DRIFTING FISH AGGREGATING DEVICE (DFAD), AN EMERGING THREAT TO SEISMIC SURVEYS IN DEEP OFFSHORE OIL EXPLORATION IN NIGERIA.

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ABSTRACT

The deeper offshore waters of Nigeria are home to diverse ichthyofauna and also endowed with abundant oil and gas. Exploration of oil and gas in these locations is opening up a new environmental and navigational challenge, namely the advent of drifting Fish Aggregating Devices (dFADs). These artificial structures, which are sometimes of other nationalities than Nigeria, drift into Nigerian waters where they wrap themselves around seismic cables and also destroy some equipment. Therefore, the objective of this paper was to assess the growing overlap of drifting Fish Aggregating Devices (dFADs). This study investigates the growing overlap of drifting FAD use and seismic survey work in the deep offshore region of Nigeria with the aims to provide baseline statistics about dFAD sightings in survey blocks, assess associated operational risks, and recommend strategic mitigation pathways for industry stakeholders. Data were collected by trained fisheries liaison officers (FLO) aided by DJI Pro 3, unmanned aerial vehicles (UAVs) situated on the bridge of source vessel at 17.35m.a.s.l. for eight months. Drifting aggregating devices detected were recovered, photographed and classified. Overall, 57 dFADs were recovered and spatially and seasonally trends were found. The report found at-sea observation rate of 0.066 dFAD/h and recorded four entanglement events resulting in 32 hours of lost Seismic operations. This study shows that an average of 7dFADs is encountered for every 100-hr operation, thereby increasing the risk of seismic equipment damage and loss of man hour during recovery. Hence, regionally coordinated management and application of the tools for advanced surveillance to address dFAD-related oil and gas versus fisheries interactions is recommended. This investigation has provided a baseline statistic about dFAD sightings in survey blocks, assess associated operational risks and recommend strategic mitigation pathways for industry stakeholders.

Keywords: Seismology; Hydrocarbon Exploration; Fisheries; Conflict; Mitigation

INTRODUCTION

The Niger Delta region of Nigeria is populated with ethnic nationalities like Ijaws, Itsekiris, Calabaris, Ilajes etc. whose main occupation had been fishing from past generations till today. Fishing is not merely a source of livelihood; it has been part of a tradition that has been carried through generations, and thus it is almost integrally linked with the identity of the people of the region. Coincidentally, the same water bodies that support their livelihoods in the ultra-deep offshore region is a rising frontier for hydrocarbon exploration, containing enormous proportions of Nigeria's oil and gas reserves. Seismic surveys, specifically 3D and 4D seismic methods, are the pivotal tools in subsurface imaging that enable precise reservoir characterization of the ultra-deep waters (Okafor *et al.*, 2020; Nwankwo and Ibitoye, 2023). These surveys require seismic vessels fitted with cables about 500 to 1000m long towing arrays of guns that can get tangled up with fishing gears. Over the past decade, major international oil companies operating in Nigeria including Shell, ExxonMobil, Chevron and Total Energies have actively divested from onshore and Shallow-water assets, citing operational risk, community disruptions and theft, while directing investment towards more secure and economically viable deep offshore fields where returns are higher and regulatory framework more predictable (Adeoye, 2024).Unfortunately, the most recent offshore explorations are now challenged by the drifting component of the Fishing Aggregating Device (FAO, 2024)

The presence of dFADs complicates seismic survey operations in several aspects. First, they may be mistaken for surface noise artifacts or unidentified floating objects during data analysis from the survey. Secondly, marine animals getting entangled in nets and the materials used for netting will trigger unnecessary shutdowns to surveys at a cost to the project and extended schedules (Onuoha and Briggs, 2023). Moreover, the devices can interfere with towed streamers of hydrophones or air gun arrays, creating navigational hazards and compromising data quality (Ezenwa *et al.*, 2022). Drifting aggregating devices had been at the center of attention for some ecologists outside Africa, although the same could not be said for environmental scientists in Africa and by extension, Nigeria. Thus, very little information is available on dFADs interaction with seismic operations in Nigerian waters. To state a specific fact, the Federal Department of Fisheries (pers. Com.) informed that the revised sea fisheries act of Nigeria 2022, forbids the deployment of fish aggregating devices as a gear. However, other nations within the Gulf of Guinea (i.e., Benin, Equatorial Guinea, Ghana, Togo and Cameroun) have different regulatory framework. Non-anchored FADs deployed in these countries invariably drift into Nigerian waters as dFADs constituting an environmental challenge to Nigerian deep offshore hydrocarbon exploration. (Olakunle *et al.,* 2025)

As mounting anecdotal data from seismic activities and marine mammals' observers operating offshore Nigeria accumulates, there has been no scientific literature to estimate the magnitude of frequency and operational impact of dFADs in the Gulf of Guinea (Olakunle and Ndubisi, 2021). Currently, there are no existing maritime laws that comprehensively address this complex interaction between fisheries technology and oil geophysics (Olalekan *et al*., 2025). Hence, the objective of this paper is to provide baseline statistics about dFAD occurrence in deep offshore survey blocks, assess associated operational risks, and recommend strategic mitigation pathways for industry players and regulators alike.

MATERIALS AND METHODS

Study Area*:*
Survey area was 7817km, with preplot lines three times, which covered 118 sail lines over a total of 6000 Sq km. The lines averaged 66.3 km and had a spacing of 750m between them. The survey was roughly 70 km from the Nigerian southern regions. Bottoms ranged from 50m at the southeast corner to 2000m at the western survey boundary. The coordinates of the surveyed area are as shown in Table 1.

Table 1: Coordinates of study Area

Point ID	Easting (Metres)	Northing (Metres)
1	977795.5	424982.1
2	978322.2	337276.6
3	939197.4	337180.3
4	864977.1	334071.6
5	709241.9	333701.6
6	588823.4	333553.2
7	588756.6	414611.6
8	588367.2	525151.9
9	612672.9	525179.5
10	649642.8	527085.5
11	721755.1	527260.7
12	745715.2	527341.3
13	745703.8	516272.9
14	827308.4	424355.3
15	977795.5	424982.1

Methodology
Joint Nature Conservation Committee (JNCC, 2017) guidelines and methodology was adopted for on-board data collection.

Trained Fisheries Liaison Officers (FLOs) complemented the use of unmanned aerial vehicles (UAVs) from the source vessel's bridge at 17.35m.a.s.l. There were naked-eye observations, aided by high-definition hand-held reticule binoculars (Nikon Ocean Pro-Marine 7 x 50 IF-PW compass daylight and night vision adapted binoculars nocturnal). Appropriately equipped dFADs with GPS transmitters were also tracked on the OCRA (Ocean Control Real-time Acquisition) software of the source vessel, which has data stream subscriptions from three of the largest providers: Zunibal, Global Marine, and Satlink.

To monitor and track offshore drifting Fish Aggregating Devices (dFADs) in the study area, DJI Pro 3 UAVs were employed. The UAV model is equipped with an Integrated Zenmuse X9-8k Air gimbal camera that provides high-quality imaging necessary for stable video capture detail. Tailored flight plans were created in Speed, Navigation aids, Approach briefing and Pre-landing (SNAP) checklist from Waypoint Pro's altitude, direction of heading, speed, and camera tilt capabilities, and all mission routes simulated prior to execution to guarantee precision and safety. Three DJI Pro 3 UAVs were used interchangeably throughout the survey duration. Drones were flown from the source ship's helideck at a height of 14.35 meters mean sea level. Flights were made from 6am to 7pm UTC. Each UAV had a 1.5km operational range diameter and flew up to 65m above sea level for up to one hour, with four-hour rotations all around the three drones. A total of 293 flights consisting of 89 hours and 17 minutes of shooting over a distance of 2197km were conducted for eight months in equally divided wet and dry seasons.

Pre-flight included RTK calibration, battery tests, and gimbal alignment tests. Two operators were responsible for navigation and camera control, with raw video recorded in 8k/25fps pro-res mode and stored on DJI PROSSD drives configured to a RAID-5 system. Synchronous metadata such as GPS coordinates and log timestamps were used in conjunction with GIS software in spatial-temporal analysis.

Workboats were employed for retrieving dFADs, taking photographs of them, and sorting them based on their transmitters (Fig. 1). Real-time tracking of different units with GPS trackers was facilitated using OCRA software, retrieving data streams from Zunibal, Global Marine, and Satlink for effective retrieval. Retrieved dFADs were sorted, photographed, weighed, and GPS-location-tagged, timed, and dated on desk forms adapted from Joint National Conservation Committee (JNCC) guidelines, 2017.

In order to assess the seasonal difference of dFADs, dry season (November to February) and wet season (July to October) total weights recovered of dFADs were compared. The weight data yielded for both seasons were tested by a two-sample independent t-test to determine if there was any statistically significant difference between dFAD presence during the wet season and dry season. The $p \leq 0.05$ was utilized as the t-test significance level. Data were also analysed using descriptive statistics, including frequencies and percentages. The results were presented in tables and illustrated in bar charts and pie charts for clearer visualization.

RESULTS

The intensive monitoring campaign involved a total of 293 unmanned aerial vehicle (UAV) sorties with a total effective effort of 89 hours and 17 minutes of flight time at a total distance of 2,197 kilometers. Flights operated at an average height of 37.5 meters sea level. This organized activity, which was held over a span of seven months between July 2023 and February 2024, led to the recovery of 63 drifting Fish Aggregating Devices (dFADs) weighing a total of 2,631 kilograms. The field survey period was also separated into the wet season (July to October 2023) and the dry season (November 2023 to February 2024).

Observation tallies reported at-sea dFAD abundance of 0.001 devices/km² and a sighting frequency of 0.066 dFADs per hour of search effort spent observing. On seismic, four individual entanglement incidents were reported directly resulting in a total of 32 hours of lost operational time. This equates to an average encounter rate of approximately 7 dFADs per 100 hours of seismic activity.

Identification of the recovered dFADs revealed three different models of GPS locator transmitters: T8E (Zunibal), MGiGO (Global Marine), and SLX (Satlink). A large percentage of the recovered dFADs, 42 out of 63 (66.7%), were unidentifiable as no distinguishable manufacturer codes or transmitters were present. Among the identifiable units, 14 were from Zunibal, 4 from Satlink, and 3 from Global Marine (Table 2).

Monthly recovery data reported varied instances of occurrence of dFAD. The highest incidence of dFAD was in September at 12 units, and the lowest was in January at 4 units (Table 2). The recovered weights were highest in September at 625 kg, and lowest in January at 221 kg. The other recovered weights of interest were in August at 544 kg and in November at 556 kg (Figure 2 and Figure 3).

An independent two-sample t-test was used to establish seasonal variation in the frequency of dFAD encounters based on contrasts of the total weight of dFADs encountered during the wet (July-October) and the dry season (November-February). There was no statistically significant variation in the weights of dFADs between the two seasons ($p > 0.05$) (Figure 4). The implication of this is that dFAD encounters are a ubiquitous phenomenon, with monthly intensities varying (Figure 7).

Regional distribution of dFADs within the study area showed varying densities and some regions had increased concentrations of recoveries (Figure 6) and thereby reflect increased areas of operation risk. Incidents of entanglement incidents in dFADs and seismic cables were reported and documented (Figure 1).

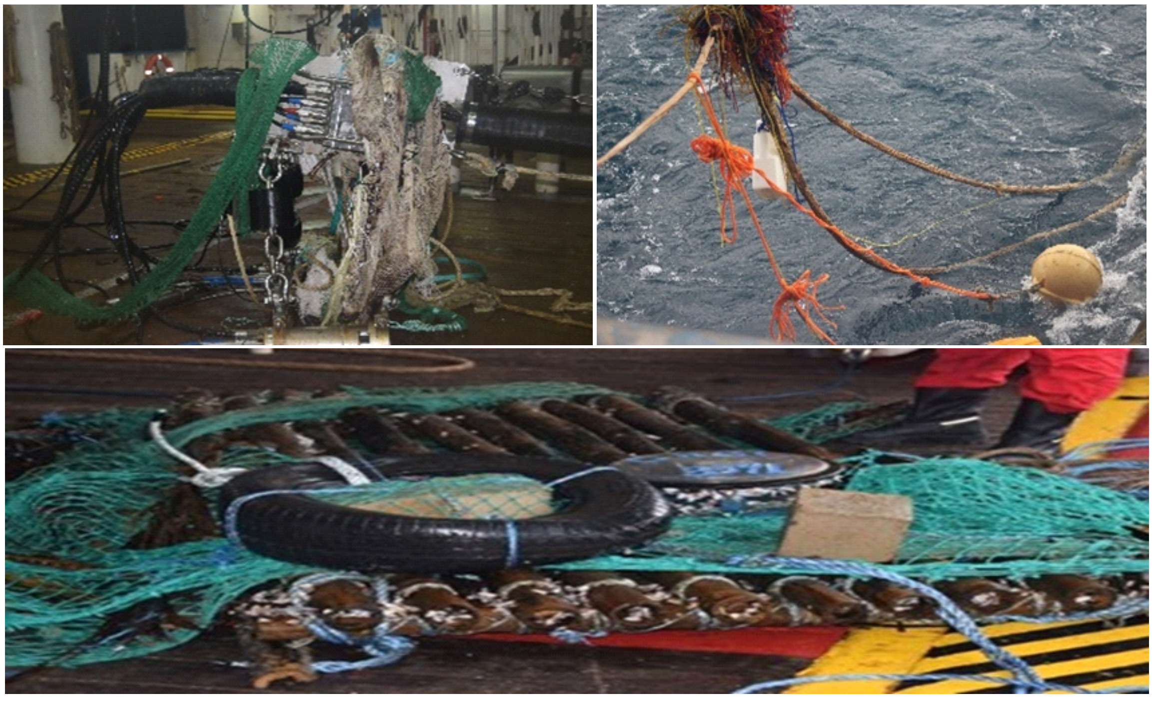

Table 1: Classification of retrieved dFADs based on GPS ID

Month	Zunibal	Global Marine	Satlink	Unidentified	Total
July	4	0	0	3	7
Aug.	4	0	0	4	8
Sept.	2	0	0	10	12
Oct.	1	1	1	2	5
Nov.	0	0	0	12	12
Dec.	1	1	0	7	9
Jan.	0	0	2	2	4
Feb.	2	1	1	2	6
Sub-total	14	3	4	42	63

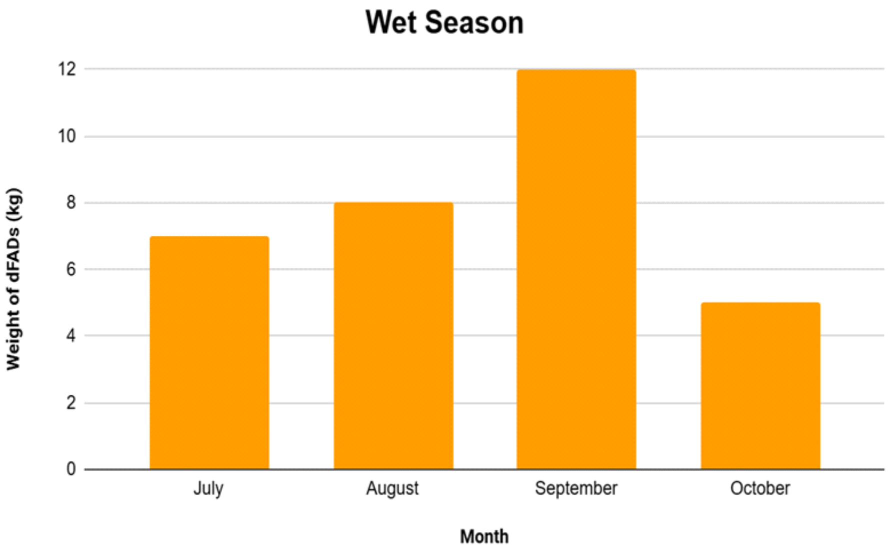

Fig. 2: dFADs by Weight recovered During Wet months of July- Oct., 2023

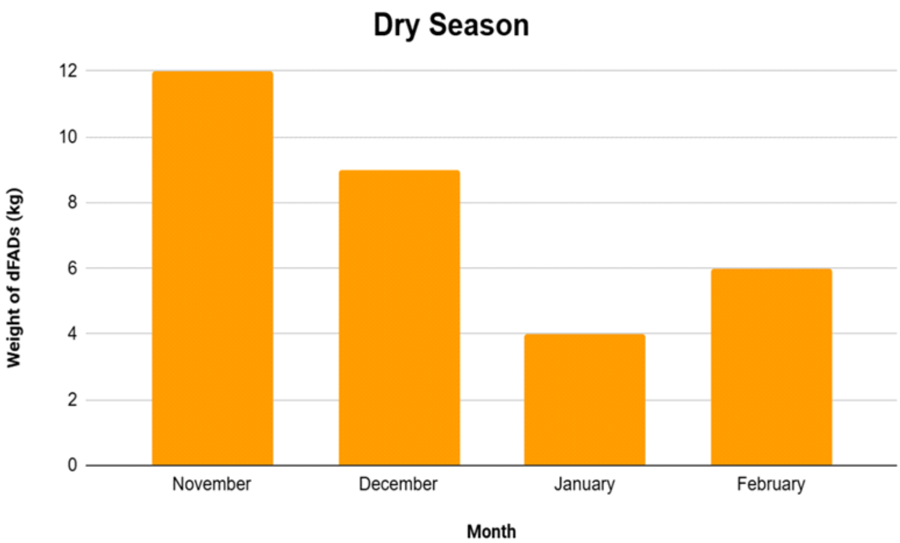

Fig. 3: dFADs by Weight recovered during dry months of Nov., 2023 to Feb., 2024

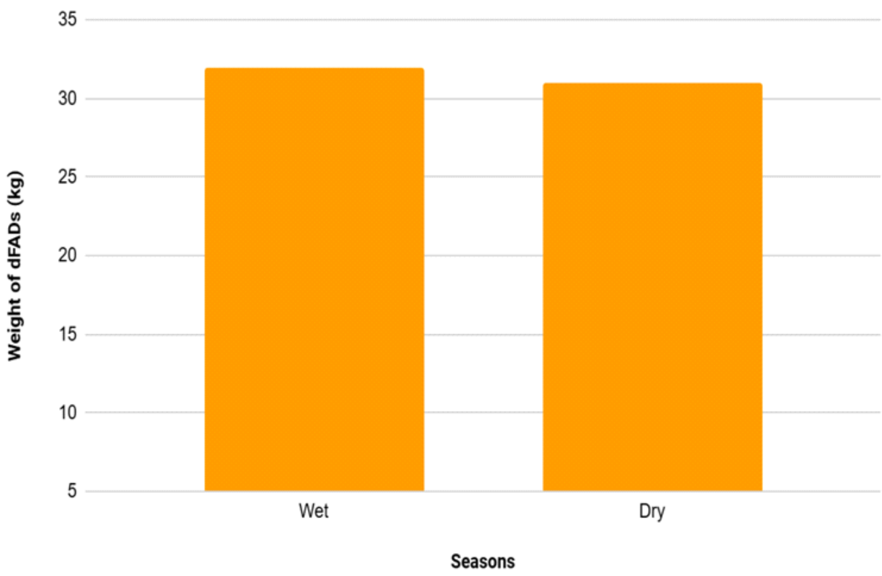

Fig. 4: Comparison of dFADs by Weight recovered During Wet and dry seasons

Fig. 5: spatial distribution of dFADs in Study Area

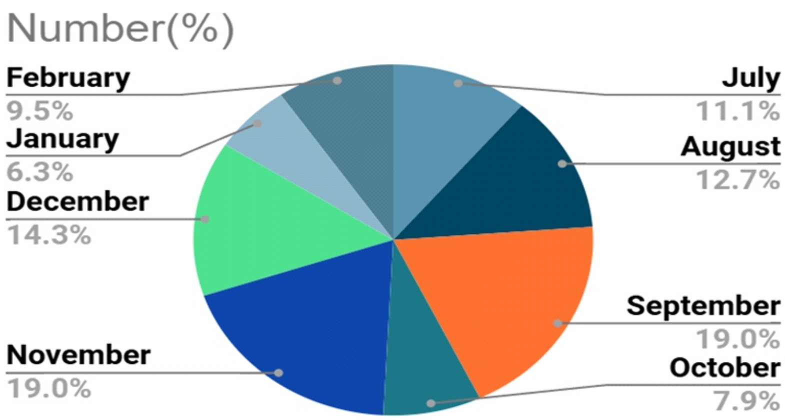

Fig 6: Percentile Monthly dFADs Occurrence

DISCUSSION

The surveillance campaign using unmanned aerial vehicle (UAVs) from July 2023 to February 2024 yielded significant insights into the prevalence and impact of drifting Fish Aggregating Devices (dFADs) on deep offshore seismic operations in Nigeria. The recovery of 63 dFADs, totaling 2,625 kilograms, over eight months, alongside the extensive UAV flight data (89 hours, 17 minutes of effort, 293 flights covering 2,197 km), underscores the substantial presence of these devices in the study area. The calculated dFAD density of 0.001 per km^2 and a sighting rate of 0.066 dFADs per hour, while seemingly low, translate to a considerable operational risk given the size and duration of seismic surveys. Entanglement sometimes could result into damage of expensive seismic cables and where damage is minimal considerable man-hour is lost disentangling the dFADs.

The monthly analysis of dFAD recovery weights revealed dynamic patterns. While September recorded the highest recovery at 625 kg and January the lowest at 221 kg, the notable recoveries in August (544 kg) and November (556 kg) suggest that dFAD presence is influenced by regional oceanographic conditions that vary throughout the year, rather than being strictly confined to a single "fishing season." The lack of a statistically significant difference in total weights between the wet (July–October) and dry (November–January) seasons ($p > 0.05$) Fig.5, shows that dFAD entanglement is a year-round concern, albeit with fluctuating monthly intensities (Fig.7). This finding is crucial for proactive risk management, emphasizing the need for continuous monitoring rather than seasonal interventions.

The classification of dFADs by transmitter codes highlighted a critical issue: a vast majority (70%) were untagged. The presence of tagged dFADs from international vendors like Zunibal (14 units), Satlink (4 units), and Global Marine (3 units) in Table1 confirms the trans-boundary nature of this problem. This suggests that a significant proportion of dFADs encountered in Nigerian waters originate from beyond its maritime boundaries, likely drifting from neighboring countries where FAD deployment is permitted for pelagic fisheries. Recorded entanglement cases as shown in Fig. 2 directly demonstrate the economic and operational impact of dFADs. Man-hour loss in order to disentangle the dFADs translates to significant financial implications for exploration companies, further emphasizing the need for effective mitigation strategies.

The spatial distribution of dFADs as depicted in Fig.6 strongly underscore the threat posed by dFADs to seismic operations, particularly in regions with active pelagic fishing industries and dynamic ocean currents. The current prohibition of FAD deployment in Nigerian waters by the Federal Department of Fisheries (FDF) is rendered insufficient by the influx of dFADs from neighboring nations. This necessitates a broader, collaborative approach. The proposed real-time monitoring and rapid-response systems, leveraging UAVs and trained Fisheries Liaison Officers, are a pragmatic step towards mitigating immediate risks. However, the long-term solution requires a regional framework for dFAD management.

Adeoye, (2024) reported the increasing shift of oil exploration into deep offshore fields in Nigeria, driven by security concerns in coastal areas. This exacerbates the vulnerability of seismic operations to dFAD entanglement. Given that countries like Ghana, with established tuna fisheries that utilize FADs, are also emerging as oil producers, the potential for conflict between the oil and gas and fishing industries in the Gulf of Guinea is escalating. Therefore, intergovernmental agencies within ECOWAS must prioritize discussions on harmonized regulations and collaborative solutions for dFAD tracking and removal. Future research should focus on tracing the origins of untagged dFADs through advanced tagging and tracking technologies and expand its scope to encompass the Exclusive Economic Zones (EEZs) of multiple countries. Such a regional study would provide a comprehensive understanding of the problem's scale and facilitate the development of effective, trans-boundary management strategies. This research provides foundational information and recommendations for navigating the delicate interface between two vital economic sectors, aiming to prevent potential conflicts and ensure sustainable resource exploitation in the sub-region.

CONCLUSION

This investigation has provided a baseline statistics about dFAD sightings in survey blocks, assess associated operational risks, and recommend strategic mitigation pathways for industry stakeholders and has established that non-anchored fish aggregating devices (FADs) deployed in some of the countries like Ghana, equatorial Guinea, Togo and Benin within the gulf of Guinea invariably drift into Nigerian waters as dFADs constituting an environmental challenge to Nigerian deep offshore hydrocarbon exploration. This study recommends a regional collaboration in the management of an incredibly delicate interface between oil and gas, and fishery sector, which harbors explosive potential for conflicts.

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AUTHORS CONTRIBUTION

OGW and AD collected the Data, OGW analysed the data and wrote the draft of this manuscript, while BF and RO provided the platform from which the data was collected and all logistic support for the project. All authors agreed that the manuscript should be submitted for publication.

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