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RESEARCH ARTICLE

OPTIMIZATION OF CONSERVATION CONDITIONS AFTER LIFE-STATE CAPTURE OF CALLINECTES AMNICOLA

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Abstract

The aim of this study was to determine the optimal conditions for the preservation of Callinectes amnicola from the Sud-Comoé region after capture in the live state, with a view to extending their lifespan outside their natural habitat, and making good-quality Callinectes amnicola available to help alleviate the shortage of animal protein in the Assinie mafia region, Côte d'Ivoire. To this end, a fractional factorial design was set up and enabled eight (08) experiments observed over ten (10) days to be carried out. The study variables are : $\mathbf{X_1}$ (Number of species), $\mathbf{X_2}$ (Volume of water), $\mathbf{X_3}$ (Number of leaves), $\mathbf{X_4}$ (Quantity of sand) and Y (Mortality rate). The analysis of the optimization results of the first-stage model was performed by the Excel solver based on the GRG algorithm. The results obtained indicate the values of $\mathbf{X_1}$ (82.58 or 83 species), $\mathbf{X_2}$ (0.479 L), $\mathbf{X_3}$(93.78 or 94 leaves) and $\mathbf{X_4}$ (3.798 Kg) of sea sand for a life span increasing from three (03) to nine (09) days.

Introduction:-

A close link has been established between diet and health (WHO, 2007). A good, healthy, balanced diet is a guarantee of good health. A number of factors influence health: heredity, environment, stress, smoking, available health care, lifestyle and, above all, food consumption patterns (WHO, 2007). The link between nutrition and health is so obvious that a balanced diet is a real factor in disease prevention.Adequate nutrition is a basic human need and a prerequisite for good health (WHO, 2000). Nutritional needs are therefore diverse. According to the WHO, a stable diet comprises 50-55% carbohydrates, 30-35% lipids and 10-15% proteins (Desalme, 2004). Proteins come from a variety of sources and origins. Particularly in terms of aquatic resources, crustaceans have long been touted as an important source of animal protein and therefore considered one of the essential components of a nutritious diet (FAO, 2012). The nutritious diet could consist of crustaceans occupying a prominent place in the human diet, as they are an important, highly digestible source (Sankare et al., 2014). Animal proteins are also particularly well-balanced in terms of amino acids. In Côte d'Ivoire, lagoon environments abound in a biodiversity rich in marine products, particularly those of the southern Comoé region, with mangrove ecosystems serving as breeding grounds

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for numerous marine species, in this case Callinectes amnicola (Kone et al., 2023).Callinectes amnicola are animal species prized throughout West Africa, and particularly in Côte d'Ivoire, for their nutritional importance (Koussemon et al., 2008). Callinectes amnicola are available in markets, stored in baskets and are the object of financial transactions outside their natural habitat, resulting in a rapid mortality rate (Manou et al., 2020). Based on the literature consulted, very few works on life-state conservation using mathematical models have been tackled. Mathematical models have the ability to optimize any process or system (Abouo et al., 2020; Abouo et al., 2021; Abouo et al., 2023; Abouo et al., 2024).The general objective of this study is to optimize the post-capture conservation conditions of Callinectes amnicola from the Sud-Comoé region in order to reduce the mortality rate of the species outside its natural habitat prior to sale. Specifically, this involved :

1. Carry out experimental conservation trials on Callinectes amnicola
2. Determine optimal storage conditions

Material and Methods:-

Sampling

Callinectes amnicola were purchased live in the town of Assinie, precisely on the banks of the Aby lagoon in the Sagbadou district. A total of 640 Callinectes amnicola were purchased on the same day, all adult females weighing between 95 and 110 g.

Figure 1:- Basket of Callinectes amnicola used in the study.

Conservation procedure in place

The conservation process began with the setting up of a degree 1 experimental design, which defined the conservation conditions for the experimental trials illustrated in Table I.

Table I:- Experimental area used for the conservation of Callinectes amnicola.

Factors	High level (+1)	Low level (-1)
X_1 : Number of species (Unit)	100	60
X_2 : Water volume (L)	0.5	0.25
X_3 : Number of leaves (Unit)	120	60
X_4 : Quantity of sand (Kg)	4	3.5

In order to optimize experimentation costs, the Yates matrix of the full factorial design was translated to its corresponding fractional factorial design (Feinberg, 1996). Parameter X_4 was thus expressed as a function of the first three (03) (X_1, $X_2$and X_3), resulting in the experimental Table II below. It should also be noted that the objective of this study is to extend the life span of Callinectes amnicola: variable Y is the objective to be achieved, observed over the period of ten (10) days.

Table II:- Summary values of experiments conducted.

Trial no.	X_1 (Unit)	X_2 (L)	X_3 (Unit)	X_4(Kg)
1	60	0.25	60	3.5
2	100	0.25	60	4

3	60	0.5	60	4
4	100	0.5	60	3.5
5	60	0.25	120	4
6	100	0.25	120	3.5
7	60	0.5	120	3.5
8	100	0.5	120	4

Statistical analysis

The Excel Office 2016 analysis utility tool was used to model (linear regression) the degree 1 polynomial experimental design (Fofana et al., 2023). After the eight (8) trials of the experimental design, the central trial was repeated in triplicate to select the parameters to be retained in the degree 1 model to be obtained (N'Guessan et al., 2023). Finally, the optimization of storage conditions was determined using the GRG algorithm in the Excel Office solver (Kakou et al., 2015; Karidioula et al., 2018; Abouo et al., 2020).

Results And Discussion:-

Results:-

✓ **Conservation tests**

The results of the experiments carried out are recorded in Table III, giving an overview of all the trials applied during the ten days of the study. The table shows daily mortality rates according to the type of test carried out. There appears to be some variability in this rate. In the E_1 trial, the lowest mortality rate was 0 (day 1), and 20% higher on day 4. The same applies to trial E_2, where the mortality rate on day 4 was around 34.78%, compared with 18.18% on day 1 for trial E_3. In trials E_4, E_5, E_6, E_7 and E_8, the following mortality rates were reported: 27.77 (day 5), 21.42 (day 3), 36.84 (day 1) 28.57 (day 2) and 47.82 (day 4).The mortality rate was 0% for trials E_1 and E_2 on the first day. This was not the case for the other trials, which had respective mortality rates of 18.18; 11.11; 7.14; 36.84; 7.14 and 8.69% (trials E_3, E_4, E_5, E_6, E_7 and E_8 respectively). There were no live Callinectes amnicola on day 10 of the experiments. Only trial E_5 reached nine days with 14.28% of species still alive. On day 8, only trials E_2, E_3 and E_4 recorded 4.34 ; 9.09 and 5.55% respectively of species that were previously alive.

Table III:- Summary of the mortality rate variable in the study.

RESULTS														
Study variables					**Mortality rate Y (%)**									
Tests	X_1	X_2	X_3	X_4	Jr_1	Jr_2	Jr_3	Jr_4	Jr_5	Jr_6	Jr_7	Jr_8	Jr_9	Jr_{10}
E_1	60	0.25	60	3.5	0	0	13.33	20	20	40	6.66	0	0	0
E_2	100	0.25	60	4	0	4.34	13.04	34.78	8.69	30.43	4.34	4.34	0	0
E_3	60	0.5	60	4	18.18	0	18.18	18.18	18.18	18.18	0	9.09	0	0
E_4	100	0.5	60	3.5	11.11	16.66	11.11	22.22	27.77	5.55	0	5.55	0	0
E_5	60	0.25	120	4	7.14	14.28	21.42	14.28	7.14	14.28	7.14	0	14.28	0
E_6	100	0.25	120	3.5	36.84	26.31	10.52	10.52	0	10.52	5.26	0	0	0
E_7	60	0.5	120	3.5	7.14	28.57	14.28	14.28	14.28	14.28	7.14	0	0	0
E_8	100	0.5	120	4	8.69	8.69	0	47.82	17.39	17.39	0	0	0	0

With : X_1: number of crabs (Callinectes amnicola) ; X_2: volume of water (in liters); X_3: number of leaves; X_4 : quantity of sand (in kg); **Jr**: day; **E**: Test

✓ **Optimisation des conditions de conservation**

Linear regression modelling based on the factor matrix of the deployed split factorial design yields the following linear model after coefficients:

$$Y= 11.13 + 0.1 X_1+ 0.14 X_2 + 3.81 X_3 -2.64 X_4– 4.40 X_1X_2+ 4.79 X_1X_3 – 7.18 X_1X_4 + 3.02 X_2X_3X_4$$

Optimization of the said model by the Excel solver based on the GRG algorithm, taking into account the experimental field of study, yields the following optimal conservation conditions in coded values:X_1 = 0.129 ; X_2 = 0.838 ; X_3 = 0.129 ; X_4 = 0.193.

This corresponds to the following actual values:

- X_1 = 82.58 or**83**Callinectes amnicola

- X_2 = **0.479**liter of water to use
- X_3 = **93.87** or 94 leaves
- X_4 = **3.798**Kg of sand to be incorporated in the conservation basket

✓ **Validation of the experimental plan put in place**

The experimental design was validated by analyzing the standardized residuals of the trials carried out. Figure 3 shows a random and uniformly distributed distribution of the points obtained around the straight line with equation Y= 0.

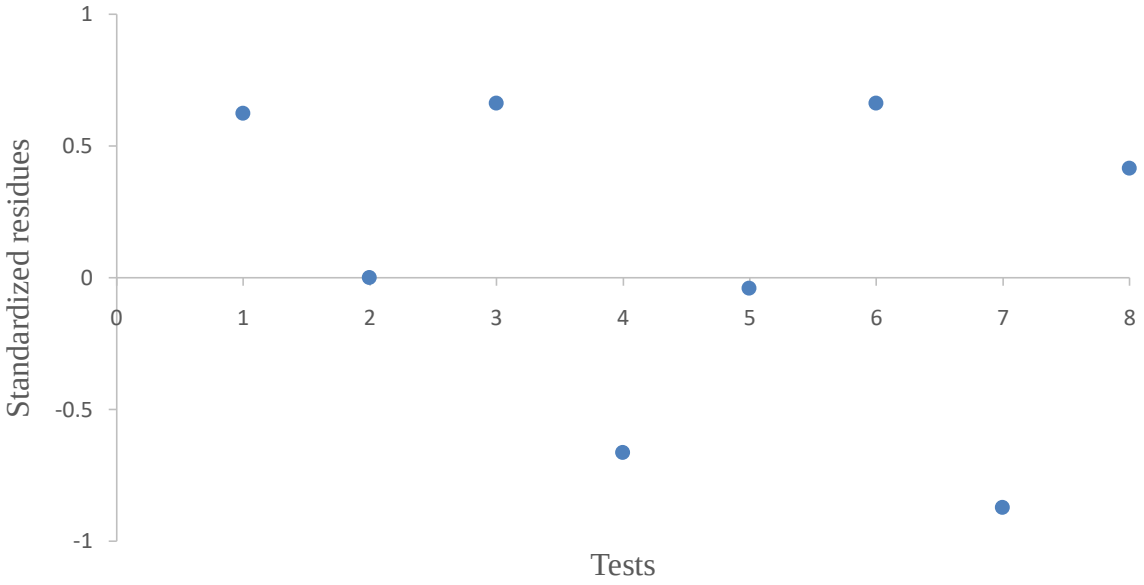

Figure 3:- Distribution of standardized residues from preservation tests.

Discussion:-

The study showed that, 640 Callinectes amnicola were purchased and then distributed in eight (8) bamboo baskets by application of the experimental domain of the present study taking into account the variability of all levels of all factors (N'guessan et al., 2023). Each basket contained 60 or 100 female Callinectes amnicola. Each trial was run according to the following parameters: number of Callinectes amnicola, volume of water, number of leaves and quantity of sand. Analysis of the results obtained after the experimental phase shows mortality rates that vary from one trial to another, with a maximum lifespan not exceeding 6 days (E_8), 7 days (E_7, E_6, E_1), 8 (E_2, E_3 and E_4) and 9 days (E_5). This difference in mortality rate ($F<0.05$) could be explained by the variability of aerodynamic conditions such as environmental aeration, the number of species present, and the quantity of sand and water, as highlighted in the work of Cartois et al. (1994).In terms of water volume, the results are virtually identical for the 0.5 L and 0.25 L trials E_7 and E_5 respectively. As for the number of leaves, the values recorded show that trial E_5 with 120 leaves had a crab survival time of 9 days, in contrast to trial E_1 with 60 leaves, which had a survival time of 7 days. This discrepancy in results can be explained by the definite positive impact of mangrove leaves on the environment of Callinectes amnicola (Goussanou et al., 2017). In this respect, as Gemert (2019) points out, mangrove crabs are considered bio-indicators of the health of Mayotte's mangroves. The parameter quantity of sand relative to 3.5 and 4 kg shows a divergence concerning the mortality rate of crabs. Experimental testing also produced a degree 1 model (N'guessan et al., 2023). Optimization of the model derived from the experimental calculations by the Excel solver yielded the optimal conditions ($\mathbf{X_1}$ (83 species), $\mathbf{X_2}$ (0.479 Litre), $\mathbf{X_3}$ (94 leaves) and$\mathbf{X_4}$(3.798 Kg sand)) for this study (N'Goran et al., 2009). Analysis of the standardized residuals indicates a random distribution around the straight line with equation Y=0. This denotes the validity of the results obtained. This has been noted by several works based on the use of experimental designs in planning and conservation system modelling (N'Goran et al., 2009).

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