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Bait testing for the invasive Asian crabs (*Hemigrapsus* spp.)

Wang, Willy; willywang@live.de

Abstract

Hemigrapsus sanguineus and *Hemigrapsus takanoi* are invasive shore crabs in the German Wadden Sea. The monitoring is an important task to evaluate their impact on the ecosystem. This paper analyzes the preference of *Hemigrapsus* sp. for different bait types. The results of the chi square test based on Pearson shows a preference for *Mytilus edulis* as bait. *M. edulis* is the superior bait type for Hemigrapsus sp.

Introduction

Hemigrapsus sanguineus was first sighted in 2007 (LANDSCHOFF et al. 2013) and *Hemigrapsus takanoi* was first sighted in 1993 (GOLLASCH 1999) in the German Wadden Sea. Both species originated in the North-West Pacific (WOLFF 2005; ASAKURA and WATANABE 2005). Both species placed in category 2 in the Neobiota survey published by the Slesvig Holsteinian government (LASCHKEWITZ et al. 2014), indicating that it is important to monitor their population. A successful monitoring requires catching a sufficient number of *Hemigrapsus* sp. individuals. Crab traps are a common method to catch commercially important crabs. The success of this method depends among other things on the right bait. Information about which bait *Hemigrapsus* sp. prefer is lacking. The present study evaluates the preference of *Hemigrapsus* sp. for the baits cheese, *Mytilus edulis* or *Gadus morhua*.

Fig. 1. Blue marked sites are the sampling sites for *M. edulis* and the *Hemigrapsus* sp. The sites are in the german northern wadden sea between List and Ellenbogen

Material and Methods

Fellow students collected the clusters of *M. edulis* in the German Wadden sea near List Sylt (Figure 1). From these *M. edulis* clusters, I collected 33 individuals of *Hemigrapsus* sp.. No individuals were fully-grown. Due to their small sizes, I could not determine the species. As types of bait, I used cheese and pieces of meat of *G. morhua*, both purchased from the local supermarket (EDEKA). The cheese bait was "Alter Schwede" from Rücker. The energy content of 100g cheese was 347kcal. The *G. morhua* filet was "Atlantischer Kabeljau Filetportionen". The energy content of 100g *G. morhua* was 76kcal. As third type of bait, I used pieces of *M. edulis* collected from the Wadden Sea. The energy content of 100g *M. edulis* was 42kcal (SOUCI et al. 2016). I conducted the experiment in the Alfred Wegener Institute in Hafenstraße 43 25992 List/Sylt, Germany. The Hemigrapsus sp. bait choice was recorded as a time-lapse video. I used the telephoto lens of the "Samsung S20 FE 5G" to record the time lapse. The time-lapse program was the free app "Framelapse". I divided the petri dishes in 3 areas of similar size.

The experiments were conducted in 12 petri dishes at a time. Each petri dish contained all three baits. I put the baits in the prepared area of the petri dish and the distance between the baits was maximized. All baits had a similar size. All *Hemigrapsus* sp. were put in the middle of a petri dish. To avoid flight reactions elicited by the observer, the experiments were recorded with a smartphone camera and the time-lapse app "Framelapse". After each run, I removed the Hemigrapsus sp. from the petri dish. I discarded the used baits, washed every petri dish with fresh water and wiped them with a disinfectant towel.

The first run started on April the tenth in the evening. The first video was recorded with a frame (capture) interval of 1 second, the observed duration in real time was 3 hours and 26 minutes [min] long and the recorded video was 6 minute and 53 second long. The second run started on April the eleventh in the noon. The second video was recorded with a frame (capture) interval of 10 seconds, the observed duration in real time was 3 hours and 20 min long and the video was 40 seconds long. The third run started on April the eleventh in the evening. The third video was recorded with a frame (capture) interval of 10 seconds, the observed duration in real time was 3 hours and 15 min long and the video was 39 seconds long.

Due to the different video lengths and frame (capture) interval for the time-lapse, I decided to analyze 39 time points in each video. In the first video, I analyzed every 10 seconds. In the two other videos, I analyzed every second. 5 minutes in real time have elapsed between each analyzed time points. The analysis started in all videos at 00:00.

I noted the position of an individual crab in the area of a type of bait at a certain time point. That resulted in 39 positions for each *Hemigrapsus* sp. individual. I used the chi-square test based on Pearson for the statistical analysis.

Results

In total, I counted the individuals of *Hemigrapsus* sp. in the vicinity of cheese bait 401 times, in the vicinity of *M. edulis* 471 times and in the vicinity of *G. morhua* 415 times (Figure 2). I conducted a chi-square test to compare my observed frequencies and the frequencies of a pure random distribution. The ratio for each bait type in a purely random distribution would be 1:1:1 (Table 1). No expected cell frequencies were below 5. The Results are significant between observed frequencies and the expected frequencies $\chi^2(2) = 6.396$, $p = .0408$. I conducted further Chi-square test. The results showed a slightly favor for the *M. edulis* (Sup. Table 2-4).

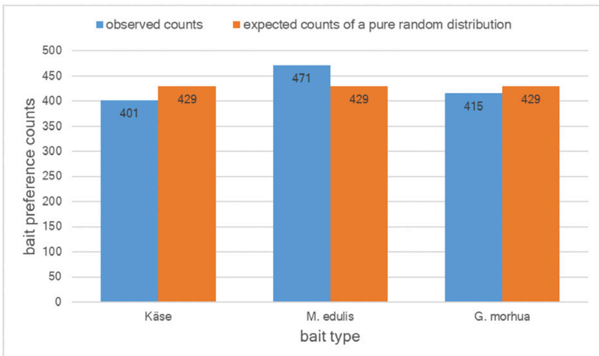

Fig. 2. On the x-axis are the different bait types. On the y-axis are the bait preferences counts. The blue columns are the observed counts and the orange columns are the theoretical count-numbers of a pure random distribution.

Discussion

The chi-square test resulted in a significant difference between the observed and expected frequencies. The H0 can be rejected and it can be assumed that the bait preference is not randomly distributed.
The frequencies distribution of the baits is not expected. I assumed that cheese would be the preferred bait, because the energy intake for a *Hemigrapsus* sp. individual would be higher with cheese compared to G. morhua or M. edulis. BLEIE & THIELTGES (2021) compared the preference of *Hemigrapsus sanguineus* and *Hemigrapsus takanoi* between the prey items *M. edulis*, *Gammarus locusta*, *Littorina littorea* and *Ulva lactuca*. They used different prey items, but their results shown that *M. edulis* was generally preferred. CORNELIUS et al. (2021) used *Hemigrapsus takanoi* in their experiments and compared the consumption rate between the sexes and their prey preference for *M. edulis* or *G. locusta*. Their results shown that the male individuals had a preference for *M. edulis*. While the female preferred *G. locusta*. Here, I could show that immature individuals of *Hemigrapsus* sp. already prefer *M. edulis*. The observed preference could be explained by the fact that *M. edulis* is the natural prey for *Hemigrapsus* sp. and Cheese and *G. morhua* do not occur regularly in the *Hemigrapsus* sp. habitats. I conclude *M. edulis* would be the best bait type for *Hemigrapsus* sp..

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Supplementary material

Bait	Observed counts	Expected counts	Difference
Cheese	401	429	-28
M. edulis	471	429	42
G. morhua	415	429	-14
Sum	1287	1287	-

Table 1: Chi-square test between observed counts and expected counts with a pure random distribution (1:1:1)**Supplements**

Subject number	Cheese	*M. edulis*	*G. morhua*
1	8	17	14
2	13	3	23
3	7	31	1
4	7	29	3
5	14	17	8
6	19	15	5
7	0	34	5
8	32	2	5
9	0	2	37
10	0	6	33
11	21	7	11
12	19	2	18
13	2	35	2
14	15	8	16
15	7	22	10
16	1	20	18
17	35	2	2
18	17	5	17
19	5	3	31
20	26	2	11
21	0	35	4
22	0	7	32
23	4	35	0
24	9	16	14
25	2	31	6
26	4	14	21
27	7	19	13
28	27	0	12
29	13	11	15
30	32	6	1
31	14	19	6
32	4	14	21
33	37	2	0
Sum	401	471	425

Sup. Table II: Raw data: in the first column are the subject number; in the second column are the observed and counted choices for cheese; in the third column are the observed and counted choices for *M. edulis*; in the fourth column are the observed and counted choices for *G. morhua*

Bait	Observed choices	Expected choices	Frequency	Difference
Cheese	401	411	1	-10
M. edulis	471	465	1.131	6
G. morhua	415	411	1	4
Sum	1287	1287		-

Sup. Table 2: Chi-square test between observed counts and expected counts with the frequency (1:1.131:1)

Bait	Observed choices	Expected choices	Frequency	Difference
Cheese	401	465	1.131	-64
M. edulis	471	411	1	60
G. morhua	415	411	1	4
Sum	1287	1287		-

Sup. Table 3: Chi-square test between observed counts and expected counts with the frequency (1,131:1:1)

Bait	Observed choices	Expected choices	Frequency	Difference
Cheese	401	411	1	-10
M. edulis	471	411	1	60
G. morhua	415	465	1.131	-50
Sum	1287	1287		-

Sup. Table 4: Chi-square test between observed counts and expected counts with the frequency (1:1:1,131)

I counted every choice for one bait (Sup Table 1). To find out a tendency for a more suitable ratio, I tested different ratios. I tried to choose a ratio that slightly favors one bait.

I conducted a second chi-square test (Sup. Table 2). This time I used a different expected frequency. The frequency was 1(cheese):1.131(*M. edulis*):1(*G. morhua*). No expected cell frequencies were below 5. The Results are not significant between observed frequencies and the excepted frequencies $\chi^2(2) = 0.36$, $p = .8354$.

I conducted a third chi-square test (Sup. Table 3). I used a different expected frequency. The frequency was 1.131(cheese):1(*M. edulis*):1(*G. Morhua*). No expected cell frequencies were below 5. The Results are significant between the observed frequencies and the excepted frequencies $\chi^2(2) = 17.607$, $p = .00015$.

I conducted a fourth chi-square test (Sup. Table 4). I used a different expected frequency. The frequency was 1(cheese):1(*M. edulis*):1.131(*G. morhua*). No expected cell frequencies were below 5. The Results are significant between the observed frequencies and the excepted frequencies $\chi^2(2) = 14.379$, $p = .00075$.