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Effect of guinea pig (*Cavia porcellus*) droppings on zooplankton productivity in a model system in the western highlands of Cameroon

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Abstract

Zooplankton serves as an intermediary organism in aquatic food webs, transferring energy from planktonic algae to fish and other higher animals. This research aimed to evaluate the effect of guinea pig (*Cavia porcellus*) droppings on zooplankton productivity in a model system in the Western Highlands of Cameroon agroecological zone. For this purpose, an experimental design consisting of 4 treatments (T_0, T_1, T_2, and T_3) in three replicates, corresponding to ponds fertilised with 0, 10, 16, and 21g of guinea pig droppings, seeded with zooplankton at densities of 29 individuals, was setup from mid-May to mid-June 2024 at the Application and Research Farm of the University of Dschang. Physicochemical and biological parameters were monitored every 2 days for 30 days. The highest values of electrical conductivity (18.13 ± 1.39 µS/cm) and dissolved oxygen (5.2±1.61 mg/L) were obtained with the 21g dose of guinea pig droppings, and the lowest values in unfertilised tanks. Except for rotifers and copepods, whose production peak was observed on the 14th day, the production peaks of other zooplankton groups varied according to the administered fertiliser dose. For cladocerans, this peak was recorded on the 10th day with the 10g dose, the 12th day with the 16g dose, and the 14th day with the 0 and 21g doses. However, the production peak of nauplii occurred on the 12th day with the 21g dose and the 14th day with the 0, 10, and 16g doses. The topmost rotifer density was observed with the 10, 16, and 21g doses. Meanwhile, the highest density of cladocerans (136 ind/L) and copepods (302 ind/L) were observed with the 21g dose. The highest daily production (55 ind/L/day) and intrinsic biomass growth rate (3.4Kr/day) were obtained with the 21g dose. In closing, zooplankton productivity was significantly affected by *C. porcellus* droppings.

Keywords : *zooplankton, fertiliser, dose, guinea pig droppings, model system, Cameroon.*

Résumé

Effet des excréments de cobaye (*Cavia porcellus*) sur la productivité du zooplancton dans un système modèle des hautes terres occidentales du Cameroun

Le zooplancton sert d'organisme intermédiaire dans les réseaux trophiques aquatiques, transférant l'énergie des algues planctoniques aux poissons et autres animaux supérieurs. Cette recherche visait à évaluer l'effet des crottes de cobaye (*Cavia porcellus*) sur la productivité du zooplancton dans un système modèle de la zone agroécologique des Hautes Terres de l'Ouest du Cameroun. À cet effet, un dispositif expérimental composé de 4 traitements (T0, T1, T2 et T3) en trois répétitions, correspondant à des étangs fertilisés avec 0, 10, 16 et 21 g de crottes de cobaye, ensemencés avec du zooplancton à des densités de 29 individus, a été mis en place de mi-mai à mi-juin 2024 à la Ferme d'Application et de Recherche de l'Université de Dschang. Les paramètres physicochimiques et biologiques ont été suivis tous les 2 jours pendant 30 jours. Les valeurs les plus élevées de conductivité électrique (18,13 ± 1,39 µS/cm) et d'oxygène dissous (5,2 ± 1,61 mg/L) ont été obtenues avec la dose de 21 g de fientes de cobaye, et les valeurs les plus faibles dans les bacs non fertilisés. À l'exception des rotifères et des copépodes, dont le pic de production a été observé au 14e jour, les pics de production des autres groupes de zooplancton ont varié en fonction de la dose de fertilisant administrée. Pour les cladocères, ce pic a été enregistré au 10e jour avec la dose de 10 g, au 12e jour avec la dose de 16 g et au 14e jour avec les doses de 0 et 21 g. En revanche, le pic de production de nauplii s'est produit au 12e jour avec la dose de 21 g et au 14e jour avec les doses de 0, 10 et 16 g. La densité de rotifères la plus élevée a été observée avec les doses de 10, 16 et 21 g. Parallèlement, la densité la plus élevée de cladocères (136 ind/L) et de copépodes (302 ind/L) a été observée avec la dose de 21 g. La production journalière la plus élevée (55 ind/L/jour) et le taux de croissance de la biomasse intrinsèque (3,4 Kr/jour) ont été obtenus avec la dose de 21 g. En conclusion, la productivité du zooplancton a été significativement affectée par les excréments de C. porcellus.

Mots-clés : *zooplancton, engrais, dose, excréments de cobaye, système modèle, Cameroun.*

1. Introduction

The exponential growth of the world population raises critical issues about the future capacity to produce and provide access to adequate food for all [1]. This increase of the of the population raises the necessity to produce more food in limited space, hence the promotion of aquaculture as one of the solutions. Aquaculture has significant potential to feed a global population with an average annual growth rate of 6.7 % [2]. Moreover, fish and fishery products play a key role in global nutrition and food security[3]. In Cameroon, the annual importation of fish is around 180 000 tons, in order to cover the demand for fish is estimated at 500,000 tons as the local production is still at 330 000 tons [4]. The deficiency in fish production is partly linked to inadequate feeding caused by the high cost of balanced exogenous feed in fish farming [5 - 7]. In pisciculture, feed represents 70 % of the cost of fish [8]. Hence the development of semi-intensive aquaculture systems that boosters the outputs of land-based farms, particularly fertilisers, the use of which permits the maintenance and improvement of primary production [9]. Indeed, metabolic wastes from organic fertilisers stimulates zooplankton production. Zooplankton refers to all animals, heterotrophic, unicellular or multicellular, microscopic, floating in the water mass and incapable of performing proper movements independently of water currents [10]. They represent an important source of proteins and play a vital role in the development and growth of larvae and juvenile fish [11]. Several studies have been carried out on zooplankton productivity with different types of fertilisers including organic fertilisers : chicken droppings, cow dung, pig droppings and other associated techniques in ponds, tanks and aquariums [12 - 18]. Of these, chicken droppings appear to be the best fertiliser. However, its use in pisciculture remains very limited due to the high competitiveness for agricultural production [19], its increasingly high cost and the nature of the zooplankton produced [13]. The need to find alternative sources of fertilisers that can stimulate zooplankton production, suitable for fish feed, is indeed essential. The newly integrated caviaculture into family farming systems in Cameroon [20], is then an opportunity. Thus, the comparative effect of fertilisation with chicken droppings and guinea pig droppings on zooplankton productivity has been assessed [15]. The results of this study remain limited because the dose of guinea pig droppings used in this study is the equivalent of the optimal dose of chicken droppings as recommended by previous findings [13]. To the current state of our knowledge, no study aimed at finding the optimal dose of guinea pig droppings has yet been done. However, this research should precede any comparative study with the optimal dose of chicken droppings. It was therefore a necessity to carry out this research, aimed to evaluate the effect of guinea pig (*Cavia porcellus*) droppings on zooplankton productivity in a model system in the Western Highlands of Cameroon agroecological zone. More specifically, this research evaluated the effect of the dose of guinea pig droppings on the physicochemical parameters of the water and zooplankton productivity (diversity, density, biomass, daily production, intrinsic rate of increase in biomass and the abundance index). The output of this work is a contribution to the improvement of fish production by looking for the optimal dose of guinea pig droppings for better zooplankton production.

2. Material and methods

2-1. Period, area and site of the study

The study was carried out between mid-May and mid-June 2024 at the Application and Research Farm (FAR) and the Ichthyology and Applied Hydrobiology Research Unit of the Faculty of Agronomy and Agricultural Sciences of the University of Dschang ***(Figure 1)***. The city of Dschang is in the agro-ecological zone of the West Highlands of Cameroon, Menoua Division and Dschang Subdivision. With an average altitude of 1420 m and an average temperature of 20°C, the annual rainfall fluctuates between 1500 and 2000 mm, with a rainy season extending from March to November and a dry season from November to March.

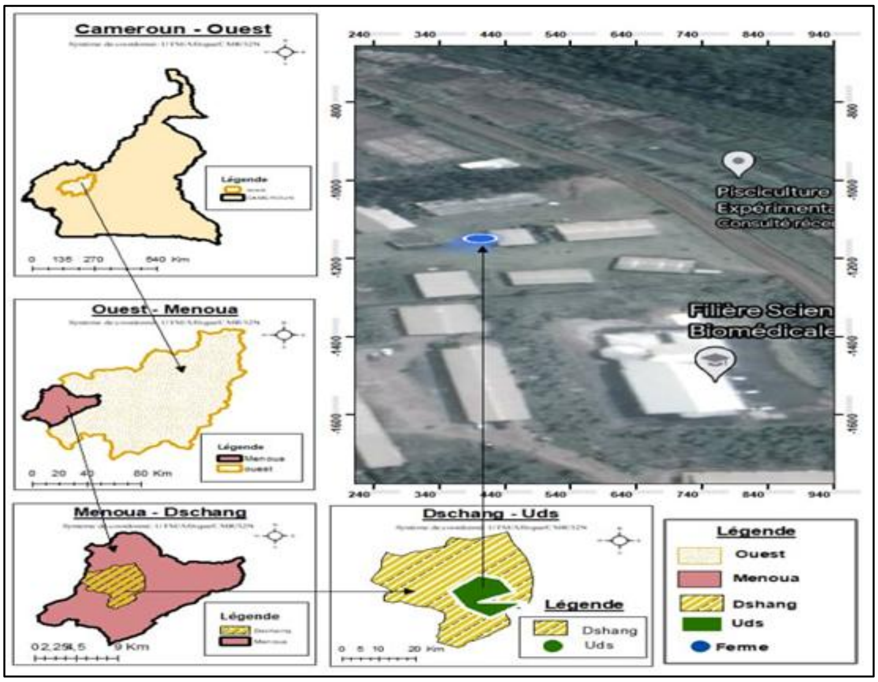

Figure 1 : *Geographical location of the study area*

2-2. Experimental design and zooplankton culture

The experimental design consisted of 4 treatments: T1, T2, T3 corresponding respectively to doses 10; 16; 21 of guinea pig droppings and T0 control (unfertilised basins) distributed randomly and in triplicate in 12 basins with a capacity of 30 L, all protected against rain by a plastic sheet in the form of a greenhouse. These basins placed on a shelf were filled with 25 L of borehole water and fertilised at different doses of fertiliser apart from the control basin. The set-up was allowed for acclimatisation for 10-days to promote the phytoplankton development process before seeding copepods, rotifers and cladocerans at the respective densities of 18, 2 and 9 ind/L of water, obtained by filtering 100 L of water from a local pond using a plankton net with a 40µm mesh size according to the standard methodology [13]. Guinea pig droppings were collected from a semi-intensive guinea pig farm in the town of Mbouda. A 20g sample of this fertiliser was taken and sent to the Soil Science Laboratory of the University of Dschang to determine its concentration of Nitrogen, Phosphorus and Cellulose ***(Table 1)***.

Table 1 : *Chemical composition of fertilisers*

Sample (% DM)	Crude Cellulose	Nitrogen	Phosphorous
Guinea pig droppings	26	1.97	1.04

DM = Dry Matter.

2-3. Determination of water physicochemical quality and zooplankton population structure

The temperature, dissolved oxygen, conductivity and depth of the water were measured in each basin every two days using an multiparameter, a conductivity meter and a limnimetre respectively. The contents of nutrient salts (nitrate, nitrite, ammoniacal nitrogen and phosphates) were measured by the colorimetric method with Nitraver3, Nitriver3, Nessler, and Phosver3 reagents respectively. The concentration of non-ionized ammonia was deduced from that of ammoniacal nitrogen following ***Equation 1***.

$$N - NH3 = \frac{N - NH_4^+}{1 + 10^{10 - pH - 0.03T}} \quad (1)$$

With, N-NH$_3$ and N-NH$_4^+$ in mg / L ; T is the temperature in °C.

Zooplankton collection was done immediately after collecting physicochemical data between 6:30 and 8:00 a.m. according to the specific method by filtration of 2 L of water using a 40 µm diameter plankton net [13]. The retained filtrate, 10 mL was fixed with 5 % formalin and then transported to the Laboratory of Ichthyology and Applied Hydrobiology (University of Dschang) for identification. The observation was done using a binocular optical microscope (MOTIC type, B 4X) for a qualitative and quantitative inventory following the analysis method of three sub-samples of 2 mL each. Zooplankton were identified using classic identification keys [21 - 26]. Following this inventory, the density (D), daily production (P), intrinsic biomass growth rate (Kr) and relative abundance index (RAI) of zooplankton were calculated.

2-3-1. Density (D)

This refers to the measurement and analysis of the concentration of zooplankton per water volume. It is calculated using the following ***Equation 2***:

$$D = \frac{n}{V1} \times \frac{V2}{V3} \quad (2)$$

with, n = number of individuals counted ; v1 = volume of filtrate collected ; v2 = volume of concentrated filtrate ; v3 = total volume of water filtered.

2-3-2. Daily production (P)

This refers to the amount of new biomass produced daily by zooplankton. It determines the availability of food for higher trophic levels (fish). The daily production is calculated according to ***Equation 3***.

$$P = \frac{NT - No}{t} \quad (3)$$

with, NT = Final number per ml of filtrate ; N0 = Initial number/ml of filtrate ; t = Colonisation time of zooplankton species (in days).

2-3-3. The intrinsic rate of increase in zooplankton biomass (Kr)

This variable measures how quicky zooplankton can grow under ideal conditions. It is a factor of growth and mortality rates as sweel as age structure. It was computed following ***Equation 4***.

$$Kr = \frac{\ln NT - \ln No}{t} \quad (4)$$

Where, NT = Final number per ml of filtrate ; N0 = Initial number/ml of filtrate ; t = Colonisation time of zooplankton species (in days).

2-3-4. The relative abundance index (RAI)

The RAI is a description of the proportion of each species in a community or an ecosystem, in relation to the total number of individuals present. It was calculated following ***Equation 5***.

$$RAI = \frac{NT}{NG} \times 100 \quad (5)$$

with, NG=Number of individuals in a group; NT=Total number of individuals.

2-3-5. Biomass

Zooplankton biomass was calculated using the standard methods [27], i.e. 0.07 mg/ind for rotifers, 0.08 mg/ind for copepods at the nauplius stage and 0.47 mg/ind for copepod mixtures. 3.5; 2.7 and 0.2 mg/ind respectively for adult females, juveniles and neonates of cladocerans [28]. Ultimately, the biomass of each group of zooplankton is its density multiplied by these previously defined indices ***(Equation 6)***.

$$B = D \times P \quad (6)$$

with, D = density (ind/L); P = dry weight (µg/ind).

2-4. Statistical analyses

Data was keyed by means of Microsoft 365 Family, then imported into SPSS version 21 for various analyses. To test the effect of guinea pig droppings dose on zooplankton productivity, the collected data were subjected to one-way analysis of variance (ANOVA I). In case of significant difference, Duncan's test at the 5 % significant level was used to separate the means. Pearson correlation tests were used to determine the relationship between the physicochemical characteristics of the water and the density of zooplankton groups.

3. Results

3-1. Effect of fertiliser dose on physicochemical parameters of water

Apart from electrical conductivity and dissolved oxygen, the other physicochemical parameters of water were not significantly affected by the fertiliser dose. Indeed, significantly high values ($p < 0.05$) of electrical conductivity (181.33 ± 13.96 µs/cm) and dissolved oxygen (5.2 ± 1.61 mg/L) of water were observed with the 21g dose of guinea pig droppings. However, the highest but not significant temperature values (22.94 ± 1.84°C) were recorded in the unfertilised basins compared to the basins fertilised at doses 10, 16 and 21g. While pH (8.25 ± 0.44 IU) and nitrate (7.11 ± 5.89 mg/L) presented the lowest values in the unfertilised basins ***(Table 2)***.

Table 2 : *Mean and standard deviations of the physicochemical characteristics of water according to the fertiliser dose*

Physicochemical characteristics of water	Doses of guinea pig droppings				
	0 g	**10 g**	**16 g**	**21 g**	***p***
pH	8.25 ± 0.44^a	8.46 ± 0.46^a	8.33 ± 0.50^a	8.36 ± 0.54^a	0.701
Conductivity (µS/cm)	91.55 ± 5.32^a	143.55 ± 4.62^b	168.88 ± 5.98^b	181.33 ± 13.96^c	0.000
Nitrites (mg/L)	1.73 ± 1.70^a	1.46 ± 1.27^a	1.2 ± 1.08^a	1.2 ± 1.08a	0.638
Phosphates (mg/L)	797.77 ± 495.12^a	782.22 ± 279.13^a	808.88 ± 263.2^a	842.22 ± 252.7^a	0.968
Temperature (°C)	22.94 ± 1.84^a	22.74 ± 1.91^a	22.77 ± 1.96^a	22.78 ± 1.86^a	0.999
Dissolved Oxygen (mg/L)	3.75 ± 0.86^a	4.17 ± 0.74^b	4.24 ± 0.71^b	5.2 ± 1.61^c	0.004
Nitrates (mg/L)	7.11 ± 5.89^a	7.66 ± 6.77^a	8.33 ± 5.23^a	7.33 ± 4.57^a	0.940

a, b, c, d; values assigned the same letter on the same line do not differ significantly ($p > 0.05$); p = probability.

3-2. Effect of the dose of guinea pig droppings on biological parameters

3-2-1. Density of zooplankton groups as a function of the dose of guinea pig droppings

Apart from copepods whose densities increased significantly ($p < 0.05$) with the dose of guinea pig droppings, the densities of the other zooplankton groups varied regardless of the dose ***(Figure 2)***. The highest significantly ($p < 0.05$) rotifer density values (279 ind/L) were observed with doses of 16 and 21 g of guinea pig droppings and the lowest values in the unfertilised basins. The highest density values for cladocerans (136 ind/L) and copepods (302 ind/L) were obtained with the 21 g dose. As for nauplii, the lowest values (20 ind/L) were observed in the unfertilised basins. At equal doses, apart from the unfertilised basins where the densities of zooplankton groups were low, the densities of zooplankton groups varied overall. Indeed, rotifers were denser in the basins fertilised at doses of 10 and 16 g while copepods were denser in the basins fertilised at the dose of 21 g of guinea pig droppings.

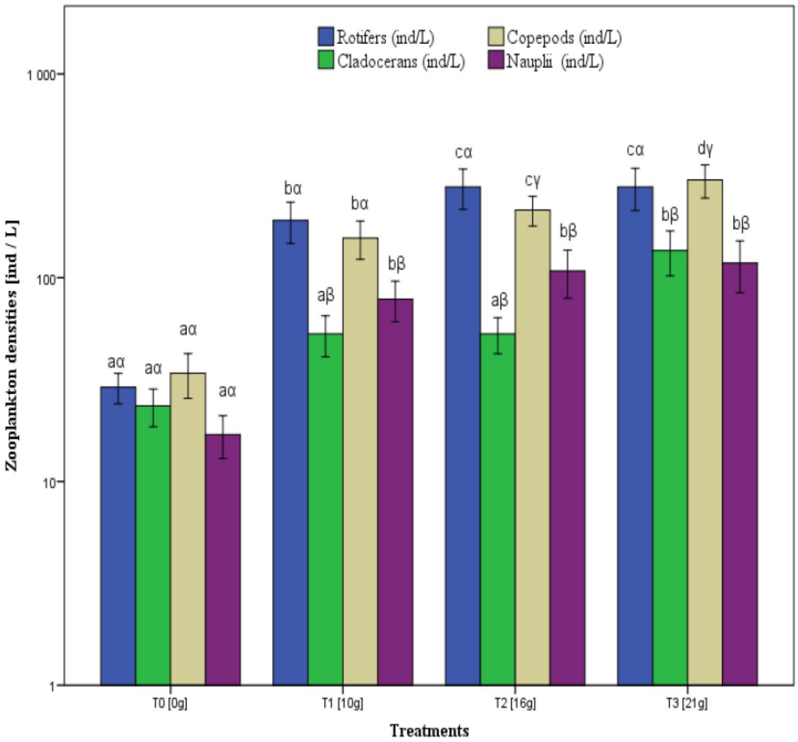

Figure 2 : *Densities of zooplankton groups as a function of the dose of guinea pig droppings : α, β, γ : bands with the same symbol and from the same treatment do not differ significantly (p ≥ 0.05). a, b and c : bands with identical letters and colours do not show any significant difference (p ≥ 0.05)*

3-2-2. Biomass of zooplankton according to the dose of guinea pig droppings

Except for nauplii whose significantly ($p < 0.05$) highest biomass values are observed with doses 10, 16 and 21 g, the highest biomasses of all zooplankton groups are recorded with dose 21g ***(Table 3)***. At equal doses, cladocerans were significantly ($p < 0.05$) more productive in terms of biomass both in unfertilised basins and those receiving different doses of fertiliser.

Table 3 : *Influence of the dose of guinea pig droppings on the biomass of zooplankton groups*

Zooplankton groups	**Biomass (mg)** **Doses of guinea pig droppings**			
	T0	T1	T2	T3
Rotifers	$1.89 \pm 0.52^{a\alpha}$	$12.74 \pm 0.33^{b\alpha}$	$21.14 \pm 2.75^{c\alpha}$	$21.00 \pm 1.09^{c\alpha}$
Cladocerans	$67.50 \pm 0.75^{a\beta}$	$135.00 \pm 2.00^{b\beta}$	$135.00 \pm 0.15^{b\beta}$	$405.00 \pm 4.75^{c\beta}$
Copepods	$13.16 \pm 0.66^{a\gamma}$	$75.20 \pm 3.09^{b\gamma}$	$112.80 \pm 4.00^{c\gamma}$	$159.80 \pm 2.02^{d\gamma}$
Nauplii	$1.20 \pm 1.11^{a\alpha}$	$7.04 \pm 2.21^{b\lambda}$	$8.80 \pm 3.00^{b\lambda}$	$6.00 \pm 2.75^{b\lambda}$

- *a, b, c, d; values assigned the same letter on the same row do not differ significantly (p ≥ 0.05).*
- *α, β, γ, λ; values assigned the same symbol on the same column do not differ significantly (p ≥ 0.05).*

3-2-3. Daily production of zooplankton groups as a function of guinea pig droppings dose

The daily production of zooplankton groups as a function of guinea pig droppings doses as illustrated in ***Figure 3*** shows a significant increase ($p < 0.05$) with the guinea pig droppings dose for cladocerans, copepods and nauplii. In rotifers, the significantly highest daily production values were observed in the fertilised tanks. Independent of the fertiliser dose, the highest daily production value was recorded in nauplii (57 ind/L/d) followed by copepods (46 ind/L/d); while the lowest value was observed in rotifers (2.00 ind/L/d). At equal doses, apart from unfertilised basins where no significant difference was observed in terms of daily production between copepods and nauplii, the significantly higher values ($p < 0.05$) were recorded only with nauplii in fertilised basins.

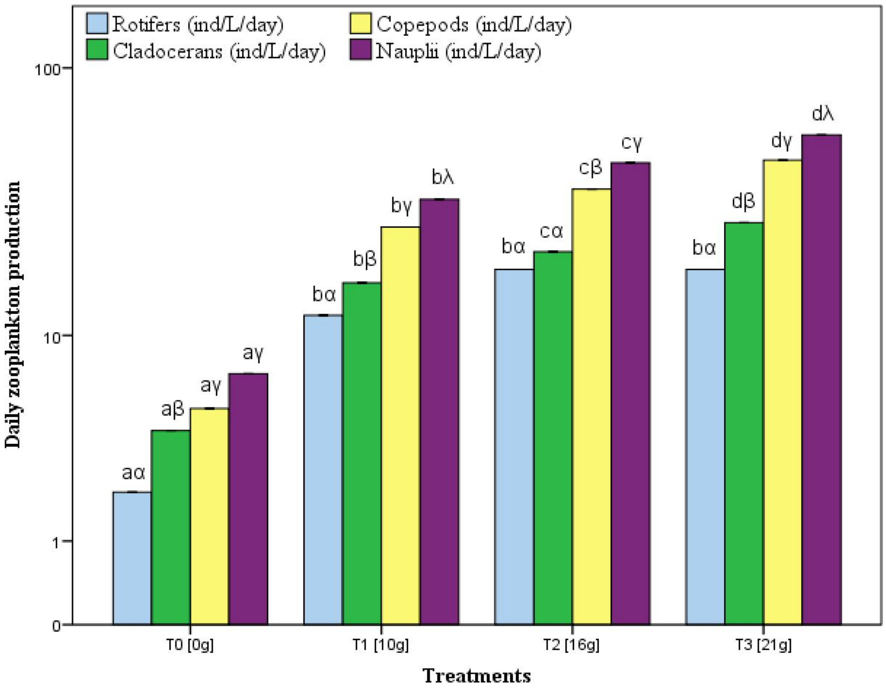

Figure 3 : *Daily production of zooplankton groups as a function of the dose of guinea pig droppings : α, β, γ ; λ : bars with the same symbol and from the same treatment do not differ significantly ($p > 0.05$). a, b, c, d: bands with identical letters and colours do not show any significant difference ($p > 0.05$)*

3-2-4. Intrinsic rate of increase of zooplankton groups as a function of the dose of guinea pig droppings

Except for the basins fertilised with doses 16 and 21g, this rate was low overall. However, the highest values of the nauplii increase rate significantly were observed with doses 16 and 21g of fertiliser. While the highest intrinsic rate of increase in copepod biomass was significantly recorded with the 21 g dose ***(Figure 4)***. At the same dose, with doses 0 and 10g, no significant difference in the intrinsic rate of increase in biomass was observed between zooplankton groups. In the ponds fertilised at the 16g dose, the highest rate of increase was observed in nauplii. However, in the ponds fertilised at the 21g dose, the highest intrinsic rate of increase in biomass values were significantly obtained in copepods and nauplii.

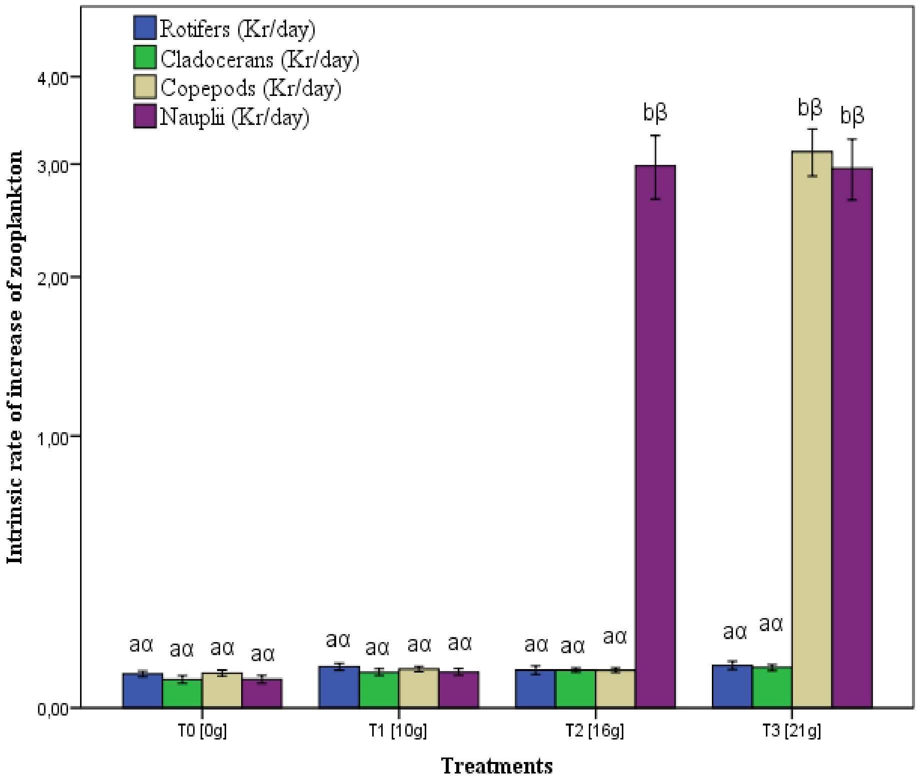

Figure 4 : *Intrinsic growth rate of zooplankton groups as a function of the dose of guinea pig droppings; α, β : bars with the same symbol and from the same treatment do not differ significantly (p > 0.05). a, b, c, d: bands with identical letters and colours do not show any significant difference (p > 0.05)*

3-2-5. Biological evolution of the density of zooplankton groups as a function of the dose of guinea pig droppings

The biological evolution of the densities of zooplankton groups as a function of the dose of guinea pig droppings is illustrated in ***Figure 5***. Except for copepods where the evolution is sawtooth, the density evolution curves of all other zooplankton groups presented the same profile, the same shape and trend materialized by a colonisation and decolonisation phase. In Rotifers ***(Figure 5A)***, the peak of production was reached on the 12th day with doses 10 and 16 g, on the 14th day with doses 0 g (80 ind/L) and 21 g (832 ind/L). In Cladocera ***(Figure 5B)***, peak production was reached on day 10 with the 10 g dose (248 ind/L), day 12 with the 16 g dose and day 14 with the 0 and 21 g doses (432 ind/L). Regardless of the fertiliser dose, peak production in Copepods ***(Figure 5C)*** was reached on day 14. However, the highest values were observed with the 21 g dose and the lowest in the basins receiving no fertiliser. Apart from Day 4 where the highest copepod density was observed with the 16 g dose of fertiliser, copepod densities were higher with the 21 g dose throughout the trial period. Furthermore, in Nauplii ***(Figure 5D)***, the highest production peak was observed on day 12 with the 21g dose (512 ind/L) followed by doses of 16 g (432 ind/L), 10 g (232 ind/L) and 0g (56 ind/L) on day 14, respectively. Nevertheless, at the end of the trial, the highest densities of all zooplankton groups were observed with the 21 g dose and the lowest in the unfertilised ponds.

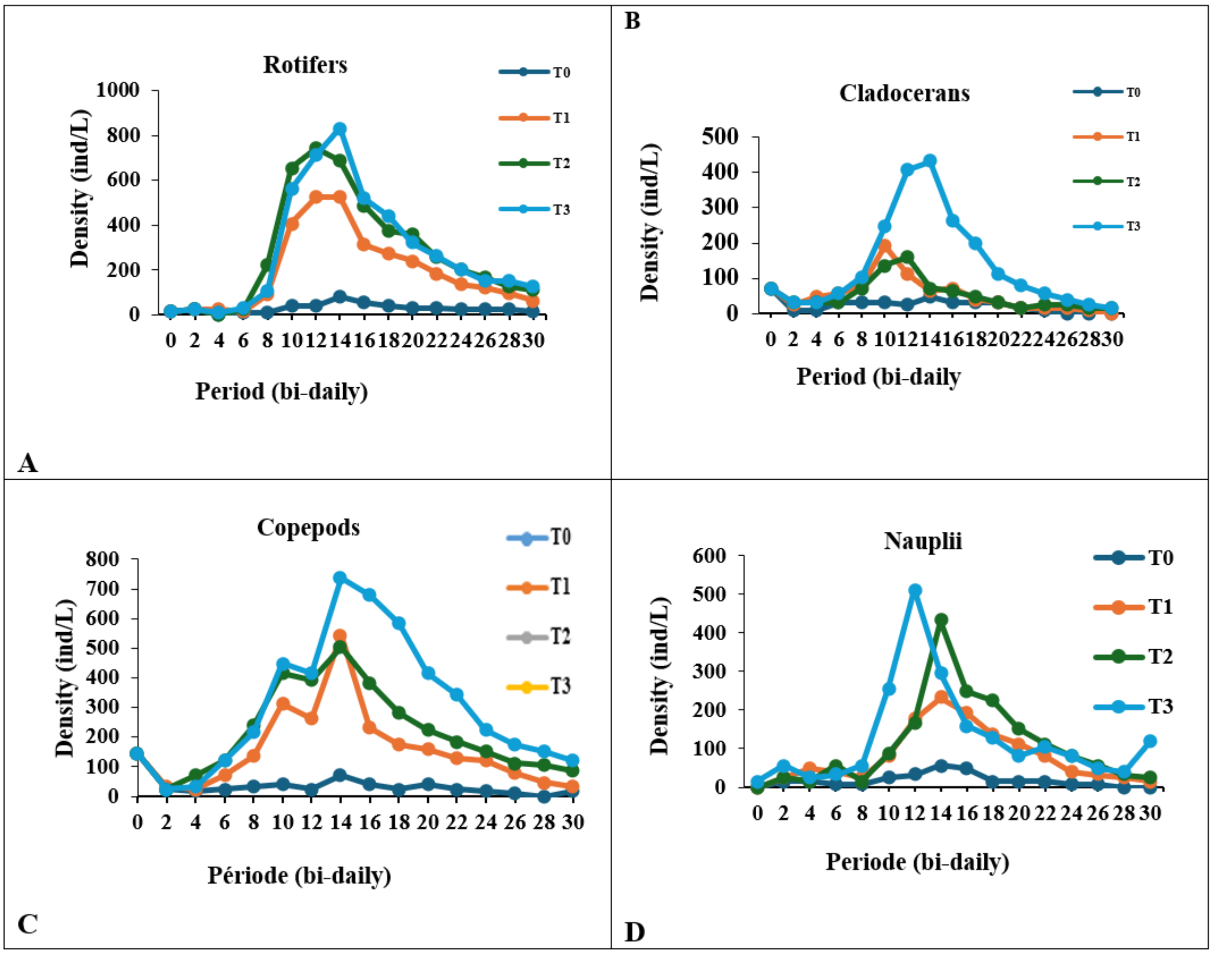

Figure 5 : *Jewel-like evolution of the density of zooplankton groups as a function of the fertilization dose : T0, T1, T2 and T3 : basins fertilised respectively at doses 0, 10, 16 and 21 g*

3-2-6. Relative abundance index of zooplankton groups as a function of the dose of guinea pig droppings

Rotifers were more abundant in the basins fertilised at doses 16 and 21g, while cladocerans and copepods were more abundant in the basins fertilised at dose 21g *(Figure 6)*. As for nauplii, they were significantly more abundant in the basins fertilised regardless of the dose. At equal doses, copepods were more abundant compared to other zooplankton groups in the control basins. While copepods and rotifers were more prolific in the basins fertilised at doses 10 and 21g. As for the ponds fertilised at the 16g dose, the rotifers were significantly more abundant.

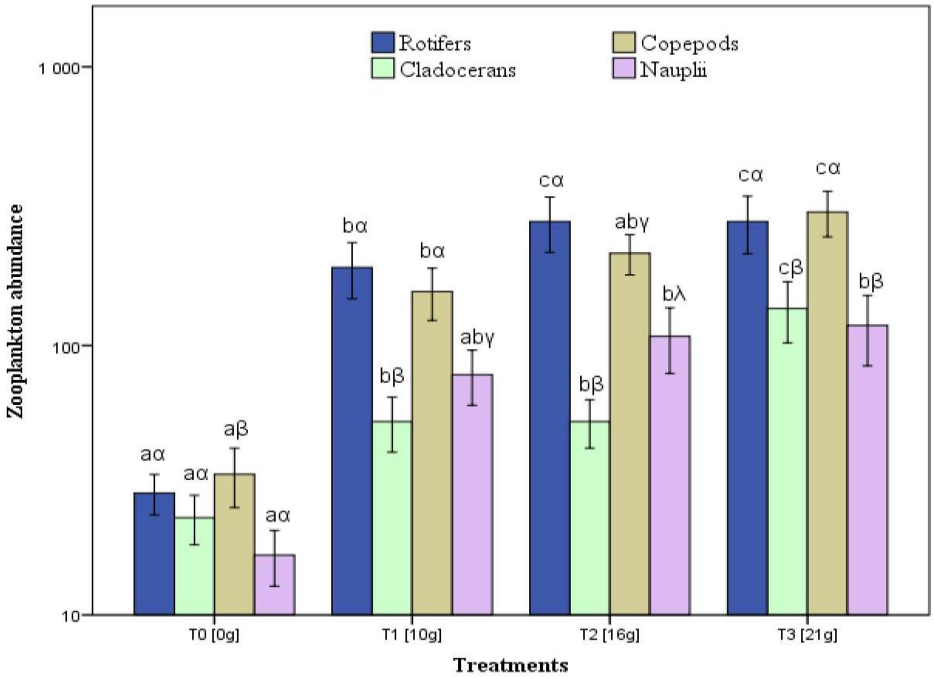

Figure 6 : *Relative abundance index of zooplankton groups as a function of the dose of guinea pig droppings : α, β, γ; λ: bars with the same symbol and from the same treatment do not differ significantly (p ≥ 0.05). a, b, c: bands with identical letters and colours do not show any significant difference (p ≥ 0.05)*

3-3. Association between water physicochemical quality and zooplankton density

Correlations were generally significantly medium between the density of the zooplankton groups and the physicochemical characteristics of the water ***(Table 4)***. The densities of rotifers, cladocerans and copepods were negatively and moderately correlated ($p < 0.05$) with the electrical conductivity of the water in the basins fertilised at doses of 10 and 16 g of guinea pig droppings. The densities of cladocerans and copepods in the control treatments of guinea pig droppings were highly correlated, positive and strong ($p < 0.01$) with the water temperature. In addition, the densities of cladocerans with doses of 10 and 16 g and nauplii with dose 10 g of guinea pig droppings were positively correlated ($p < 0.05$) with water pH. Nitrite (NO_2-) showed significant and positive correlations with the densities of cladocerans, copepods and nauplii at doses of 10, 16 and 21 g ($p < 0.05$). Phosphates were positively and strongly correlated ($p < 0.05$) with the densities of copepods in unfertilised ponds.

Table 4 : *Correlations between the physicochemical characteristics of water and the densities of zooplankton groups*

Zooplankton groups	Treatments	Physicochemical characteristics of water						
		EC	Temp.	pH	DO	NO_2^-	NO_3^-	PO_4^{3-}
Rotifers	T_0	+0.010	+0.049	+0.293	-0.061	+0.359	-0.437	+0.330
	T_1	-0.604*	-0.604*	+0.465	+0.101	+0.359	+0.015	-0.165
	T_2	-0.541*	+0.039	+0.169	-0.425	+0.456	-0.292	-0.028
	T_3	+0.095	-0.197	-0.304	-0.196	+0.443	-0.277	+0.210
Cladocerans	T_0	-0.354	+0.668**	-0.008	-0.316	+0.109	-0.217	+0.209
	T_1	-0.541*	+0.085	+0.541*	-0.207	+0.258	+0.119	+0.171
	T_2	-0.502*	+0.065	+0.498*	-0.269	+0.169	-0.209	-0.021
	T_3	+0.032	-0.225	-0.151	-0.052	+0.537*	-0.203	+0.266
Copepods	T_0	-0.336	+0.848**	-0.226	-0.266	-0.045	-0.217	+0.848**
	T_1	-0.504*	+0.052	+0.447	+0.014	+0.255	+0.014	-0.136
	T_2	-0.571*	-0.033	+0.166	-0.404	+0.567*	-0.176	+0.124
	T_3	+0.051	-0.199	-0.305	-0.229	+0.136	+0.000	+0.084
Nauplii	T_0	-0.290	-0.077	+0.291	-0.077	+0.408	-0.294	+0.336
	T_1	-0.479	-0.232	+0.515*	+0.151	+0.503*	-0.004	-0.082
	T_2	-0.358	-0.222	-0.058	-0.435	+0.759**	-0.217	+0.152
	T_3	+0.130	-0.400	-0.374	-0.253	+0.274	+0.018	+0.195

** Correlation is significant at the 0.05 level (two-tailed), ** Correlation is significant at the 0.01 level (two-tailed), EC : electrical conductivity, DO: dissolved oxygen, NO_2^-: nitrite, NO_3^-: nitrate, PO_4^{3-}: phosphates, Temp : temperature; T0, T1, T2, T3: basins fertilised respectively at doses 0, 10, 16 and 21g.*

4. Discussion

4-1. Water physicochemical quality

The results relating to the effect of the dose of guinea pig droppings on the physicochemical parameters of the water showed that the physicochemical characteristics of the water remained within the range tolerated by the zooplankton species with high values obtained in the fertilised environments. Indeed, the variations in water temperature observed in the different environments enriched with fertiliser were homogeneous and are in the range of 20 to 30 ° C as previously recommended [29]. This temperature homogeneity (in all culture media) could be linked to the regulating action of the greenhouse. The high dissolved oxygen concentrations recorded in basins fertilised with guinea pig droppings, compared to the control media, would be linked to the biological activity of the microorganisms that are more abundant there [15]. Except for phosphates, the contents of dissolved nutrients (nitrites and nitrates) remained below previously described thresholds [30]. However, the high nitrite and nitrate contents recorded in the fertilised basins can be related to the high nitrogen content (1.97). On the other hand, the decomposition of the fertiliser was relatively rapid overall because of its low cellulose content (26 %). This result differs from that obtained previously on the comparative production of zooplankton in basins fertilised with chicken droppings and guinea pig droppings where the latter (guinea pig droppings) containing a higher cellulose content, took a relatively long time to decompose [15].

4-2. Zooplankton density, biomass and daily production

The high values of density, biomass and daily production were obtained in the basins fertilised with guinea pig droppings at doses of 10, 16 and 21 g respectively. The high densities of zooplankton groups obtained with the fertilised basins can be related to the high contents of biogenic elements (nitrogen and phosphorus) in the fertiliser. Indeed, the multiplication of zooplankton organisms increases as soon as they find abundant algal food (rich in nitrogen and phosphorus) in their environment [31]. This would explain the high values of physicochemical parameters such as pH, nitrates and orthophosphates obtained in the basins fertilised with guinea pig droppings. These results corroborate with previous findings on the effect of pig manure dose on zooplankton productivity in microcosm according to which basins fertilised with pig manure with the 25g dose presented high densities those of [14]. The biomass values of the different zooplankton groups increased with the guinea pig droppings dose. The highest biomass value was obtained with cladocerans in all treatments. This would be related to the difference in weight between zooplankton groups (0.07 µg/ind for rotifers, 0.08 µg/ind for copepods at the nauplius stage, 0.47 µg/ind for adult copepod mixtures and 3.5; 2.7; 0.2 µg/ind (dry weight) for adult females, juveniles and neonates of cladocerans respectively [32]. The results relating to the relative abundance of zooplankton groups showed that rotifer and copepod species were more dominant in the basins fertilised with guinea pig droppings with doses of 16 and 21 g compared to cladocerans and nauplii. This could be explained by food competition within zooplankton groups. This assertion is consistent with previous findings that emphasised that the high representativeness of rotifers in an environment biologically indicates its trophic level [33]. These results differ from those previously obtained [13], and could be explained by the fact that species belonging to rotifer groups have an organism that is tolerant enough to resist an enrichment of the environment in organic matter and a gradual depletion of oxygen [21]. The almost identical development of rotifers, cladocerans, copepods and nauplii corroborates previous research [15]. However, it differs from previous reports according to which, one week after fertilisation, rotifers abound in the environment while cladocerans and copepods abound after two weeks [34]. This result could be explained by the fact that the low cellulose content would have impacted the degradation time of guinea pig droppings. Rotifers having reproduction by parthenogenesis and a varied mode of nutrition can filter suspended organic matter to quickly grow and reproduce. Copepods being adults at the time of seeding, will reproduce quickly and give the nauplii that will populate the environment; this will result in a relationship of predation of copepods exerted on other zooplankton groups in the production environments. Regarding the dynamics of zooplankton populations, the rapid drop in zooplankton densities after peak production is thought to be due to lack of food (phytoplankton), self-regulation, decreased fertility, and pollution [35]. According to a previous report, periodic harvesting of zooplankton eliminates older individuals from the production environment [14],. Indeed, the older the parental females of rotifers become, the more they exert a negative influence on fertility [36].

4-3. Zooplankton and water abiotic variables

All the zooplankton groups (rotifers, cladocerans and copepods) had a significant associated with water abiotic variables such as conductivity, temperature, pH and nutrients. This is an indication that these taxa can be exploited as bioindicators of water abiotic variables as earlier reported [33, 37]. Water abiotic variables should then be well monitored in aquaculture systems to ensure production.

5. Conclusion

At the end of this study on the effect of the dose of guinea pig droppings on zooplankton productivity in a model system, the main conclusions are as follows: the density, biomass, dynamics, daily production, intrinsic rate of increase in biomass and the relative abundance index of the different zooplankton groups were significantly affected by the dose of guinea pig droppings. The dose of 21 g of guinea pig droppings is the one that significantly affected zooplankton productivity and should be recommended in the production of fish fry. Physicochemical parameters such as water temperature, pH, orthophosphates and nitrites seem to positively influence better productivity of zooplankton organisms, while electrical conductivity negatively impacts the densities of these organisms.

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