: the Rhone and Ain Rivers, France. Advances in Odonatology 3, 23–40

Castella E, Richardot-Coulet M, Roux C, Richoux P (1991) Aquatic macroinvertebrate assemblages of two contrasting floodplains: the Rhone and Ain Rivers, France. Regulated Rivers: Research and Management 6, 289–300

Chovanec A (2017) Die Libellenfauna (Insecta: Odonata) der Klosterneuburger Donau-Au (Niederösterreich): Bewertung, Entwicklungstendenzen und Managementempfehlungen. Wiss. Mitt. Niederösterr. Landesmuseum 27, 39–68

Chovanec A (2019) Bewertung von Oberflächengewässern anhand libellenkundlicher Untersuchungen (Odonata) – Methoden für stehende und fließende Gewässer sowie ihre beispielhafte Anwendung an der Mattig (Oberösterreich). Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen 71, 13–45

Chovanec A, Waringer J (2001) Ecological integrity of river-floodplain systems assessment by dragonfly surveys (Insecta: Odonata). Regulated Rivers: Research & Management 17, 493–507

Chovanec A, Waringer J, Raab R, Laister G (2004) Lateral connectivity of a fragmented large river system: assessment on a macroscale by dragonfly surveys (Insecta: Odonata). Aquatic Conservation: Marine and Freshwater Ecosystems 14, 163–178

Chovanec A, Waringer J, Straif M, Graf W, Reckendorfer W, Waringer-Löschenkohl A, Waidbacher H, Schultz H (2005) The Floodplain Index – a new approach for assessing the ecological status of

river/floodplain-systems according to the EU Water Framework Directive. Large Rivers Vol. 15 (1–4) Arch. Hydrobiol. Suppl. 155/1–4, 169–185

Chwala E, Waringer J (1996) Association patterns and habitat selection of dragonflies (Insecta: Odonata) at different types of Danubian backwaters at Vienna, Austria. Archiv für Hydrobiologie Supplementum 115, Large Rivers 11 (1), 45–60

Dziock F, Henle K, Foeckler F, Follner K, Scholz M (2006) Biological Indicator Systems in Floodplains – a Review. Internat. Rev. Hydrobiol. 91 (4), 271–291

Fischer I, Sittenthaler M, Chovanec A (2018) Zum Vorkommen von drei Arten der Gattung *Leucorrhinia* in Wien (Österreich) mit dem Erstnachweis von *L. albifrons* (Odonata: Libellulidae). – Libellula 37(1/2), 79–90

Fischer I (2016) Neuer Nachweis der Zierlichen Moosjungfer, *Leucorrhinia caudalis* (Charpentier, 1840) (Odonata: Libellulidae), in Wien. Beiträge zur Entomofaunistik, 17, 127–167

Godreau V, Bornette G, Frochot B, Amoros C, Castella E, Oertli B, Chambaud F, Oberti D, Craney E (1999) Biodiversity in the floodplain of Saône: a global approach. Biodiversity and Conservation 8, 839–864

Graf W, Chovanec A (2016) Entwicklung eines WRRL-konformen Bewertungssystems für Auen großer Flüsse auf Basis des Makrozoobenthos unter besonderer Berücksichtigung der Donau. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien, 48p

Graf W, Chovanec A, Hohensinner S, Leitner P, Schmidt-Kloiber A, Stubauer I, Waringer J, Ofenböck G (2013) Das Makrozoobenthos als Indikatorgruppe zur Bewertung großer Flüsse unter Einbeziehung auenökologischer Aspekte. Österr. Wasser- und Abfallwirtschaft 65, 386–399

Haidvogl G, Preis S, Hohensinner S, Muhar S, Poppe M (2009) Flusslandschaften im Wandel. In: Egger G, Michor K, Muhar S, Bednar B (Hg.), Flüsse in Österreich. Lebensadern für Mensch, Natur und Wirtschaft. StudienVerlag, Innsbruck, Wien, Bozen, 32–43

Hohensinner S, Herrnegger M, Blaschke A P, Habereder C, Haidvogl G, Hein T, Jungwirth M, Weiß M (2008a) Type-specific reference conditions of fluvial landscapes: a search in the past by 3D-reconstruction. Catena 75, 200–215, ISSN 0341-8162

Hohensinner S, Eberstaller-Fleischanderl D, Haidvogl G, Herrnegger M, Weiß M (2008b) Die Stadt und der Strom – Historische Veränderungen der Wiener Donau-Auen seit dem 18. Jahrhundert. Abh. Geol. B.-A. 62, 87–93

Hohensinner S, Jungwirth M, Muhar S, Schmutz S (2011) Spatio-Temporal Habitat Dynamics In A Changing Danube River Landscape 1812–2006. River Research & Applications 27 (8), 939– 955

Januschke J, Jachertz H, Hering D (2018) Machbarkeitsstudie zur biozönotischen Auenzustandsbewertung. Bundesamt für Naturschutz, BfN-Skripten 484, 64p + Anhänge

Korn N, Jessel B, Hasch B, Mühlinghaus R (2005) Flussauen und Wasserrahmenrichtlinie. Bedeutung der Flussauen für die Umsetzung der europäischen Wasserrahmenrichtlinie – Handlungsempfehlungen für Naturschutz und Wasserwirtschaft. Naturschutz und Biologische Vielfalt 27, 1–254

Laister G (1998) Leitbild – Libellen, Donau-Traun-Krems-Auen. Naturkundliches Jahrbuch der Stadt Linz 42/43, 1996/97, 181–196

Laister G (2008) Die Libellenfauna der Linzer Donauauen – alles beim Alten oder? Öko•L 30/3, 3–12

Lazowski W, Schwarz U (2014) Auenland – das Aueninventar als Grundlage einer österreichweiten Auenstrategie. Österreichischer Naturschutzbund (Hg.), 103p + Karten

Lohr M (2010) Libellen zweier europäischer Flusslandschaften. Arbeiten aus dem Institut für Landschaftsökologie Münster, 183p

Oertli B (2008) The use of dragonflies in the assessment and monitoring of aquatic habitats. In: Córdoba-Aguilar A. (Ed.), Dragonflies and Damselflies. Model Organisms for Ecological and Evolutionary Research. Oxford University Press, New York, 79–95

Ott J (2013) Erstnachweis der Östlichen Moosjungfer – *Leucorrhinia albifrons* (Burmeister, 1839). In Rheinland-Pfalz (Insecta: Odonata). Fauna Flora Rheinland-Pfalz 12, 1075–1086

Raab R (2000) Die Libellenfauna in den Maßnahmenbereichen Untere Lobau und Orth. Bericht im Auftrag des Nationalpark Donauauen im Rahmen des LIFE-Projektes „Gewässervernetzung und Lebensraummanagement Donauauen"

Raab R (2004) Die Libellen (Insecta: Odonata) des dynamischen Altarmsystems der Donau bei Regelsbrunn (Niederösterreich). Abhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich 34, 99–122

Raab R (2006) Rote Liste der Libellen Österreichs. In Raab R, Chovanec A, Pennerstorfer J Libellen Österreichs 325–334. Springer, Wien, New York

Reckendorfer W, Böttiger M, Funk A, Hein T (2013) Die Entwicklung der Donau-Auen bei Wien – Ursachen, Auswirkungen und naturschutzfachliche Folgen. Geographica Augustana. 13, 45–53

Roni P, Hall JE, Drenner SM, Arterburn D (2019) Monitoring the effectiveness of floodplain habitat restoration: A review of methods and recommendations for future monitoring. WIREs Water. 2019;6:e1355, https://doi.org/10.1002/wat2.1355

Schorr M (1996) Flußauenlibellen der Mosel und ihre Indikatorfunktion. Teil I. Aut- und Ethoökologie ausgewählter Arten. Im Auftrag der Bundesanstalt für Gewässerkunde – Ref. U3 (Tierökologie). Faunistisch-Ökologische Arbeitsgemeinschaft, Trier-Kernscheid, 79p

Schorr M, Götz K (1996) Flußauenlibellen der Mosel und ihre Indikatorfunktion. Teil II Möglichkeiten ihrer Förderung im Rahmen von Kompensationsmaßnahmen. Im Auftrag der Bundesanstalt für Gewässerkunde – Ref. U3 (Tierökologie). Faunistisch-Ökologische Arbeitsgemeinschaft, Trier-Kernscheid, 43p

Schultz H, Waringer J, Chovanec A (2003) Assessment of the ecological status of Danubian floodplains at Tulln (Lower Austria) based on the Odonata Habitat Index (OHI). Odonatologica 32, 355–370

Schultz H (2008) Erhebung der Libellenfauna der Unteren Lobau, 7–41. In: Schultz H, Schulze C H, Waringer-Löschenkohl A, Zornig H Faunistische Beweissicherung Dotation Untere Lobau (2007). Erhebung der Libellen, Amphibien und Brutvögel mit Gewässerbindung. Bericht im Auftrag der Magistratsabteilung 45 (Wasserbau), Wien

Schulze C H, Schneeweihs S (2013) Auenhabitatindex: Die Libellen (Odonata) der Unteren Lobau – Ergebnisse der Erhebungen aus dem Jahr 2012. Projektbericht im Auftrag der Magistratsabteilung 45 – Wiener Gewässer

Seidel M, Li F, Langheinrich U, Lüderitz V (2019) Bioindikatorische Typisierung der Anbindung von Altwässern der Mittelelbe. Wasserwirtschaft 11, 47–53

Sladecek V (1964) Zur Ermittlung des Indikations-Gewichtes in der biologischen Gewässeruntersuchung. Archiv für Hydrobiologie 60, 241–243

Staufer M, Pöchhacker-Florian H (2018) Erste aktuelle Reproduktionsnachweise der Östlichen Moosjungfer (*Leucorrhinia albifrons*) und der Zierlichen Moosjungfer (*Leucorrhinia caudalis*) aus Wien mit Beiträgen zur Phänologie in Ostösterreich (Odonata: Libellulidae). Beiträge zur Entomofaunistk 19, 95–110

Sternberg K, Schiel F-J, Buchwald R (2000) *Leucorrhinia pectoralis* (Charpentier, 1825), Große Moosjungfer. In Sternberg K, Buchwald R (Hg.) – Die Libellen Baden-Württembergs, Band 2, 415–427. Ulmer, Stuttgart

Ward J V, Stanford J A (1995) Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research & Management 11, 105–119

Ward J V, Tockner K, Arscott D B, Claret C (2002) Riverine landscape diversity. Freshwater Biology 47, 517–539

Ward J V, Tockner K, Schiemer F (1999) Biodiversity of floodplain river ecosystems: ecotones and connectivity. Regulated Rivers: Research & Management 15, 125–139

Waringer J (1989) Gewässertypisierung anhand der Libellenfauna am Beispiel der Altenwörther Donauau (Niederösterreich). Natur und Landschaft 64, 389–392

Waringer J, Chovanec A, Straif M, Graf W, Reckendorfer W, Waringer-Löschenkohl A, Waidbacher H, Schultz H (2005) The Floodplain Index – habitat values and indication weights for molluscs, dragonflies, caddisflies, amphibians and fish from Austrian Danube floodplain waterbodies. Lauterbornia 52, 177–186

Wassermann G (1999) Odonata (Libellen). Forschung im Verbund, Schriftenreihe 50, 118–128

Weigelhofer G, Hein T, Kucera-Hirzinger V, Zornig H, Schiemer F (2011) Hydrological improvement of a former floodplain in an urban area: Potenzial and limits. Ecol. Eng. 37, 1507–1514

Weigelhofer G, Reckendorfer W, Funk A, Hein T (2013) Auenrevitalisierung – Potential und Grenzen am Beispiel der Lobau, Nationalpark Donauauen. Österreichische Wasser- und Abfallwirtschaft 2 65, 400–407

Weigelhofer G, Feldbacher E, Trauner D, Pölz E, Hein T, Funk A (2020) Integrating conflicting goals of the EC Water Framework Directive and the EC Habitats Directives into floodplain restoration schemes. Front. Environ. Sci. 8:538139. doi: 10.3389/fenvs.2020.538139

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