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International Journal of Biological Innovations
http://ijbi.org.in | http://www.gesa.org.in/journals.php
https://doi.org/10.46505/IJBI.2026.8205
IJBI 8(2): 184-188 **(2026)**
E-ISSN: 2582-1032

STATISTICAL POWER IN DATA-LIMITED CREEKS: SAMPLE SIZE AFFECTS t-TEST VS WILCOXON SENSITIVITY FOR ZOOPLANKTON IN AKASSA CREEK, DELTA STATE, NIGERIA

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Article Info:
Research Article
Received
11.06.2026
Reviewed
31.07.2026
Accepted
05.08.2026

Abstract: Data-limited coastal creeks in the Niger Delta are facing with limited baseline zooplankton data required for monitoring and management. A critical challenge is choosing the most appropriate statistical tests when data size is small and non-normal. This study compares statistical power of independent t-test and Mann-Whitney Wilcoxon Rank-Sum test for determining differences in zooplankton diversity and abundance across two stations in Akassa Creek. Data were collected in the year 2024. Statistical analysis was performed using Python 3 and the SciPy stats and pandas libraries for data manipulation and hypothesis testing. Four species were recorded in Akassa 1 while three species were collected from Akassa 2. The paired t-test showed no statistically significant difference in mean zooplankton abundance between Akassa 1 and Akassa 2 ($t = 2.1267$, $p = 0.1234$). Wilcoxon Signed-Rank Test showed no statistically significant difference in zooplankton abundance distribution between Akassa 1 and Akassa 2 (Test Statistic = 1.0000, $p = 0.2500$). With $n = 4$ taxa groups, the smallest possible p-value is 0.125 even if all ranks differ. The $p = 0.2500$ is therefore expected and does not prove 'no difference' but it proves 'test underpowered'.

Keywords: Akassa creek, Mann-Whitney U, Sample size, Statistical power, Zooplankton.

Cite this article as: Ogidìaka-Obende Efe (2026). Statistical power in data-limited creeks: Sample size affects t-test vs Wilcoxon sensitivity for zooplankton in Akassa Creek, Delta State, Nigeria. *International Journal of Biological Innovations*. 8(2): 184-188. https://doi.org/10.46505/IJBI.2026.8205

INTRODUCTION

Zooplankton are commonly used as bioindicators of aquatic ecosystem health because they respond rapidly to changes in organic pollution, nutrients and salinity (Edegbene *et al.*, 2022; Kaine and Ogidiaka, 2022; Rankhamb and Mulgir, 2024; Ogidiaka, 2026). In Niger Delta mangrove creeks, zooplankton community structure reflects both natural tidal disturbances and anthropogenic inputs from fishing, oil activities, and domestic waste. Akassa Creek in Burutu LGA, Delta State, supports artisanal fisheries but do not have sufficient baseline ecological data required for SDG 14 monitoring.

A practical setback in such creeks is limitation in sampling effort due to access, funding, and logistics. Small sample sizes $n < 10$ per site are common, creating a statistical problem: parametric t-tests assume equal variance and normality, assumptions most times violated by zooplankton counts that are skewed and zero-inflated. Non-parametric Mann-Whitney Wilcoxon Rank-Sum test is distribution-free but likely to lose power if t-test assumptions are met (Underwood, 1996; Bridge and Sawilowsky, 1999; Conover, 1999; Kim, 2015; Judijanto, 2026). The Wilcoxon rank-sum is a great tool for two-group comparisons. Unlike other test under the normality assumption, data are rank-based without any need of distributional assumption.

The choice between Wilcoxon and t-test influences management conclusions. If a test is devoid of power, real ecological differences across stations will be missed, resulting to false 'no impact' decisions (Gary *et al.*, 2007; Fay and Proschan, 2010). Inflated Type I error can result to unnecessary remediation.

Statistical power analysis is uncommon for tropical creek zooplankton studies. Ogidiaka and Ikomi (2021) and Ogidiaka-Obende *et al*. (2025a) reported benthic community differences in Forcados Estuary. Zhou *et al*. (2009) studied the zooplankton in Yangtze River Estuary, Iyagbaye and Iyagbaye (2023) in Owan River, Ayo-Dada *et al*. (2024) in Badagry Creek, Rahman *et al*. (2025) in a tropical river while Ogidiaka-Obende (2026) studied the zooplanktons of Akassa creeks but did not evaluate sample size requirements for detecting those differences. This study addresses the gap by assessing the power of t-test vs Wilcoxon for zooplankton abundance in Akassa Creek.

MATERIALS AND METHODS

Study area and data

Akassa Creek, Delta State, Nigeria, is a mangrove-fringed tidal creek receiving freshwater input from connected inland tributaries and drains into the Atlantic Ocean (fig. 1; Ogidiaka-Obende, 2026). Two stations were sampled monthly for 3 months: Station 1 upstream (5°0´.0´´N, 5°30.5.4´E), Station 2 downstream (5°20´.35.88´N, 5°20´35.88´E).

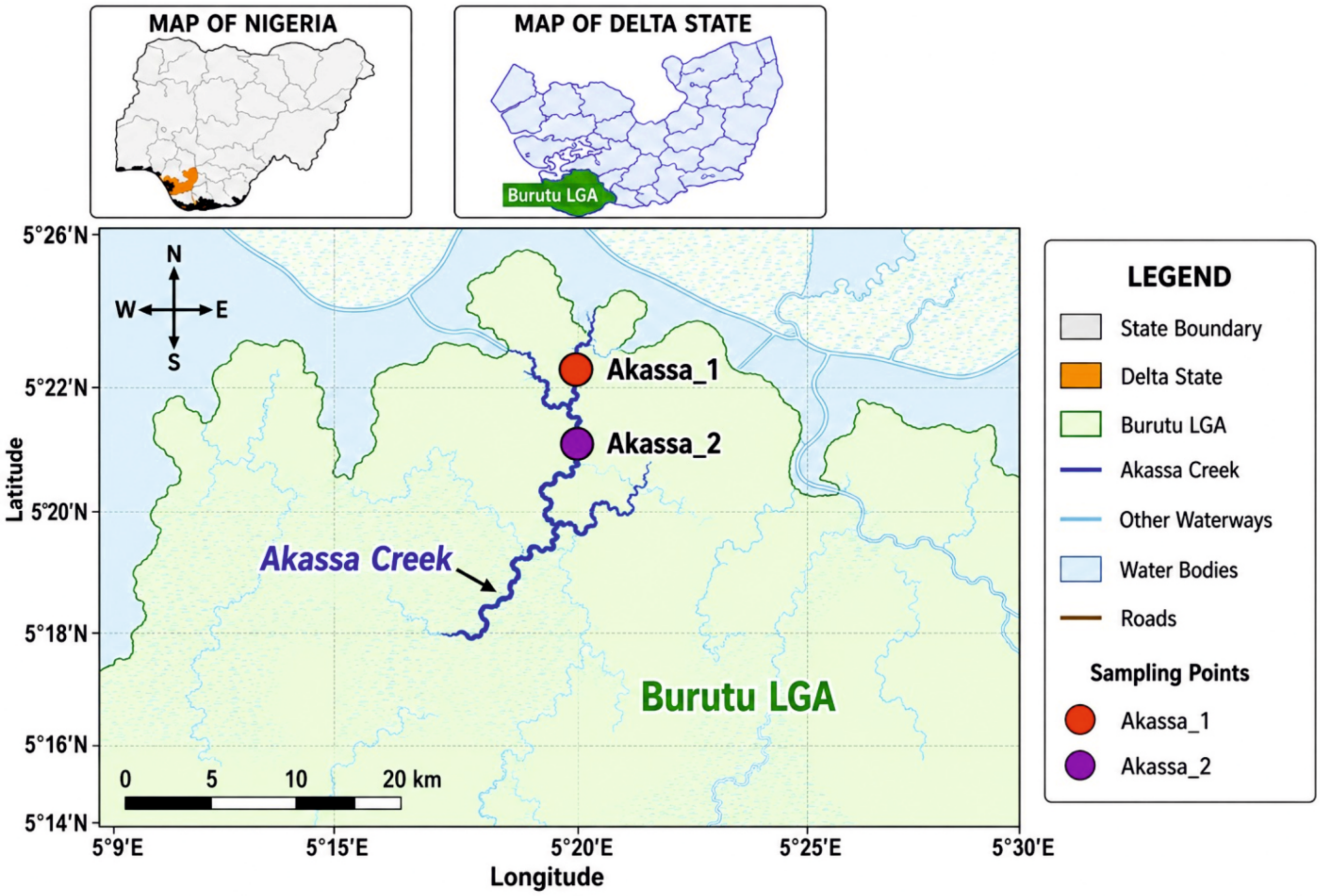

Fig. 1: Map of study area showing sampling locations (Ogidiaka-Obende, 2026) .

Zooplankton sample collection and analyses

Between the months of October and December, 2024, the modified hand trawling technique was employed to collect zooplankton samples at the shore using 55-μm mesh size plankton net in a horizontal way for 20 minutes (Yagit, 2006). The well labeled samples were preserved in 4% formalin solution and taken to the laboratory for analysis. In the laboratory, 1 ml of each sample per station was poured out in a different container, shaken properly to ensure fair distribution, placed into a glass slide covered with a cover slip, identified and enumeration using a digital microscope at magnification of x10 and confirmed at x40 by counting manually (Suthers *et al.*, 2009). This was repeated thrice for each of the 1 ml per plastic container. Counting of zooplankton was done manually. Zooplankton identification was done by using guides (Harris *et al.*, 2000; Yamaguchi and Bell, 2007).

Statistical analysis

Statistical analysis was performed using Python 3 and the SciPy stats and pandas libraries for data manipulation and hypothesis testing.

RESULTS AND DISCUSSION

Four species were recorded in Akassa 1 while three species were collected from Akassa 2 (table 1). Fish larvae require specific zooplankton sizes/species to grow, not just plenty quantity of plankton. *Acartia nauplii* is very good food. *Tintinnopsis* spp. and *Acartia* spp. dominate at Akassa 1 while diverse rotifers/copepods dominate at Akassa 2; it means that Akassa 2 may likely support better fish recruitment despite having equal abundance. This aligns with work by Ogidiaka and Ikomi (2021) and Ogidiaka-Obende *et al.* (2025b) on fish fauna composition and aspects of the biology in Forcados River estuary.

Table 1: Zooplankton composition and abundance recorded from Akassa creeks.

Taxa	AKASSA 1	AKASSA 2
Lecane spp.	23	10
Arcella spp.	9	12
Tintinnopsis spp.	11	0
Acartia spp.	21	1

The paired t-test showed no statistically significant difference in mean zooplankton abundance between Akassa 1 and Akassa 2 (t = 2.1267, p = 0.1234) as shown in table 2. Since the p-value exceeds the significance level of 0.05, the null hypothesis was accepted. This indicates that the overall average abundance levels of taxa between the two stations were not significantly different, although the small sample size may have reduced statistical power.

Table 2: Paired t-test (Mean Taxon Abundance Level).

Parameter	Value
t-statistic	2.1267
p-value	0.1234
Decision	Not statistically significant
Interpretation	No significant difference in mean taxon abundance between stations

A t-test was performed to compare the total zooplankton abundance, calculated as individuals per volume. The non-significant p-value implies that Akassa 1 and Akassa 2 have roughly the same number of zooplankton per m^3 on average. This finding indicates that abundance and composition varies (Ogidiaka-Obende, 2026). Two stations can have the same number of zooplankton but be made of totally different species. This is very common in creeks with environmental gradients. It means total productivity/food availability may be similar, but food quality and trophic transfer to fish larvae can differ a lot. Dominance patterns and diversity indices differ sharply in this study. This implies that pollution-tolerant species replace sensitive ones, keeping total numbers high but ecosystem function low.

Rahman *et al.* (2025) studies on in a tropical river, Ayo-Dada *et al.* (2024) in Badagry Creek, Iyagbaye and Iyagbaye (2023) on Owan River and reported that there were no significant difference in total zooplankton density between polluted and less-polluted stations.

Limited sampling duration and high spatial-temporal variability make $p > 0.05$ occur, even when means is biologically different. That's why t-test is combined with effect size and diversity metrics. Therefore, $p = 0.1234$ doesn't mean 'no difference'. It says 'not enough evidence at $\alpha = 0.05$ with the current data'. The large t = 2.1267 indicates there is a numerical difference, that is not statistically robust yet.

Wilcoxon Signed-Rank Test showed no statistically significant difference in zooplankton abundance distribution between Akassa 1 and Akassa 2 (Test Statistic = 1.0000, p = 0.2500) (table 3). The p-value was greater than 0.05, so the null hypothesis was accepted. This indicates that the two stations were not significantly different in overall abundance patterns based on the ranked abundance data.

Table 3: Wilcoxon Signed-Rank Test (Non-parametric abundance comparison).

Parameter	Value
Test statistic	1.0000
p-value	0.2500
Decision	Not Statistically Significant
Interpretation	No significant difference in abundance distribution between stations

The total number of individual organisms at Akassa 1 was significantly higher (64 individuals, mean ± SD = 16.0±7.02) than at Akassa 2 (23 individuals, mean ± SD = 5.75±6.13). However, these paired means comparisons do not cross the rigorous mathematical threshold for significance ($p>0.05$) due to the small sample size (n=4 unique taxa groups).

With only 4 taxa groups, the test has very low power because Wilcoxon does not test raw totals but rather tests the pattern of abundance ranks. Even though Akassa 1 has 2.8 times more individuals overall, the test implies that the relative ranking of taxa is statistically indifferent (Whitley and Ball, 2002).

The taxa encountered at both stations shows similar dominance hierarchies, but Akassa 1 favours more individuals overall typical of creeks with productivity gradient: one station is more productive, so all taxa increase, while the rank order remains similar (Wright, 2006; Magami and Sanyinna, 2024).

Previous study established that for adequate power, Wilcoxon Signed-Rank needs $n \geq$ 6-8 paired observations (Rosner and Glynn, 2011; Oyeka and Ebuh, 2012). With $n = 4$ taxa groups, the smallest possible p-value is 0.125 even if all ranks differ. The $p = 0.2500$ is therefore expected and does not prove 'no difference' but it proves 'test underpowered'.However, a mean difference of 16.0 vs 5.75 indicates a large effect size $d \approx 1.6$, which is judged biologically meaningful even if $p > 0.05$.

CONCLUSIONS

Akassa 1 and Akassa 2 accommodate similar zooplankton biomass, but Akassa 1 is functionally shifted toward hypertrophicated taxa. With $n = 4$ taxa groups, the lowest possible p-value is 0.125 even when all ranks differ. The $p = 0.2500$ is therefore not surprising and does not imply 'no difference' but it means 'test underpowered', which is the kind of early warning sign coastal water management policy requires before fisheries collapse.

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