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Short communication

Trapping efficiency of plastic bottle "wickertraps" for population assessment of river *Macrobrachium* (Crustacea: Decapoda)

Eric Fouilland *, Odile Fossati

ORSTOM / ITRMLM B.P. 30 Papeete, Tahiti, French Polynesia

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Abstract

Small wickertraps made from plastic bottles are used to sample *Macrobrachium* communities (Crustacea Decapoda) in the rivers of Nuku-Hiva (Marquesas Islands, French Polynesia). Relations are established between sampling effort (number of traps per m^2), number of crustacea caught, and surface of the pool. Catch per trap decreased with increasing trap density up to a threshold of about 8 traps per m^2. Escape measurements, in a river and in the laboratory, help to describe the behaviour of the shrimps towards the traps. Escape was greater at night than during the day. The number of shrimps entering the traps was inversely proportional to the number of shrimps already in the traps. Sampling efficiency of the traps was estimated, in a single trial, at 40–47% for a trap density of 8.3 traps per m^2.

Keywords: Crustacea; *Macrobrachium*; Shrimp; Sampling; Stream; Wickertrap; Crustacés; Echantillonnage; Cours d'eau; Nasses

1. Introduction

The crustaceans locally known as "chevrettes" (*Macrobrachium* spp.) are abundant in the Polynesian rivers. Diverse methods have been used to sample these shrimps in Nuku-Hiva (Marquesas Islands, French Polynesia) and traps made from transparent plastic bottles, used with the opening downstream, have been chosen. The wickertraps catch about 50% of the present *Macrobrachium* populations, when compared with

* Corresponding author. Present address: Laboratoire d'hydrobiologie marine et continentale-USTL, Place E. Bataillon, 34095 Montpellier Cédex France. Fax: (33-67) 143719; e-mail: phyto@hyd.univ-montp2.fr

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electric fishing, but the larger animals are not caught. The hypothesis that a greater fishing effort does not always produce a greater number of animals caught has been proposed (Fossati and Danigo, 1996).

In this paper, we describe the variability of capture in relation to fishing effort (number of traps/m^2) and pool size. The behaviour of the shrimps towards the fishing device is also analysed using escape experiments, to get a better understanding of the capture. The efficiency of the sampling device is then estimated with data from a capture–recapture experiment.

2. Materials and methods

Nuku-Hiva is a small 340 km^2 volcanic island with mountains to a maximum height of 1224 m. This topography and a tropical humid climate create a hydrographic network made from numerous springs and streams converging in few rivers with less than 700 l s^{-1} discharge during dry periods. Those streams flow on coarse sediments, with usually clear successions of pools and rapids or even cascades (Fig. 1). Two *Macrobrachium* species dominate in the rivers chosen for this study. *M. lar* Fabricius is fished for human consumption while *M. australe* Guérin-Méneville is too small to be of interest for fishery. Those two benthic species are often found in the pools, where they are more active at night (Kubota, 1972).

Small wickertraps were made with 1.5 l mineral water plastic bottles (28 mm aperture diameter, 1 l inside volume in the trap, see drawing in Fossati and Danigo, 1996) by cutting the upper part and inverting it inside the bottom of the bottle. The traps used with the opening downstream were found the most efficient capture device in the rivers of Nuku-Hiva (Fouilland and Fossati, unpublished). The influence of variation in sampling effort on catch was tested in three pools similar in depth, current velocity and bottom particle composition but with different areas (2.1 m^2 and 4.8 m^2 in Pakiu-River just upstream Taiohae during March–April 1993 and 6.7 m^2 in the same river but about 1 km upstream from the village and during May 1991, respectively pool 2, pool 9 and pool 1 in Table 1), with stable environmental and hydrological conditions. To determine the role of the pool surface area on the capture, 15 samples were taken in 11 different pools with a density of 5–10 traps per m^2 (pool 1: 3rd and 4th measurements, pool 2: 3rd measurement, pool 4–7, pool 9: 4th to 7th measurements, pool 10, 11, 14 and 15, in Table 1). Multilinear regressions based on 27 samples from 16 pools between March 20 and April 10 1993 during similar weather conditions (pools 2–18, Table 1) were taken to study the relationship between the number of shrimps caught and the area of the pools or the density of the traps (Snedecor and Cochran, 1967; Scherrer, 1984). Data obtained during 1991 by Danigo in a different site (pool 1 of the Table 1) were not taken into account for this calculation.

Escape experiments were conducted in the natural environment (unknown *Macrobrachium* densities) in the same site and with stable environmental and hydrological conditions. Numbered traps were laid in the evening and picked up early the following morning. The shrimps were individually identified by sex and species, by measuring

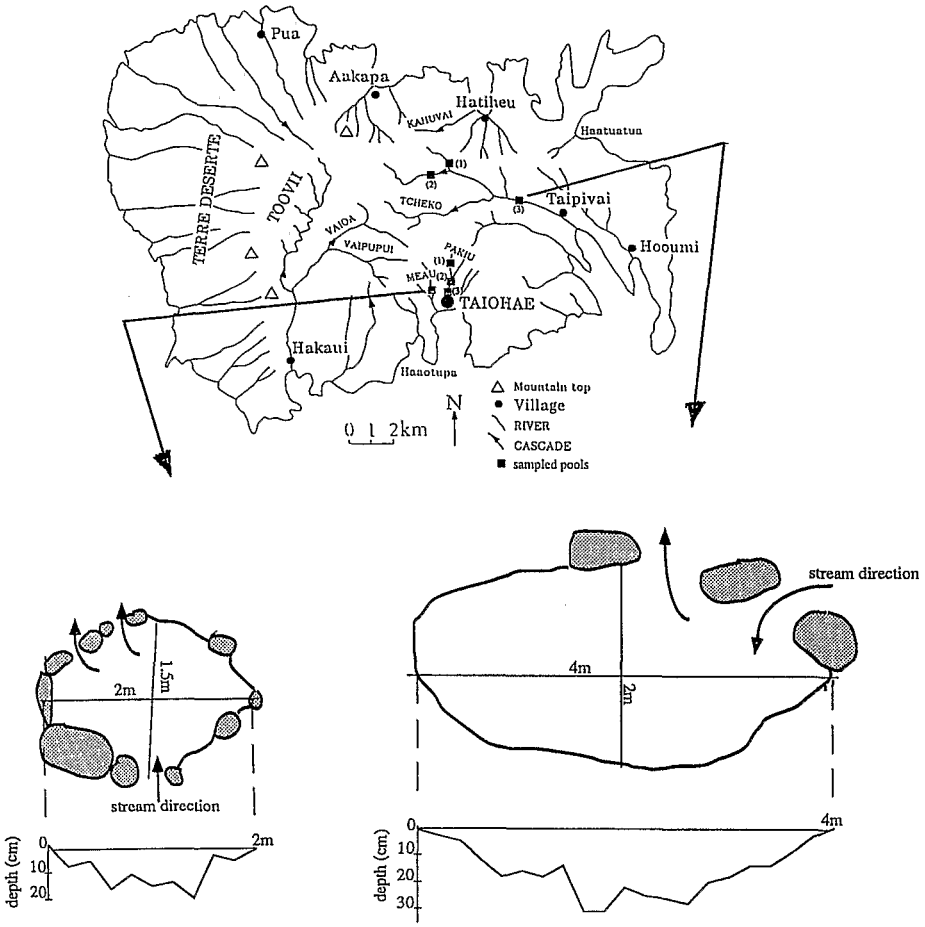

Fig. 1. Nuku-Hiva map with the sampling sites, profiles of two pools (pools 5 and 15, data in Table 1).

with precision of ± 0.1 mm the distance between the bases of the ocular peduncles and the limit of the cephalothorax, and by a small mark made at the limit of cephalothorax. The shrimps were put back in the same trap and the trap laid at the same place in the pool. Shrimps were checked in the evening to test day escape and, the following morning, to measure night escape. Other experiments were conducted with manipulated numbers of shrimps in the traps at the beginning, in order to determine the effect of initial density in the traps on capture. Some non-parametric tests were done on number of obtained distributions (Kolmogorov-Smirnov and *U*-Mann Whitney, Scherrer, 1984).

Similar measurements were made in the laboratory, with seven or eight shrimps and one trap in each tank at the beginning of the experiment (about 8 traps per m^2). All animal used for laboratory experiments had been caught in the traps, which eliminated the bigger males and reduced the proportion of very small individuals (Fossati and

Table 1
Captures from the river pools

Pool	River (site)	Month/year	A_{pool} (m^2)	D_{trap} ($/m^2$)	N_{cru}	Shrimps/trap
1	Pakiu (1)	5/91	6.7	4.2	89	3.2
				4.5	105	3.5
				5.8	88	2.3
				9.4	111	1.8
2	Pakiu (2)	4/93	2.1	2.4	10	2.0
				4.8	16	1.6
				9.5	35	1.8
				16.7	30	0.9
3	Pakiu (2)	4/93	2.2	3.2	12	1.7
4	Pakiu (2)	3/93	2.4	8.3	23	1.2
5	Meau	4/93	3.0	10.0	27	0.9
6	Pakiu (2)	4/93	4.0	6.2	38	1.5
7	Pakiu (3)	4/93	4.5	7.1	39	1.2
8	Pakiu (2)	4/93	4.8	1.2	18	3.0
9	Pakiu (2)	3/93	4.8	1.2	18	3.0
		4/93		2.1	20	2.0
				2.1	23	2.3
				5.2	31	1.2
				8.3	33	0.8
				8.3	38	1.0
				8.3	45	1.1
				11.5	70	1.3
10	Taipivai (1)	4/93	5.5	6.7	19	0.5
11	Pakiu (3)	4/93	5.6	8.9	65	1.3
12	Pakiu (1)	3/93	6.0	4.2	30	0.8
13	Taipivai (1)	3/93	7.0	3.6	26	1.0
14	Taipivai (2)	3/93	7.0	5.7	35	0.9
15	Taipivai (3)	3/93	7.0	8.6	86	1.4
16	Pakiu (2)	3/93	15.0	1.7	45	1.8
17	Pakiu (2)	3/93	15.5	0.5	26	4.3
18	Pakiu (3)	3/93	16.0	4.1	90	1.4

First column: pools selected for the Figs. 1–3; A_{pool} = area of the pool; D_{trap} = number of traps/m^2; N_{cru} = number of crustaceans caught. The data from the 6.7 m^2 pool were obtained by A.H. Danigo.

Danigo, 1996). A stone was added to each of the five tanks (0.25 m^2, 20 cm water depth) in order to simulate, with the available equipment, the river pools.

Sampling efficiency was assessed in one pool (4.8 m^2, 8.3 traps per m^2, Pakiu River, March 1994) with a capture–recapture experiment. The capture–recapture, or marking–recapture, method enables the assessment of total population size. Shrimps are marked after the first capture and released in the pool. The mark (a partial cut on an uropod) is visible until the next molting and does not seem to hinder the animal as marked prawns have been kept in the laboratory for months. Recapture was conducted the following night, so death, molting and migration in and out from the pool are supposed negligible.

Population estimation was done using the Lincoln-Petersen method, modified by Bailey (1951, 1952). The principal hypothesis is that the proportion of marked animals

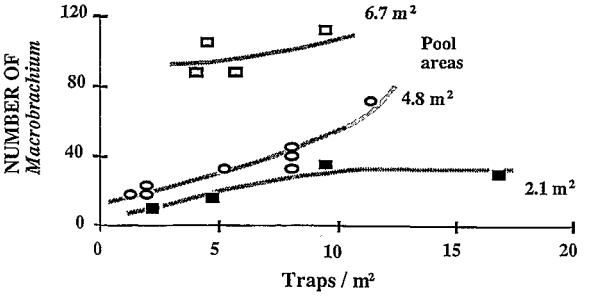

Fig. 2. Relation between total number of *Macrobrachium* caught and trap densities in three pools. Data are in Table 1 (pools 1, 2 and 9).

observed in the recaptured sample (M/m) is the same as their proportion in the sampled population (N/n). The size of the population is then easy to calculate:

$$N = (M/m) \times n$$

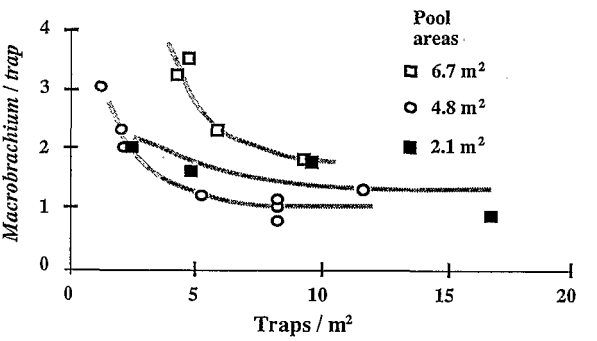

Fig. 3. Relation between mean number of *Macrobrachium* caught per trap and trap densities in three pools (pools 1, 2 and 9).

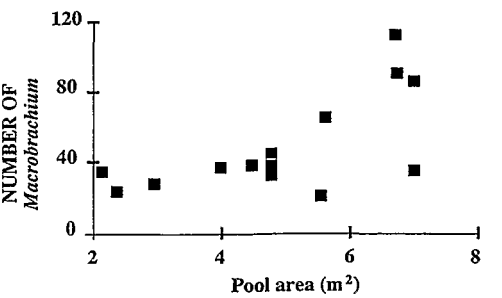

Fig. 4. Relation between pool area and total number of prawns caught (pools 4–7, 10, 14 and 15; pools 2, 9 and 1 from 5–10 traps/m²). Data are in Table 1.

3. Results

3.1. Sampling effort

In a given pool, the number of shrimps caught increased with the number of traps (Fig. 2). In the smaller pool, there might be an inflexion of the curve between 5 and 10 traps per m^2 but no threshold can be seen in the other pools. It is hypothesized that

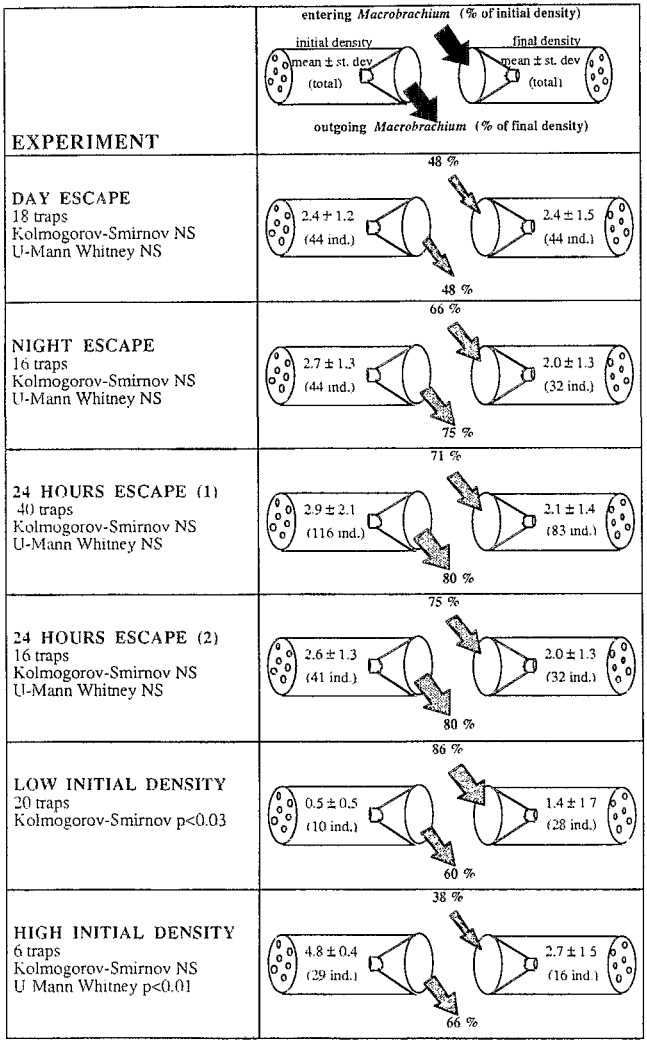

Fig. 5. Escape experiments day and night, 24 h, and with manipulated initial densities in river pools (Pakiu-River upstream from Taiohae, 25–27th and 27–29th of March 1994).

ecological diversity is related to the area of the pool. This area is thus more explicative of shrimp density than of shrimp number.

The number of *Macrobrachium* per trap decreased when trap density increased, as is frequently observed in exploited populations (Ricker, 1975), with an inflexion of the curves between 5 and 10 traps per m^2 (Fig. 3). For such trap densities, the total number of *Macrobrachium* increased with the pool area (Fig. 4). Those observations led us to explore the variability of the capture in relationship to the fishing effort (number of traps per m^2) and to the area of the pools.

The number of shrimps caught (N_{cru}) depended on the area of the pool (A_{pool}) and on the density of the traps (D_{trap}). The correlation was improved when log A_{pool} and log N_{cru} were used. Multilinear correlation coefficients were 0.30 and 0.16 [log N_{cru}/log A_{pool}; (log N_{cru})/D_{trap}]. Moreover, log A_{pool} and D_{trap} were not co-linear (correlation = −0.39). The following model explained 72.5% of the variability of the number of prawns caught:

$$\log(N_{cru}) = 0.79 \times \log(A_{pool}) + 0.10 \times D_{trap} + 1.56$$

3.2. Escape experiments

Under natural conditions, escape was greater during the night than the day (Fig. 5). No significant differences between capture distributions in natural conditions were

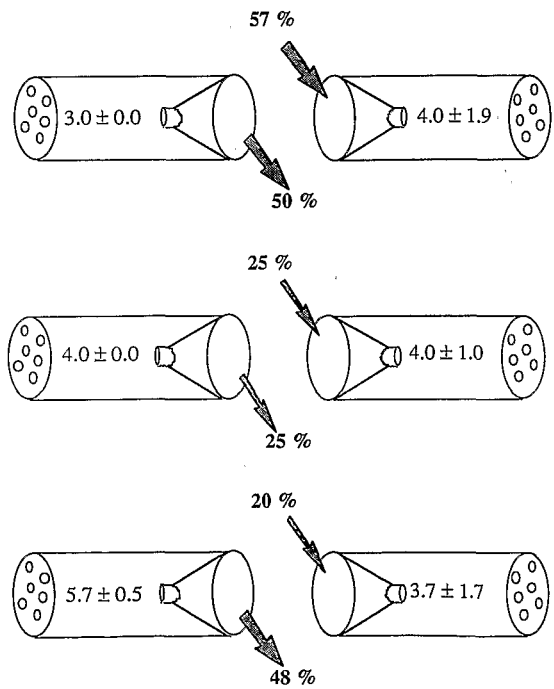

Fig. 6. Escape experiments in tanks, with manipulated initial densities in the traps and known densities in the tanks.

observed (Fig. 5). The proportion of animals escaping from the traps did not change when the initial density in the traps was manipulated (Fig. 5). In contrast, the number of shrimps going into the traps depended on initial densities. A high (or low) imposed initial density induced a reduction (or an increase) of the entrances, which was confirmed by significant differences in capture distributions (Fig. 5).

No death was observed in the traps and we assume that the shrimps escaping from the traps were not more vulnerable. As there had been no perceptible environmental modification during the experiment, either the prawns were aware of the traps and were able to avoid them, or the number of animals going into the traps was related to the number of prawns already in them.

In the laboratory, as in natural conditions, entrances were changed by a modification of initial densities in the traps (Fig. 6) to reach a final number of 3.5–4 shrimps per trap, showing a capture efficiency of about 50%.

3.3. Sampling efficiency

In the capture–recapture experiment, the estimated number of shrimps in the entire population was 96, with 34% efficiency for the first sampling and 46% for the recapture. In this pool, 38–45 *Macrobrachium* were caught with a trap density of 8.3 traps per m^2 (cf. Table 1), thus a global capture efficiency of 40–47%.

4. Discussion

The number of shrimps caught depends on the pool area and, to a lesser extent, on the trap density and on a relation between the two parameters. To get more shrimps, a bigger pool and a greater number of traps are needed. In a single pool, the number of *Macrobrachium* caught increased with the number of traps laid, except in one small pool where the Fossati and Danigo hypothesis (no relation between a greater fishing effort and a bigger capture) seemed confirmed. In general, the number of shrimps per trap decreases with increasing trap density, at least up to a threshold of about 8 traps per m^2.

Results from escape experiments in the laboratory and in a natural environment are similar, as already observed by Yamane and Flores (1989) for *Palaemon paucidens*. The traps are in equilibrium with their environment, not acting as an accumulating device. The number of shrimps going into the traps depends on the population density in the pool. The same result has been described for *Macrobrachium nipponense* in small pots (Yamane and Iitaka, 1990). The capture is an instantaneous picture of present populations (accessible and vulnerable).

There is a relation between the shape and the size of the mouth of the trap and escape (Koike et al., 1981, Yamane and Flores, 1989, Yamane and Fujiishi, 1992). Our apertures (28 mm) allow an equilibrium between inside and outside the traps for the smaller individuals (they do not allow the bigger *M. lar* to go in, Fossati and Danigo, 1996). The animals caught are those too small to be fished for eating. Captures are less dependent on the recent visit of the river by a fisherman than are captures of larger individuals and give a good idea of the stock of animals under the fishing size. Escape is

more important during the night than during the day, which can be related to the greater nocturnal activity of the shrimps (Kubota, 1972).

The sampling efficiency of plastic bottle "wickertraps" has been estimated at 40% in natural conditions and 50% in the tanks, for 8–9 traps per m^2. These results are in agreement with a previous capture–recapture experiment (Fossati and Danigo, 1996) and an electric fishing measurement done in Tahiti (Fossati, unpublished results).

5. Conclusions

The traps have been tested in isolated pools, under stable environmental conditions. In such conditions, about 40% of the capturable prawns are caught with 8 traps per m^2. The capture is an instantaneous picture of available populations. Experiments in other rivers and with other environmental conditions would allow a description of the relationship between *Macrobrachium* communities and their environment.

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