Morphological alteration of land reclamation canals by beavers (*Castor fiber*) in Lithuania

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Abstract. Land reclamation canals (drainage canals) are the most abundant type of water bodies found in the agricultural landscape in Lithuania. Beavers have a potential to improve the ecological value of these artificial habitats; however, little is known about the extent and mechanisms of the process. Our study describes and quantifies some morphological aspects of beaver impact on land reclamation canals under the conditions of a high beaver density. Through damming activity, beavers impacted about 18% of the total length of the drainage canals in our study area, producing impoundments with a mean water area of 0.4 ha per beaver site. Their intensive burrowing activity (ca 36.4 burrows/km) can initiate geomorphologic processes on canal slopes and provide reliable underground infrastructure conditions for other species. From one average burrow beavers can potentially release about 1.3 m^3 of soil (sediment). The microrelief variations were significantly more pronounced in canal segments occupied by beavers than in the control segments. Transformations of drainage canals induced by beaver activity improve the ecological value and lead to re-naturalization of these artificial water bodies.

Key words: *Castor fiber*, impact on environment, morphological alterations, drainage canals, geomorphology, re-naturalization.

INTRODUCTION

Land reclamation canals comprise more than 80% of the hydrographical network of Lithuania (Gailiušis et al., 2001). Many of these canals were abandoned due to unsuitable soil or infrastructure conditions necessary for intensive agriculture and are no longer maintained. These canals are deteriorating and beaver activity is accelerating this process (Kvaraciejus, 2001). Land reclamation canals are attractive habitats for these semi-aquatic mammals (Balodis, 1990). In the last decades more than one third of the Lithuanian beaver population was estimated to inhabit these canals (Balodis et al., 1999; Ulevičius, 1999; Ulevičius, unpubl.). The intensive impacts of beavers on the drainage canals are well documented in regions of developed agriculture in central Lithuania (Lamsodis, 2000, 2001).

The newest estimates of beaver abundance in Lithuania range from 80 000 to 120 000. These numbers result in a mean population density of approximately 16 individuals/1000 ha (Ulevičius, unpubl.). Observations of habitat distribution and beaver abundance indicate a considerable influence of these animals on different characteristics of land reclamation canals in Lithuania. Beavers are considered as important geomorphologic agents in aquatic environments, due to their dam building activity and its consequences (flooding effects, sedimentation) (Butler, 1995, for review).

Beaver activities in drainage canals can be controversial from both economic and ecological points of view (Balodis, 1990). Re-naturalization of the ecologically low-valued drainage canals can be considered as a benefit for ecosystem functioning (Balodis, 1990). However, economically re-naturalization can be a significant loss due to the initial drainage system installation expenses and damage to agricultural land. In this paper we examine the aspect of ecosystem function and concentrate on how beavers alter anthropogenic structures increasing their ecological value.

This paper describes and quantitatively evaluates specific aspects of beaver impacts on land reclamation canals in a human-transformed landscape with a high-density beaver population.

STUDY AREA

Lithuania is approximately 65 000 km^2 in area with a hydrographical network of approximately 77 000 km (mean density 1.18 km/km^2). Streams ≥3 km make up 49% of the hydrographical system and streams <3 km account for 51% of the total length. Streams with a regulated bed (human-managed) comprise 82.6% and streams with a natural bed 17.4% of the total length of the hydrographical network (Gailiušis et al., 2001).

Canals that are 30 years old or older prevail in the hydrographical network of Lithuania. This creates a relevant problem of canal maintenance, especially if canals have been abandoned for a long time. The banks of the abandoned canals are usually overgrown by woody vegetation (Lamsodis et al., 2006) and have become a suitable habitat for beavers.

A study area of 625 km^2 (25 × 25 km) situated in central Lithuania (Fig. 1) (centre point co-ordinates: 55°37′ N, 24°11′ E) was examined to evaluate the density of the beaver population and the extent of beaver activity in the drainage canals. First-order and second-order tributaries prevail among drainage canals in the study area. The density of the hydrographical network in this area is ca 1.2 km/km^2. The major part is comprised of forest and riparian sections of canals (80%), whereas natural streams are of relatively little importance (ca 16%). Only a small part (ca 4%) is made up of lakes, reservoirs, and other water bodies (oxbows, peatland excavations, small artificial ponds). The territory is intensively exploited for agriculture.

Damming, burrowing, and other geomorphological activities of beavers in drainage canals were investigated also in various other areas, scaterred throughout the country.

Fig. 1. Geographical location of the model area (25 × 25 km; black square) in central Lithuania.

MATERIAL AND METHODS

Identification of beaver sites in the study area was carried out using aerial photographs (1 : 10 000) combined with consequent checking in situ. Preliminary detection of beaver sites on the aerial photographs was based on specific characters of beaver impoundment images (beaver dam and water table upstream the dam) in canals.

The density of beaver sites in drainage canals was estimated separately for (1) forest and outskirt canals and for (2) field canals. It was expressed as a beaver site number per 10 km of a canal.

A beaver site was defined as an area (water body segment and adjacent land) occupied by a beaver family (including a pair or single beaver) in which signs of beaver activity were found. In dense beaver populations borders of neighbouring beaver sites often overlap so we considered only the centre of a beaver site when counting beaver sites along canals. The centre of a beaver site was situated at the main burrow or semi-lodge, or the main dam. Additional features of a beaver site centre were the winter food cache and the concentration of trails and cuttings.

The extent of beaver activity in drainage canals was evaluated in two steps:

1. The mean length of beaver impoundment per beaver site was estimated and then multiplied by the number of beaver sites (existing in drainage canals) in the study area.
2. The product was expressed as a percentage of the total length of the drainage canals in the study area.

The length of beaver impoundment within a beaver site was measured using a GPS receiver by locating the beginning (first dam) and the end (end of the last impoundment) points. The mean accuracy of navigation was 5 m. The end point was determined by locating where a canal bed was not affected any longer by the beaver impoundment. In the case of branching canals, side branches were added if affected by impoundment.

The area of water surface of a beaver impoundment was estimated by calculating the area of an isosceles triangle (base – width of the dam, considered as maximum width of the impoundment; apex – end point of the impoundment) or an isosceles trapezium (downstream base – width of the dam, upstream base – width of the impoundment at the next upstream dam).

The burrowing activity of beavers in drainage canals was documented in two ways:

– the density of beaver burrows along a canal
– the morphology of beaver burrows in canals.

Estimating burrow density was performed by careful counting of burrow entrances in both sides of a canal along segments that were occupied by beavers. In total 9.4 km of such segments was investigated on eight canals. The number of entrances does not always match the number of burrows because often two or more entrances belong to the same burrow. Thus, it is possible that burrow density might be slightly overestimated. However, if the number of entrances is used as an index of beaver burrowing activity and density it can be a reliable indicator. The character of burrow distribution along canals was estimated using the coefficient of dispersion (CD), which defines the variance-to-mean ratio of beaver burrow number in the 100 m cutoffs within the studied canal segments ($CD \ll 1$ regular distribution, $CD \approx 1$ random distribution, $CD \gg 1$ clumped distribution).

The shape and other morphological parameters of the beaver burrows were investigated using a metal rod to penetrate through the ground into a burrow. The diameter of the cavity and the depth and direction of a burrow were measured at points located every 50 cm from the entrance. This procedure allowed estimating the following parameters of a burrow:

– general configuration of a burrow (horizontal projection) (by joining consecutive points of rod penetration)
– length of a burrow (distance from the entrance to the point of last penetration by joining consecutive points)
– height and width of a burrow cavity at every 50 cm
– vertical inclination of a burrow.

In total, 261 burrows situated in canals in different parts of Lithuania were examined. Of them, 17 burrows were studied for estimating inner parameters (cavity diameter, vertical inclination).

Beaver impacts on the microrelief of canal slopes were examined in segments occupied by beavers for more than 10 years. Canal segments that have never been occupied by beavers, but situated as close as possible to the treatment segments, were chosen as control. The microrelief along and across canals was described as the departure from a baseline every 50 cm in 10 m segments. The principal scheme of measurements is given in Fig. 2. In total, 14 segments altered by beavers and 12 control segments were studied. One cross profile was measured for every 10 m segment along the canal. We collected data for 15 cross profiles altered by beavers and 10 control profiles.

Data were analysed using *t* and Welch ANOVA (non-homogeneous variances) tests. Homogeneity of variances was tested using the Levene test. Normality of data was tested by the Shapiro–Wilks method. Analyses were performed in the STATISTICA 6.0 and PAST (Ryan et al., 1995) environments.

RESULTS AND DISCUSSION

Extent of beaver impact on land reclamation canals

We documented 125 beaver sites in land reclamation canals in our study area. The mean linear density of beaver sites was very different among two kinds of drainage canals. The majority of beaver sites (82%) were found in the forest and outskirt canals despite the relatively low availability (47%) of these canals. Field canals, which comprised the majority of canals in the study area (53%), had only

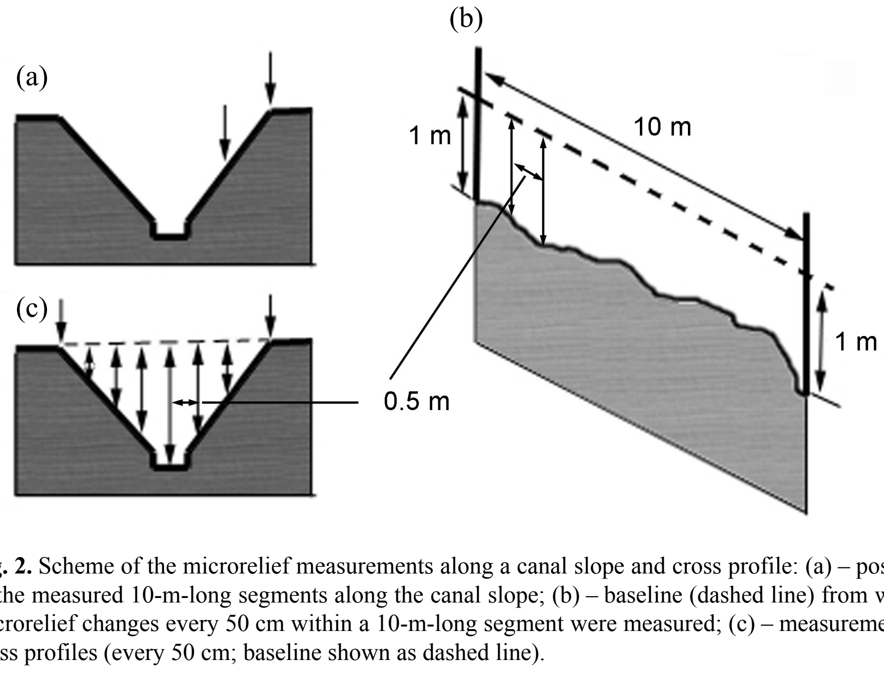

Fig. 2. Scheme of the microrelief measurements along a canal slope and cross profile: (a) – position of the measured 10-m-long segments along the canal slope; (b) – baseline (dashed line) from which microrelief changes every 50 cm within a 10-m-long segment were measured; (c) – measurement of cross profiles (every 50 cm; baseline shown as dashed line).

18% of the beaver sites (Table 1). This clearly indicates a different selectivity by beavers towards field and forest drainage canals, which is related to the different ecological value of the canals for beavers.

The mean density of beaver sites in land reclamation canals was 2.1 sites/10 km of canal, and it was significantly higher in the forest and outskirt canals than in the field canals (Table 1). Our earlier investigations of beaver site density on natural rivers revealed a higher density (up to 1 site/km) than we found along drainage canals (Ulevičius, 1999) in this study. The study area is situated in a region of intensive agriculture resulting in more intensive maintenance of canals. This factor could partially explain the relatively low occupancy of the field canals by beavers.

The most obvious impact of beavers on drainage canals is the consequences of the damming activity. Average damming intensity was estimated to be 3.1 dams/beaver site (Table 2). This index varied considerably, which was probably influenced by a number of factors including relief, hydrographical parameters, beaver family size, occupation time, and dispersion of feeding resources.

Table 1. Density of beaver sites in the land reclamation canals in the 25 × 25 km study area in central Lithuania

Type of drainage canal	Total length, km (%)	Number of beaver sites, *n* (%)	Density of beaver sites, sites/10 km of canal
Forest and outskirt canals	281 (47)	103 (82)	3.7
Field canals	312 (53)	22 (18)	0.7
Total	593 (100)	125 (100)	2.1

Table 2. Damming intensity and its consequences on beaver impoundment parameters in land reclamation canals in Lithuania

Indicator	*n*	Mean	Min–max	SD
Number of beaver dams per one beaver site	43	3.1	1–10	1.78
Length of beaver impoundment per one beaver dam, m	43	285	83–633	134.10
Length of beaver impoundment per one beaver site in various localities of Lithuania, m	33	793	200–2300	476.80
Length of beaver impoundment per one beaver site in the 25 × 25 km model territory in central Lithuania, m	15	857	350–2000	424.2
Area of beaver impoundment in one beaver site, ha	33	0.36	0.07–1.07	0.25
Maximum width of beaver impoundment at the main dam, m	33	9.3	3.3–44.5	7.15

Geomorphologic and hydrographical properties of the drainage canals predict the shape and quantitative characteristics of beaver impoundments in these water bodies. Usually, one beaver dam results in a 300 metres-long and nearly 10 metres-wide (at the dam) impoundment. The mean hydrological impact of beavers per site extended up to 800 m along an impounded canal and the mean water area was estimated to be about 0.4 ha per site (Table 2). The ecological value of such relatively long and narrow water bodies at a landscape and local scale is not clear; however, beaver ponds in canals are expected to be more ecologically valuable than non-impounded stretches of these water bodies. We observed many species of frogs using beaver ponds in drainage canals, whereas non-impounded stretches were of significantly less importance to these animals (Trakimas, 1997). According to our unpublished data, some other vertebrate species were often observed in beaver ponds situated in canals: mallard (*Anas platyrhynchos*), grey heron (*Ardea cinerea*), American mink (*Neovison vison*), and otter (*Lutra lutra*). Such beaver ponds can be important feeding habitats for these species in an agricultural landscape.

Estimates of beaver site density and intensity of damming activity allow us to predict potential beaver impacts on land reclamation canals at a landscape scale (Table 3). In the 25 × 25 km study area in central Lithuania, beavers potentially impact about 18% of the total length of the drainage canals (about 30% of the forest and outskirt canals and about 6% of the field canals). These estimates can be considered as very case specific estimates for this specific region, where canals prevail among other beaver habitats. Our earlier investigations showed that canal

Table 3. Prediction of the extent of beaver impact on land reclamation canals using the mean length of beaver impoundment per one beaver site in the 25 × 25 km study area in central Lithuania

Indicator	Code	Formula	Value
Mean length of beaver impoundment per one beaver site in the 25 × 25 km study area in central Lithuania, km	M		0.857
Total length of the forest/outskirt canals, km	For		281
Total length of the field canals, km	Fld		312
Total length of the land reclamation canals in the study area, km	Tot	For + Fld	593
Number of beaver sites situated in forest/outskirt canals	N_{For}		103
Number of beaver sites situated in field canals	N_{Fld}		22
Total number of beaver sites situated in canals	N_{Tot}	$N_{For} + N_{Fld}$	125
Proportion of the forest/outskirt canals impacted by beavers, %	P_{For}	$[(M \times N_{For})/For] \times 100$	31
Proportion of the field canals impacted by beavers, %	P_{Fld}	$[(M \times N_{Fld})/Fld] \times 100$	6
Total proportion of the land reclamation canals impacted by beavers in the study area, %	P_{Tot}	$[(M \times N_{Tot})/Tot] \times 100$	18

selectivity by beavers was different in various regions of Lithuania, and probably depended on the availability of natural habitats such as natural rivers, lakes, and swamps (Ulevičius, unpubl.). Thus, levels of beaver impact can also be different. Since land reclamation canals contain the largest proportion of the beaver population in Lithuania (36% of all beaver sites in 2008) and because significant parts of drainage canals are not properly maintained, the extent of beaver impacts on these water bodies has the potential to increase in the whole country, as it was observed in the neighbouring Latvia (Balodis, 1990).

Impact of beavers' burrowing activity on land reclamation canals

The mean estimated density of beaver burrows in land reclamation canals was 36.4 burrows/km of a canal (Table 4). Within certain canal segments beaver burrows were distributed in clumps (dispersion coefficient CD in individual segments studied varied from 1.6 to 5.2). Within burrow clumps the burrow density was impressive reaching as high as 16 burrows/100 m of a canal. However, these estimates, although high, are not the highest that have been reported. In the Darwin Reserve (Russia), the beaver burrow density was reported to be as high as 27 burrows/100 m in sites situated on small rivulets (Zav′yalov et al., 2005). It also seems that burrow density has a cumulative character over time, as along canal segments with longer periods of beaver occupancy the density of burrows was higher.

The morphological properties of beaver burrows in land reclamation canals are relatively simple. Four main types of beaver burrow configuration were distinguished in drainage canals (Fig. 3). The majority of burrows examined (37%) were simple and without branches. Branching burrows comprised 23%, U-shaped burrows 22%, and combined burrows 18% of all the burrows we investigated (total n = 230).

Table 4. Density and distribution character (dispersion coefficient, CD) of beaver burrows in the studied segments of land reclamation canals in Lithuania

Canal segment code	Studied canal segment length, km	Burrow number, *n*	CD	Burrow density, n/km
Šventupis - 1	1.94	30	5.22	15.5
Ramygala - 1	2.24	113	4.15	50.4
Pašiliai - 1	1.27	57	1.61	44.9
Stumbrynas - 1	2.06	69	3.58	33.5
Stumbrynas - 2	0.66	39	3.50	59.1
Liaušė - 3	1.25	34	3.30	27.2
Giedraičiai - 1	3.50	123	–	35.1
Zdoniškiai - 1	4.90	123	–	25.1
Total and average	17.82	588	–	36.4 ± 14.4 SD

– Not measured.

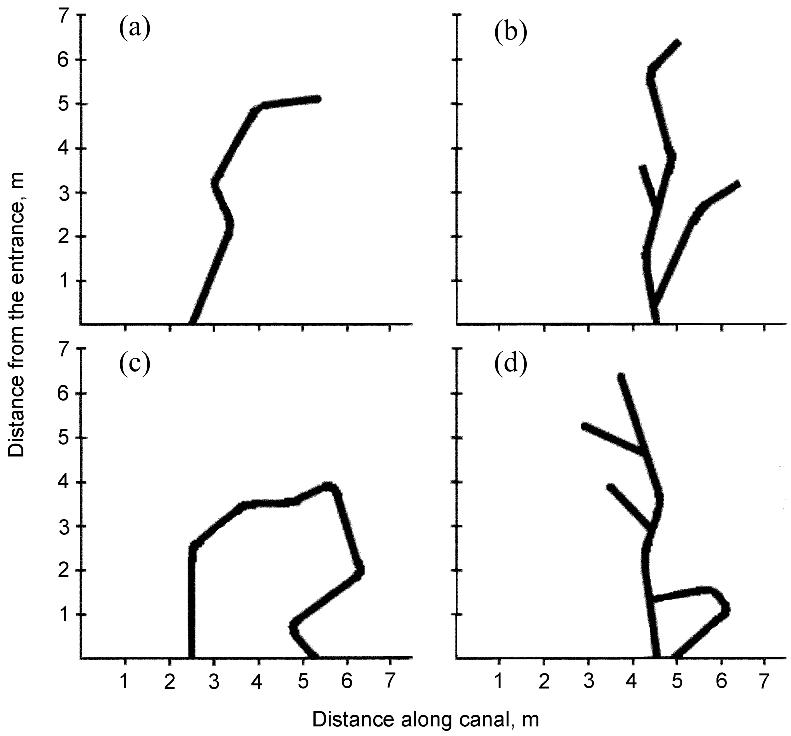

Fig. 3. Four main types of beaver burrow configuration in canals of land reclamation: (a) – simple, (b) – branchy, (c) – U-shaped, (d) – combined.

The majority of the burrows were not long, penetrating into the ground on average nearly 8 m. The longest burrow was found to be almost 20 m long (Table 5). Beaver burrows penetrate relatively deep layers of subsurface ground. The mean estimated depth of burrow floors was 70 cm and the mean estimated thickness of the ground arch above a burrow was about 30 cm (Table 5). The

Table 5. Some morphological parameters of beaver burrows in land reclamation canals

Parameter	N (sum n_i)	Mean ±SD	Min	Max
Mean burrow length, m	204	7.8±3.5	2.5	19.5
Mean* slope gradient of burrow floor, cm/0.5 m	15 (132)	11±4	4	18
Mean* depth of burrow floor, cm	17 (154)	70±16	46	95
Mean* thickness of ground arch above burrow, cm	17 (154)	31±9	18	46
Mean* height of burrow cavity, cm	17 (154)	39±8	26	50
Mean* width of burrow cavity, cm	17 (162)	49±4	41	54

* Calculated as weighted mean and weighted SD.

thickness of the ground arch above a burrow was relatively constant along the whole burrow length.

Beavers are relatively large animals and they dig wide burrows. Analysis of inner measurements revealed that the mean height of the burrow cavity was nearly 40 cm and the mean width nearly 50 cm (Table 5). These dimensions indicate that beavers are capable of releasing large amounts of subsurface ground (up to 0.16 m^3 from every metre of a burrow) into the bottom of an impoundment. For example, from one average burrow beavers can potentially release about 1.3 m^3 of ground, and from one beaver site the amount of released ground can be tens of cubic metres. This substrate can accumulate in the impoundment or be partially released as sediment when a beaver dam collapses. Large amounts of sediments with clear tendencies of accumulation over time were described in beaver ponds existing in small tributaries of North America (Meentemeyer & Butler, 1999). A significant part of these sediments could be caused by burrowing activity of beavers resulting in an erosion rate of 0.054 m^3 per 10 m of stream per year (Meentemeyer et al., 1998).

Microrelief alterations

Beavers can significantly increase the microrelief variation along the occupied canal segments. Variation of the ground surface altitude on the top and in the middle of canal slopes was obviously higher along segments that were inhabited by beavers (treatment) than in those that were not inhabited (control) (Fig. 4). This was especially pronounced in the middle of canal slopes. We found statistically significant differences (t-test, $df = 530$, $p = 0.0002$) in the mean departure of altitude from the baseline between the top and the middle of slopes in beaver sites. Statistically significant differences (t-test, $df = 492$, $p = 5.072E\text{-}06$) also were found in the variation of the middle slope microrelief between the treatment and the control segments, but no significant differences were revealed between the top of the canal slope of the treatment and control segments (Table 6). This suggests different geomorphologic impact of beavers on different zones along land reclamation canals. The main geomorphological impact seems to be pronounced in the middle of slopes, which is closer to the water.

We found that quantitatively beaver impact on the microrelief variation of canal slopes was significantly different among the treatment segments (top of slope: Welch ANOVA, $F = 6.035$, $df = 96.71$, $p = 4.248E\text{-}21$; middle of slope: Welch ANOVA, $F = 5.613$, $df = 96.49$, $p = 1.620E\text{-}07$). This also can be clearly seen in Fig. 3. This means that the effectiveness of microrelief alterations induced by beavers depends on certain conditions. Mechanical composition of ground could be one of these conditions. It seems that heavy clayey ground is more resistant to beaver alterations than light turfy ground.

The impact of beavers on cross profiles of drainage canals was not clear. However, we did find statistically significant differences (t-test, $df = 515$, $p = 0.0003$) in the mean slope gradient, which was higher in canal segments that were not affected by beavers (Table 7).

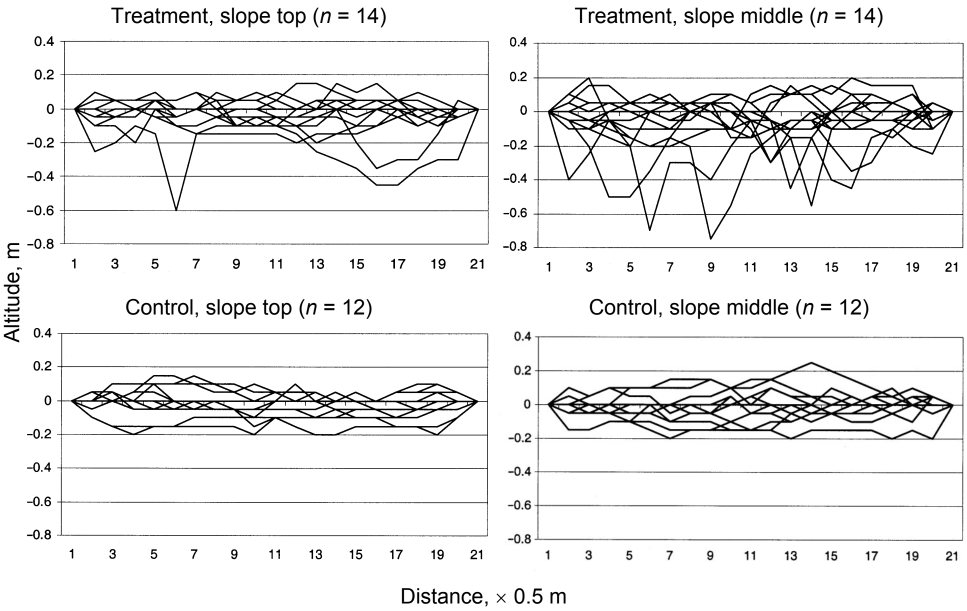

Fig. 4. Variation of the ground surface altitude on the top and in the middle of canal slopes along segments inhabited (treatment) and uninhabited (control) by beavers. Altitude was measured every 0.5 m and expressed as a departure from the baseline joining two points on the ground surface at the beginning and the end of a segment studied. Each curve represents one studied segment.

Table 6. Differences (m) in mean departure of the ground surface altitude from a baseline on the top and in the middle of canal slopes along segments inhabited and not inhabited (control) by beavers

Segment	*n*	Top of slope, mean ± SD	Middle of slope, mean ± SD	*t*-test
Inhabited by beavers	266	0.06 ± 0.084	0.10 ± 0.112	$p = 0.0002$
Control	228	0.05 ± 0.053	0.06 ± 0.056	$p = 0.3476$
	t-test	$p = 0.1032$	$p = 5.072\text{E-}06$	

Table 7. Differences (m) in the mean slope gradient in cross profiles of canal segments inhabited and not inhabited (control) by beavers

Segment	Number of cross profiles studied	Total number of measurements	Mean slope gradient, m/0.5 m ±SD
Inhabited by beavers	15	317	0.20 ± 0.131
Control	10	200	0.24 ± 0.106
		t-test	$p = 0.0003$

The collapse of beaver burrows and the discharge of subsurface ground (during burrow construction and collapse) are considered the main impacts of beavers on the microrelief in land reclamation canals. The basic tendency of the drainage canal microrelief alterations can be described as the formation of numerous ravines, which are perpendicular to the watercourse, and flattening of canal slopes. Overall the sinking of the canal cross profiles seems to be determined by the subsurface ground discharge from burrows and by accumulation of mineral and organic sediments in beaver impoundments (Butler, 1995; Butler & Malanson, 2005; Lamsodis & Poškus, 2006).

The described transformations of drainage canals induced by beavers generally lead to the re-naturalization of these anthropogenic aquatic systems. The original function of drainage canals determines their simplicity and low suitability for biodiversity. However, at the same time land reclamation canals are very unstable structures (at least in their functional aspect) prone to self-destruction under impacts of various natural processes. Vegetation is probably one of the first causes of canal function deterioration and their consequent destruction (Lamsodis & Poškus, 2006). Therefore, the maintenance of their original function seems to be extremely costly and resource consuming. This factor can result in relatively high rates of abandonment of drainage canals in Lithuania (Kvaraciejus, 2001).

Beavers are not the sole agents in the drainage canal re-naturalization process, but they can effectively initiate and enforce more pronounced geomorphologic processes due to raising the ground water level, digging burrows, releasing significant amounts of subsurface ground from burrows into the canal bed, and triggering changes in terrestrial and aquatic vegetation. In this context, beavers can be considered as the leading agents of drainage canal re-naturalization, acting like ecosystem engineers (Müller-Schwarze & Sun, 2003). In areas with an abundant and dense beaver population these impacts can be significant. These impacts are usually considered negative from a land management perspective, especially if management is oriented on agricultural production. The observed level of beaver impact on 18% of all drainage canals in the study area has the potential to grow in the future due both to the increase of beaver abundance and overgrowth of canals by woody vegetation, especially in the vicinity of forests (Lamsodis et al., 2006).

How much time is needed to re-naturalize a canal, if this is possible at all? We studied canals that had usually been occupied by beavers for a period of ten to twenty years. Comparison of the treatment and control segments allows us to predict that microrelief alterations can be significantly faster under beaver impact. However, these canals are still canals by their appearance. Elimination of a human element from canal physiognomy probably takes far longer than 10–20 years. The cumulative character of beaver impacts (continuous renewal of burrowing and building activity, accumulation of ground and sediments, beaver initiated lateral erosion, etc.) suggests that beavers are capable of radically altering the geomorphologic appearance of agricultural drainage canals. In this early stage of beaver impact on drainage canals (10–20 years) we can clearly identify the initial features of re-naturalization and observe a potential for future geomorphologic changes.

CONCLUSIONS

- In our study area with a dense drainage canal network (up to 1 km/km^2) and abundant beaver population (ca 0.2 beaver colonies/km^2) beavers impact about 18% of the total length of the drainage canals (about 30% of the forest and outskirt canals and about 6% of the field canals). With a mean density of 2.1 active sites/10 km, beavers build approximately 3 dams/site resulting in about 800 m of impounded canal/site and forming a mean water surface area of 0.4 ha/site.
- The burrowing activity of beavers is another significant aspect of the beaver impact on land reclamation canals. The mean estimated density of beaver burrows was 36.4 burrows/km of a canal. Beaver burrows were clumped (dispersion coefficient CD in the studied segments varied from 1.6 to 5.2).
- The majority of beaver burrows in land reclamation canals were relatively simple and averaged nearly 8 m in length. Beaver burrows penetrate deep layers of subsurface ground. The mean estimated depth of burrow floors was 70 cm and the mean estimated thickness of the ground arch above a burrow was about 30 cm. Beaver burrows gradually rose up with the mean gradient slightly more than 10 cm/0.5 m as they receded from water. The average volume of a beaver burrow was 0.16 m^3 per every metre of a burrow. This allows us to predict that beavers can release 1.3 m^3 of subsurface ground from an average burrow. The excavated ground can accumulate on the canal bed or be partially washed out when a beaver dam collapses.
- Beavers can significantly impact the microrelief of drainage canals, especially in the middle of canal slopes. We found significant differences in the ground surface altitude variations between the canal segments inhabited by beavers for more than 10 years and the control segments that were not impacted by beavers. The impact of beavers on cross profiles of drainage canals was not clearly pronounced; however, we did find statistically significant differences in the mean slope gradient, which was higher in canal segments not affected by beavers. The basic tendency of the canal microrelief alterations can be described as the formation of numerous ravines, which are perpendicular to the water course, and flattening of canal slopes. The collapse of beaver burrows and the discharge of subsurface ground might be regarded as the main factors of the microrelief alterations in canals of land reclamation.
- The described morphological transformations of drainage canals induced by beavers can generally lead to the upgrading of the ecological value and re-naturalization of these artificial water bodies. The intensive damming and burrowing activity of beavers can improve infrastructure conditions in the artificial drainage canal environment, which can then support more species of the riparian biota than it could before. However, the results of our investigations also demonstrate the potential of beavers to encourage and accelerate the geomorphologic processes in land reclamation canals that may be at odds with agricultural land management.

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Kopra (*Castor fiber*) tegevuse mõju kuivenduskraavide struktuurile Leedus

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Kuivenduskraavid on Leedu agraarmaastiku kõige arvukamad veekogud. Koprad on võimelised selle kunstliku elupaiga ökoloogilise väärtuse parandamiseks, kuid selle protsessi ulatusest ja mehhanismist on seni vähe teada. Artiklis on analüüsitud kopra tegevuse mõju kuivenduskraavide struktuurile kopra suure asustustiheduse puhul. Kopratammide mõju oli märgatav uuritud kraavide kogupikkusest umbes 18% ulatuses. See väljendub paistiikide tekitamises pindalaga umbes 0,4 ha ühe kopra pesapaiga kohta. Kobraste intensiivne kaevamistegevus (umbes 36,4 urgu/km) võib vallandada geomorfoloogilisi protsesse kraavikallastel ja varustab teisi liike kindlate maa-aluste varjupaikadega. Keskmise uru kaevamise käigus kuhjab kobras vette umbes 1,3 m^3 mulda (setteid). Mikroreljeefi varieeruvus oli kobraste poolt asustatud aladel oluliselt suurem kui kontrollaladel. Kuivenduskraavide muutmine kobraste poolt tõstab kraavide ökoloogilist väärtust ja soodustab nende renaturaliseerimist.