



Extended Fix Intervals Improve GPS/GPRS Tracking Device Accuracy

Mohammed A. Lazim

Ministry of Education\ General Directorate of Education in Wasit

Email: mohammedlazim89@gmail.com

Abstract:

In this study, the effectiveness of GPS/GPRS tracking devices used in ecological investigations is investigated in relation to fix interval and animal deployment. Our goal is to ascertain whether the devices' accuracy is improved by extending the fix interval and whether animal deployment has an impact on their functionality. In order to evaluate device accuracy, we carried out field deployments on a variety of animal species and environments. According to our research, longer repair intervals enhance device performance whereas animal deployment has no effect.

Keywords: GPS, GPRS, tracking devices, fix interval, animal deployment, accuracy.

فترات الإصلاح الممتدة في تحسين دقة جهاز التتبع GPS/GPRS

م.م. محمد عبدالله لازم

وزارة التربية / المديرية العامة للتربية في محافظة واسط

إيميل: mohammedlazim89@gmail.com

المستخلص:

في هذه الدراسة، تم التحقق من فعالية أجهزة التتبع GPS/GPRS المستخدمة في التحقيقات البيئية فيما يتعلق بتحديد الفاصل الزمني ونشر الحيوانات بعد زرع الأجهزة فيها. هدفنا هو التأكد من تحسين دقة الأجهزة من خلال تمديد الفاصل الزمني للإصلاح وما إذا كان نشر الحيوانات له تأثير على وظائفها. من أجل تقييم دقة الجهاز، قمنا بتنفيذ عمليات نشر ميدانية على مجموعة متنوعة من الأنواع الحيوانية والبيئات. وفقاً لبحثنا، فإن فترات الإصلاح الأطول تعمل على تحسين أداء الجهاز، في حين أن نشر الحيوانات ليس له أي تأثير.

الكلمات المفتاحية: نظام التوقع العالمي (GPS)، الخدمة الراديوية العامة (GPRS)، أجهزة التتبع، فترات الإصلاح، نشر الحيوانات، الدقة.

1. Introduction

Insights into unique behavioral patterns and the collection of high-resolution geographical and temporal data for species conservation and management have been made possible by technological advancements, which have had a substantial influence on the collection of animal movement data. [1]. By enabling precise monitoring across several species and habitats, GPS technology has transformed movement ecology [2, 3]. These tracking devices have the ability to broadcast or remotely retain GPS position data, which makes it easier to monitor elusive animals and gather data at longer fix intervals independent of animal movement or memory restrictions [3]. The Global System for Mobile Communications/General Packet Radio Service (GSM/GPRS) transmission protocol makes it feasible to communicate copious volumes of GPS data globally



at a reasonable cost [4]. Device endurance and data collection have been considerably enhanced by solar power and inexpensive remote data transfer [5]. The spatial resolution of GPS position data varies due to environmental and technological variables. Environmental variables such as topography and habitat can affect GPS accuracy, and closed-canopy forests often have less GPS signal availability [5, 6]. Precision can also be impacted by technological aspects like satellite setup and dilution of precision (DOP), with greater DOP values suggesting poorer precision [7]. Although the quantity of satellites and DOP can help with location identification to a certain extent, they are not always reliable forecasters [8,9]. Morphology, mobility, and behavior can have an impact on a GPS device's accuracy and fix acquisition success after being attached to an animal [10,11]. Therefore, it is crucial to measure device accuracy both before and after deployment. Prior to deployment, performance may be assessed by comparing predicted device locations to actual locations, whereas accuracy is often assessed using animals after deployment [12]. For research used in conservation and policymaking, estimating spatial resolution and accuracy is crucial because low accuracy can affect studies on habitat selection, flight altitude, collision risk, and 3D habitat utilization distributions [13]. Poorly precise position identification would enable researchers to improve the caliber of location databases and minimize the limitations brought on by inaccurate GPS locations. The number of tracking devices has increased as GPS tracking becomes more widespread, and each one has different hardware and software that might affect how successful it is [14]. It is essential to examine the precision and accuracy of this equipment in order to determine whether it is suitable for ecological investigations. We evaluate the horizontal and vertical accuracy and precision of a novel GPS/GPRS tracking system for wildlife using stationary testing and deployment on large birds. We consider the potential for detecting low-precision locations using GPS-Error, a measurement provided by GPS devices, and we investigate the potential device variability that may come from this. We also talk about the instruments' potential for ecological and conservation research and evaluate their field effectiveness.[15]

2. Materials and methods GPS/GPRS devices

The Global System for Mobile Communications/General Packet Radio Service (GSM/GPRS) transmission protocol makes it feasible to communicate copious volumes of GPS data globally at a reasonable cost [4]. Device endurance and data collection have been considerably enhanced by solar power and inexpensive remote data transfer [5]. The spatial resolution of GPS position data varies due to environmental and technological variables. Environmental variables such as topography and habitat can affect GPS accuracy, and closed-canopy forests often have less GPS signal availability [5, 6]. Precision can also be impacted by technological aspects like satellite setup and dilution of precision (DOP), with greater DOP values suggesting poorer precision [7]. Although the quantity of



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3. Accuracy And Precision of the GPS/GPRS Tracking Devices

To evaluate their performance, eleven GPS/GPRS tracking devices were subjected to a stationary test. Each animal-deployable device has a 1.5 to 2 millimeter thick nylon plastic housing. The test site was a triangulation station in southern Portugal. You'll find gently sloping plains in this area, along with vast tracts of unirrigated agriculture and only a few cork oak (*Quercus suber*) and holm oak (*Quercus ilex*) trees. On the triangulation station, which was placed about 2 meters from the ground, the equipment was immediately thrown down. When the devices had a clear view of the sky, we remotely programmed them to collect GPS data every minute, twenty minutes, and sixty minutes. We identified the gap between the device coordinates and the precise DGT coordinates for the triangulation station in order to assess horizontal accuracy [46]. The height of the triangulation station above the ellipsoid and the elevations recorded by the instruments were compared to determine the vertical accuracy. The height was overstated when the outcome was positive, while the altitude was underestimated when the result was negative. As a result, we were able to quantify the measurement inaccuracies that are inherent in height measurements.[21] To determine the horizontal accuracy, we computed the mean and standard deviation of the geodesic distance between each point recorded by each tracking device.



The average absolute inaccuracy of each instrument's total height measurements was chosen as a stand-in for vertical accuracy.

We used the Kruskal-Wallis test in a statistical study to compare the accuracy and precision of the devices. This study compared the precision and accuracy of locations acquired at various times using data from all devices.[22]

4. Identification of inaccurate positions

We investigated the potential of identifying places with both horizontal and vertical defects using the GPS-Error measure of the tracking equipment. We focused on areas where the difference exceeded 10 meters. According to how far off the actual locations were, they were divided into three categories: 11–20 meters, 21–30 meters, and more than 30 meters.

In order to assess the usefulness of the statistic, we excluded 1%, 3%, 5%, and 10% of the locations for each tracking device that had the highest GPS-Error values. As a result, it was feasible to determine how many more locations in the dataset included mistakes that exceeded the defined boundaries.

To determine how effectively the GPS-Error measure could identify the locations with the most extreme horizontal and vertical inaccuracy, we compared the three device schedules.

5. Accuracy and precision after deployment on birds

Prior to deployment, we tested the accuracy and precision of 17 GPS-GPRS devices in a fixed location. These devices were designed to go off every 20 minutes and featured a reinforced housing that was 3–4 mm thick. These gadgets were meant to be distributed by white storks. As part of the stationary test, the GPS devices were placed at a triangulation location for four to fifteen days. We obtained three GPS positions and three altitude measurements using a differential GPS mode (dGPS) Ashtech ProMark 220 with an external antenna (Ashtech 660), averaged them, and utilized the results to pinpoint the precise horizontal and vertical coordinates of the triangulation station. The accuracy of the dGPS readings was 0.98 meters (0.07 meters) in the horizontal direction and 0.57 meters (0.42 meters) in the vertical direction. By re-creating the protocol with dGPS coordinates rather of those provided by DGT (Direco-Geral do Território), we were able to accurately assess the GPS device's performance before and after deployment.

17 devices were attached to juvenile white storks (*Ciconia ciconia*) within a 50-kilometer range of the fixed test. This decision was made in light of the numerous geographic and ecological factors that may create errors in GPS readings. The juvenile white storks that were selected for identifying labels had to weigh at least 2.9 kilograms and have wingspans of at least 400 millimeters. Since birth, around 50 days have elapsed. Less than 3% of the bulk of the storks' total body weight



was taken up by the entire equipment, including the harness. The loggers were fastened to the chicks' backs using a Teflon harness that had a biodegradable cotton weak link sewed beneath the sternum. The University of East Anglia's School of Biological Sciences' Animal Welfare & Ethical Review Board approved this work, which was carried out in compliance with the guidelines established by the Instituto do Conservaço do Natureza e das Florestas. The Instituto do Conservaço do Natureza e das Florestas has issued licenses 364/2020/CAPT through 368/2020/CAPT for the loggers' deployment.

As part of the experiment, tools were employed to track the juvenile white storks in their nests in the trees.

Table 1. Number of devices and locations collected during stationary and deployment tests.

Treatment	Fix interval	Number of devices	Number of locations	Horizontal		Vertical	
				Accuracy Mean (sd)	Precision Mean (sd)	Accuracy Mean (sd)	Precision Mean (sd)
Stationary	1 min	1	1929	3.40 (3.10)	4.93 (4.15)	4.95 (4.12)	3.60 (5.94)
	20 min	10	2203	4.23 (4.28)	6.14 (5.46)	6.56 (6.72)	8.79 (9.17)
	60 min	7	1488	6.50 (8.34)	9.15 (9.46)	9.69 (19.28)	14.31 (24.95)
Before Deployment	20 min	17	7333	4.21 (18.0)	7.10 (23.4)	7.00 (71.0)	11.00 (85.1)
After Deployment	20 min	17	5204	4.10 (15.0)	6.72 (19.7)	6.00 (56.0)	10.00 (66.8)

The nests were located high in trees to provide for a wide field of vision. To calculate the precise horizontal and vertical positioning of each nest, we averaged three GPS coordinates that were obtained using dGPS technology from the top of each nest. To assess the precision and accuracy of the tracking devices, we concentrated on the GPS coordinates obtained during the first week after deployment. Given that white stork chicks typically do not leave their nests until 65 days after hatching, this timeframe was chosen to ensure that data would be collected before the young birds fledge. Using the methodologies described above, we evaluated the devices' horizontal accuracy, vertical accuracy, horizontal precision, and vertical precision both before and after deployment.

The Kruskal-Wallis test was used in our statistical analysis to assess the precision and accuracy before and after deployment. The study was carried out in the statistical package R, and the distances were calculated using R's geosphere module.

6.Results

6.1 Stationary Test

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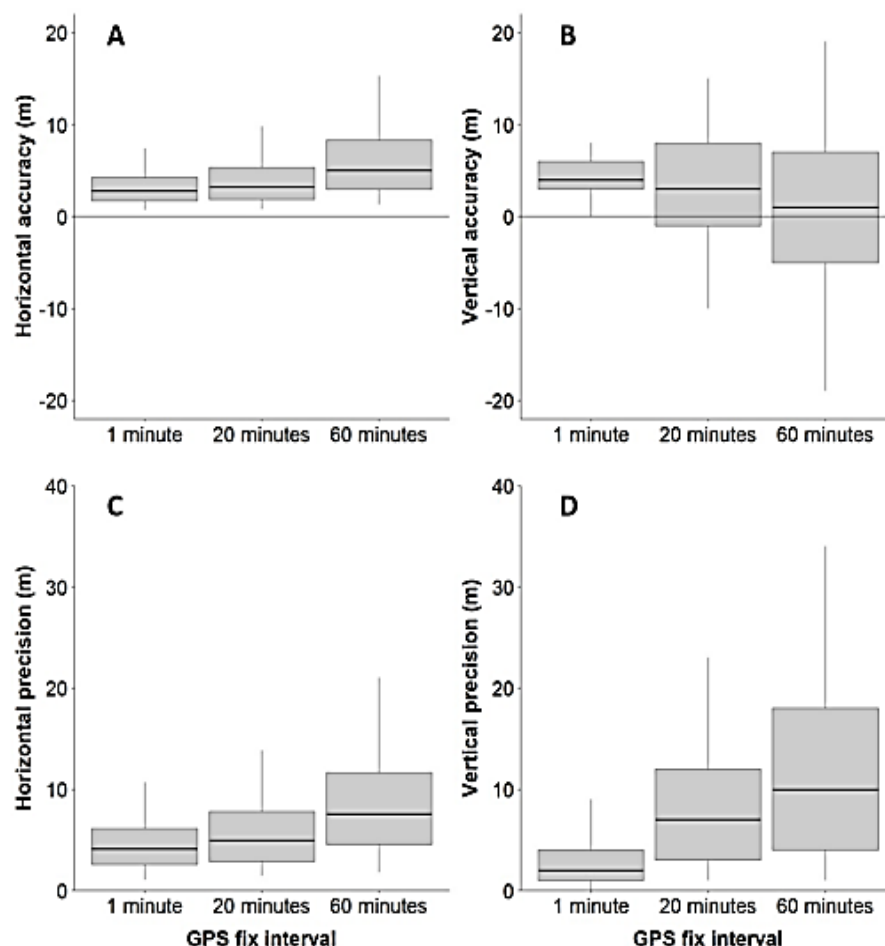


Fig 1. Horizontal and vertical accuracy and precision of devices programmed in different GPS fix intervals. Horizontal (A) and vertical (B) accuracy, and horizontal (C) and vertical (D) precision in meters of devices programmed with fix intervals of 1 minute, 20 minutes and 60 minutes. The box represents 25, 50 and 75% of the data and the error bar represents 5% and 95% of the data.



6.2 Performance after deployment

While the test was stationary, a total of 7,333 GPS positions were collected from all 16 devices, while only 5,204 were collected during deployment. When the devices were implanted in white storks, there was no discernible change in horizontal accuracy ($t = 3.80$, $df = 1$, p -value = 0.051). The average horizontal accuracy was 4.21 meters (18 meters) before deployment; after deployment, it was 4.10 meters (15 meters) (Figure 4). Vertical accuracy, however, improved after deployment, rising from 7 meters (71 meters) to 6 meters (56 meters) ($t = 43.72$, $df = 1$, $p = 0.001$). Following the deployment, accuracy both horizontally and vertically improved. According to Table 1, after deployment, the vertical accuracy increased from 11 m (85 m) to 10 m (67 m), whereas the horizontal accuracy decreased from 7.10 m (23 m) to 6.72 m (19.7 m).

7. Discussion

This study evaluated the Flyway 50 Movetech Telemetry tracking devices' precision and accuracy as well as their applicability for high-resolution research. Reduced fix intervals resulted in higher horizontal accuracy (3.40 m at a 1 minute fix interval) and vertical accuracy (4.95 m at a 1 minute fix interval). Importantly, once the devices were implanted in the birds, these precisions remained intact. Researchers can undertake ecological and behavioral investigations, which call for accurate and reliable data, since they are able to obtain such exact geographical data..

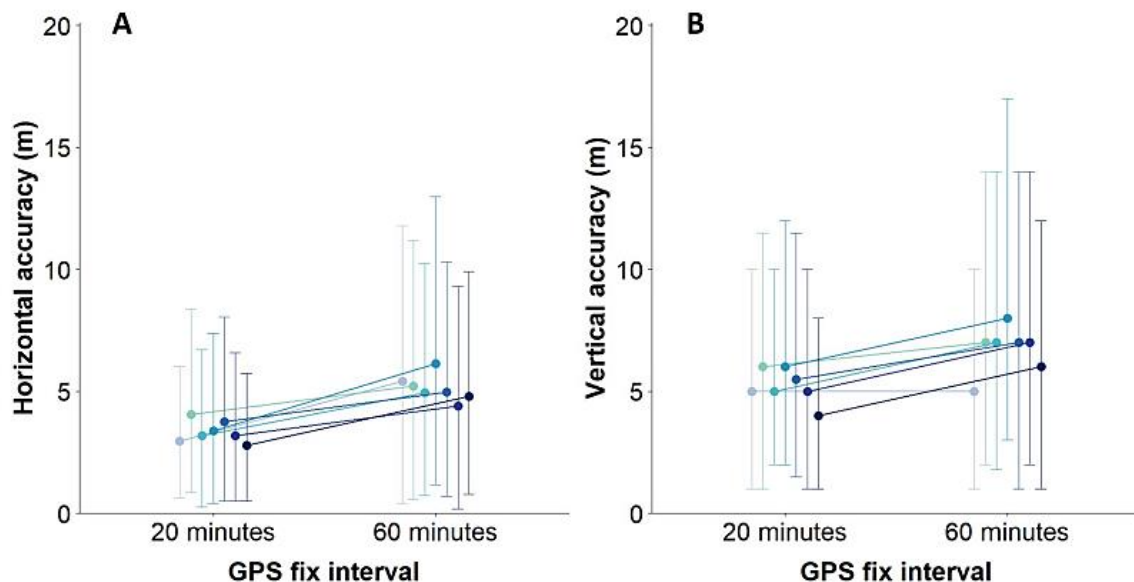


Fig 2. Horizontal and vertical accuracy variability of devices programmed on a 20 and 60 min GPS fix interval. Horizontal (A) and vertical (B) accuracy of tracking devices programmed to collect GPS locations every 20 and 60 minutes. The error bars represent 95% confidence intervals.

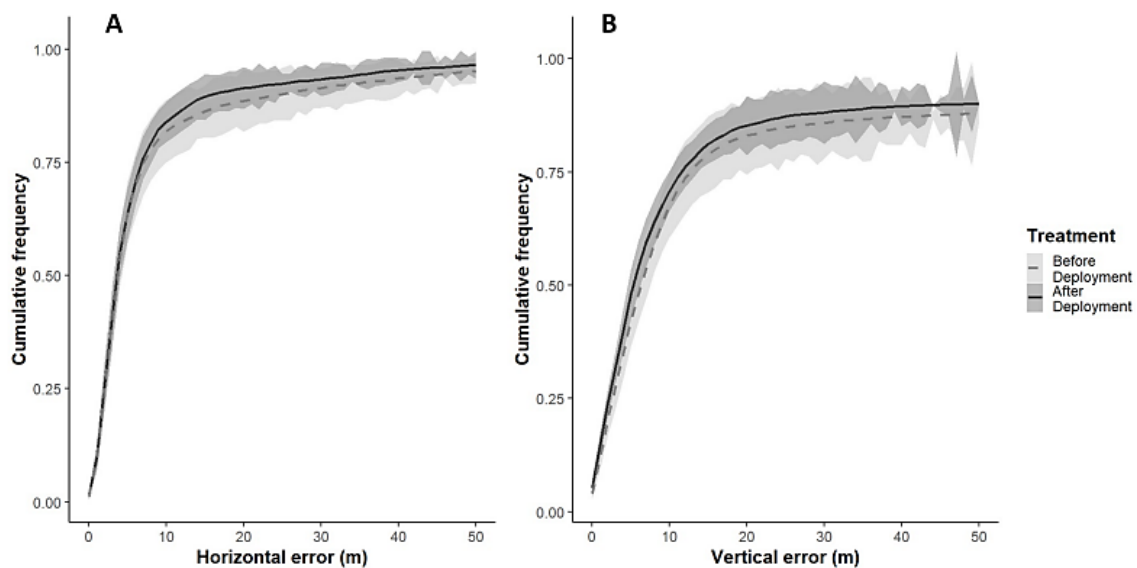


Fig 4. Cumulative frequency of horizontal and vertical accuracy before and after deployment on white storks. Cumulative frequency of (A) horizontal and (B) vertical errors (in m) of 16 GPS/GPRS devices before deployment (grey dashed line) and after deployment on white storks (black line). Shaded areas represent the standard deviation of the errors.

The chosen interval had a significant influence on the instruments' accuracy and precision. Vertical accuracy drops by 4.74 m and horizontal accuracy reduces by 3.10 m, totaling 6.50 m and 9.69 m, respectively, when comparing a 1 minute fix interval to a 60 minute fix period. Longer fix intervals lead to less accurate location estimations, as evidenced by the fact that devices programmed with 20- or 60-minute fix intervals performed worse than those configured with a 1-minute fix period. With shorter fix intervals, the preservation of ephemeris data by GPS units—which aids in the computation of new locations—is more efficient, leading to faster acquisition and improved performance. Regarding the impact of fix intervals on accuracy, many research have produced conflicting findings, indicating that the device's manufacturer and the habitat's features may have an impact. Additionally, it is critical to take the fix interval into account when evaluating device accuracy due to the introduction of recorders that modify repair intervals based on battery performance.

We discovered that the devices' horizontal accuracy decreased by 3.10 meters and their vertical accuracy decreased by 4.74 meters, for a total of 6.50 meters and 9.69 meters, respectively, when comparing a 1 minute fix interval to a 60 minute fix interval. The majority of devices performed worse in the 20 minute and 60 minute fix intervals compared to the device set with 1 minute fix intervals, supporting other research showing that lengthy fix intervals reduce location accuracy. Ephemeris retention, which occurs when GPS receivers retain the constellation of satellites used to obtain a prior fix, speeds up the acquisition of a fix and increases accuracy when computing new locations. There are conflicting results from several studies addressing how fix intervals affect accuracy. While



some research did not find a significant difference, other investigations discovered that accuracy was decreased by extended fix intervals. According to one study, if a low-accuracy site affected later positions, the temporal connection between modifications might lead to a reduction in total accuracy. Despite similar fix intervals and open environment, our results, however, did not corroborate this idea. These discrepancies highlight the need to evaluate GPS devices made by different manufacturers since they may yield different findings. Furthermore, it is crucial to take the fix interval into account when assessing the accuracy of a device since recorders that adjust fix intervals based on battery performance, such as dynamic fix transmitters, have developed.

Conclusion

In conclusion, as the fix interval rises, GPS/GPRS tracking devices become more effective, suggesting increased precision and accuracy at shorter intervals. This result is in line with earlier studies showing that location accuracy suffers during prolonged fix intervals. Furthermore, our research showed that the gadgets' precision and accuracy were unaffected by their usage on animals. This suggests that monitoring systems continue to function and remain reliable after being implanted in animals, enabling the collection of precise and accurate data during ecological and behavioral research.

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