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Survey of Forest Elephants *Loxodonta cyclotis* (Matschie, 1900) (Mammalia: Proboscidea: Elephantidae) in the Bia Conservation Area, Ghana

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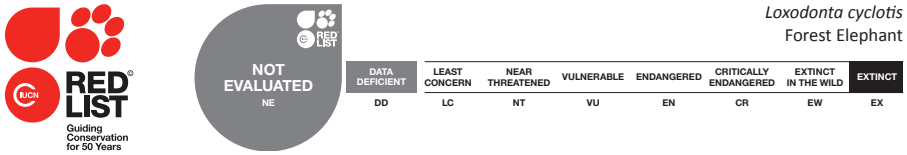
Abstract: Information on elephant ranges and numbers is vital for effective conservation and management, especially in western Africa where elephant populations are small and scattered. The Bia Conservation Area (BCA) in southwestern Ghana is a priority site for the conservation of Forest Elephants in western Africa. A dung count was conducted using a systematic segmented track line design to determine the density and distribution of the BCA elephant population. The mean density of dung-piles was 452.15 per sq.km. and mean dung survival time was estimated to be 54.64 days (SD 2 days), leading to an estimate of 146 elephants (95% confidence interval 98–172) with a density of 0.48/km^2 for the BCA. This estimate probably makes the Bia forest elephant population the largest in Ghana. Records of BCA elephant activities were also made. This study augments the Regional African Elephant Database and should facilitate strategic planning and management programmes.

Keywords: Distribution, dung-piles, elephants, forest, range, settlements, tourism.



Loxodonta cyclotis
Forest Elephant

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INTRODUCTION

The African Forest Elephant *Loxodonta cyclotis* (Matschie, 1900) (Order Proboscidea; Family Elephantidae; Subtribe Loxodontina) is a threatened keystone species that plays a pivotal role in structuring plant and animal communities, and often dominates mammal biomass in the habitats it occupies (Dublin 1995; Stiles 2004). Western Africa shelters the smallest and most fragmented elephant populations on the African continent (Blanc et al. 2007).

In Ghana, nine separate elephant populations exist; two populations occur 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) and their occurrence in the Bia Conservation Area (Sam et al. 2006; Blanc et al. 2007), they are not well-monitored and their status is not regularly updated. Since Sam et al. (2006) counted 126 elephants in a dung survey of the park in the year 2004, no effort has been made to determine the size of this elephant population or monitor changes in distribution. This study provides current information on forest elephant numbers and distribution in the Bia Conservation Area. These data are necessary for the effective monitoring and management of this population, which faces enormous pressures from poaching and habitat loss.

Ghana's Wildlife Division is active in supporting elephant conservation (Wildlife Division 2000) and has identified the Bia elephants as requiring further studies 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 (Wildlife Division 2000; AfESG 2005).

MATERIALS AND METHODS

The dung count technique (Barnes 1993) was used to estimate the density of elephants in BCA. A dung survival experiment (Laing et al. 2003) was also conducted to estimate the mean dung survival time during the dung count survey.

Study Area

The Bia Conservation Area (BCA) forms a 306km^2 block in the moist evergreen and moist semi-deciduous forest zones of western Ghana (Taylor 1960; Hall & Swaine 1976) between 6^{0}20'–6^{0}40'N and 3^{0}00'–3^{0}10'W, sandwiched between the Bia River and the border with Cote d'Ivoire (Fig. 1).

Rainfall is bimodal, peaking in June and October, with an annual rainfall of between 1500–1750 mm (Hall & Swaine 1976). Average monthly temperature in the area is 24–28 ^{0}C, with extremes from 18–34 ^{0}C. The farming system is rain-fed, with farming activities undertaken throughout the year.

The BCA was originally part of a larger (about 1500km^2) ecosystem for forest elephants known as the Bia Group of Forest Reserves. The Bia elephant range has reduced due to clearance for cocoa cultivation, and is now an isolated population in an ecological island of forest with hard boundaries and no transitional zone to farmland (PADP 2001).

Pilot Survey

A pilot survey was conducted in March 2009 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 2009. BCA was divided along the five wildlife patrol zones, and each zone thoroughly searched for elephant dung using meandering transects in a predetermined compass bearing. The idea was to limit excessive cutting of vegetation, which would have had to be done had straight transects been used. Meandering transects also enabled teams to cover much of the forest within a short period of time. The lengths of the meandering transects were measured with the Garmin 12XL Global Positioning System (GPS).

Main Survey (dung count)

An estimated total length of 50km (i.e., sample size of 50 transects of 1km each) was calculated in order to achieve a target coefficient of variation of 10% in the main survey (Buckland et al. 2001). The ArcView 3.2 software package was used to superimpose a grid of cells 1km by 1km over a map of BCA. The intersections of the grid formed possible starting points for each transect. Based on the estimated sample size, 50 intersections were systematically selected. This represented a sample size of 50 transects which conformed to a systematic segmented line transect design suggested by MIKE (Monitoring the Illegal Killing of Elephants) (Hedges & Lawson 2006). Transect orientation was perpendicular to the main drainage lines of the study area.

Two teams of four people undertook the survey. Each team was made up of a transect cutter, a compass

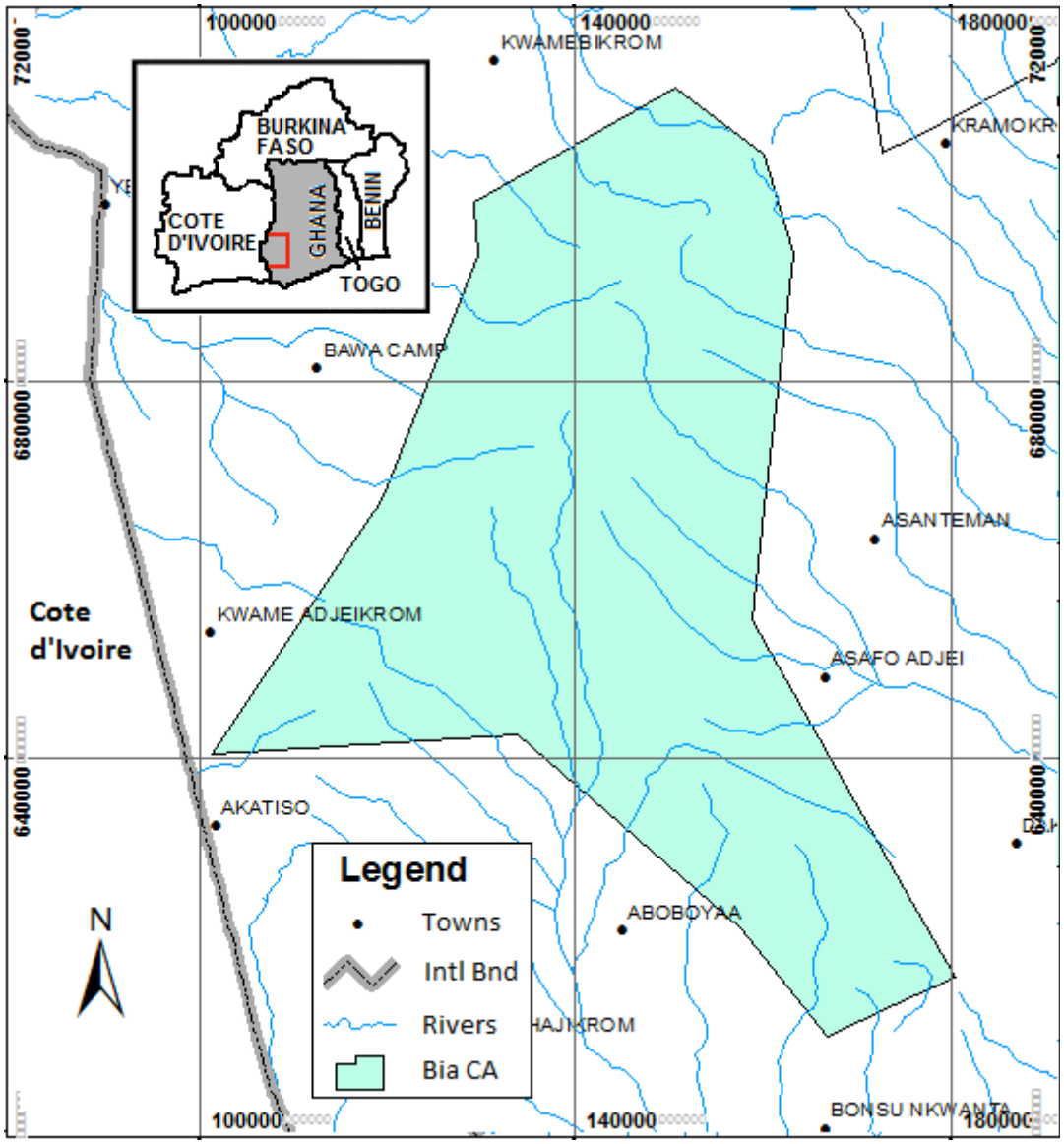

Figure 1. The Bia Conservation Area (BCA). The inset map shows the location of BCA in Ghana.

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 transect were measured with a tape measure.

Dung Survival Survey (persistence rate experiment)

An experiment was conducted to estimate the mean dung survival time in order to convert estimates of dung density to estimates of elephant density (Barnes & Jensen 1987; Laing et al. 2003; Hedges & Lawson 2006). This involved monitoring the decay of freshly dropped dung-piles until they disappear. Five groups of freshly deposited dung-piles of approximate same age (cohort) were identified. Each cohort consisted of 10–15 intact and moist dung-piles. These were assumed <48 hours old (*S1*) based on criteria by Hedges & Lawson (2006). Cohort initiation dates were 10 days apart and ranged from March 1 to April 20, 2009. GPS coordinates of the dung-piles were recorded, location maps drawn, and flagging tapes tied on the nearest trees to help with relocation. A total of 70 fresh (*S1*) dung-piles were marked. Each dung-pile was revisited from May 6–9, 2009, which was between 67 and 70 days after the first visit. At this time each pile was assigned a binominal response (decayed or not decayed) following the Hedges

& Lawson (2006) classification.

Data Analysis

Dung-pile Survival Time Estimate: Estimate of mean survival time of elephant dung-piles and coefficient of variation (CV) was calculated using Genstat 7.0 software package (Laing et al. 2003; Hedges & Lawson 2006).

Elephant Density Estimate: Estimate of elephant dung density was calculated using DISTANCE 4.1 software package (Thomas et al. 2002; Laake et al. 2003). Best model selection was based on values of the Akaike's Information Criterion (AIC), Chi-square (X^2), Component Percentages of Var(D) and visual observation of the visibility curve (Buckland et al. 2001).

To convert estimates of dung density to estimates of elephant density, two rates are required: the defecation (production) rate and the dung-pile survival time (alternatively referred to as persistence rates) (Barnes & Jensen 1987; Laing et al. 2003; Hedges & Lawson 2006).

Hence, density of elephants, *De* was estimated following Laing et al. (2003):

$$De = Ds / (p \times s) \text{----------(1)}$$

where *Ds* is the estimated density of elephant dung-piles in BCA, *s* is the estimated mean dung-pile survival time for the survey period, and *p* is the estimated defecation (production) rate for African Forest Elephants (18.07 dung-piles per 24 hr; Hedges & Lawson 2006). The density was multiplied by the area of BCA (306km^2) to estimate total elephant numbers.

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. The map of the study area was then overlain onto the elephant distribution map using GIS, to indicate elephant range in BCA.

RESULTS

One-hundred and sixty-two dung-piles were spotted on the 50 transects. Detectability was best modeled as a function of half normal with cosine adjustment, which matched our data reasonably well (Fig. 2). 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 the Coefficient of Variation (CV). Therefore, the observations were not truncated (Fig. 2).

The dung-pile density estimate was 452.15 dung-piles/km^2 (confidence interval from 396.22 to 596.32) and a CV = 13.53%. The estimated mean dung-pile survival time was 54.64 days (SD = 2 days). The estimated elephant density was 0.48 elephants/ km^2 (CV = 11.14%). Assuming a defecation rate of 18.07 dung-piles per day (Hedges & Lawson 2006), the population of elephants in BCA is estimated at 146, with a 95% confidence interval of 98 to 172 elephants.

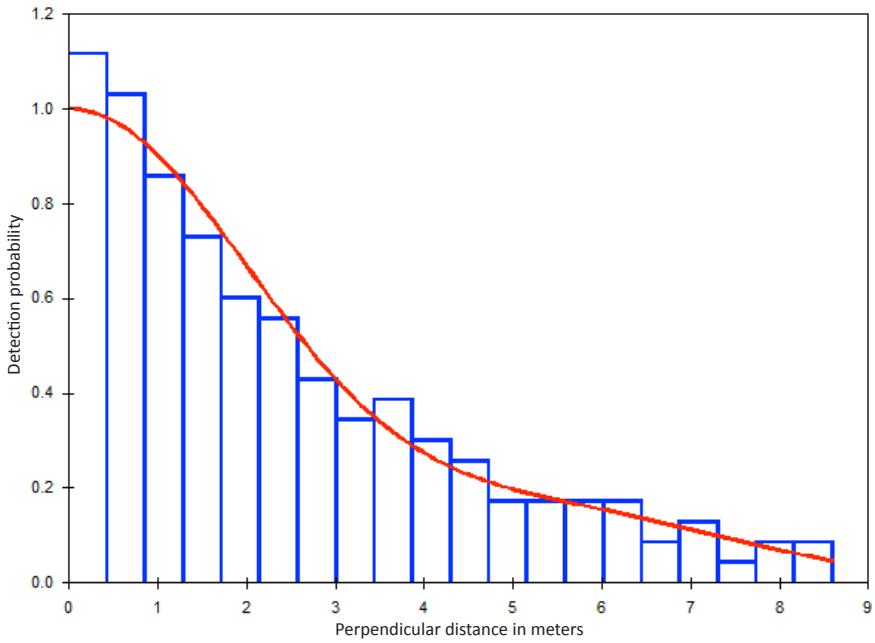

Figure 2. Histogram produced by DISTANCE showing the perpendicular distances and the fitted visibility curve (half normal + cosine).

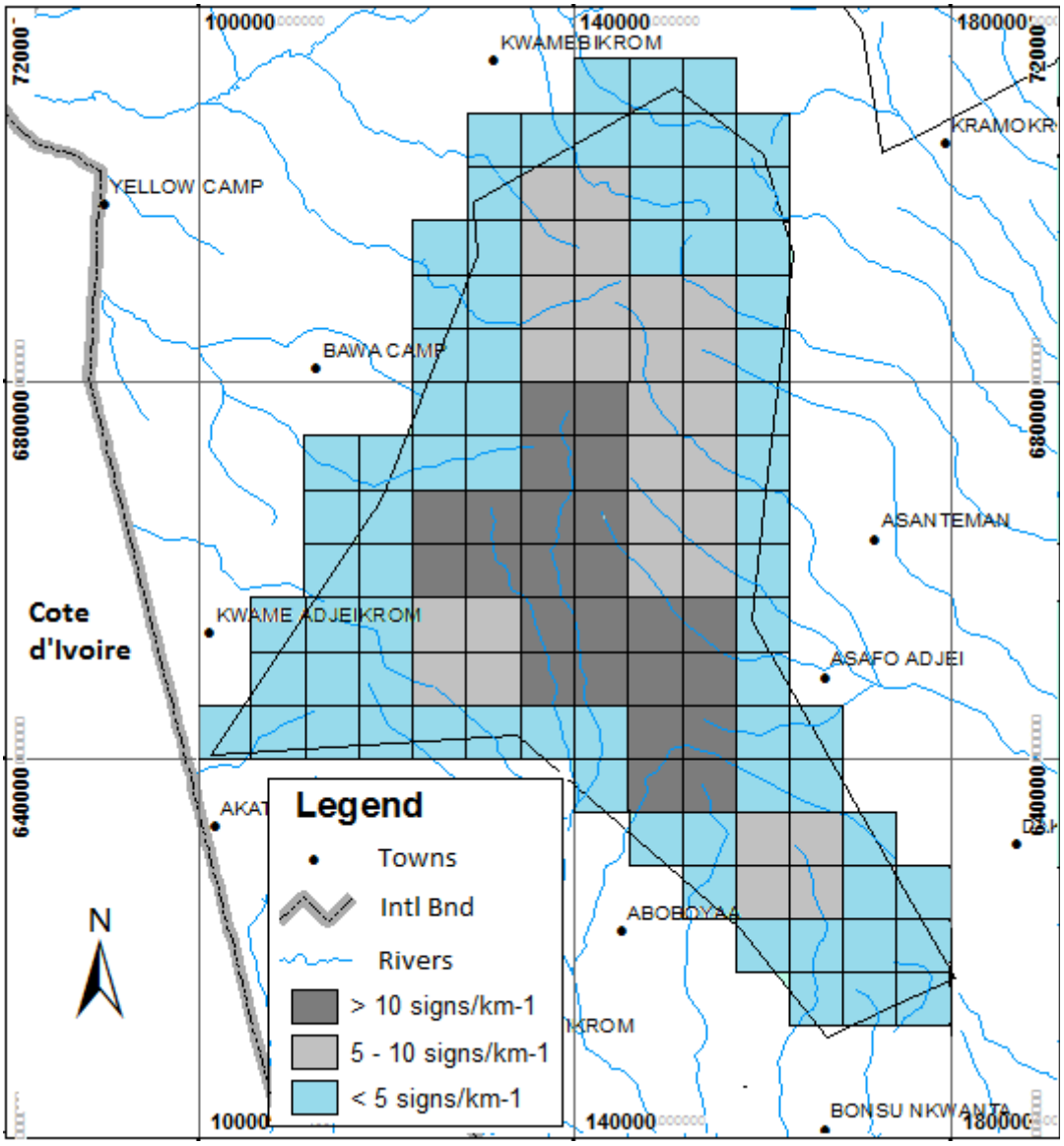

Figure 3. BCA showing distribution and intensity of elephant activities (signs).

Records of elephant dung-piles were made throughout BCA with the highest concentrations of dung-piles occurring in the southern portions of BCA (Fig. 3).

DISCUSSION

Dung counts relate elephant density to the number of dung-piles observed on transects, adjusted for factors such as elephant defecation rate and dung-pile survival rate (Barnes & Jensen 1987; Laing et al. 2003; Hedges & Lawson 2006). Unfortunately, seasonal differences cause decay rates to vary between sites, and in many situations elephant surveyors have used decay rates from other sites far from their place of work. This approach can result in serious biases in the mean dung-pile survival rate at the time of the survey (Laing et al. 2003). Our approach is a seemingly more advantageous method which estimates the mean dung-pile survival rate present at the time of the survey (Laing et al. 2003). While the mathematical theory underpinning this method is well tested (Laing et al. 2003; Hedges & Lawson 2006), it involves less fieldwork and does not require repeated visits to marked signs.

Our dung-pile survival rate experimental design is different from most traditional surveys. The dung-piles were marked during a 'recce'-style survey, where the objective was to cover a large area of BCA over the period and to mark dung from as many individuals

and ecological zones as possible. This style is like rapid assessment surveys, whose goal is to quickly assess presence and absence of species in an area.

With an estimated population of 146 elephants, Bia may be the largest population of forest elephants in Ghana, followed by Kakum Conservation Area (KCA). Its density of 0.48 elephants/km^2 compares well with other Ghanaian forest elephant populations like KCA (0.45 elephants/km^2) (ARocha 2004) and Digya National Park (0.44 elephants/km^2 for elephant range only) (Kumordzi et al. 2008), but is high compared to elephant densities of 0.04 for Ankasa Conservation Area (Danquah et al. 2009a), and 0.03 for the Goaso Block of Reserves (Danquah et al. 2009b). Bia, therefore, is a priority population in Ghana, where many elephant populations are not viable due to genetic isolation and small numbers (Blanc et al. 2007).

The BCA was originally part of a larger (about 1500 km^2) forest ecosystem for forest elephants known as the Bia Group of Forest Reserves; however, most of the forest reserves are currently non-existent. The Bia elephant range has reduced due to clearance for cocoa cultivation, and is now an isolated population in an ecological island of forest with hard boundaries and no transitional zone to farmland (PADP 2001) (Image 1). Elephants are more or less squeezed into an area of less than 400km^2.

Elephants distribution is clumped to the southern and south-eastern portions of BCA (de Leede 1994; Sam et al. 2006; Danquah et al. 2007) due to possibly higher levels of hunting activity in the northern section (Danquah et al. 2007). Compared to the south, access to the northern section and ease for hunting is better in terms of proximity to roads and larger settlements. The present distribution on the ground has not changed significantly (Mann-Whitney U test: U=185.5, P>0.05), though elephants may currently be accessing more areas of the park, with the highest concentrations still occurring southwards of BCA. With the current increase in law enforcement in BCA during the recently ended Protected Areas Development Programme Phase II in 2010 (Danquah et al. 2009a), it is expected that elephant range will further extend into the northern sectors of BCA.

In many parts of Africa elephants are pillars of the tourism industry (Vollrath & Douglas-Hamilton 2002). BCA has great potential for tourism and it is expected that there will be an increasing interest in the park, coupled with more research activities, because of its emerging popularity as a major forest elephant stronghold in Ghana. However, BCA receives little tourist or research attention despite its relatively good access roads from Kumasi (the second largest city in Ghana). Ecologically sensitive tourism could constitute a powerful incentive for the conservation of this elephant population if managed with care. The importance of BCA is further highlighted by the fact that it is one of five priority regions or hotspots for biodiversity conservation (Myers et al. 2000). The area has also been proposed as a transfrontier corridor for elephants moving between forest reserves on the Cote d'Ivoire side of the border and those in Ghana (Parren & Sam 2003). In this light the IUCN African Elephant Specialist Group has developed an Action Plan for the Management of Transfrontier Elephant Conservation Corridors in western Africa (Sebogo & Barnes 2003), a

Image 1. Forest Elephants group in a large clearing in Bia (2010).

blueprint to guide the development of transfrontier elephant conservation in the area.

REFERENCES

AfESG (2005). Strategy for the Conservation of West African Elephants. Revised Edition, African Elephant Specialist Group, Nairobi, Kenya.

ARocha (2004). CITES - MIKE Kakum National Park retrospective elephant survey 2004. Technical report prepared for CITES/MIKE Programme, Nairobi, Kenya, 35pp.

Barnes, R.F.W. & K.L. Jensen (1987). How to count elephants in forests. African elephant and rhino specialist group. Technical bulletin (1).

Barnes, R.F.W. (1993). The elephants of Kakum and Assin Attandanso forests. Technical report for Conservation International.

Blanc, J.J., R.F.W. Barnes, H.T. Craig, C.R. Thouless, I. Douglas-Hamilton & J.A. Hart (2007). *African Elephant Status Report 2007: an update from the African Elephant Database*. Occasional Paper Series of the IUCN Species Survival Commission, No. 33. IUCN/SSC African Elephant Specialist Group, IUCN, Gland, Switzerland, vi+276pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers & L. Thomas (2001). *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*. Oxford University, 432pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham & J.L. Laake (1993). *Distance Sampling: Estimating Abundance of Biological Populations.* Chapman & Hall, London, 446pp.

Danquah, E., M.K. Sam & P. Marshal (2009a). Monitoring Matters: A survey of large mammals of the Ankasa and Bia Conservation Areas. Report submitted to EU/WD Protected Areas Development Programme Phase II Project.

Danquah, E., M.K. Sam, E. Akom, S.K. Appiah-Kubi & T. Ayiku (2009b). Elephant Conservation and Possibilities of Creating Corridors in Western Ghana. Project AFE-0348. Technical report submitted by A Rocha Ghana to African Elephant Conservation Fund of the US Fish and Wildlife Service.

Danquah, E., M.K. Sam & P. Marshal (2007). A survey of large mammals of the Ankasa and Bia Conservation Areas. Report submitted to EU/WD Protected Areas Development Programme Phase II Project.

de Leede, B.M. (1994). Feasibility study on the establishment of corridors for Forest Elephants (*Loxodonta africana cyclotis* Matschie) between forest reserves in western Ghana and eastern Cote d'Ivoire. Ghana Wildlife Department, Accra, 39pp.

Dublin, H.T. (1995). Vegetation dynamics in the Serengeti-Mara Ecosystem; the role of elephants, fire and otherfactors, pp. 71–90. In: Sinclair, A.R.E. & P. Areese (eds.). *Serengeti II: Dynamics, Management and Conservation of An Ecosystem*. Chicago: University of Chicago, USA.

Hall, J.B. & M.D. Swaine (1976). Classification and ecology of closed canopy forest in Ghana. *Journal of Ecology* 64(3): 913–951.

Hedges, S. & D. Lawson (2006). Monitoring the Illegal Killing of Elephants, Dung Survey Standards for the MIKE programme. CITES/MIKE programme, Kenya.

IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 25 July 2013.

Kumordzi, B.B., W. Oduro, S.K. Oppong, E. Danquah, A. Lister, & M.K. Sam (2008). An elephant survey in Digya National Park, Ghana, and implications for conservation and management. *Pachyderm* 44: 28–34.

Laake, T.L., J.L. Strindberg, S. Marques, F.F.C. Buckland, S.T. Borchers, D.L. Anderson, D.R. Burnham, K.P. Hedley, S.L. Pollard & J.R.B. Bishop (2003). *Distance 4.1. Release "x"1.* Research Unit for Wildlife Population Assessment, University of St Andrews, UK.

Laing, S.E., S.T. Buckland, R.W. Burns, D. Lambie & A. Amphlett (2003). Dung and nest surveys: estimating decay rates. *Journal of Applied Ecology* 40(6): 1102–1111; http://dx.doi.org/0.1111/j.1365-2664.2003.00861.x

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858; http://dx.doi.org/ 0.1111 /10.1038/35002501

[PADP] Protected Area Development Project (2001). Bia Conservation Area Management Plan. Wildlife Division, Ghana

Parren, M.P.E. & M.K. Sam (2003). Elephant corridor creation and local livelihood improvement in West Africa. Paper presented at The International Conference on Rural Livelihoods, Forests and Biodiversity 19–23 May 2003, Bonn, Germany.

Sam, M.K., E. Danquah, S.K. Oppong & E.D. Bosu (2006). Elephant survey in the Bia Conservation Area, western Ghana. *Pachyderm* 40: 42–50.

Sebogo, L. & R.F.W. Barnes (eds.) (2003). Plan d'action pour la gestion des éléphants des corridors transfrontaliers d'Afrique de l'Ouest. Rapport non-publié, UICN Groupe de Specialistes de l'Eléphant d'Afrique, Bureau d'Afrique de l'Ouest, Ouagadougou, 49pp.

Stiles, D. (2004). The ivory trade and elephant conservation. *Environmental Conservation* 31(4): 309–321; http://dx.doi.org/10.1017/S0376892904001614

Taylor, C.J. (1960). *Synecology and Sylviculture in Ghana.* Thomas Nelson and Sons, Edinburgh, 418pp.

Thomas, L., J.L. Laake, S. Strindberg, F.F.C. Marques, S.T. Buckland, D.L. Borchers, D.R. Anderson, K.P. Burnham, S.L. Hedley. & J.H. Pollard (2002). Distance 4.0, Release 1. Research Unit for Wildlife Population Assessment, University of St. Andrews, U.K.

Vollrath, F. & I. Douglas-Hamilton (2002). African bees to control African Elephants. *Naturwissenschaften* online publication. Website www.saveelephants.org. publication - accessed 11 June 2012.

Wildlife Division (2000). *Strategy for The Conservation of Elephants in Ghana.* Wildlife Division, Ghana, 32pp.