ACTA ZOOLOGICA BULGARICA

Applied Zoology
Research Article

Acta zool. bulg., 72 (1), 2020: 131-136
Published online 30 December 2019
http://www.acta-zoologica-bulgarica.eu/002235

Effects of Hexagonal- and Diamond-shaped Mesh Traps on Size Selectivity of Freshwater Crayfish *Astacus leptodactylus* Eschscholtz, 1823 (Decapoda: Astacidae) in the Eğirdir Lake, Turkey

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Abstract: The size selectivity of crayfish traps (fyke-nets) with 34, 38 or 42 mm mesh size and with diamond-shaped (D) or hexagonal-shaped (Hex) mesh was compared for narrow-clawed crayfish *Astacus leptodactylus* Eschscholtz, 1823 in the Eğirdir Lake, Turkey. The SELECT model was used to fit the logistic selection curves and to calculate selectivity parameters. The selectivity curves and parameters were calculated by comparing the size frequencies of the crayfish retained in the traps, including the 34 mm diamond (D) trap control. The 50%-selectivity length (l_{50}) and selection range (SR) of fyke-net traps with diamond mesh were 8.70 cm and 3.16 cm for 38 mm (38 D) and 8.69 cm and 1.99 cm for 42 mm (42 D) bar length. The l_{50} and *SR* values of hexagonal mesh traps were 8.06 cm and 3.42 cm for 34 mm (34 Hex), 10.23 cm and 2.80 cm for 38 mm (38 Hex) and 11.00 cm and 2.62 cm for 42 mm (42 Hex) bar length, respectively.

Key words: *Astacus leptodactylus*, mesh size, mesh shape, size selectivity, diamond-shaped mesh, hexagonal-shaped mesh, SELECT method

Introduction

Stewart & Ferrell (2003) pointed out the popularity of the SELECT (Share Each LEngth's Catch Total) method (Millar 1992, Millar & Walsh 1992, Wileman et al. 1996) for analysing data from selectivity experiments using comparative catches from two or more gears. The method was used to estimate the selectivity of traps and pots for crustaceans (Xu & Millar 1993, Treble et al. 1998).

Traps and pots typically have openings permitting easy entry of fish, crustaceans or molluscs but making their escape difficult. When the escape from the trap opening is impeded, then the size selectivity is determined by the ability of the animal to pass through the mesh (Millar & Fryer 1999). Drum-like cylindrical traps with two funnel entrances had been used by fishermen in Turkey until 1985 (Balik et al. 2003, Harlioğlu 2004). Fyke-net traps with one funnel entrance have been used for crayfish since 2001 (Bolat 2001, 2004, Balik et al. 2003). They are widely used for catching crayfish in inland waters across the world. Mesh size is one of the most important parameters affecting selectivity in this type of nets

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and, therefore, the most frequently studied (Deval et al. 2007). After the fishing has been carried out with the net, small individuals that are under the minimum landing size have to be returned to the water from on-board. However, this means not only loss of time and labour but also a stressful operation for released crayfish individual that could not escape from the nets into the water. Therefore, the optimal mesh size for capturing crayfish with fyke-nets must be identified (Bolat et al. 2010). Crayfish traps (fyke-nets) traditionally used by fishermen in Turkey have mesh size 17 mm (knot to knot). There is no legal regulation regarding mesh size selection. In this context, this study aims to compare the mesh size and mesh shape on the effects of selectivity on crayfish catch.

Materials and Methods

We used crayfish traps with two different mesh shapes and three different mesh sizes for crayfish catching in order to estimate the size selectivity of the narrow-clawed crayfish (*A. leptodactylus*) in the Eğirdir Lake. The traps were set and hauled during the legal catching season (July – December 2010) in the Eğirdir Lake. A total 600 D-shape fyke-nets with four hoops and double funnels at each end (Fig. 1) were set in the late afternoon in randomly selected study area. Traps were hauled approximately 65 h after setting. Crayfish were sampled three times a month and with a total of 12 hauls per mesh size. The total length and live weight of the crayfish were measured and the length-frequency distribution was classified by 1 cm intervals. We compared the size selectivity of the traditional commercially-used 34 mm diamond mesh-shaped traps (34 D) (control) with those of 38 and 42 mm diamond mesh-shaped (38 D and 42 D) and 34, 38 and 42 mm hexagonal mesh-shaped (34 Hex, 38 Hex and 42 Hex) traps.

The SELECT model was used to fit the logistic selection curves, using the size frequencies of mesh sizes and shapes (Millar & Walsh 1992, Wileman et al. 1996). Selection curves and parameters of the combined operations were calculated by specialised software (Tokai & Mitsuhashi 1998) run by the Solver facility of MS-Excel. Selectivity curves were obtained by fitting the logic function:

$$r(l) = \exp(a + bl) / [1 + \exp(a + bl)]$$ (Fryer 1991),

where $r(l)$ is the probability that a fish of size l will be retained, and parameters a and b are estimated, with $a < 0$ and $b > 0$. The length at 50% retention (l_{50}) is given by the formula $l_{50} = - a / b$ (Fryer 1991). The SELECT model includes a "split" parameter (p), which can be defined as the relative fishing power and can be split into: (i) relative fishing effort and (ii) relative fishing efficiency of the trap types, given that all crayfish captured were measured (Millar 1992, Millar & Walsh 1992). In addition, the split value (p) can be obtained from the proportion of the catch in the large mesh by the formula:

$$F = p \exp(a + bl)/[1 - p + \exp(a + bl)]$$ (Fryer 1991).

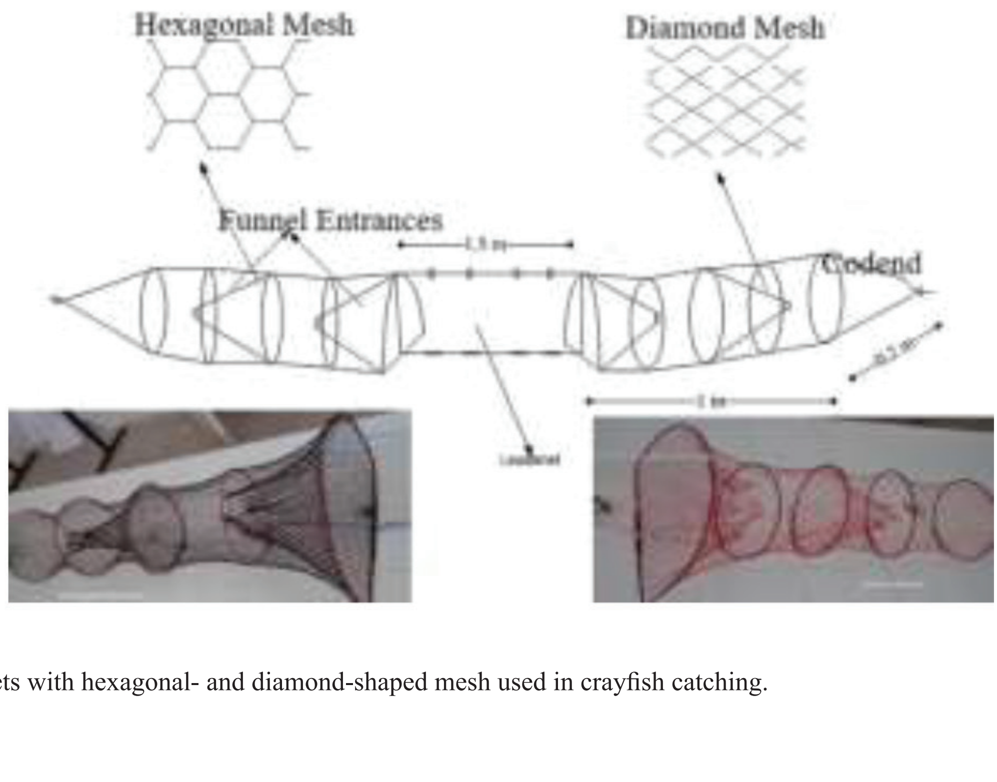

Fig. 1. Fyke-nets with hexagonal- and diamond-shaped mesh used in crayfish catching.

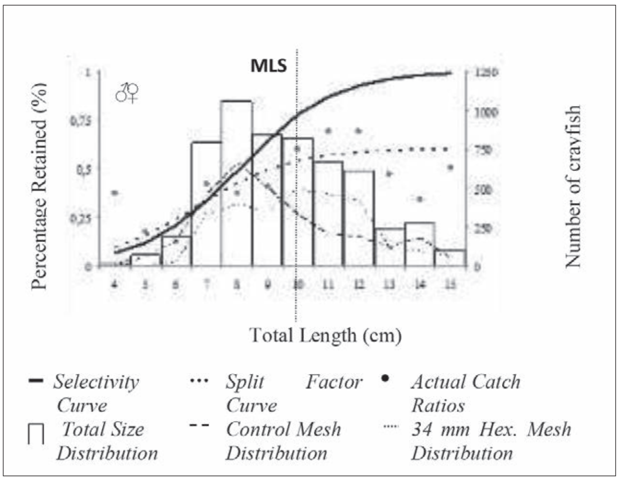

Fig. 2. Selection curve for 34 mm hexagonal-shaped mesh traps. The estimated l_{50} value (♂♀=8.06). Total Length (TL, cm) and Minimum Landing Size (MLS=10 cm TL).

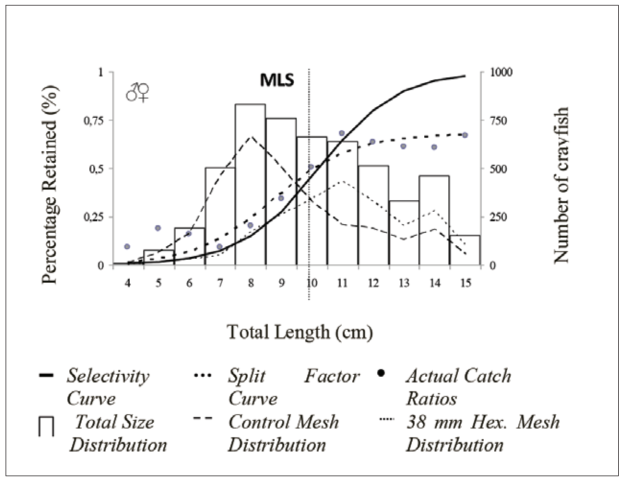

Fig. 3. Selection curve for 38 mm hexagonal-shaped mesh traps. The estimated l_{50} value (♂♀=10.23). Total Length (TL, cm) and Minimum Landing Size (MLS=10 cm TL).

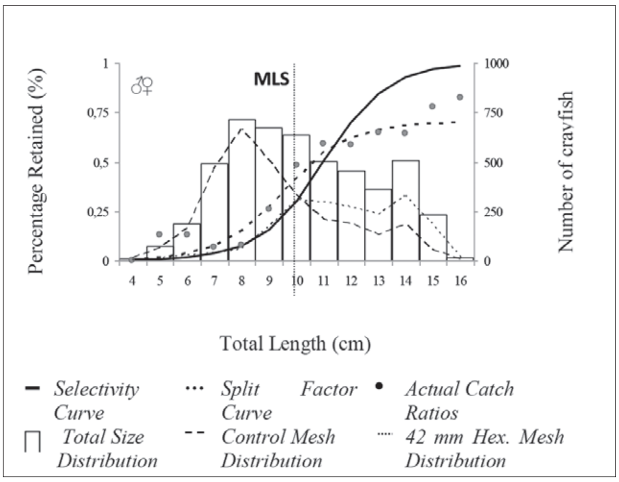

Fig. 4. Selection curve for 42 mm hexagonal-shaped mesh trap. The estimated l_{50} value (♂♀=11.00). Total Length (TL, cm) and Minimum Landing Size (MLS=10 cm TL).

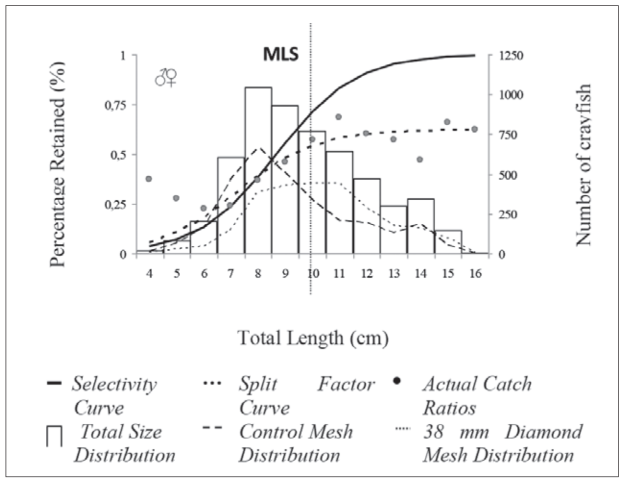

Fig. 5. Selection curve for 38 mm diamond-shaped mesh trap. The estimated l_{50} value (♂♀=8.70). Total Length (TL cm) and Minimum Landing Size (MLS=10 cm TL).

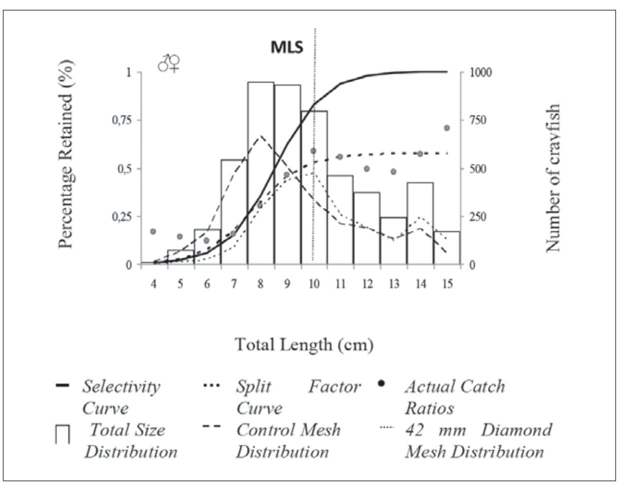

Fig. 6. Selection curve for 42 mm diamond-shaped mesh trap. The estimated l_{50} value (♂♀=8.60). Total Length (TL cm) and Minimum Landing Size (MLS=10 cm TL).

Results

The mean crayfish length in traps with 34 mm diamond mesh and hexagonal mesh were similar to the mean crayfish length in traps with diamond mesh at 38 and 42 mm mesh sizes, while the mean crayfish length in hexagonal mesh traps with 38 and 42 mm mesh were higher than in both of these traps (Table 1) and legal catchable size for the crayfish in inland waters of the Turkey.

The numbers of individuals caught in the traps were 5702 for 34 mm, 4836 for 38 mm and 4147 for 42 mm mesh sizes (Fig. 2–6). While the lowest number of crayfish (1919) was caught in 42 Hex (Fig. 4), the numbers of crayfish were 2941 for 34 D, 2761 for 34 Hex (Fig. 2), 2634 for 38 D (Fig. 5), 2202 for 38 Hex (Fig. 3) and 2228 for 42 D (Fig. 5) traps.

Table 1. The number of crayfish, legal size ratios (Minimum Landing Size MLS = 10 cm for freshwater crayfish in Turkey), mean length and weight of crayfish caught in diamond-shaped (D) and hexagonal-shaped (Hex) mesh traps.

Mesh size	34 mm		38 mm		42 mm	
Mesh shape	D	Hex	D	Hex	D	Hex
Number of crayfish	2941	2761	2634	2202	2228	1919
Mean total length (TL±SE, mm)	87.92±0,39	80.63±0.29	86.87±0.46	102.29±0.25	85.54±0.14	109.95±0.24
Mean weight (W±SE, g)	28.35±0.44	33.61±0.45	34.48±0.52	42.70±0.53	40.32±0.63	50.06±0.70
Total Catch (kg)	76	93	91	94	90	96
Legal size (%) (>10 cm)	25.80	41.60	44.03	61.21	41.42	68.70

Table 2. Estimated selectivity parameters for *Astacus leptodactylus* in the Eğirdir Lake: l_{50}, 50% retention total length; SR, selection range; *a* and *b*, regression parameters; *p*, estimated split parameters. All parameters presented with standard errors.

Mesh size and shape	*a*	*b*	*p*	l_{50}	SR
38 D	-6.04±0.46	0.70±0.07	0.62±0.02	8.70±0.26	3.16±0.31
42 D	-9.43±0.67	1.10±0.09	0.58±0.01	8.60±0.14	1.99±0.16
34 Hex	-5.19±0.53	0.64±0.08	0.60±0.02	8.06±0.29	3.42±0.43
38 Hex	-8.02±0.41	0.78±0.05	0.68±0.02	10.23±0.25	2.80±0.20
42 Hex	-9.23±0.41	0.84±0.05	0.70±0.02	11.00±0.24	2.62±0.16

In contrast, the highest amount of catch by weight was determined for 42 Hex traps. A similar result was also found for the minimum landing size (MLS >10 cm). While 68.7% of the crayfish caught with 42 Hex traps exceeded the legal size, MLS ratio was 25.8% for 34 D mesh trap.

Mean l_{50} values and SR of crayfish were 8.70 cm and 3.16 cm for 38 D, 8.60 cm and 1.99 cm for 42 D, 8.06 cm and 3.42 cm for 34 Hex, 10.23 cm and 2.80 cm for 38 Hex, 11.00 cm and 2.62 cm for 42 Hex mesh traps, respectively. When l_{50} values were compared, the 38 and 42 Hex traps had values over the MLS for crayfish. When 38 and 42 Hex traps were used, more than half the crayfish individuals at MLS were retained. Moreover, selectivity was positively affected by the increase of mesh size and preference of Hex mesh.

Discussion

The first and the simplest step of increasing the selectivity is to change the mesh size and mesh shape (Nguyen & Larsen 2012). Most of the selectivity studies are focused on the effects of the mesh size on the selectivity. The mesh size is believed to represent the most important factor affecting selectivity (Guillory & Prejean 1997, Karakulak & Erk 2008, Bolat et al. 2010, Acarli et al. 2013, Kumova et al. 2015, Özdemir et al. 2015, Demirci & Akyurt 2017). Size selectivity can be used to evaluate the minimum legal size and the effects of changing escape vent or mesh size regulations on the future productivity of the resource (Treble et al. 1998). If mesh shape and size of traps used for crayfish catching are proportionally smaller than MLS (< 10 cm) individuals trapped and landed, it is impossible to manage a sustainable crayfish catching. The procedures of capture, sorting and re-releasing cause stress and accidental organ loss to crayfish (Brown & Caputi 1983, Hunt et al. 1986). Additionally, contacts with air, handling and return to the life habitat procedures reduce the productivity of the stock (Groeneveld et al. 2005). The best approach is to allow sub-legal individuals to escape before the traps are hauled and mesh size and shape of the crayfish traps are essential to reverse the disadvantage into an advantage.

It is more important to use the traps that can select crayfish in their natural habitat rather than selecting them on land after catching the crayfish. The crayfish traps with 34 D mesh are commercially used by fishermen but they have poor selectivity. Moreover, according to the l_{50} values, the selectivity of the 38 and 42 D mesh traps are both quite poor. Therefore, increasing mesh size in the hexagonal-shaped mesh traps has a positive effect on selectivity. In this study, the remarkable finding is that selectivity of crayfish traps using traditionally 34 D mesh is improper for *A. leptodactylus* in the Lake Eğirdir. We have demonstrated that crayfish traps with 34 mm mesh size have poor selectivity and are not suitable for commercial use. Furthermore, the 34 mm diamond mesh may cause a considerable loss in marketable crayfish (Bolat et al. 2010).

It was determined that the l_{50} values in diamond mesh traps did not change with the mesh size but increased with the mesh size in hexagonal-shaped mesh traps (Table 2). The selectivity curves were shifted to the right especially in the trap with 38 and 42 Hex mesh sizes in our study (Figs. 3 and 4). A similar result has been reported by Jeon et al. (2000) stating that the trap selectivity depends on the mesh size.

Our results have demonstrated that 34 mesh D-shaped traps have not been selective for crayfish in the Lake Eğirdir. If most of the individuals caught are below legal size, the sustainability of the population is severely affected (Cerim & Ateş 2016). According to l_{50} and MLS values, 38 and 42 Hex have been identified as the most selective among the tested traps. Consequently, the Hex traps with 42 mesh had the most appropriate selection for the crayfish in the Eğirdir Lake.

Acknowledgements: This study was supported by the Scientific Research Fund of the Süleyman Demirel University with project number SDUBAP-1983-YL-09. This paper is summarized from the MSc Thesis by Erdem Uçgun. Authors are grateful to the Aboo Chico Junior, English Lecturer Ülkü Diken and Dr. İsmail Yüksel Genç for English editing.

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Received: 15.05.2018
Accepted: 27.08.2018