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SHORT COMMUNICATION

Capture rate and distribution patterns of newly-stocked common carp (*Cyprinus carpio*) in a put and take lotic fishery: a multi-year case study

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Abstract Common carp is one of the most important game fish in Europe. Due to the high exploitation and limited natural recruitment, direct stockings became a common and widespread stock enhancement practice in recreational fisheries. Sustainable recreational fisheries management requires continuous monitoring programs to define the stocking size and distribution of newly-stocked fish. In this study, we assess the capture rate and distribution patterns of hatchery-reared common carps in a dammed, lotic ecosystem using data from a seven-year tagging survey. Mean capture rate was 7.4% and one-third of captures happened within the first two months after release. High interannual differences were observed both in the capture rate and the temporal dynamics of captures. Movement patterns also showed interannual and interindividual differences; 30.8% of the fish were captured within 5 km of their release site, and 55.6% of the fish were captured within 10 km. More than ten per cent (12.8%) of fish caught more than 25 km far from release site. Distance travelled did not associate consistently with time between the release and capture. Our findings suggest that repeated surveys in consecutive years would be preferable than increasing the number of tagged fish in one year in angler report-based tagging surveys, and that 15-20 kms between stocking sites can ensure proper distribution of common carp in a lotic fishery even under high angling pressure.

Keywords Recreational fisheries . Angling . Tagging . Movement . Mark-recapture . Fish

Introduction

The popularity of recreational fisheries, especially angling, has increased in the last decades. The participation rate is more than 10% of the adult population of industrialized countries (Arlinghaus and Cooke 2009; Arlinghaus et al. 2015). Nowadays, recreational fisheries are the dominant use of freshwater fish stocks (Arlinghaus et al. 2002). Exploitation, however, is limited to several game or trophy species (Elmer et al. 2017). To compensate for this highly imbalanced, species-specific exploitation, direct stocking became a commonly applied practice in recreational fisheries management in Europe (Riepe et al. 2017), even out-

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side the native range of the targeted species (Cucherousset et al. 2021). High exploitation and low natural recruitment decrease drastically the time frame of stock enhancement programs, frequently far below the life-cycle of the species, moving the fisheries towards a 'put and take' management model (Molony et al. 2003).

In Europe, the common carp (*Cyprinus carpio*) is one of the most preferred game fishes (Wolos et al. 1998; Arlinghaus and Mehner 2003; Boukal et al. 2012; Specziár and Turcsányi 2014). As is common with popular gamefish, common carp catches are almost exclusively supported by regular stocking in many fisheries (Boukal et al. 2012; Specziár and Turcsányi 2014). Thus, the economic success of fisheries strongly depends on a successful stocking strategy. However, stocking practices are frequently based purely on managers' ecosystem-specific experiences and anglers' expectations (Arlinghaus et al. 2022). Common carp, on the other hand, is known as an ecosystem engineer species (Weber and Brown 2009). Under high density, it can considerably affect the recipient ecosystem. For instance, it triggers the internal nutrient cycle (Matsuzaki et al. 2007), contributes to the disappearance of macrovegetation through bioturbation (Bajer and Sorensen 2015) and creates high predation pressure on macroinvertebrates (Matsuzaki et al. 2007; Rahman et al. 2008). Therefore, better understanding of dispersal patterns and capture dynamics of newly-stocked common carp is a keystone of the economic and environmental sustainability of recreational fisheries.

The establishment of sustainable stocking strategy requires monitoring programs that reveal the capture rate both in temporal and spatial scale and the dispersion of newly-stocked fish. However, studies on common carp stocking strategies in recreational fisheries are quite limited. The present study aimed to reveal the (i) capture rate and (ii) dispersion of hatchery-reared common carps in a dammed lotic fishery with a special emphasis on (iii) the interannual differences. We believe that the outcomes of such case studies can increase the sustainability of recreational fisheries management by establishing cost-effective and more environmentally-friendly stocking practices.

Materials and methods

Study site

The Ráckeve-Soroksár Danube (RSD; Fig. 1.) is a eutrophic side arm (length: 57.3 km, width: 80 – 300 m, water surface: 14 km^2, mean depth: 3-3.5 m, velocity: 0.1 – 0.3 ms^{-1}) of the Danube River, situated between 1642 river km (rkm) and 1586 rkm (Vadadi-Fülöp et al. 2007). The water level of RSD is highly regulated; its fluctuation is less than 50 cm (Vadadi-Fülöp et al. 2007). Although the main channel is highly modified (surrounded by houses and bungalows), islands and channels increase the habitat diversity. In addition to the wide, open lotic main channel, well-vegetated lentic habitats and swamps also occur in RSD.

The fish fauna of RSD is dominated by bleak (*Alburnus alburnus*), prussian carp (*Carassius gibelio*), common carp, roach (*Rutilus rutilus*), pumpkinseed (*Lepomis gibbosus*), asp (*Leuciscus aspius*), bream (*Abramis brama*), white bream (*Blicca bjoerkna*), european perch (*Perca fluviatilis*), pikeperch (*Sander lucioperca*), and northern pike (*Esox lucius*) (Udvari and Györe 2020). Although common carp is among the most abundant fish species (Ugrai and Györe 2007), natural recruitment of common carp is insufficient due to the deleterious effects of water quality, habitat and spawning ground degradation, and human disturbance (Udvari et al. 2003).

Angling has a long tradition in RSD; the first angling associations were established in 1935. Hatchery-reared common carp have been stocked regularly since the construction of the fish hatchery in Ráckeve in 1948. In recent years, due to excessive angling pressure, annual catch (dominated by common carp) can reach 15.5 t per km^2 in RSD. To counterbalance this enormous pressure, the average common carp stocking was 205.4 tonnes (min: 161.4 t; max 284.2 t) in the last 10 years, constituting 14.7 tonnes stocked common carp per km^2 annually.

Tagging

A tagging survey was conducted in seven distinct years between 2003 and 2015 (2003, 2004, 2008, 2009,

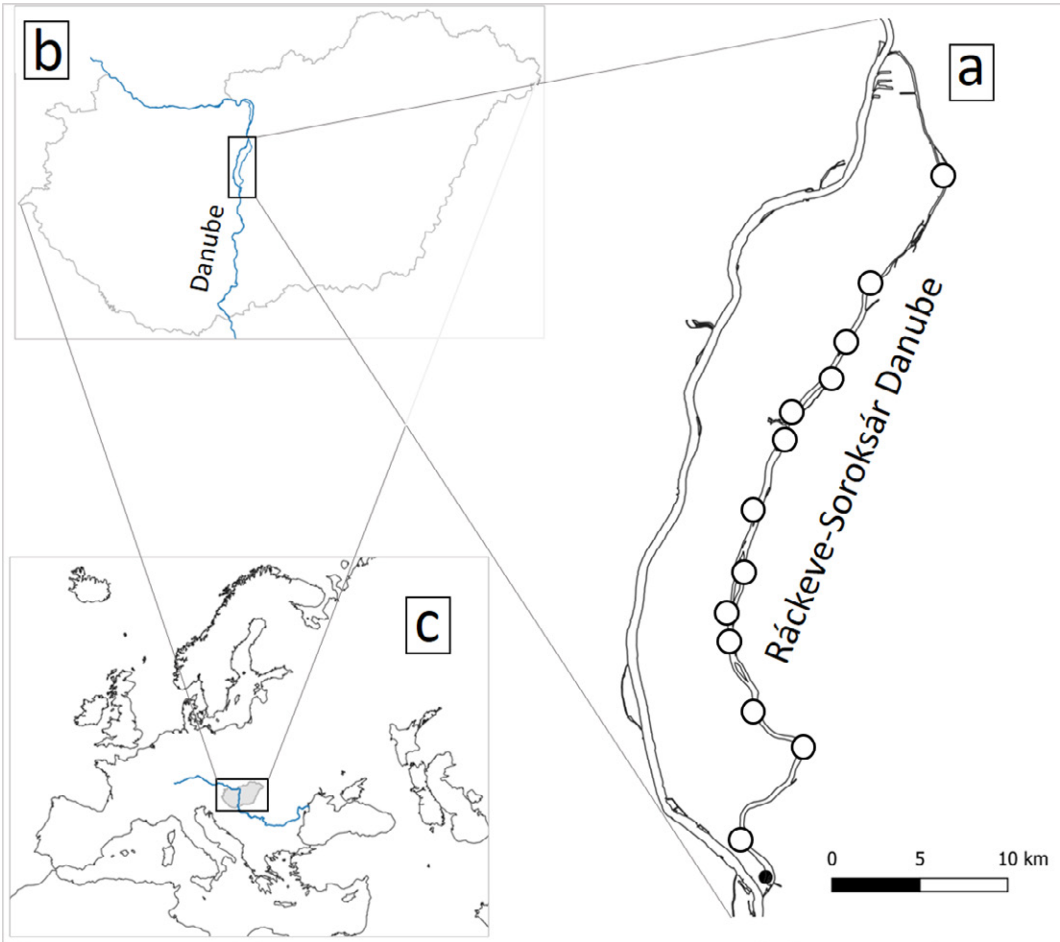

Fig. 1 Ráckeve-Soroksár Danube, and release sites of common carp.
Circles indicate release sites of tagged fish (a). The geographic position of RSD in Hungary and Hungary in Europe are indicated in the inserts "b" and "c", respectively

Table 1 Descriptive statistics of tagged common carp and recapture in Ráckeve-Soroksár Danube, Hungary

Stocking date	number of tagged fish	mean size (kg)	size range (kg)	number of recaptures	recapture rate (%)	mean distance (km)	distance range (km)	mean time (days)	time range (days)
2003. Oct.	1000	0.65	0.3 – 1.5	67	6.7	14.3	<1 – 48.5	215	16 – 563
2004. Oct.	216	1.12	0.4 – 2.0	20	9.2	18.8	2.5 – 44.5	128	18 – 386
2008. Oct.	499	0.90	0.2 – 4.3	71	14.2	10.8	<1 – 28.5	220	3 – 766
2009. Oct.	500	0.41	0.2 – 1.8	19	3.8	16.5	<1 – 49.5	248	4 – 615
2010. Oct.	500	0.50	0.2 – 2.9	57	11.4	6.4	<1 – 37	163	2 – 655
2013. Oct.	1000	0.66	0.1 – 2.2	59	5.9	12.2	<1 – 32.5	98	1 – 610
2015. Nov.	500	0.33	0.1 – 4.5	21	4.2	13.6	<1 – 27.5	176	26 – 357
all year	4216	0.62	0.1 – 4.5	314	7.4	13.2	<1 – 49.5	178	1 – 766

2010, 2013, 2015). The number and size of tagged common carp varied from 200 to 1000 individuals and from 0.18 to 2.98 kg (1-3 years old), respectively (Table 1). A total of 4216 common carp were tagged before stocking with individually numbered T-bar anchor external tags. Tags were installed under the dorsal fin, by trained experts, using a tagging gun. Released fish were of a local carp strain and were hatched and reared in the aquaculture facility of the Ráckeve Danube Branch Angling Association (RDBA). Carp were released in October and early November from tanker trucks using a simple fish slide at 14 release sites along the main channel of RSD (Fig. 1).

Information on the tagging survey was promulgated in the fishery regulations, which are received with the fishing licence. The tag was described, and anglers were informed of the needed data (i.e., location and date of catch, weight and length of the fish, contact details of angler). Anglers were also informed of how to report data (mailing the tag and required information to fishery manager headquarter) and of the rewards for response. Accurate and complete data reports are rewarded by small value gifts of fishing tackle, such as a pack of hooks or fishing line.

Data handling

Catch data were geolocated using the angler reports, which usually contained settlements and street name, rkm, and natural (e.g., islands, bays) or artificial formations (e.g., ferries, markets, bridges). Most catch locations could be determined within 1 km. Ambiguous locations were excluded from further analysis.

Data analysis

Annual differences in temporal intensity of capture were assessed by Kruskal-Wallis H test and subsequent pairwise comparisons. In the comparisons, we use the capture data of the first years. Pearson correlation was used to assess the relationship between number of tagged individuals and number of captures and capture rate. Statistical analyses were performed in Past software (Hammer et al. 2001).

A general linear model (GLM) was fitted to the distance between release and capture location as response variable and year (i.e., year of the release), time (i.e., days spent in RSD) and body size (i.e., body weight at release) of common carp as explanatory variables. Model contained the main effects and first order of interactions. To improve model fit, we log-transformed the distance between release and capture location and time spent in RSD. Assumptions of the model was checked via residual analysis using diagnostic plots (Quinn and Keough 2002). Subsequent pairwise comparisons and linear regressions were made on the significant terms. The general linear model was built in Statistica 6.0 (StatSoft, Tulsa, OK USA) software.

Ethical consideration

Fish were tagged according to the rules in force in Hungary. No animal welfare permit was required.

Results

Capture

During the seven years of the survey, altogether 314 recapture events were recorded, resulting in a 7.4% mean capture rate, but high interannual variances were observed (Table 1). Significant interannual differences were observed also in the temporal dynamics of capture (Kruskal-Wallis H test, $H=51.45$ $p < 0.0001$). Fourteen to sixty-one percent (mean: 31.8%) of tagged common carp were captured in the year of stocking (within 60 days after stocking). The vast majority (95.5%) of captures were recorded within a year after release (Fig. 2). Number of tagged individuals was uncorrelated with number of captures (Pearson, $r= 0.61$, $p=0.14$) or capture rate (Pearson, $r= -0.29$, $p=0.52$).

Distribution

Mean distance travelled by common carp was 12 km, with high interindividual differences. Altogether, 30.8% of the fish were caught within 5 km of the release site and 55.6% moved less than 10 km (Fig. 3), while 12.8% of common carp captured more than 25 km far from release site. The general linear model revealed that the dispersion (i.e., distance between the release and capture site) differed significantly among the years (Table 2) and the relationship between dispersion and time spent in RSD was affected by year (Table 2). The distance between the release and capture sites decreased with increasing time spent in RSD ($R^2_{adj}=0.38$; $F_{1;17}=12.24$; $p=0.0027$) in 2004. Further significant relationships were not observed (Fig. 4). Body size did not affect the dispersion.

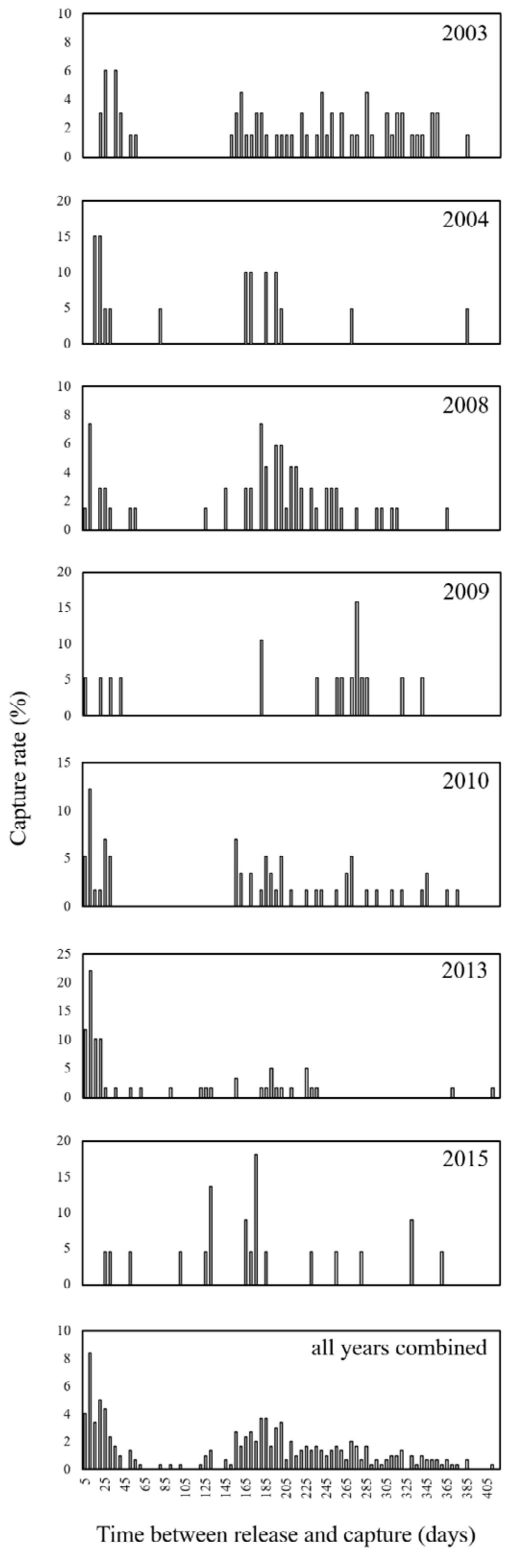

Fig. 2 Temporal dynamics of common carp captures in Ráckeve-Soroksár Danube, Hungary. Scales of Y-axes differ

Discussion

Capture – Tag recovery

Capture rate is obviously a cornerstone of the success and reliability of tagging surveys. It is determined

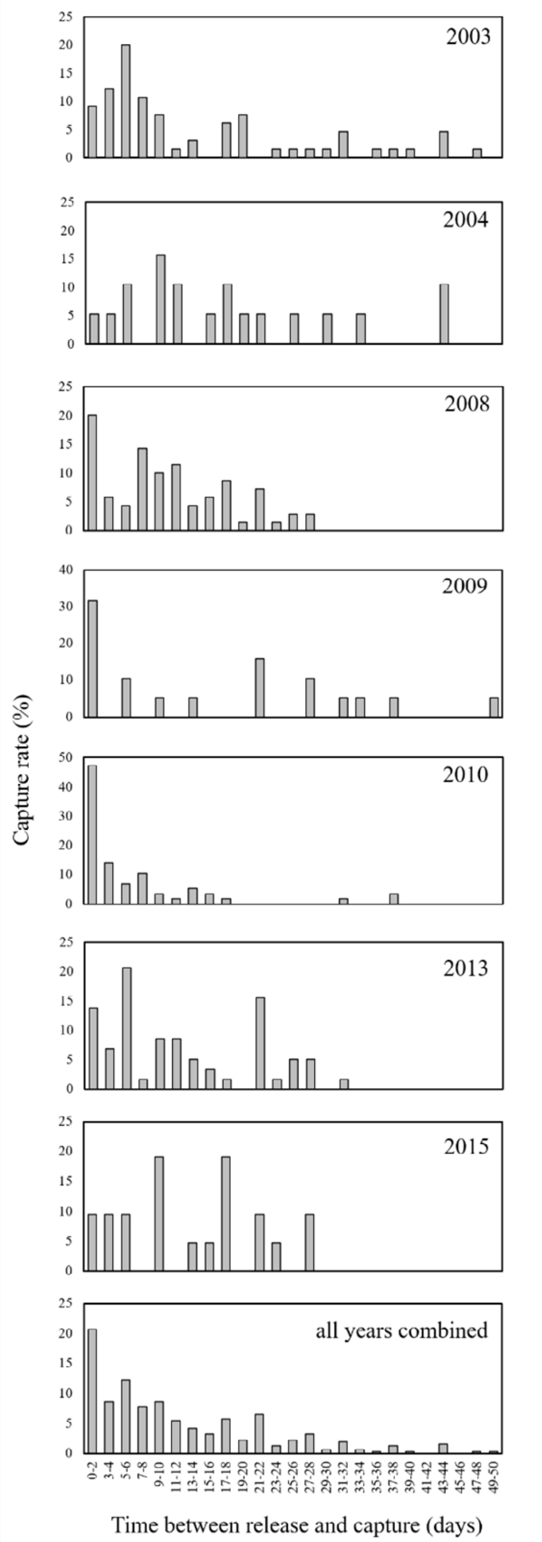

Fig. 3 Distance between release and capture sites of common carp in Ráckeve-Soroksár Danube, Hungary. Scales of Y-axes differ

by tag retention (Arnason and Mills 1981), post-release mortality (Ellis et al. 2017), and the behaviour of data providers (i.e., commercial and recreational fishers; Crandall et al. 2018). Retention of T-bar anchor tags has presumably species-specific differences, but it can be as high as 90% (Clugston 1996; Livings et al. 2007; Rude et al. 2011) for the first year. Captures continuously decreased during the first year and more than 90% of captures happened within this period. Therefore, tag loss presumably did not considerably

Table 2 Results of General Linear Model for newly stocked common carp distribution (distance between the release and recapture site) in Ráckeve-Soroksár Danube (RSD)

	SS	df	MS	F	p	R^2_{adj}	F	p
Intercept	1.34	1	1.34	4.34	0.037	0.13	3.25	<0.001
Year	6.07	6	1.01	3.26	0.004			
Weight	0.07	1	0.07	0.25	0.614			
Time to capture	0.02	1	0.02	0.07	0.785			
Year x body size	1.51	6	0.25	0.81	0.560			
Year x time	7.56	6	1.26	4.06	<0.001			
Body size x time	0.11	1	0.11	0.37	0.542			
Error	88.36	285	0.31					

Note: year = year of release; weight = weight of the released common carp; time to capture = days spent in RSD

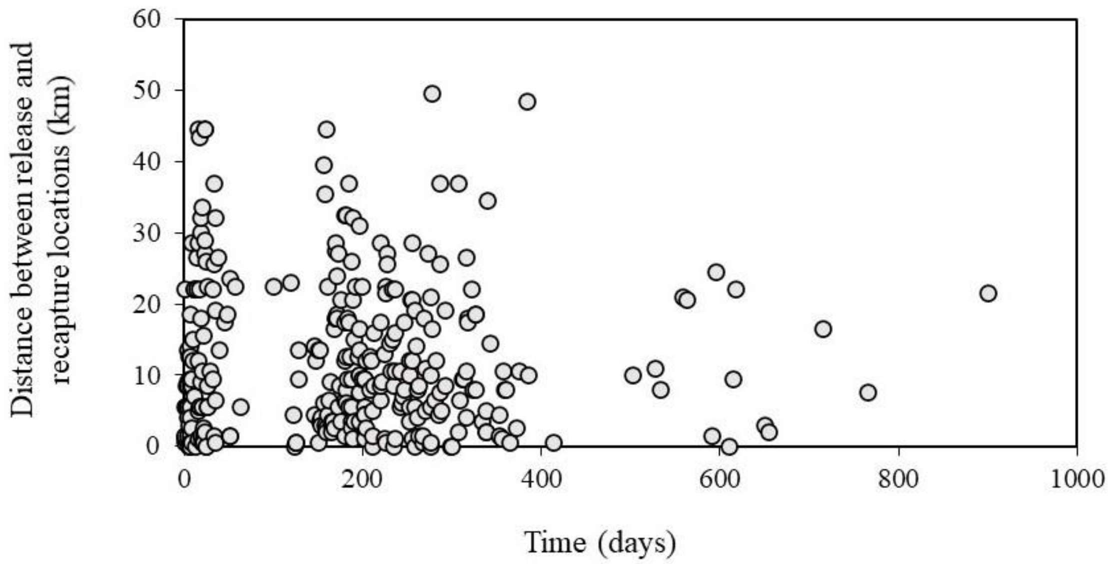

Fig. 4 Distance (km) between release and capture sites of common carp in relation to time (day) spent in Ráckeve-Soroksár Danube, Hungary

reduce capture rate in the time frame of the present study. Due to the less favourable environmental conditions (e.g., food resource availability), post-release mortality can be higher in winter; thus the late autumn stocking events potentially reduced the capture rate. However, angling pressure remained high in the first half of winter; one-third of total captures were recorded in the first two months (14 – 61%) after stocking. This rapid capture potentially compensated for the effect of overwintering mortality on capture rate. Such high angling pressure may result from the fact that most anglers are residents who live permanently around the side arm (two-thirds of reporting anglers live permanently within 5 km of RSD). In general, the reward positively affects the motivation for providing data and increases the general and interannual reporting rate (Taylor et al. 2006). A general positive effect of the reward to capture rate cannot be excluded in the present study, but we did not observe any increase in reporting rate over the years. One explanation might be that the value of the reward (fishing tackle) was not high enough. Indeed, we believe that the resident anglers feel responsible for fish stocks and intend to help or take part in fisheries management regardless of rewards. Although the average capture rate (7.4%) is comparable to values recorded in common carps in lotic ecosystems (e.g., Stuart and Jones 2006), we expected a higher capture rate because the common carp-oriented angling dominates the angling behaviour in the study site. Earlier studies achieved 15%, 16.6% (Vostradovský 1991) and 17.5% (Specziár and Turcsányi 2014) recapture rates for carp, relying exclusively on angler catches. A capture rate close to those earlier studies was observed in 2008 (Table 1), but the interannual differences were high despite the use of the same tag type, stocking practices and constant reward practices. Such high interannual variance has been reported also in former studies (e.g., Taylor et al.

2006; Sitar et al. 2017) suggesting high stochasticity in tagging surveys.

Distribution patterns

Dispersion and movement patterns of fish depend on habitat (size and complexity), temperature, water discharge and individual traits (size and sex; Radinger and Wolter 2014). In addition, considerable differences are assumed between newly stocked fish and wild populations because the homing behaviour obviously can occur only in fish with a pre-existing home range. Yet, substantial overlaps have been reported in distance between stocking and capture location in both stocked and wild fish, an important proxy of dispersion. For instance, newly-stocked common carps migrate on average 10.5 km to 23 km in a large shallow lake (Specziár and Turcsányi 2014). In some studies (Stuart and Jones 2006; Jones and Stuart 2009), migration varied between 14.3 and 26.2 km in wild populations, suggesting less importance of the origin of fish. However, in other studies with common carp (Brown et al. 2001; Crook 2004), strong site fidelity (<1 km movement) has been observed. Late-autumn stocking and well-vegetated, diverse habitat resulted in moderate migration of common carp in our study. Indeed, the mean distance between the stocking and capture location was low in comparison with formerly published values (Stuart and Jones 2006; Jones and Stuart 2009; Specziár and Turcsányi 2014). Although the mean migration distance of newly stocked and wild common carp overlaps, the rate of sedentary specimens differs considerably. Strong site fidelity is common in wild common carp. Stuart and Jones (2006) and Osborne et al. (2009) reported, respectively, that 80% and 85% of individuals moved less than 5 km. Jones and Stuart (2009) recaptured 63% of the tagged common carps within 10 km during a 20 month survey. These studies also observed long-distance migration (>100 km) in 7% (Stuart and Jones 2006) and 10% (Jones and Stuart 2009) of the individuals. High interindividual differences occur also in newly stocked fish, but, similarly to Specziár and Turcsányi (2014), we experienced less skewed dispersion. Almost forty percent of the captures were recorded within 5 – 15 km of the release location, and more than 10 percent of the individuals were captured more than 25 km away from the release location. Exploratory behaviour seems more pronounced in newly stocked fish, resulting in higher proportion of mobile individuals and rapid and balanced dispersion of introduced stock. The traditional put-and-take fisheries management practice relies on the rapid dispersion of newly stocked fish, but the increasing popularity of catch-and-release practice (Lyach and Čech 2018) requires a better understanding of long-term changes in movement of stocked common carps.

Implication for management

Feedback from stocking actions is essential for sustainable fisheries management relying on stocking of fish. However, the costs (financial and time) and potentially deleterious effects (handling stress) of tagging surveys restrict its extent (both intensity and duration). Based on the high interannual differences in capture rate and the weak association between the number of tagged fish and capture events in our study, we suggest extending the duration of studies (i.e., repeated surveys in consecutive years) rather than increasing the number of tagged fish.

Despite constant reward practices, substantial differences in capture rate occurred among the years. We believe that the low-value rewards did not constitute considerable motivation. However, the anglers, especially the residents, feel responsibility for the fish stock and ecosystem, and they are open to take part in management actions (Copeland et al. 2017). We believe the responsibility of anglers can be the base of monitoring programs for more sustainable recreational fisheries in the future.

Frequency of stocking is restricted primarily by the availability of fish to stock but should reflect the feedback of anglers to maintain their satisfaction. In the study system, stocked fish were usually captured within a year, suggesting substantial angling pressure. In general, capture events showed a permanent decline during the year, indicating the depletion of stock and decrease in overall angler catch. This single-stocking model is presumably based on local traditions and feedback of resident anglers (Arlinghaus et al. 2022), and it could be sustainable, but it also has risks. On one hand, the survival of introduced stock, especially in winter, is doubtful. On the other hand, our results highlight the possibility of rapid depletion. In 2013, more than 60% of captures occurred in the first two months after the stocking. Finally, a split stocking into multiple events over the year could decrease or even eliminate the potentially deleterious effects of common carps on the recipient ecosystem.

Distribution of the stocked fish is important in both conservation- or fisheries-aimed stockings. Because the dispersion of stocked common carp is a function of time spent in the new ecosystem (Specziár and Turcsányi 2014) the extent of angling pressure can play a crucial role. However, our results highlighted rapid dispersion of newly stocked common carps which can compensate for high angling pressure. Fifteen to twenty km between stocking sites ensured proper distribution even under high angling pressure.

In conclusion, the high interannual variability in capture rate, independent of the number of tagged individuals suggests that a multi-year survey even with lower number of tagged fish would presumably provide more reliable outcomes. Reporting rate was low despite the low value rewards, so we question the benefit of the reward program. Newly stocked common carp dispersed rapidly in the receiving environment, thus 15-20 kms between release sites can provided a sufficiently balanced distribution in lotic fisheries.

Competing interests The authors declare that they have no competing interests.

Authors' contribution Attila Mozsár, Zsolt Udvari and Béla Halasi-Kovács designed the study. Zoltán Vitál, Dorottya Lilla Fazekas, Flórián Tóth, Attila Mozsár and Zoltán Ugrai handled and analysed the data. Attila Mozsár and Zoltán Vitál wrote the first draft manuscript. All authors reviewed and approved the manuscript.

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References

Arlinghaus R, Cooke SJ (2009) Recreational fisheries: socioeconomic importance, conservation issues and management challenges. In: Dickson B, Hutton J, Adams WM (eds) Recreational hunting, conservation and rural livelihoods: science and practice. Blackwell Publishing, Oxford

Arlinghaus R, Mehner T (2003) Socio-economic characterisation of specialised common carp (*Cyprinus carpio* L.) anglers in Germany, and implications for inland fisheries management and eutrophication control. Fish Res 61:19–33

Arlinghaus R, Mehner T, Cowx IG (2002) Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. Fish Fish 3:261–316

Arlinghaus R, Riepe C, Theis S, Pagel T, Fujitani M (2022) Dysfunctional information feedbacks cause the emergence of management panaceas in social-ecological systems: The case of fish stocking in inland recreational fisheries. J Outdoor Recreat Tour 38:100475

Arlinghaus R, Tillner R, Bork M (2015) Explaining participation rates in recreational fishing across industrialised countries. Fish Manag Ecol 22:45–55

Arnason N, Mills KH (1981) Bias and loss of precision due to tag loss in Jolly–Seber estimates for Mark–Recapture experiments. Can J Fish Aquat Sci 38:1077–1095

Bajer PG, Sorensen PW (2015) Effects of common carp on phosphorus concentrations, water clarity, and vegetation density: a whole system experiment in a thermally stratified lake. Hydrobiologia 746:303–311

Boukal DS, Jankovský M, Kubečka J, Heino M (2012) Stock–catch analysis of carp recreational fisheries in Czech reservoirs: Insights into fish survival, water body productivity and impact of extreme events. Fish Res 119–120:23–32

Brown RS, Power G, Beltaos S (2001) Winter movements and habitat use of riverine brown trout, white sucker and common carp in relation to flooding and ice break-up. J Fish Biol 59:1126–1141

Clugston JP (1996) Retention of T-bar anchor tags and passive integrated transponder tags by Gulf sturgeons. N Am J Fish Manag 16(3):682–685

Copeland C, Baker E, Koehn JD, Morris SG, Cowx, IG (2017) Motivations of recreational fishers involved in fish habitat management. Fish Manag Ecol 24(1):82–92

Crandall CA, Monroe M, Dutka-Gianelli J, Fitzgerald B, Lorenzen K (2018) How to bait the hook: Identifying what motivates anglers to participate in a volunteer angler data program. Fisheries 43(11):517–526

Crook DA (2004) Movements associated with home-range establishment by two species of lowland river fish. Can J Fish Aquat Sci 61:2183–2193

Cucherousset J, Lassus R, Riepe C, Millet P, Santoul F, Arlinghaus R, Buoro M (2021) Quantitative estimates of freshwater fish stocking practices by recreational angling clubs in France. Fish Manag Ecol 28:295–304

Ellis JR, Mccully Phillips SR, Poisson F (2017) A review of capture and post-release mortality of elasmobranchs. J Fish Biol 90(3):653–722

Elmer LK, Kelly LA, Rivest S, Steell SC, Twardek WM, Danylchuk AJ, Arlinghaus R, Bennett JR, Cooke SJ (2017) Angling into the future: Ten commandments for recreational fisheries science, management, and stewardship in a good anthropocene. Environ Manage 60:165–175

Hammer Ø, Harper DAT, Ryan PD (2001) PAST: Paleontological statistics software package for education and data analysis. Palaeontol Electron 4(1):9

Jones MJ, Stuart IG (2009) Lateral movement of common carp (*Cyprinus carpio* L.) in a large lowland river and floodplain. Ecol Freshw Fish 18:72–82

Livings ME, Schoenebeck CW, Brown ML (2007) Long-term anchor tag retention in yellow perch, *Perca flavescens* (Mitchill). Fish Manag Ecol 14:365–366

Lyach R, Čech M (2018) A new trend in central european recreational fishing: More fishing visits but lower yield and catch. Fish Res 201:131–137

Matsuzaki SS, Usio N, Takamura N, Washitani I (2007) Effects of common carp on nutrient dynamics and littoral community composition: roles of excretion and bioturbation. Fundam Appl Limnol 168:27–38

Molony BW, Lenanton R, Jackson G, Norriss J (2003) Stock enhancement as a fisheries management tool. Rev Fish Boil Fisher 13:409–432

Osborne MW, Ling N, Hicks BJ, Tempero GW (2009) Movement, social cohesion and site fidelity in adult koi carp, *Cyprinus carpio*. Fish Manag Ecol 16:169–176

Quinn GP, Keough MJ (2002) Experimental design and data analysis for biologists. Cambridge university press, Cambridge

Radinger J, Wolter C (2014) Patterns and predictors of fish dispersal in rivers. Fish Fish 15(3):456–473

Rahman MM, Verdegem MCJ, Nagelkerke LAJ, Wahab MA, Milstein A, Verreth JAJ (2008) Effects of common carp *Cyprinus carpio* (L.) and feed addition in rohu *Labeo rohita* (Hamilton) ponds on nutrient partitioning among fish, plankton and benthos. Aquac Res 39:85–95

Riepe C, Fujitani M, Cucherousset J, Pagel T, Buoro M, Santoul F, Lassus R, Arlinghaus R (2017) What determines the behavioral intention of local-level fisheries managers to alter fish stocking practices in freshwater recreational fisheries of two European countries? Fish Res 194:173–187

Rude NP, Whitledge GW, Phelps QE, Hirst S (2011) Long-term PIT and T-bar anchor tag retention rates in adult muskellunge. N Am J Fish Manag 31(3):515–519

Sitar SP, Brenden TO, He JX, Johnson JE (2017) Recreational postrelease mortality of Lake Trout in lakes superior and huron. N Am J Fish Manag 37(4):789–808

Specziár A, Turcsányi B (2014) Effect of stocking strategy on distribution and recapture rate of common carp *Cyprinus carpio* L. in a large and shallow temperate lake: implications for recreational put-and-take fisheries management. J Appl Ichthyol 30(5):887–894

Stuart IG, Jones MJ (2006) Movement of common carp, *Cyprinus carpio*, in a regulated lowland Australian river: implications for management. Fish Manag Ecol 13:213–219

Taylor RG, Whittington JA, Pine WE, Pollock KH (2006) Effect of different reward levels on tag reporting rates and behavior of common snook anglers in Southeast Florida. N Am J Fish Manag 26:645–651

Udvari Zs, Györe K (2020) Fish species pool of the Ráckeve (Soroksár) Danube Branch (1902-2020). Pisces Hungarici 14:151–162 (in Hungarian)

Udvari Zs, Stibinger É, Pekli J, Zellei Á, Keresztessy K, Váradi L (2003) Possibilities of the natural spawning of common carp (*Cyprinus carpio*) in Ráckeve Danube Arm, Hungary. Fish Aquac Dev 28:123–140 (in Hungarian)

Ugrai Z, Györe K (2007) Survey of fish community in the Ráckevei Danube Branch. Pisces Hungarici 2:95–100 (in Hungarian)

Vadadi-Fülöp Cs, Mészáros G, Jablonszky Gy, Hufnagel L (2007) Ecology of the Ráckeve-Soroksár Danube – A review. Appl Ecol Environ Res 5(1):133–163

Vostradovský J (1991) Carp (*Cyprinus carpio* L.) "put-and-take" fisheries in the management of angling waters in Czechoslovakia. In: Cowx IG, (ed.) Catch effort sampling strategies. Their application in freshwater fisheries management. Fishing New Books, Blackwell Publishing, Oxford

Weber MJ, Brown ML (2009) Effects of common carp on aquatic ecosystems 80 years after "Carp as a Dominant": Ecological insights for fisheries management. Rev Fish Sci 17(4):524–537

Wolos A, Teodorowicz M, Grabowska K (1998) Effect of ground-baiting on anglers' catches and nutrient budget of water bodies as exemplified by Polish lakes. Aquacult Fish Manage 23:499–509

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