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Factors influencing nine-spined stickleback (*Pungitus pungitus*) trapping success

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Information about factors influencing catch per unit effort (CPUE) are not only interesting in commercial and sport fisheries contexts, but also for scientists fishing for research purposes. Here, the influence of trap type, baiting and attractors on CPUE in pond nine-spined sticklebacks (*Pungitius pungitius*) were investigated. The results show that baiting improved CPUE considerably, but trap type had a smaller effect on CPUE. Visual attractors (i.e. aluminium foil) did not improve CPUE. Apart from showing that nine-spined sticklebacks are likely to use olfactory cues for locating food, the results should provide useful information for those interested in catching nine-spined sticklebacks with the aid of minnow traps.

Introduction

In fisheries sciences, factors influencing catch per-unit-effort (CPUE) have long been the focus of intensive research (e.g. Paloheimo & Dickie 1964, Hinton & Nakano 1996, Bigelow *et al*. 2002). Similar work has also been done in a sport-fisheries context (e.g. Peterman & Steer 1981), but when it comes to commercially or recreationally less important species, factors influencing CPUE have seldom been studied in detail. Yet, such information can be important for instance when evaluating population size trends (Kidd *et al*. 2007) or relative abundances of species in different sites or habitats (Gryska *et al*. 1998).

Sticklebacks (Gasterosteidae) are important model species for ecological and evolutionary biology research (Bell & Foster 1994, Östlund-Nilson *et al*. 2007). Therefore, both three-spined (*Gasterosteus aculeatus*) and nine-spined sticklebacks (*Pungitius pungitius*) are used regularly in a relatively large number of studies in different parts of the world. Catching sticklebacks is usually easy with the aid of a purse seine or minnow traps, or even, with dipnets. In fact, when used as raw material to extract fish oil in the first half of the 1900 century in Finland, more than 100 000 tonnes of marine three-spined sticklebacks were caught yearly from the Gulf of Finland with the aid of dipnets and attractor lights (Merilä 2010). However, in the course of catching sticklebacks for research purposes, we have noticed that there appears to be large systematic differences in the CPUE depending on methods and gear used. Nevertheless, as far as the author is aware of, there are no quantitative studies published on factors influencing CPUE in sticklebacks.

The aim of this study was to explore factors influencing trapping success on nine-spined

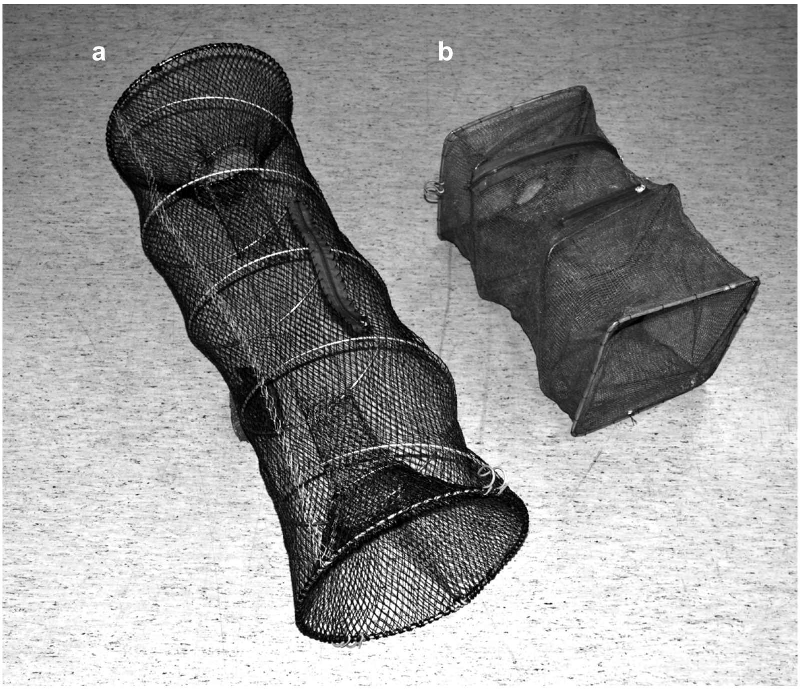

Fig. 1. Two kinds of Promar traps used in the study: (**a**) "black" TR-503 trap, and (**b**) "brown" TR-501.

sticklebacks. In particular, the interest was on testing how trap type and baiting influenced trapping success. To this end, the influence of various factors on trapping success were quantified in a field experiment conducted in northwestern Finland.

Materials and methods

This study was conducted between 13 and 14 July in an isolated pond, Rytilampi, in northwestern Finland (66°23´N, 29°19´E). This pond has a surface area of < 5 ha and a maximum depth of ca. 5 meters. The shores are swampy, and there is little submerged vegetation in this mud-bottomed pond. Nine-spined stickleback is the only fish species occurring in this pond, and are known to reach giant sizes (> 110 mm; Herczeg *et al*. 2009a). During the test trapping, the water column in the pond was totally transparent (i.e. turbidity was effectively zero).

Trapping was performed by using Promar (Gardena, California, USA) collapsible minnow traps made of polyethylene netting. Two models were used: TR-501 (henceforth: "brown") 457 × 254 mm trap with round dual entrances (63.5 mm diameter) and TR-503 (henceforth: "black") 914 × 304 mm trap with round dual entrances (127 mm diameter) (Fig. 1). A total of 21 brown and 23 black traps were used, and all traps were set on 13 July 2011 between 14:45 and 17:00, and taken up on 14 July 2011 between 09:15 and 11:00. The exact trapping time varied at maximum one hour between different traps as they were checked in the same order as set. Hence, the catch effort for each trap was more-or-less constant. Therefore, number of fish caught per trap can be equated to catch per unit effort (CPUE).

Also the influence of baiting on CPUE was investigated by baiting 35% of traps (9 brown and 6 black) with blue cheese (17% fat content; Valio, Finland). This was done by placing ca. 10 g of ground blue cheese in pouches on the top of the traps. In unbaited traps, the pouches were left empty.

To test whether visual attractors had an impact on CPUE, a ca. 40-cm-long piece of 25-cm-wide aluminium foil was attached to the top part of 41% of the traps (13 brown, 6 black). Although the study design was not entirely balanced, the three factors (*viz*. trap type, bait and attractor) were applied in crossed manner (i.e. all possible combinations used [black:foil:bait =

2; black:foil:no bait = 4; black: no foil:bait = 4; black:no foil:no bait = 13; brown:foil:bait = 7; brown: foil:no bait = 5; brown:no foil:bait = 2; brown:no foil:no bait = 7).

In addition to investigating the effects of the three above mentioned factors, also the effects of trap depth (the depth in which the given trap was placed; 0.3–1.5 m), trap orientation with respect to shore line (parallel *vs*. 90° angle), and approximate trap distance from the shoreline were recorded and analysed. All traps were set within two meters from the shoreline.

The data were analysed with generalized linear models treating the total number of fish per trap as a response variable. I also performed a separate analysis using total number of "giant" fish as a response variable. Here, "giant" was a fish having a total length ≥ 90 mm (cf. Herczeg *et al*. 2009a). I did these analyses as normal sized (mostly juveniles) and "giant" fish may exhibit behavioural differences and therefore also differ in catchability. Both response variables were modelled as being Poisson distributed using a log-link function. Trap type, bait and attractor were treated as fixed factors. Also trap orientation was treated as a fixed factor, whereas trap depth and distance from shoreline were treated as covariates. Since trap orientation, trap depth and distance from shoreline can be considered as nuisance variables, only their main effects were fitted. For all other variables, all two-way interactions were initially fit, but subsequently dropped if evaluated to be not statistically significant. Final models consisted of all main effects and significant interactions. All analyses were performed with JMP statistical software (ver. 9.0.0; SAS Institute Inc.) using an Apple Macintosh computer.

Results

Altogether 214 nine-spined sticklebacks were caught, with on average 4.81 (SD = 5.69, min = 0, max = 30; median = 3) fish per trap ($n = 44$). Of these, 11.2% ($n = 24$) were "giants".

A generalized linear model revealed that the total CPUE was influenced by both baiting and trap type (Table 1A). Baiting increased CPUE, and the black traps caught more fish than the brown ones. However, as indicated by the significant interaction between these variables (Table 1A), the positive effect of baiting on CPUE was much more pronounced in the case of the black, as compared with the brown traps. Further, CPUE increased with trap depth, but decreased with distance from shore line, whereas the trap orientation and attractors had no influence on CPUE (Table 1A).

The results and conclusion were more-or-less similar when the analysis was restricted to giants only (Table 1B). Baiting still had the largest positive effect on CPUE, whereas the effects of trap type and trap type × bait interaction disappeared (Table 1B). Furthermore, while trap depth no longer influenced CPUE, the effect of distance was reversed (Table 1B). Likewise, the influence of trap orientation became significant

Table 1. The effects of different explanatory factors on CPUE as estimated with mixed linear models treating response variables as Poisson distributed. χ^2 = Likehood-Ratio chi-square. The baseline factor level is given in brackets.

Source	df	**A**: effects on total catch			**B**: effects on catch of "giants"		
		Estimate ± SE	χ^2	p	Estimate ± SE	χ^2	p
Intercept	1	1.67 ± 0.25	32.57	< 0.0001	–2.68 ± 0.97	10.23	0.0010
Trap type [Black]	1	0.35 ± 0.08	19.15	< 0.0001	0.50 ± 0.31	3.38	0.0650
Foil [No]	1	0.12 ± 0.08	2.25	0.13	–0.13 ± 0.24	0.32	0.5700
Bait [No]	1	–0.61 ± 0.08	60.67	< 0.0001	–1.07 ± 0.31	18.52	< 0.0001
Depth	1	0.48 ± 0.21	4.73	0.029	–0.41 ± 0.70	0.34	0.5500
Distance	1	–0.59 ± 0.25	5.48	0.019	2.02 ± 0.91	5.71	0.0170
Orientation [90°]	1	0.15 ± 0.12	1.76	0.18	–1.01 ± 0.48	6.78	0.0090
Trap type [Black] × Bait [No]	1	–0.17 ± 0.08	4.63	0.031	0.34 ± 0.31	1.44	0.230

(Table 1B): traps parallel to shoreline caught more giant sticklebacks than those placed at a 90° angle to the shoreline. Attractors did not influence CPUE of giants (Table 1B).

Discussion

The most salient findings of this study were that both trap type and baiting had significant effects on CPUE, and the effect of baiting exceeded that of the trap type. The fact that the effect of baiting on CPUE was quite large provides a potentially important cue to improve CPUE in attempts to catch nine-spined sticklebacks from lakes. Namely, it has proven very difficult to locate and catch nine-spined sticklebacks from lakes with predatory fish (own unpubl. obs.). One possible explanation for this is that in lakes with predators, nine-spined stickleback densities are low, and they may hide in rocky bottoms exhibiting little movements. For instance, previous attempts to capture nine-spined sticklebacks from eastern Finnish lakes and ponds employed over 15 000 trap hours (unbaited), yet verified the presence of nine-spined sticklebacks in only three of the ca. 200 ponds and lakes fished (own unpublished results). With use of baited traps, it might be possible to improve chances of catching nine-spined sticklebacks when their densities are low.

The fact that baiting improved CPUE suggests that nine-spined sticklebacks might make use of olfactory cues in locating food. Use of olfactory cues in locating food is known from many fish species (e.g. Stoner 2004), and although nine-spined sticklebacks have relatively simple olfactory organs (Teichmann 1959, Honkanen & Ekström 1992), they are likely to be able to make use of olfactory cues in both feeding (Fokina & Kausmyan 2003, Kasymyan & Mikhailova 2004) and mating contexts (reviewed in McLennan 2003). However, since it is unknown what exactly attracted nine-spined sticklebacks to blue-cheese baited traps, the current results do not allow me to infer more than that they are attracted to blue-cheese odours.

Although the difference in CPUE due to trap type was smaller than that between baited and unbaited traps, the two trap types did differ in their CPUE. The larger, darker and more coarsely meshed (black) traps yielded better catches than the smaller, paler and more densely meshed (brown) traps. A number of possible explanations for this difference could be hypothesized (e.g. differences in shading provided by the two trap types, attraction/avoidance of particular colours, difference in entrance diameter), but the data at hand would not allow differentiating between these alternative explanations.

Interestingly, adding sunlight reflecting aluminium foil into the traps did not influence the CPUE. This was unexpected as our previous experience from catching three-spined sticklebacks with metallic minnow traps seems to suggest that shiny galvanized traps consistently capture more fish than similar traps painted black. However, it is possible that three-spined and nine-spined sticklebacks differ in respect to how they are attracted to shiny objects. More studies in different weather conditions (sunny weather prevailed during the current study) and locations would be needed to confirm the generality of this result.

While the results in respect to bait, trap and attractor effects were more or less similar when all or "giant" fish were analysed, there were some differences in respect to covariate effects. In particular, it is noteworthy that the effect of distance from shoreline was significant for both sets of analyses, but the sign of the effect was reversed in the two set of analyses: while the total catch decreased with distance from the shoreline, more giants were caught further away from shoreline. Likewise, while trap orientation did not explain any variance in total catch, traps parallel to shoreline caught more giants than those orientated against the shoreline. These differences could be understood in terms of behavioural differences among giants and juvenile fish: if the giants are patrolling further away and parallel to the shoreline whereas the juvenile fish stick closer to shoreline making less directed movements, these are results which one would expect. More detailed studies are needed to test these suggestions, but the results clearly show that trap placement may have different influence in trappability of different fractions of the population.

Whether the results of this study can be extrapolated to other habitats and populations of nine-spined sticklebacks remains to be tested.

However, given that blue cheese baited traps seem to also attract another species — the three-spined stickleback (pers. obs.) — it seems likely that baiting would be equally useful in other nine-spined stickleback populations. Yet, one should keep in mind that there are consistent and apparently genetically based differences in many behavioural (Herczeg *et al*. 2009b, 2009c) and neural (e.g. Gonda *et al*. 2009a, 2009b) traits among different nine-spined stickleback populations, and these differences might also be reflected in differences in their trappability. Likewise, seasonal and environmental differences may influence trappability of sticklebacks, as many other fishes too (Stoner 2004).

In conclusion, the results of this study show that nine-spined sticklebacks are attracted to blue-cheese odours, and baiting can increase CPUE when using minnow traps.

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References

Bell, M. A. & Foster, S. 1994: *The evolutionary biology of the threespine stickleback*. — Oxford University Press.

Bigelow, K. A., Hampton, J. & Miyabe, N. 2002: Application of a habitat-based model to estimate effective longline fishing effort and relative abundance of Pacific bigeye tuna (*Thunnus obesus*). — *Fisheries and Oceanography* 11: 143–155.

Fokina, E. S. & Kasumyan, A. O. 2003: Comparison of taste preferences in different generations of nine-spined stickleback population *Pungitius pungitius*. — *Doklady Biological Sciences* 389: 570–573.

Gonda, A., Herczeg, G. & Merilä, J. 2009a: Habitat-dependent and -independent plastic responses to social environment in the ninespine stickleback (*Pungitius pungitius*) brain. — *Proceedings of the Royal Society B* 276: 2085–2092.

Gonda, A., Herczeg, G. & Merilä, J. 2009b: Adaptive brain size divergence in nine-spined sticklebacks (*Pungitius pungitius*)? — *Journal of Evolutionary Biology* 22: 1721–1726.

Gryska, A. D., Huberta, W. A. & Gerowb, K. G. 1998: Relative abundance and lengths of Kendall Warm Springs Dace captured from different habitats in a specially designed trap. — *Transactions of the American Fisheries Society* 127: 309–315.

Herczeg, G., Gonda, A. & Merilä, J. 2009a: Evolution of gigantism in nine-spined sticklebacks. — *Evolution* 63: 3190–3200.

Herczeg, G., Gonda, A. & Merilä, J. 2009b: Predation mediated population divergence in complex behaviour of nine-spined stickleback (*Pungitius pungitius*). — *Journal of Evolutionary Biology* 22: 544–552.

Herczeg, G., Gonda, A. & Merilä, J. 2009c: The social cost of shoaling covaries with predation risk in nine-spined stickleback (*Pungitius pungitius*) populations. — *Animal Behaviour* 77: 575–580.

Hinton, M. G. & Nakano, H. 1996: Standardizing catch and effort statistics using physiological, ecological, or behavioral constraints and environmental data, with an application to blue marlin (*Makaira nigricans*) catch and effort data from Japanese longline fisheries in the Pacific. — *Bulletin of Inter-American Tropical Tuna Commisson* 21: 169–200.

Honkanen, T. & Ekström, P. 1992: Comparative study of the olfactory epithelium of the three-spined stickleback (*Gasterosteus aculeatus*) and the nine-spined stickleback (*Pungitius pungitius*). — *Cell and Tissue Research* 269: 267–273.

Kasumyan, A. O. & Mikhailova, E. 2004: Comparison of taste preferences and behavioral taste response in nine-spined stickleback *Pungitius pungitius* from Moscow River and the White Sea basin. — In: Kapoor, B. G. & Reutter K. (eds.), *Fish chemosenses*: 1–8. Scientific Publishers, Enfield.

Kidd, K. A., Blanchfield, P. J., Mills, K. H., Palace, V. P., Evans, R. E., Lazorchak, J. M. & Flick, R. M. 2007: Collapse of a fish population after exposure to a synthetic estrogen. — *Proceedings of the National Academy of Sciences of the United States of America* 104: 8897–8901.

McLennan, D. A. 2003: The importance of olfactory signals in the gasterosteid mating system: sticklebacks go multimodal. — *Biological Journal of Linnean Society* 80: 555–572.

Merilä, J. 2010: Kymmen- ja kolmipiikin levinneisyys Suomessa. — *Luonnon Tutkija* 114: 13–16.

Paloheimo, J. E. & Dickie, L. M. 1964: Abundance and fishing success. — *Rapports et Proces-verbaux des Reunions, Conseil Permanent International pour l'Exploration de la Mer* 155: 152–163.

Peterman, R. M. & Steer, G. J. 1981: Relation between sport-fishing catchability coefficients and salmon abundance. — *Transactions of American Fisheries Society* 110: 585–593.

Stoner, A. W. 2004: Effects of environmental variables on fish feeding ecology: implications for the performance of baited fishing gear and stock assessment. — *Journal of Fish Biology* 65: 1441–1471.

Teichmann, H. 1959: Vergleichende untersuchungen an der nase der fische. — *Zeitscrift für Morphological Oekological Tiere* 43: 171–212.

Östlund-Nilsson, S., Mayer, I. & Huntingford, F. A. 2007: *Biology of the three-spined stickleback*. — CRC Press, Boca Raton.