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LINED IRRIGATION CANALS IN FIELD HUNTING GROUNDS OF VOJVODINA AND THEIR INFLUENCE ON WILDLIFE

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ABSTRACT: Irrigation canals lined with smooth materials (e.g. geomembrane, concrete) are potential barriers which disturb and restrict wildlife movement in numerous field hunting grounds in Vojvodina. The adverse effect of lined irrigation canals can be additionally increased due to drowning of both wild and domestic animals, or because of a permanent fence erected along some lined irrigation canals. This paper presents the results of multiannual monitoring of wildlife behaviour related to the lined irrigation canal "Kula-Mali Iđoš" (Bačka region), with special emphasis on wildlife overpasses and their efficacy in connecting the parts of the fragmented habitat. The study results show that the overpasses are used by different wildlife species, the most frequent of which are brown hare (*Lepus europaeus*), roe deer (*Capreolus capreolus*) and fox (*Vulpes vulpes*).
Keywords: irrigation canal, fragmentation, wildlife overpasses, Vojvodina.

1 INTRODUCTION

Vojvodina is the most significant agricultural region in the Republic of Serbia, thanks to good-quality soil types of high production value (chernozem and humogley), large water resources (Danube, Sava, and Tisza), the canal system (Danube-Tisza-Danube), and temperate continental climate. Agricultural land occupies more than 80% of its total area (2.15 million hectares), and the percentage of arable land is about 75%. Forests and forest lands occupy about 140,000 ha (6.5%). In all municipalities, agricultural land occupies above 70%, except for Beočin (45.6%), Sremski Karlovci (50.4%) and Šid (59.7%). The structure of agricultural land shows the prevalence of arable-vegetable farming, because ploughland and gardens account for 90% of farmland [11]. Agricultural land (field hunting grounds) supports many small and big game species, among which roe deer, brown hare and pheasant have the highest biological and economic significance in hunting economy. However, their populations are increasingly threatened by the intensification of agricultural and industrial production, the use of plant preservatives and mineral fertilisers, disasters (floods and droughts), road infrastructure (emission of exhaust gases, game disturbance and wildlife-related traffic accidents, fragmentation of habitats), predator species, and man-made specific effects (e.g. illegal hunting, nomadic pastoralism, concrete and plastic lining of irrigation channels) [3, 10, 13].

Based on the Law on Game and Hunting (Official Gazette RS, number 18/10), the Provincial Secretariat of Agriculture, Water Economy and Forestry has established altogether 147 hunting grounds, of which 18 are specific-purpose hunting grounds (they are managed by Public Enterprise "Vojvodinašume" (17 hunting grounds) and the National Park "Fruška Gora"), 13 hunting grounds in the area of registered fishponds, 115 hunting grounds in the wild (the so called "open hunting grounds" managed by Hunting Associations), and one private hunting ground [10]. In hunting grounds managed by Hunting Associations (about 90% of the total hunting area in Vojvodina), roe deer is the principal and almost the only reared big game species. The dominant land use type in the hunting grounds is arable farmland which occupies about 17,470 km^2 or 87.9%. Forests and other wooded land occupy about 530 km^2 or 2.7%. The low percentage of forests and wooded land has an adverse effect on the survival and density of principal reared small game species (brown hare and pheasant).

Lined canals are potential barriers which disturb the wildlife movement and can cause their drowning [4, 7, 8, 9]. In the field hunting grounds of Vojvodina, wildlife drowning in irrigation canals lined with plastic was frequent during the late eighties. Despite that, with the exception of recording the total number of drowned individuals of the principal wildlife species (roe deer and brown hare), adequate protection measures have not been defined and some of the proposed technical solutions have not been tested (e.g. wooden stairs for wildlife escape from the canal). Because of the lack of financial means (disintegration of the former SFRY and economic sanctions), almost all activities on irrigation canal construction and lining were stopped. At the present time, in the region of Vojvodina, the canals on porous soils are lined to mitigate the effects of severe and frequent drought periods. Also, each year, high financial means are invested in the construction of the commenced regional hydrosystems (Bačka and Banat). These systems cross many field hunting grounds and supply water to the areas with water shortage and they are long-term water potentials for the expansion of the area of irrigated lands. Some of the newly constructed canals are lined with plastic to preserve water, prevent seepage into adjacent land or roads, and enable reduced and faster maintenance. Also, the bed and sides of lined channels are more stable and thus less susceptible to erosion.

To prevent or mitigate the wildlife drowning risk and the site fragmentation, to solve this problem adequately, and harmonise the relations between agriculture and hunting (Public Water Management Company "Vode Vojvodine", agricultural enterprises, and hunting associations), large-scale research on the lined irrigation canal "Kula-Mali Iđoš" started in Vojvodina for the first time in the spring 2008 [2, 3]. This paper presents a small part of the results of multiannual monitoring (2008-2013) of the wildlife and the canal, with special emphasis on wildlife overpasses (3 concrete bridges) and their efficacy in connecting the parts of the fragmented habitat.

2 MATERIAL AND METHODS

The study area is the canal "Kula-Mali Iđoš" located along the border between the municipalities Kula and Vrbas (Bačka region). The canal is 5 km long, about 10 m wide and 2.5 m deep. The pumping station is in the suburb of Kula, on the bank of Veliki Bački Kanal, from

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which it pumps 1.2 m^3/s of water to the plateau of the Telečka Visoravan, directly to the canal "Kula-Mali Iđoš". The canal carries water for about 7-8 months/year (March to September/October). The entire canal runs through the agricultural landscape (altitude 95-125 m).

The canal was constructed and lined with plastic (polyvinyl chloride) during 2008, during the first phase of the subsystem "Mali Iđoš" and the regional hydrosystem "Severna Bačka". Several months later, a permanent fence, between 1.2 and 1.5 m high, was erected along the canal (Fig. 1). Its aim was to prevent wildlife and domestic animals from falling and drowning, and to direct their movement to overpasses.

There are three bridges built over the canal during different periods. Two bridges (B1 and B3) were built in 2008, and the third one (B2) in the spring 2010. They are similar in sizes, length about 25 m, width of the central part 8 m, and width of the approach span about 15 m. The composition of natural vegetation on the bridges was determined based on the samples collected in September 2009 and June 2013.

Bridge B1 is located at the 1+700 km (Fig. 1), B2 at the 2+500 km (Fig. 2), and B3 at the 3+350 km (Fig. 3). Initially, the main function of the bridges B1 and B3 was to enable the people, vehicles and agricultural machines to cross the canal. During the following year, the upper surface of the concrete lining was covered with soil (10 cm deep), which was soon naturally grassed. Additionally, after two years, a new bridge (B2) was built in the middle part of the canal in the aim of better connection of fragmented habitats and for wildlife crossing and migration. For this reason, there were no concrete paths for pedestrians, and the bridge approach span was in the shape of a funnel.

Table I: Monitoring the use of fauna passages

Month		Number of track recording days	Number of days	%
2009				
June		30	30	100.0
July		27	31	87.1
August		25	31	80.6
	Σ	82	92	89.1
2010				
June		26	30	86.7
July		29	31	93.5
August		30	31	96.8
	Σ	85	92	92.4

Bridge monitoring was conducted by standard and well-known methodology [6] during the period June-August 2009 and 2010 (Table I). The canal and the bridges were monitored for 167 days over two time periods (early morning – mainly from 05:30 to 08:30; and early evening – mainly from 17:30 to 20:45), which accounts for 90.8% of the total number of days. The use of bridges was evaluated by counting the tracks on the sand strip installed in the middle section of the bridge, and in a few cases directly, using a binocular or a camera. The sand strip was 6 m wide, which was the entire width of the bridges. Its length varied depending on the bridge – 3.5 m on bridge B1, 3.4 m on bridge B2, and 2.2 m on bridge B3. The sand strip was smoothed with a rake after each visit and prepared for the following track recording.

Figure 1: Lined irrigation canal "Kula-Mali Iđoš" (start)

Figure 2: The first bridge (B1) at the 1+700 km

Figure 3: The second bridge (B2) at the 2+500 km

Figure 4: The third bridge (B3) at the 3+350 km

Low land coverage with shrubs and trees made it possible for the bridges and the entire canal to be viewed from a covered and high look-out erected behind the bridge B2. Wildlife crossing was monitored using the binocular Praktica Falkon (magnification 10×50) and OpTisan PRO-III (magnification 10~40×60).

3 RESULTS

Complete monitoring of the canal "Kula-Mali Iđoš" was conducted during June-August 2009 and 2010 (Table I). The most frequent wildlife disturbing factors were tractors with various implements, combines, centre pivot irrigation systems, vehicles (Lada Niva, small trucks, Yugo 45, and Zastava 101), domestic dogs, local population (motorcyclists, cyclists and pedestrians), workers in the fields, the police (the training ground near Kula), bee keepers, and hunters.

The strongest adverse effect on wildlife was that of domestic dogs running in small groups along the canal and resting on the bridges for quite a long time. They kept barking and making a lot of noise, and continued attacking and chasing the individuals of various species.

Table II: Number of crossings per bridge (VI-VIII)

User	2009		2010			Σ
	B1	B3	B1	B2	B3	
Motorcar	16	1	20	3	-	40
Truck	3	-	1	2	1	7
Tractor	19	1	19	1	2	42
Combine	2	-	4	-	-	6
Van	-	-	1	1	-	2
Motorcycle	12	-	15	4	-	31
Bicycle	25	-	11	2	-	38
Pedestrian	21	-	18	2	-	41
Σ	98	2	89	15	3	207

Table III: Number of crossings by wild and domestic mammals (June-August)

Species	2009		2010			Σ
	B1	B3	B1	B2	B3	
Brown hare	576	152	451	461	177	1817
Roe deer	18	21	113	26	22	200
Fox	9	6	44	76	25	160
Badger	2	1	8	32	18	61
Wild boar	-	1	-	-	1	2
Martens	-	7	-	-	1	8
Dog	165	119	51	48	41	424
Cat	28	4	7	13	1	53
Unknown	1	5	-	4	6	16
Σ	799	316	674	660	292	2741

The use of various irrigation systems in the wider area along the canal "Kula-Mali Iđoš", especially on the large plough fields (more than 500 ha), caused essential changes and the deterioration of living conditions for many wildlife species as regards food and shelter. On such plough fields, at the annual level, there were minimum two harvests, primarily thanks to intensive irrigation and the application of modern machinery and chemicals for the control of weeds, insects, rodents and plant diseases, as well as thanks to favourable climate conditions. For instance, during the period May 25th - June 6th 2009, together with the harvest of peas on a large plowed field between the bridges B1 and B2 (Fig. 3), the second sowing was prepared by the ploughing of crop residues. Soon after that, between June 8th and 15th, the field was seeded with sweet corn (*Zea mays saccharata*).

Tractors, pedestrians, cars, bicycles and motorcycles were the most frequent users of the bridges, accounting for 92.7% of the total number of crossings. The use of the bridges B1 and B3 was similar in both years (Table II), although bridge B2 was built between them in the spring 2010. The highest number of crossings during June-August was recorded on the bridge B1 (98 in 2009 and 89 in 2010), and a considerably lower number on the bridges B2 and B3.

The use of bridges by wild and domestic mammals was not related to the extent of traffic along the canal during the period June-August (Table III). Along the canal, there were several earthen roads for vehicles and agricultural machines, stretching as far as the pumping station about 100 m behind the bridge B3. Also, there were several small farm settlements, and two of them were about 50 m far from the canal, before bridge B1. When agricultural works were intensive and all field roads passable, the extent of traffic along the canal was low, and even lower when the weather was bad. The intensity of human activities in the wider area along the canal was the lowest during heavy rains, especially after the rain stopped and until the ground was dry, whereas at the same time the wildlife activity was the most frequent.

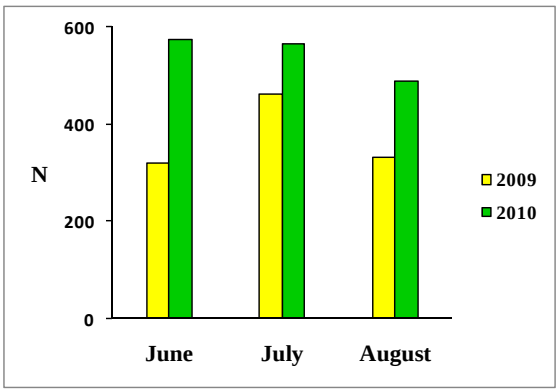

Figure 5: Monthly distribution of crossings by wild and domestic mammals

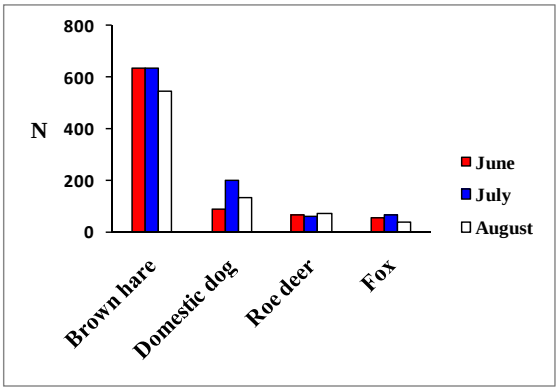

Figure 6: Number of crossings by species

All the three bridges on the canal "Kula-Mali Iđoš" are well installed and their width is adequate (8 m). Over the 6-month study periods (June-August 2009 and 2010), wild and domestic mammals crossed the bridges 2248

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and 477 times, respectively. Of the total number of crossings on the bridges, there were more crossings during the second year (2010) caused by the construction of the bridge B2 in the middle part of the canal (Fig. 5). The greatest number of crossings was recorded on the bridge B1 (799 in 2009 and 674 in 2010), and the lowest number on the bridge B3 (316 in 2009 and 292 in 2010). Brown hares and domestic dogs were the bridge frequent users, accounting for 81.8% of the total number of crossings, roe deer (7.3%) and foxes (5.8%) (Fig. 6). Wild boar and martens crossed only sporadically. Roe deer crossings were recorded more often on bridge B1 in June-August 2010 than in June-August 2009 (113 versus 18 passages).

In September 2009, natural ground cover on bridge B3 consisted of more plant species than that on bridge B1 (20 and 12, respectively). In June 2013, five years later, 32 plant species were identified on the bridge B1, 34 on the bridge B2, and 27 on the bridge B3. In all samples, the most numerous were plant species graded in the group of poor quality and worthless plants.

4 DISCUSSION

It is well known that droughts, depending on the intensity and duration, can cause a significant decrease in the yield of agricultural crops. In Vojvodina, droughts are becoming increasingly frequent, and especially severe droughts occurred in 2000 and 2003. Droughts are mainly the worst in July and August, when the plant need for water is the highest. On average, only 17 years out of 100 years have normal quantity and good distribution of rainfall, whereas rainfall deficit occurs in about 50 years, when drought is more or less intensive [11]. The territory of Vojvodina consists of 45 municipalities with altogether 463 settlements. There are water supply systems for various purposes, so water supply of 396 settlements is organised through the public water supply, while water for technical needs is supplied by a developed system of surface drainage network [12]. The land suitable for irrigation occupies about 1.15 million hectares, but the use of irrigation water is not at a satisfactory level (altogether about 50 million m^3/yr). The areas under irrigation systems cover about 80,000 ha, but these systems are not adequately equipped and the degree of their utilisation is low. Based on the estimation performed by water management organisations, less than 50,000 ha are irrigated at present time. Consequently, the management of drainage and irrigation areas is the strategic priority in the aim of more effective water utilisation, and efficient operation of the canal network [11].

The Danube-Tisza-Danube Hydrosystem (HsDTD), as a multi-purpose system and one of the largest hydro-engineering structures in the world, has a special significance for irrigation [15]. The main functions of DTD hydro-system are: drainage of internal waters, flood control and conveyance of waters from the neighboring countries, supply of irrigation water, supply of water for fishponds and industry, navigation, collection of waste waters, fishery, tourism and recreation. HsDTD consists of a network of canals (14 navigation canals, total length 694.2 km, of which 600.6 km are navigable), hydro-engineering structures (17 ship locks, 26 floodgates and 4 pumping stations), and other structures which enable normal function and maintenance (e.g. electro-movable, concrete, and metal bridges, power transmission lines, and access roads).

The main HsDTD canal network irrigates about 510,000 ha of agricultural land, of which 210,000 ha in Bačka and 300,000 ha in Banat. Water for the irrigation of other agricultural land is supplied by regional water systems, e.g. "Severna Bačka" with 7 subsystems for 132,000 ha, and "Srem" with 4 subsystems for 225,000 ha [11]. A great number of irrigation systems were built during the period 1986-1991. This can be presented based on the data for Zapadna Bačka (Table IV), which occupies about 168,000 ha on the territory of the municipalities Sombor and Apatin, and a part of the municipalities Odžaci and Kula. These systems differ depending on the construction type and technical solutions of irrigation systems: centre-pivot irrigation (equipment rotates around the pivot fixed to the circular foundation), linear move (equipment moves in a straight line along the pipeline with hydrants), Ranger (equipment moves in a straight line along the open canal), and lateral move - the older system with lateral wings [14].

There are no complete data referring to the total number and length of lined canals, and their effect on wildlife in the field hunting grounds in Vojvodina has not yet been researched in detail.

Table IV: Some irrigation systems in the West Bačka region

Irrigation system	Total area (ha)	Year of construction
Telep	445	1986
Kendija	206	
Kronić	95	1987
Bački Brestovac	210	1988
Istočna Gradina	113	
Staparc	340	1989
Čonoplja	399	
Cigan Hat	668	
Matarić	113	
Bački Gračac	287	1990
Srpski Miletić	972	
Prigrevica	105	1991
Juranović	310	

The main function of the canal "Kula-Mali Iđoš" is to supply water for the irrigation of about 5,000 ha of arable land. The canal is located on a loess terrace which is an unfavourable foundation because of its characteristic structure and porosity. Water tends to destroy the primary structure of loess surface zone which turns into liquid silt of very low internal strength. For that reason, it was necessary to protect the canal bed and slopes, to restrict water leaking and prevent soil flooding [1].

Soon after canal lining with plastic (PVC), there were a few drowned animals, mainly roe deer, brown hares, foxes and domestic dogs. A permanent fence was then erected along the canal, on both sides. It was 1.2-1.5 m high, made of wire and fixed to concrete posts buried in the ground at a distance of 4 m. The canal monitoring during the period 2009-2011 showed that the permanent fence was an efficient physical barrier, which prevented the crossing of the canal and the drowning of larger animals. Some authors reported that the permanent fence along the road was most frequently destroyed by people, wild boars, and agricultural machines [5]. Similarly, the permanent fence along the canal "Kula-Mali Iđoš" was mainly damaged by people and agricultural machines, but

the damage did not affect the fence efficacy because it was regularly controlled and maintained. There are 13 gates along the canal, 4 gates at each concrete bridge, and one at the beginning of the canal near the pumping station. Our monitoring proves that the workers engaged in the canal maintenance did not always close the gates (after grass mowing between the fence and the canal), but that was not the cause of animal falling in the canal.

Habitat fragmentation caused by road and canal construction has the strongest effect on animal species that populate large areas and are characterised by low population density. Small mammals are less threatened because their populations occupy the areas fenced by road and canal networks, which are often sufficiently large for their successful reproduction and survival. The area along the canal "Kula-Mali Iđoš" is a field habitat in which roe deer is the most frequent large game. There are three concrete (multi-purpose) bridges, two were built in 2008 (B1 and B3), and the third one was built in the spring 2010 (B2). The distances between the bridges are similar (800 m between B1 and B2, and 850 m between B2 and B3), although some authors claim that the optimal spacing for roe deer should be 1,500-2,500 m [5]. Our results show that the bridges are frequently used by different wildlife species together with domestic dogs, people, vehicles and agricultural machines (Tables II and III), which indicates that their width in the middle part is adequate (8 m) and that they are well distributed along the canal.

5 CONCLUSION

Irrigation canals lined with concrete and plastic are potential barriers which disturb and restrict wildlife movement in numerous field hunting grounds in Vojvodina. The adverse effect of lined irrigation canals can be additionally increased as a result of drowning of both wild and domestic animals, or because of a permanent fence erected along some lined irrigation canals.

The permanent fence along the lined irrigation canal "Kula-Mali Iđoš" was an effective physical barrier that prevented the canal crossing and the drowning of larger animals. Other protection measures such as multipurpose concrete bridges and GEOWB steps made it possible to prevent or significantly reduce the effects of lined irrigation canals on wildlife, but their efficiency should be additionally tested in natural conditions (e.g. lined irrigation canal without a permanent fence).

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