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Grasshoppers of the salt marshes of Istria (Croatia)

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Abstract

The regularly flooded salt marshes of the Istrian peninsula (Croatia) with their orthopteran populations are a very special type of habitat. However, these endangered ecosystems have received little attention to date. Therefore, the last remaining lagoon habitats in Istria and their grasshopper communities were randomly sampled from July to September between 2015 and 2024. A total of 11 grasshopper species were recorded, of which *Epacromius coerulipes*, *E. tergestinus tergestinus*, *Paracinema tricolor bisignata* and *Chrysochraon dispar giganteus* are endangered throughout Europe. The habitats are presented in the form of 'hot spots' and their threats are discussed.

Keywords: conservation, endangerment, habitat specialists, Istrian peninsula

Zusammenfassung

Die regelmäßig überfluteten Salzfluren und Marschen küstennaher Bereiche der Halbinsel Istrien (Kroatien) sind mit ihren Orthopterenbeständen ein ganz spezieller Lebensraumtyp. Bisher fanden diese gefährdeten Ökosysteme jedoch wenig Beachtung. Von 2015 bis 2024 wurden daher von Juli bis September stichprobenartig die letzten lagunären Lebensräume Istriens und deren Heuschreckenzönosen untersucht. Insgesamt wurden 11 Heuschreckenarten nachgewiesen, wobei davon *Epacromius coerulipes*, *E. tergestinus tergestinus*, *Paracinema tricolor bisignata* und *Chrysochraon dispar giganteus* europaweit gefährdet sind. Die Lebensräume werden in Form von „Hotspots" vorgestellt und auf ihre Gefährdung eingegangen.

Schlüsselwörter: Gefährdung, Habitatspezialisten, Istrien, Schutz

Introduction

In addition to its eventful history and many cultural treasures, the Istrian peninsula in Croatia also offers a wide variety of natural habitats. Dry areas such as macchia, dry grasslands, garrigues and karst heathlands are home to a diverse flora and a species-rich orthopteran fauna. This is summarised in the first annotated checklist of Croatian orthopterans by Skejo et al. (2018). Further faunistic data are provided by Us (1967) and Puskás et al. (2018). Occasional scattered data without specific locality information can also be found in older literature (e.g. Nadig 1961, Kaltenbach 1970, Harz 1975). Observations and images of the orthopteran fauna of Istria are also available in relevant databases (e.g. Orthoptera.ch by Roesti & Rutschmann 2011–2025).

One particularly special habitat type that has received little attention to date with regard to orthopterans in Istria are the regularly flooded, calm mudflats and salt marshes of the sea coast. In contrast, the Adriatic coastal areas of northern Italy in Veneto and Friuli-Venezia Giulia, which border to the west, have been well studied and are even inhabited by rare, endangered species such as *Zeuneriana marmorata* (Kleukers et al. 1997, Kleukers et al. 2015, Chobanov et al. 2016, Hochkirch et al. 2017, Tami et al. 2024).

As in the rest of Europe, Istria's remaining wetlands are seriously endangered by increasing destruction and have already become very rare. The west coast of Istria in particular has experienced a tourism construction boom in recent decades. It has been extensively developed with hotels, campsites and leisure facilities in suitable locations. Lagoon habitats have been largely destroyed or degraded by artificial drainage measures. Only a few small salt marshes have survived between the generously laid out leisure facilities.

These habitats are unique due to their ecological conditions, such as fluctuating salinity and regular flooding at high tide, as well as temporary high water levels in the rivers. Their vegetation, the halophytes, are perfectly adapted to these conditions. Only a few specialised grasshopper species, such as the two *Epacromius* species, are able to inhabit these extreme locations.

To date, there are only few concrete records of orthopteran species from the Istrian salt marshes and brackish water areas (Ingrisch 1981, Puskás et al. 2018, Observation.org 2025a). Therefore, the aim of this study was to locate the remaining coastal brackish water areas and to survey their orthopteran populations.

Material and Methods

Back in 1988, as part of the marine biology courses run by the University of Salzburg, I received a work permit from the Marine Biology Institute of the University of Zagreb in Rovinj to conduct scientific research on Mediterranean blennies (Illich & Kotrschal 1990). Since then, I have visited Istria regularly, where my interest in Orthoptera was piqued.

From 2015 to 2024, I randomly sampled the freely accessible areas of Istria's salt marshes between July and September to study their grasshopper communities. I also included the few corresponding data sets from Istria on the Observation.org reporting platform (Observation.org 2025a). The findings were documented in photographs, and the data sets are stored in the biodiversity database of the Haus der Natur – Museum of Nature and Technology in Salzburg.

Study area

The Istrian peninsula is located between the Gulf of Trieste and Kvarner Bay off Rijeka in the northern Adriatic Sea. Most of Istria (89%) belongs to Croatia. The smaller northern part of the peninsula is Slovenian territory and was not included in this study.

The coastal areas studied are mostly located on the west coast of Istria and include both the salt marshes and the river marshes of Istria's longest watercourses (Fig. 1). Most of the surveys were carried out in the Mirna/Quieto estuary.

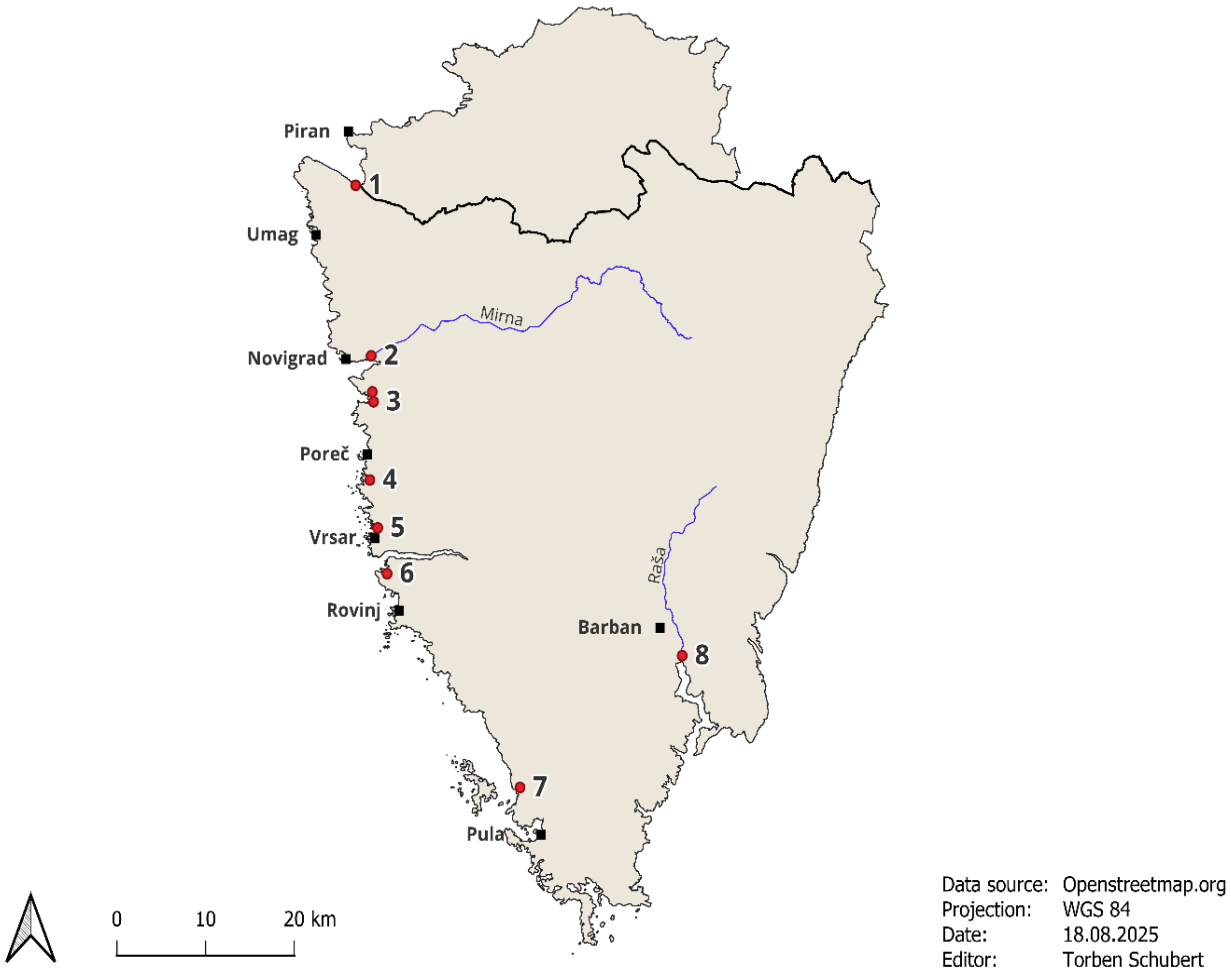

Fig. 1: Location of the study areas in Istria (labelled in Croatian/Italian): 1 Dragonja/Dragogna estuary near Kanegra/Canegra; 2 Mirna/Quieto estuary near Novigrad/Cittanova; 3 Červar Porat lagoon; 4 Plava Laguna south of Poreč/Parenzo; 5 lagoon north of

Vrsar/Osera; 6 salt marsh in the 'Val Salina' bay north of Rovinj/Rovigno; 7 Valbandon bay north of Pula/Pola; 8 Raša/Arsa estuary near Barban.

These ecosystems with their fine, clayey sediments harbour a distinctive halophyte flora. This is mainly characterised by the two salt-accumulating and salt-excreting glasswort species *Salicornia procumbens* and *Salicornia fruticosa*, as well as sea lavender (*Limonium narbonense*) and sea purslane (*Atriplex portulacoides*). The halophyte populations are regularly flooded by the tidal cycle. Water can remain longer in depressions, hollows and, particularly, in the tidal creeks. Vegetation-free, bare patches of soil also form, which heat up quickly due to solar radiation. The habitat therefore offers a very heterogeneous mosaic of vegetation with varying microclimates.

Results

A total of 11 grasshopper species, including five Ensifera and six Caelifera, were found in the salt marshes of Istria (Table 1). Of these, *Epacromius coerulipes*, *E. tergestinus tergestinus* and *Paracinema tricolor bisignata* are endangered throughout Europe (Hochkirch et al. 2016). In addition, Buzzetti et al. (2010) classified *Chrysochraon dispar giganteus* as critically endangered according to the IUCN Red List Categories (9 February 2000). This highest threat category also applies to *E. t. tergestinus* in France (Sardet & Defaut 2004).

Table 1: Grasshopper species of the coastal areas studied. Status according to IUCN Red List (EU and Europe) (Hochkirch et al. 2016; Buzzetti et al. 2010): CR = Critically Endangered, EN = Endangered, NT = Near Threatened, LC = Least Concern. (+) = missing.

Species	**Study area (see Fig. 1)**								**Red List status**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**EU 28**	**Europe**
Conocephalus fuscus		+	+	+			+	+	LC	LC
Conocephalus dorsalis		+							LC	LC
Ruspolia nitidula		+	+	+		+		+	LC	LC
Roeseliana cf. *brunneri*		+								
Pteronemobius heydenii		+		+	+				LC	LC
Tetrix ceperoi		+							LC	LC
Aiolopus thalassinus		+				+		+	LC	LC
Epacromius coerulipes	+		+	+		+	(+)		EN	NT
Epacromius tergestinus tergestinus	+		+		+	(+)			EN	LC
Paracinema tricolor bisignata		+							NT	NT
Chrysochraon dispar giganteus		+							CR	

Accompanying species were *Conocephalus fuscus, Ruspolia nitidula, Pteronemobius heydenii* and *Aiolopus thalassinus. Conocephalus dorsalis* and *Tetrix ceperoi* were only found in the estuary of the Mirna (Table 1). In contrast to the two *Epacromius* species, which were only found in the immediate coastal vicinity of the salt marshes, the other species also populate habitats inland (cf. Ingrisch 1981, Skejo et al. 2018). The richly structured margins of the salt marshes were inhabited by *Calliptamus italicus*, *Euchorthippus declivus*, *Tylopsis lilifolia*, *Tettigonia viridissima* and *Pezotettix giornae*.

Epacromius coerulipes (Ivanov, 1888)

E. coerulipes occurs throughout the Mediterranean region and as far east as East Asia. In Italy, this species is only found in the north-eastern regions of Emilia-Romagna, Veneto and Friuli-Venezia Giulia (Fontana et al. 2002, Buzzetti et al. 2010, Massa et al. 2012, Iorio et al. 2019, Tami et al. 2024).

In Croatia, *E. coerulipes* has so far only been found in Istria (Skejo et al. 2018). It was discovered by Ingrisch (1981) on the west coast south of Poreč in Plava Laguna. Although this habitat has been severely reduced in recent times, *E. coerulipes* was recorded there again on 21 September 2021 (Fig. 2a). In addition, this species was found in a fairly good population density in the Červar Porat lagoon (23 September 2021, 16 August 2024; Fig. 2b) and in the 'Val Salina' north of Rovinj (17 July 2020, 22 July 2023). At all three locations, the species inhabited saline soils, which were often sparsely covered with halophytes. It was also found in the Dragonja estuary near Kanegra (Observation.org 2025b). Its occurrence at Valbandon (Skejo et al. 2018) north of Pula could no longer be confirmed.

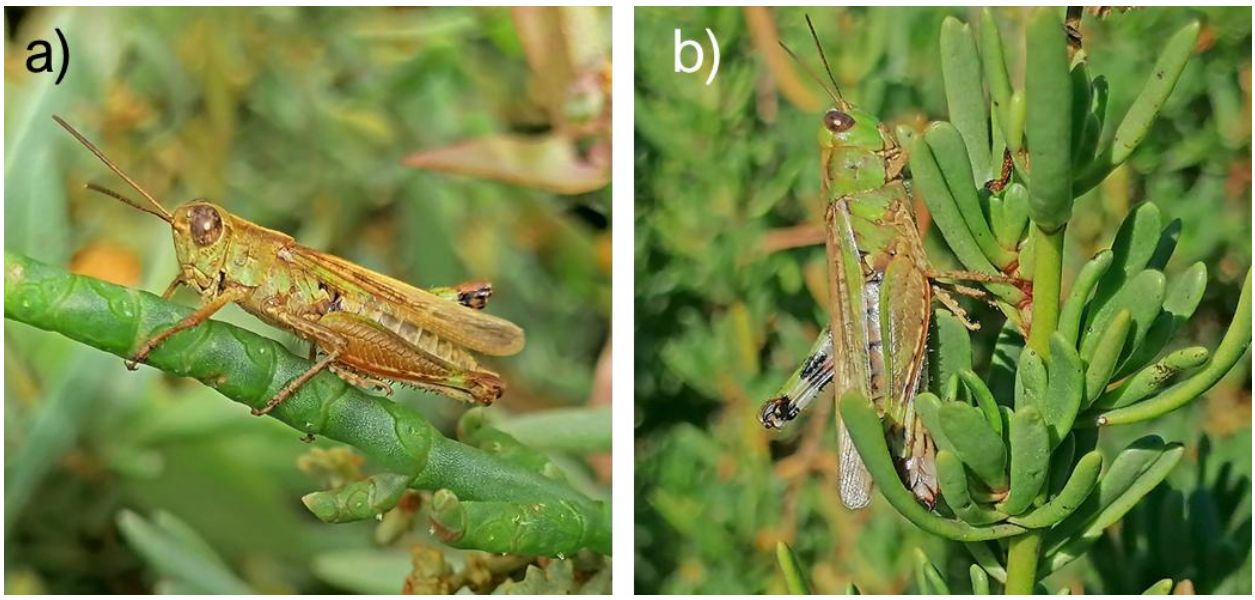

Fig. 2: a) *Epacromius coerulipes* ♂ on *Salicornia* sp.; Plava Laguna (21 September 2021). This species is slightly smaller than *E. tergestinus tergestinus*. b) *Epacromius coerulipes* ♀; Červar Porat (23 September 2021). The light blue hind tibiae have ring-shaped dark spots, the inside of the hind femur is coloured in high contrast and slightly reddish on the ventral side (photos: © I. Illich).

Epacromius tergestinus tergestinus (Megerle von Mühlfeld, 1825)

E. t. tergestinus occurs as the nominate form on the Atlantic coast of France and sporadically in the Mediterranean region. Older finds have been reported from Trieste, the Venice Lagoon and Rome (Galvagni 1948, Canestrelli 1981). Currently, this species is reported in a few coastal areas of Friuli-Venezia Giulia, Veneto (Venice Lagoon, Foci del Tagliamento) and near Lazio (Buffalotto) (Fontana et al. 2002, Buzzetti et al. 2010, Massa et al. 2012, Iorio et al. 2019).

In Croatia, the first record stemmed from the island of Cres near Osor (Puskás et al. 2018). In the course of this study, *E. t. tergestinus* was found at four locations (Table 1). Scattered individuals were observed on 19 July 2020 and 12 August 2023 at Kanegra in the Dragonja estuary (Fig. 3a) and confirmed there on 10 July 2024 (Observation.org 2025c, vidit R. Kleukers, L. Willemse and R. Felix). In the Červar Porat lagoon, this species was found in a good population density in the halophyte community of the southern salt marsh (21 July 2021, 23 September 2021). The northern brackish water area, which is already severely degraded, was populated by both *E. t. tergestinus* and *E. coerulipes* (21 July 2021, 21 September 2021; Fig. 3b). Another occurrence is located in the lagoon north of Vrsar. Like all the others, this area is now only a small remnant of what was originally a rather extensive salt marsh. Nevertheless, scattered individuals of *E. t. tergestinus* were found here (20 July 2021, 18 July 2024). In the 'Val Salina' north of Rovinj, the species seems to have disappeared. The last record was on 24 July 2006.

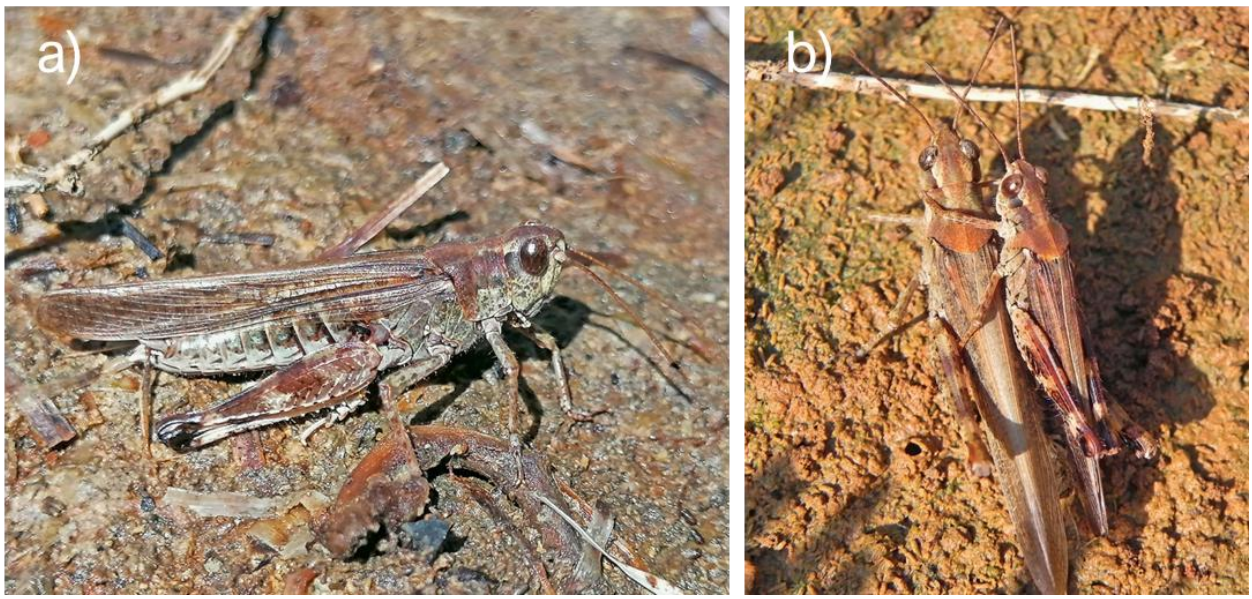

Fig. 3: a) *Epacromius tergestinus tergestinus* ♂, Kanegra/Canegra (19 July 2020). The forewings are finely mottled with dark spots. b) Copula of *Epacromius tergestinus tergestinus* on the salty, loamy 'Terra Rossa' of Červar Porat (21 July 2021). photos: © I. Illich.

Paracinema tricolor bisignata (Charpentier, 1825)

P. t. bisignata is distributed from Western and Central Europe to the Caucasus, Asia Minor, the Mediterranean region and Central and Northern Italy (Buzzetti et al. 2010, Massa et al. 2012, Marco & Leandri 2024). In Croatia, *P. t. bisignata* is considered a rare brackish water species of the Mediterranean coast, but there are no concrete records of its occurrence (Skejo et al. 2018). In the present study, this species was only found in the estuary of the Mirna (24 July 2023, 11 August 2023). There, a specimen flew several metres and then landed unerringly on *Phragmites* stems (Fig. 4).

In general, this hygrophilous and thermophilic species inhabits extensive wetlands covered with reeds and grasses, such as the banks of standing and flowing waters. In Piedmont and Lombardy, *P. t. bisignata* also lives in rice fields (Massa et al. 2012). The populations in Italy are mostly isolated and considered to be in decline (Massa et al. 2012, Iorio et al. 2019, Marco & Leandri 2024).

Fig. 4: *Paracinema tricolor bisignata* ♂ in a *Phragmites* bed on the banks of the Mirna/Quieto near Novigrad/Cittanova (24 July 2023, photo: © I. Illich).

Chrysochraon dispar giganteus Harz, 1975

This is a subspecies that was described by Harz (1975) as *C. dispar giganteus* on the basis of two populations originating from Albania, which were larger in size than the nominate form. In Italy, this subspecies is only known from Veneto (Venice Lagoon), San Giovanni al Timavo near Monfalcone (Friuli-Venezia Giulia) and Lombardy (Canestrelli 1986, Galvagni & Fontana 1993, Fontana et al. 2002, Tami et al. 2005, Buzzetti et al. 2010 and Marco & Leandri 2024).

The first documented find of *C. d. giganteus* in Croatia is about 1.3 km east of Novigrad near Kostanjica (Ingrisch (1981). Not far from there, at Ponte Porton, this species was recorded in June and July from 2014 to 2016 (Rutschmann & Roesti,

2014). In the course of this study, this species was found exclusively and repeatedly in the estuary of the Mirna near Novigrad (15 July 2019, 18 July 2021, 18 July 2023, 15 August 2024), where it preferred to stay in the reed thickets (Fig. 5 and Fig. 7). The records from this area were confirmed on 10 July 2024 (Observation.org 2025d).

Fig. 5: *Chrysochraon dispar giganteus* ♂ in the reed thicket on the banks of the Mirna/Quieto near Novigrad/Cittanova (17 July 2019, photo: © I. Illich).

***Roeseliana* sp.**

On 15 July 2019, I observed a female *Roeseliana* sp. feeding on a fish carcass at the mouth of the Mirna River near Novigrad. To date, the status of this species remains unclear, even after consulting with specialists (Bruno Massa and Paolo Fontana, written communication 2024). Despite intensive searches, no further specimens of this unknown species have been found. The habitat and accompanying species would suggest *R. brunneri*, but there is no definitive proof of this.

'Hot spots' of the Istrian coastal wetlands

In order to highlight the uniqueness of Istria's last salt marshes and their orthopteran communities, the locations where endangered species have been found (Table 1) are presented separately below. After all, they represent the last remnants of once widespread species communities. Protective measures for these orthopterologically valuable areas are urgently needed in the foreseeable future.

1 Kanegra/Canegra

Location: Southeast of Kanegra, the Dragonja River, which forms the border between Slovenia and Croatia, flows into the Gulf of Trieste. North of this river, on the Slovenian side, are the salt pans of Piran. South of the river along the Croatian coast the salt marshes were randomly surveyed (Fig. 1 and Fig. 6).

Characteristics: The coastal area covered with halophytes is heavily flooded, not only by the tides but also when the river is high.

Grasshopper fauna: The area is inhabited by *E. t. tergestinus* and *E. coerulipes*. Excellent flying ability is essential for survival in this ecosystem.

Fig. 6: Mouth of the Dragonja/Dragogna border river on the Croatian side near Kanegra/ Canegra (19 July 2020, photo: © I. Illich).

2 Novigrad/Cittanova, Antenal

Location: The Mirna estuary is located east of Novigrad. It is the largest, still relatively intact brackish water area in Istria and an important bird breeding ground. On the right bank of the river near Antenal, there is a public road about two metres above the water level that divides the area into two parts. In the present study, only a small part of the narrow shore area on the right bank was investigated (Fig. 1 and Fig. 7).

Characteristics: On both sides of the river, somewhat away from the actual shore area, there are extensive brackish water areas with a distinctive halophyte flora. The examined right bank is densely covered with *Phragmites australis* and various other true grasses. It is regularly flooded during high tides and heavy rainfall.

Grasshopper fauna: Although only a relatively small area was surveyed, most species were found here (Table 1). In addition to *Conocephalus fuscus*, *Conocephalus dorsalis* and *Tetrix ceperoi*, the two endangered species *P. tricolor bisignata* and *C. dispar giganteus* are worth mentioning. On 15 July 2019, a *Roeseliana* sp. was discovered on a fish carcass. This is possibly *Roeseliana brunneri*, but the identification needs to be confirmed. *Aiolopus thalassinus* lives in very high densities in a wetland further to the east.

Fig. 7: The banks of the Mirna/Quieto near Novigrad/Cittanova, covered with reeds and other true grasses (19 August 2022, photo: © I. Illich).

3 Červar Porat lagoon

Location: Southeast of Vabriga in the Červar Porat lagoon, there are salt marshes in the northern and southern inlets of this bay. These are separated by a land bridge of about one kilometre (Fig. 1, Fig. 8, Fig. 9).

Characteristics: The two salt marshes, covered with halophytes, are intersected with tidal creeks, through which seawater floods the area at high tide.

Grasshopper fauna: This is a particularly valuable area, home to *E. coerulipes* and *E. t. tergestinus*.

Fig. 8: Southern part of the Červar Porat lagoon (21 July 2021, photo: © I. Illich).

Fig. 9: Salt marsh in the northern part of Červar Porat Bay already severely damaged by quad bikes (21 July 2021, photo: © I. Illich).

4 Plava Laguna near Poreč/Parenzo

Location: Plava Laguna, surrounded by paved paths, is located south of Poreč. To the west, the important connection to the sea is blocked by an asphalt road, preventing water exchange (Fig. 1, Fig. 10, Fig. 11).

Characteristics: The remaining central area is still covered with original halophyte flora (Fig. 12). However, several wet areas have been covered with large stones, where *Phragmites australis* is proliferating. The paved edges of the salt marsh are mowed.

Grasshopper fauna: *E. coerulipes* inhabits only the central, still relatively intact area of what was once a much larger salt marsh.

Fig. 10: Small remnants of Plava Laguna (back right) near Poreč/Parenzo, enclosed by embankments (21 September 2021, photo: © I. Illich).

Fig. 11: Tourist activities are further encroaching upon the already very small central area of Plava Laguna near Poreč/Parenzo (21 September 2021, photo: © I. Illich).

Fig. 12: Intact central area of Plava Laguna near Poreč/Parenzo with halophyte flora, such as *Limonium* in bloom (21 September 2021, photo: © I. Illich).

5 Lagoon near Vrsar/Osera

Location: In a little bay north of Vrsar, several small headlands extend into the sea (Fig. 1 and Fig. 13). The shore area is bordered by a metre-high embankment of boulders. This has greatly reduced the size of the originally much larger lagoon.

Characteristics: The vegetation islands are exposed to the fluctuating water level of the tides and are therefore still covered with corresponding halophyte flora.

Grasshopper fauna: *E. t. tergestinus* inhabits the island-like parts of this brackish water area in low density.

6 'Val Salina' north of Rovinj/Rovingo

Location: 'Val Salina', an ancient, abandoned salt production site, is located in Valalta north of Rovinj and south of the Limski Fjord (Fig. 1 and Fig. 14). This unique site has also been increasingly encroached upon by tourist leisure facilities in the north and agricultural use by olive cultivation in the southeast.

Characteristics: The heavily clayey, muddy soils, criss-crossed by tidal creeks and covered with halophytes, are regularly flooded by the tides.

Grasshopper fauna: Until 1997, both *Epacromius* species were present; in 2006, the last record of *E. t. tergestinus* was made. In contrast, the presence of *E. coerulipes* could be confirmed.

7 & 8 Valbandon near Pula/Pola; Raša/Arsa estuary near Barban

No endangered species were found in the Valbandon salt marsh south of Fažana during this study (Table 1, Fig. 1 and Fig. 15). Although designated as a protected area, construction measures have significantly altered the water regime. No endangered species were found in the Raša estuary during this study either. The immediate shore area is densely covered with reeds, and the adjacent areas are used for agriculture.

Fig. 13: Islands of vegetation covered with halophytes in the lagoon near Vrsar/Osera (20 July 2020, photo: © I. Illich).

Fig. 14: Salt marsh of the ‘Val Salina ’north of Rovinj/Rovigno (17 July 2020, photo: © I. Illich).

Fig. 15: Reed-covered remnants of the Valbandon salt marsh north of Pula/Pola (23 July 2020, photo: © I. Illich).

Discussion

The salt marshes of Istria are home to *Epacromius coerulipes*, *E. tergestinus tergestinus*, *Paracinema tricolor bisignata* and *Chrysochraon dispar giganteus*, species that are endangered throughout Europe (Sardet et al. 2004, Sardet & Perru 2006, Buzzetti et al. 2010, Hochkirch et al. 2016). Of particular note is the syntopic occurrence of both *Epacromius* species in the Červer Porat lagoon and in the Dragonja estuary near Kanegra. Both species are pronounced specialists with a very narrow ecological niche and special adaptations to the extremely fluctuating ecological conditions of the tidal zone. Their good flying ability makes them very mobile, and even swimming and diving *E. t. tergestinus* have been observed at high tide (Robin et al. 2017). A heterogeneous mosaic of vegetation consisting of regularly flooded halophytes is essential for the survival of these populations. The salty plants are also used for foraging. Detailed studies on the biology, ecology and behaviour of *E. t. tergestinus* are available from the protected areas on the French Atlantic coast (Barataud 2005, Sardet & Perru 2006, Allou et al. 2010, Robin et al. 2017). Experiments on food choice showed a preference for *Aster tripolium* and *Limonium vulgare*, while *Puccinellia maritima* and *Salicornia* sp. were also consumed (Barataud 2005, Sardet & Perru 2006). The phenology of the two species appears to differ somewhat. According to my own observations, *E. coerulipes* developed slightly later than *E. t. tergestinus*. The latter species is already adult by mid-July (cf. Allou et al. 2010), while *E. coerulipes* only reaches the peak of its imaginal stage in August.

If the connection to the sea and thus the tidal cycle is cut off, the lagoons will die and these rare grasshopper populations will not survive in the long term. In addition the influx of rubbish, especially plastic, via the rivers but also via deposits from the sea, is a growing problem. The habitats studied are characterised by low species diversity, with only a few specialised species able to survive here. These species are endangered throughout Europe. Effective and rapid protective measures are urgently needed to preserve these unique habitats and their relict populations.

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