An elephant survey in Digya National Park, Ghana, and implications for conservation and management

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Abstract

Information on elephant ranges and numbers is vital for their effective conservation and management. This is especially true in West Africa where elephant populations are small and scattered. Digya National Park in Ghana is home to some of the least studied elephant populations in Africa. A dung count of the Digya elephant population was conducted to determine the density and distribution of elephants in the park using a systematic segmented track line design. The mean density of dung-piles was 323 dung-piles per sq km and mean dung survival time was estimated to be 44 days (SD = 2.0 days). An estimated 341±53 (95% confidence interval) elephants with density of 0.41 elephants/km^2 were obtained in the study. This makes the Digya elephant population the second largest in Ghana. Elephants occurred mainly in the south-western forested part of the park. This may be related to local abundance of wild fruits and/or conflict with squatters in other parts of the park. The possibility of the estimate being higher has been discussed. This current baseline information augments the Regional Elephant Database and should facilitate strategic planning and management programmes.

Résumé

Les informations sur les habitats des éléphants et sur leur nombre sont essentielles à leur conservation et à leur gestion efficace. C'est particulièrement vrai en Afrique de l'Ouest où les populations d'éléphants sont petites et dispersées. Le Parc National Digya au Ghana abrite quelques-unes des populations d'éléphant les moins étudiées en Afrique. On a fait un comptage de déjections de la population d'éléphants de Digya pour déterminer la densité et la distribution des éléphants dans le parc en utilisant une ligne systématique séquentielle. La densité moyenne de déjections était de 323 déjections par km^2 et le temps moyen de survie des déjections a été estimé à 44 jours (Ecart Type = 2.0 jours). Dans l'étude on a obtenu environ 341±53 (95% intervalle de confiance) éléphants avec une densité de 0.41 éléphants/km^2 Cela rend la population des éléphants de Digya la deuxième plus large au Ghana. Les éléphants sont apparus principalement dans la partie sud-ouest du parc. Cela peut être mis en rapport avec l'abondance locale des fruits sauvages et/ou des conflits avec les squatteurs dans d'autres parties du parc. Ces informations de référence augmentent la Banque régionale de données sur les éléphants et devraient faciliter une planification et une gestion stratégiques des programmes.

Introduction

The elephant is a 'keystone' species that plays a pivotal role in structuring both plant and animal communities (Dublin 1995; Stiles 2004) and often dominates mammal biomass in the habitats it occupies (White 1994). West Africa shelters the smallest and most fragmented elephant (*Loxodonta africana*) populations on the African continent (Blanc et al. 2007).

In Ghana, nine separated elephant populations exist; two populations occur in within savanna habitats, five in forest habitats and the remaining two in the forest-savanna transition zone (Blanc et al. 2007). Notwithstanding the ecological importance of elephants (Blanc et al. 2007; Magliocca et al. 2003; Nchanji and Plumptre 2003), and their occurrence in Digya National Park, (Roth and Douglas-Hamilton 1991; Wildlife Division 2000), they are not well-studied. Moreover, their precise numbers are unknown and are often speculated to be in the several hundreds (Wildlife Division 2000). Although Grainger (1994) counted eighty-nine elephants in an aerial survey of the park, no further research has been conducted to determine the actual size of this elephant population or map elephant distribution within the park, including the forested areas where the aerial survey might have missed these animals. These data are necessary for the effective monitoring and management of this keystone species that is facing enormous pressures from poaching and habitat loss.

In the West African context, Ghana's Wildlife Division is active in supporting elephant conservation (Wildlife Division 2000), and has also identified the Digya elephants as requiring further study to support park development. Population estimates are part of the global agenda for elephants under the Convention on International Trade in Endangered Species (CITES) and they are a priority for subregional and national elephant conservation strategies (AfESG 1999; Wildlife Division 2000).

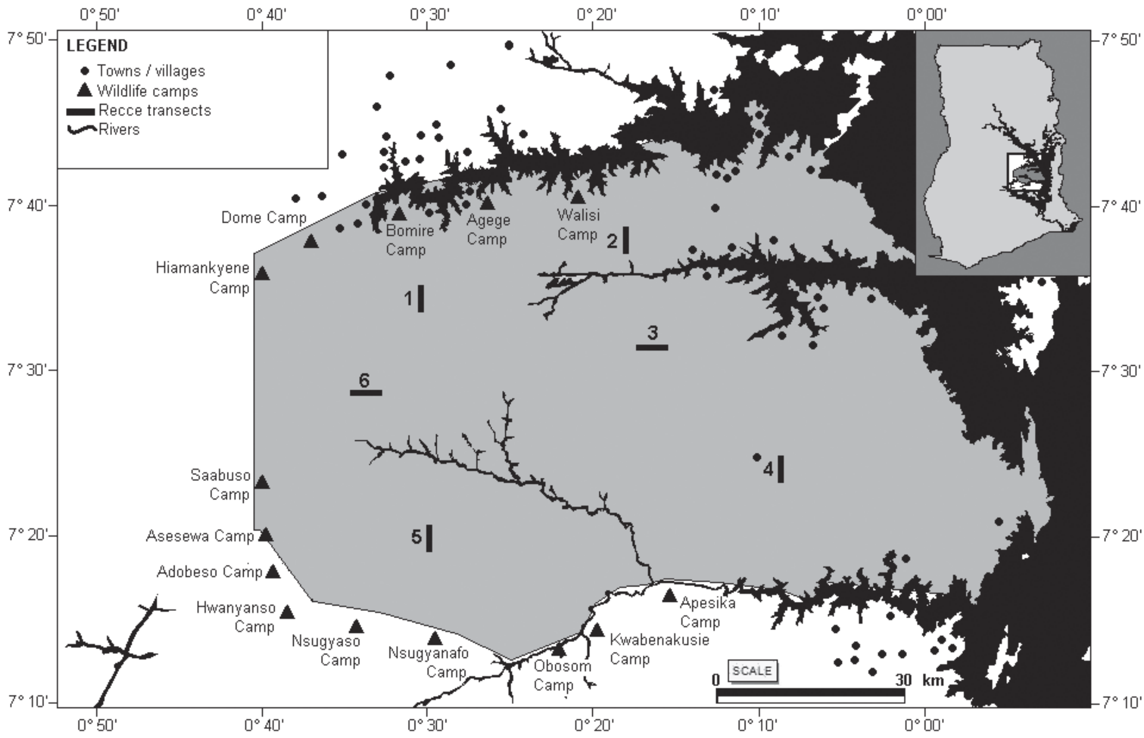

Figure 1. The location of recce transects (numbered 1 through 6) and human settlements in Digya National Park (inset), Ghana. No elephant sign was detected on transects 1, 2, 3, or 4.

This study estimates population size and spatial distribution of elephants in Ghana's DNP to facilitate current efforts to conserve elephants in the Park and add to the African Elephant Database (Blanc et al. 2007).

Study Area

Established in 1971, DNP (fig. 1) covers an area of 3478.5 km^2 and is located between latitudes 7°06' and 7°44' north and longitudes 0°06' and 0°42' west. The park is three-quarters bounded by water; on the north by the Sene river, on the east by the Volta lake and on the south-east by the Obosum River. The reserve is underlain geologically by the Voltaian system of late Precambrian to Paleozoic age (300-1,000 Myrs). The soils are mainly Haplic Acrisols (FAO/UNESCO 1988) and similar in appearance to soils of the forest-savanna transitional zones. The mean annual rainfall ranges between 1270 mm and 1370 mm (Ghana Wildlife Department 1995).

The park lies between 841 m (lake level) and 1540 m above sea level. The northern and north-western parts (Sene areas) are covered by undulating flat lands whilst the eastern section (Ntonaboma area) is covered with sandstone outcrops. The overall drainage of the park is into the Volta Lake by way of the Sene, Digya and Obosum rivers. The rivers and streams in the heart of the park dry up during the dry season (November to March). Innes (1977) classified the overall vegetation as Guinea savanna whilst Schmitt and Adu-Nsiah (1994) identified four main vegetation types: tall-grass savanna, boval vegetation (plant communities on sandstone outcrops with shallow soils), riparian forest and aquatic vegetation. The combination of these different physical habitats creates a varied environment for elephants.

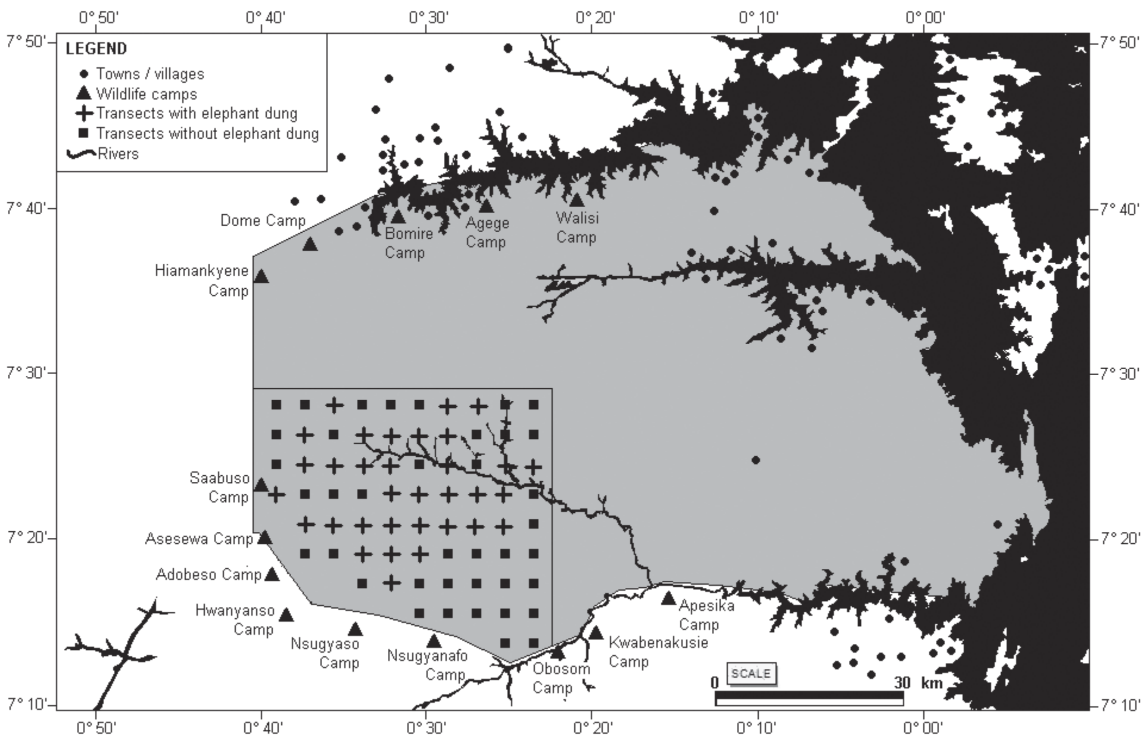

Figure 2. Distribution of transects in the census zone of Digya National Park. The map shows transects on which elephant dung was recorded and those on which it was not.

Materials and methods

The dung count technique (Barnes 1993) was used with the line transect method to estimate the density and the abundance of elephants in the park. Especially in partially forested areas, the dung count method yields more precise estimates of elephant abundance than aerial sample surveys (Barnes 2002).

Reconnaissance (recce)

A pilot survey (recce) was conducted in March 2006 to uncover possible logistical problems, test operational procedures, train the survey team, delineate the survey area and determine the length of transect needed for the full survey in June 2006. Recce-Survey Transects (RST) were used to determine dung-pile encounter rates and designate high and low elephant density strata. During the recce, the survey team walked six straight line transects, each 5 km long (fig. 1) following a compass bearing but deviating around trees, large water bodies and other obstacles and recording dung-piles found. The lengths of the RST were measured with the Garmin 12XL Global Positioning System (GPS).

Number of transects and distribution

Following Buckland et al. (2001), an estimated total length of 72 km (i.e. 72 transects of 1 km each) was calculated in order to achieve a target coefficient of variation of 10% in the main survey. No elephant activities or dung-piles were recorded in the northern and eastern portion of DNP, hence that area was treated as low density and no transects distributed there (Norton-Griffiths 1978). Using the MAPINFO software package, a grid with cells 3 km by 3 km was placed at random over the high density zone. The intersections of the lines then formed the starting point for each transect. This gave 72 transects that conformed to the systematic segmented line transect design suggested by MIKE (Monitoring the Illegal Killing of Elephants; fig. 2). Transect orientation was perpendicular to the main drainage lines of the study area. Since the main rivers flow from west to east, all transects ran from north to south.

Elephant distribution

Elephant range included transects on which elephant presence was detected. Elephant range was mapped to produce an elephant distribution map in ArcView 3.2. Study boundaries were then overlain onto the elephant distribution map using GIS, to give an impression of elephant range in DNP (fig. 2).

Data collection and density estimation

Two teams of four people undertook the survey. Each team was made up of a transect cutter, a compass and GPS/hip chain reader, a recorder and a dung spotter. The compass and GPS units were used to locate the starting point of each transect. Only dung-piles seen from the transect centre-line were recorded. The length of each transect was measured with the GPS. Perpendicular distances of dung-piles from all transects were measured with a tape measure. Using DISTANCE 4.1 (Laake et al. 2003), the six detectability models recommended by Buckland et al. (2001) were applied. Akaike's Information Criterion (AIC) was used to select the best model.

The Delta method (Seber, 1982; Buckland et al. 2001) was used to calculate elephant density **E** as $\mathbf{E} = \mathbf{Y} / (\boldsymbol{s} \cdot \mathbf{D})$, where **Y** is observed dung density per sq km, ***s*** is the estimated mean survival time, and **D** is the estimated defecation rate (18.07, Hedge and Lawson 2006). The density was multiplied by the area of the census zone (835.5 km^2; calculated by using a straight line to join the grid cell boundaries beyond the outermost transects) to estimate total elephant numbers.

Mean dung survival time

To transform the observed dung-pile density to an estimate of elephant density, how long dung-piles persist in the field was determined. Five cohorts were identified consisting of 10-15 intact and moist dung-piles; these were assumed <48 hours old (S_1) (Hedge and Lawson 2006). Cohort initiation dates were ten days apart and ranged from 1 March to April 20 2006. GPS coordinates of the dung-piles were recorded, location maps drawn and flagging tapes tied on nearest trees to help with relocation. A total of 99 fresh (S_1) dung-piles was marked. Each dung-pile was revisited during 6-9 May between 67 and 70 days after the first visit, at which time the pile was assigned a binominal response (decayed or not decayed) following the Hedge and Lawson (2006) classification. The estimated mean survival time of animal signs (reciprocal of decay rate), ***s*** with its standard error and coefficient of variation was calculated following Laing et al. (2006) and Hedge and Lawson (2006).

Table 1. The parameters estimated by each of the six models fitted to the line transect data. F(0) = Probability Density Function (probability detection function divided by effective strip width); X^2 compares the fit of the visibility curve to the histogram of the perpendicular distance data; $P(X^2)$ = probability of X^2; AIC is the Akaike Information Criterion (Buckland et al, 2001)

Model	F(0)	Dungpiles per km^2	CV(%)	X^2	P (X^2)	Delta AIC
Uniform + cosine	0.1423	367	19.8	0.00351	0.293	5.43
Uniform + simple polynomial	0.0915	235	19.6	0	0.455	96.93
Half normal + cosine	0.13315	343	20.55	0.0075	0.313	4.93
Half normal + hermite polynomial	0.13427	346	19.8	0.0000751	0.31	14.83
Hazard rate* + cosine	0.12548	323	20	0.0303	0.332	0
Hazard rate* +simple polynomial	0.12548	323	20	0.0303	0.332	0

* Model adjustments with same parameter estimates.

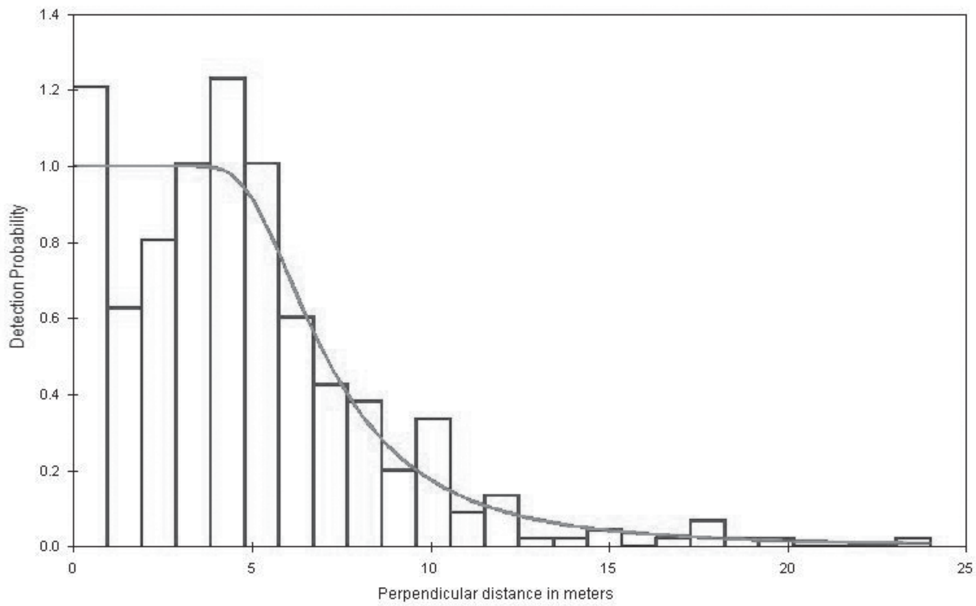

Figure 3. Histogram produced by DISTANCE 4.1 showing perpendicular distances of dung piles from the center line and the fitted visibility curve (Hazard rate + cosine model).

Results

There were 371 dung-piles on the 70 transects. Detectability was best modeled as a function of hazard rate with cosine or simple polynomial adjustment (table 1). We used the simpler of the two tied models, which matched our dung data reasonably well (fig. 3). Although Buckland et al. (1993) recommends truncation of data to delete a few dung-piles farthest from the transect line, truncation neither increased model fit nor decreased CV. Therefore, the observations were not truncated (fig.3).

The dung-pile density estimate was 323 dung-piles/ km^2. The estimated mean dung-pile survival time was 44 days (SD = 2 days). The estimated elephant density in the high density zone was 0.41 elephants/ km^2 (SE = 0.03). Assuming a defecation rate of 18.07 dung-piles per day (Hedge and Lawson 2006), the population of elephants in the Digya National Park is estimated at 341, with a 95% Confidence Interval of 288 to 394 elephants. All elephants were distributed in the south-western portion of the park (fig. 2).

Discussion

Many people have doubted the value of dung counts to estimate elephant numbers, but available evidence indicates that they give good estimates with reasonable confidence limits (Jachmann 1991; Plumptre and Harris 1995; Barnes 2001, 2002; Eggert et al. 2003). Ideally, the retrospective model estimate of 341 elephants for DNP should not be compared with the 89 elephants estimated by Grainger (1994) because different sampling methods were used. Comparisons should only be made between counts using the same methods.

Although the sampling and analytical procedures are sound (Laing et al. 2003), our estimate seems high when compared with other studies. For instance, using encounter rates for elephants in Digya and Mole National Parks, and the most recent aerial total count in Mole (401 elephants), elephant numbers in Digya for the years 2005, 2006, and 2007 were estimated. The results were 174, 95, and 173 elephants respectively (Jachmann, unpublished). However, because some elephants might have been missed in riverine forests in Mole during the aerial total count, his estimates for Digya may rather be on the low end, while there may have been several other sources of bias. The same reasons may apply in the 1994 survey (Grainger 1994).

The weakest link in the method used here is assuming a defecation rate from another site (Hedge and Lawson 2006). Unfortunately, estimating defecation rates in forest elephants before a dung count is a daunting and time-consuming exercise. It is possible that MIKE will provide a figure for the defecation rate in West African forests, in which case the calculations can be easily revised. Another problem is the fact that this involves small numbers of elephants, which may result in a large margin of error (Barnes, 2002). The margin of error is further magnified by the clumped distribution of elephants, where groups of elephants are seen on a few transects, and there are many transects where elephants are not seen.

Within the limits of data collected, there was no evidence to indicate that the population has declined, hence, we suggest a general increase in elephant numbers since the Grainger (1994) study. With an estimated population of 341 elephants, DNP may be the second largest elephant population in Ghana (after Mole National Park). Its density of 0.41 elephants/km^2 (census zone) compares well with that of the Singou Partial Faunal Reserve (Burkina Faso), but high compared to the elephant densities of 0.26 for the Pendjari Biosphere Reserve in Benin, and 0.24 for the Sapo National Park in Liberia (Sam 2004). It therefore becomes a priority population in West Africa, where many elephant populations are not viable due to genetic isolation, small numbers and distorted sex ratios and age structures caused by indiscriminate hunting (Blanc et al. 2007).

Until recently, a large number of squatters were living in the eastern part of DNP, which was never patrolled and from where numerous poaching excursions were organized on a regular basis. Over the past four years, but probably much longer, increased hostilities from squatters over resettlement issues forced park staff to patrol only the western section of DNP. Elephants were more or less squeezed into an area of less than 1,000 sq km. The present results however, suggest that elephants may be actively using only the southwestern area of the park with highest concentrations occurring between the Saabuso and the Nsugyaso Camps (fig.2). It is likely that elephants benefited from this protection (Hilborn et al. 2006). Taylor (1952) classified the vegetation of DNP as Guinea savanna woodland, but there are riparian forests, especially in southwestern DNP (Schmitt and Adu-Nsiah 1994). Perhaps, apart from this area being relatively safe from the squatters and poachers, the associated forests may influence elephant distribution positively by acting as a potential source of fruits. In Ghana, Danquah and Oppong (2006) showed that fruits are important in the diet of elephants at the Kakum Conservation Area.

Moreover, the Volta Lake, Sene and Obosum rivers in the east, north and south respectively provide a natural fence that reduces conflict with neighboring farms. Hence, proximity and easy access to agricultural fields in southwest Digya might have favoured elephant crop raiding success in the area (E. Attah-Kusi, Ghana Wildlife Division, pers. comm, July 2007; Barnes et al. 2003). Interviews and field observations also indicate that elephants move via a forested area to raid crops as far as 5 km from the reserve. It will be important to establish if this is a migratory or a raiding behaviour.

In many parts of Africa, elephants are pillars of the tourism industry (Vollrath and Douglas-Hamilton 2002). Digya has great potential for tourism, and it is expected that there will be an increasing interest in the park, coupled with more research activities. However, DNP receives little tourist or research attention despite its proximity to a major airport (Kumasi, the second largest city in Ghana (about 120 km away), with relatively good roads (Ghana Wildlife Division 1995). Ecologically sensitive tourism could constitute a powerful incentive for the conservation of this elephant population if managed with care. Lying between Mole and the forest populations to the south, the Digya population could add to the understanding of the taxonomy and distribution of the African elephant (Lister 2005).

Conclusion

Before any conclusions are made, however, it must be noted that this is the first retrospective dung survey of the Digya elephant population and it will be important to compare our results with those from other sites using the same methods. More work is needed in the area of sampling design, given the inherent difficulties and assumptions in current sampling design. However, it is believed that studies such as this one will be beneficial to managers who seek to understand elephant population dynamics at Digya as well as the factors that affect their distribution.

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