RESEARCH

Effect of artificial water points on the movement and behaviour of desert-dwelling elephants of north-western Namibia

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Abstract

In November 2002, two artificial water points (AWPs) were drilled in the Hoanib River, north-western Namibia. This arid area (< 100 mm annual rainfall) seasonally supports a relatively large desert-dwelling elephant population. The range and the distribution of these elephants are determined by the distance that they need to forage from water. Before drilling the AWPs, female family units, hindered by their young, were limited in their movement, needing to stay close to natural permanent water sources. Free-ranging adult male elephants had larger ranges as they were less constrained in their drinking frequencies. However, the drilling of AWPs allowed family units to shift their ranges spatially beyond their normal foraging areas. Free-ranging males did not spatially shift their feeding areas but foraged closer to the AWPs. The seasonal movement of one family unit was disrupted by these AWPs, its members becoming more or less permanent residents along the river. AWPs have also changed the frequency and manner of drinking behaviour in this elephant population.

Résumé

En novembre 2002, deux points d'eau artificiels (PEA) ont été creusés dans la rivière Hoanib, au nord-ouest de la Namibie. Cette région aride (< 100 mm de chutes de pluie annuelles) accueille de façon saisonnière une population relativement importante d'éléphants du désert. La répartition et la distribution de ces éléphants sont déterminées par la distance qu'ils doivent parcourir entre l'eau et l'endroit où ils mangent. Avant de creuser les PEA, les unités familiales de femelles, ralenties par les jeunes, étaient limitées dans leurs déplacements puisqu'elles devaient rester à portée des points d'eau naturels. Les éléphants mâles adultes avaient une dispersion plus grande parce qu'ils avaient moins de contrainte en ce qui concerne la fréquence où ils devaient boire. Cependant, le creusement de PEA a permis aux unités familiales de déplacer leur dispersion au-delà de leurs aires de nourrissage habituelles. Les mâles n'ont pas changé spatialement leurs aires de nourrissage, mais ils se mirent à manger plus près des PEA. Le déplacement saisonnier d'une famille fut perturbé par ces PEA, et elle est devenue plus ou moins résidente permanente le long de la rivière. Les PEA ont aussi changé la fréquence et la manière de boire de cette population d'éléphants.

Introduction

Providing artificial water points (AWPs) in an arid or semi-arid area has been regarded as detrimental to the 'natural environment', as it gives permanent access for people and domestic stock to areas that were traditionally available only seasonally (Perkins and Thomas 1993; Du Toit and Cumming 1999). The concentration of people and domestic stock around these AWPs has led to environmental degradation (Reid and Ellis 1995) and exclusion of wildlife from these areas (Verlinden et al. 1998). The greatest effect of AWPs

had been on vegetation, with dramatic changes in species composition and productivity occurring near the water point where intensive grazing forms distinctive zones or biospheres (Pickup 1994). Other authors have referred to the degraded area around AWPs as a 'sacrifice zone' (Perkins and Thomas 1993). High densities of domestic stock have been reported to induce changes in infiltration rates, soil nutrient levels, and the resistance and resilience of ecosystems (Legget et al. 2003a). However, the effect on bulk rangeland (more than a kilometre away from either AWP or human settlement) was reported to be rare (Leggett et al. 2003a,b). Leggett et al. (2003a) reported that wildlife and domestic stock had a similar effect on veld in an enclosed situation, which was a fenced area in a semi-arid environment.

Elephants vary in their home ranges from being almost sedentary (Douglas-Hamilton 1971; De Villiers and Kok 1997) to being semi-nomadic or seasonally dispersive (Viljoen 1989a; Lindeque and Lindeque 1991; Thouless 1995; Leggett 2006). The timing of seasonal movements and differential use of habitats has been linked to rainfall, forage preference and availability (Western and Lindsay 1984; White 1994; Thouless 1995; Babaasa 2000). Several authors (Viljoen 1987, 1988, 1989a,b; Lindeque and Lindeque 1991; Leggett et al. 2003c;) have described the movement, behaviour and ecology of elephants in the arid areas of north-western Namibia; however, most of these studies were undertaken before AWPs were provided.

The ephemeral rivers of north-western Namibia and their associated springs, wetlands and vegetation form linear oases for wildlife and people in an otherwise barren landscape (Leggett et al. 2003c; 2004). The Hoanib River catchment, one of the 12 western-flowing ephemeral rivers of Namibia, has been extensively studied in recent years. Its geology, vegetation and seasonal distribution of resources have been well documented (Fennessy et al. 2001; Leggett et al. 2003a,b). Wildlife tend to concentrate around water sources during the dry season within relatively small home ranges and group sizes. These populations tend to disperse during the wet season but occasionally form large feeding aggregations to take advantage of seasonally available vegetation that is not necessarily located near water points (Leggett et al. 2004). Populations of domestic stock also tend to increase in the wet season, but they are concentrated around seasonally available water sources. During the dry season domestic stock is concentrated around permanent water sources (Leggett et al. 2004).

African elephants are known to dig holes in riverbeds to gain access to water during times of seasonal or sustained aridity (Dudley et al. 2001). In arid north-western Namibia, elephants routinely drink year round from shallow holes dug in the ephemeral riverbeds, called *ghorras* (a local Damara word meaning 'dug by hand').

Using a combination of observational and GPS satellite data of collared adult males and family units, in this paper I report changes in the feeding areas (spatial) and seasonal movements within established home ranges in response to the AWPs. In addition, I report changes in drinking behaviour that occurred after the AWPs were added.

Study area

The Hoanib River catchment is located in the Kunene Region of Namibia. The location of the study area, western wetlands, ghorras, rainfall isohyets and AWPs is shown in figure 1.

In arid areas, rainfall is spatially and temporally variable. Seasonal rainfall is highly variable and the average rainfall of an area does not necessarily serve as a good indicator of the amount of rainfall that can be expected in any given season (Leggett et al. 2001a). The research reported in this paper was conducted on the desert-dwelling elephants in a zone with 0–100 mm average annual rainfall.

There are three recognizable seasons in north-western Namibia, functionally and broadly defined (after Viljoen 1988): wet season (January–May); cold dry season (June–September); and hot dry season (October–January). In practice these seasons are variable, for example, the 1999/2000 wet season commenced in October 1999, with the last rains falling in May 2000.

In the last 23 years, the number of days of flooding (flood is defined as any time there is surface water flowing in the river) in the Hoanib River varied from 4 in 1981 to 52 in 1983, with an average of 17.7 days (Leggett et al. 2001a). Before October 2002, the only water available to elephants in the western section of the Hoanib River outside of the flood periods was found in the permanent wetlands at Dubis and the seasonal wetlands near the dunes in the western section of the river. Elephants also drank from ghorras, which varied seasonally in their location but were always found close to the Dubis wetlands. During the cold dry and hot dry season, most ghorras were dug just to the west of Dubis.

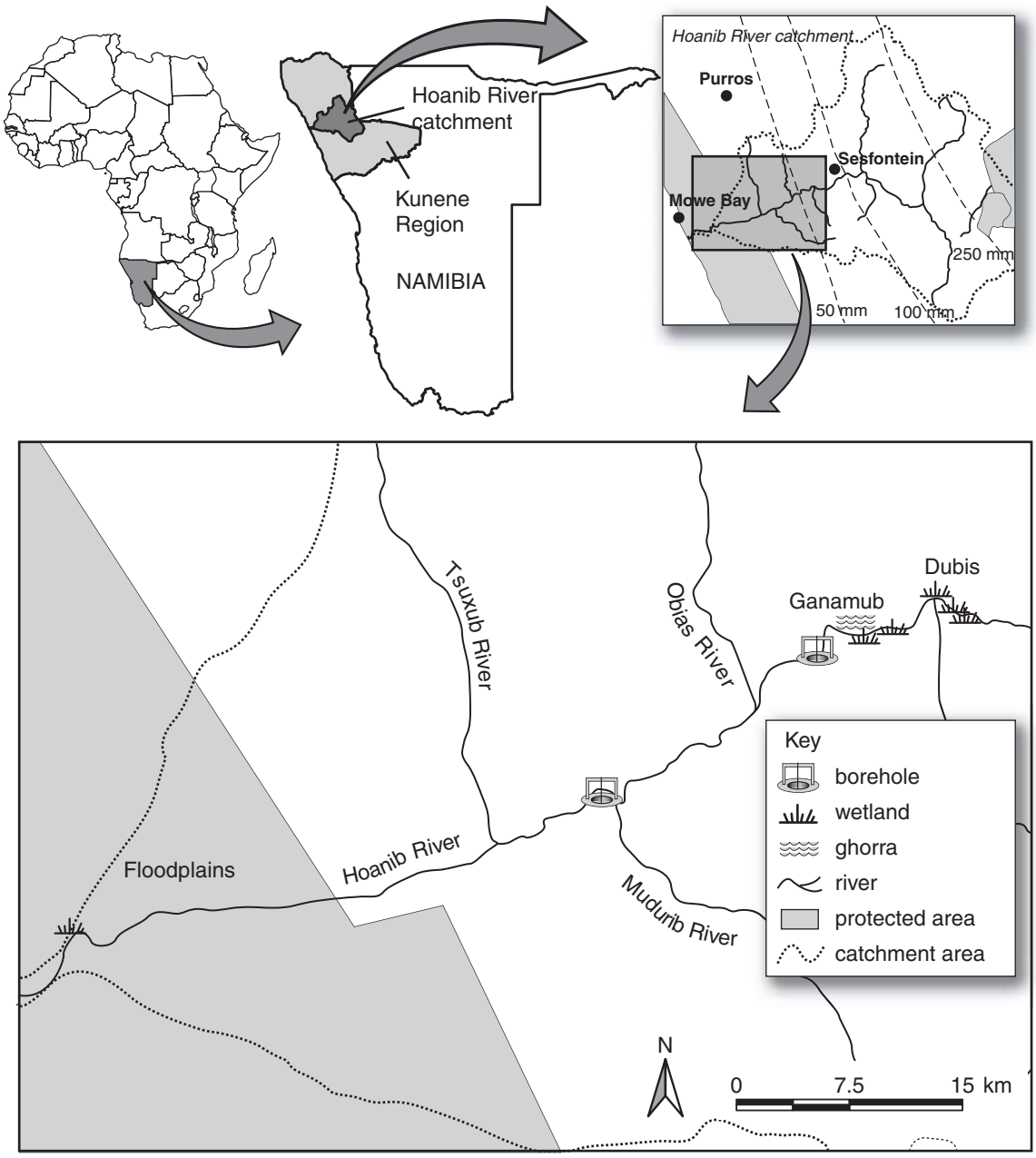

Figure 1. Location of wetlands, ghorras and artificial water points in the lower Hoanib River, north-west Namibia.

In late October 2002, two AWPs were drilled in the western section of the Hoanib River: at Ganamub Poort and at the confluence of the Mudurib and the Hoanib Rivers. The government of Namibia provided these AWPs to keep elephants away from the human settlements approximately 30 km to the east of Dubis.

Methods

The observations reported here were made between January 1998 and June 2004. From January 1998 until June 2001, transects were driven through the research area every two months and elephant identification,

location (coordinates obtained by GPS), numbers and drinking behaviour were recorded. (For a detailed description of the transect methods see Leggett et al. 2003c.) Since June 2001, I have spent a minimum of 10 days a month (weather and floods permitting) in the research area, observing elephants and recording detailed information on identification, location numbers, activities and behaviour.

Elephants were individually identified using a combination of photographs and identification sheets. The photographic techniques used were similar to techniques already described by Douglas-Hamilton and Douglas-Hamilton (1975) and Moss (1982).

For the purposes of this paper, a basic family unit is defined as a mother and offspring associated with her, a herd as a group of closely associated individuals who coordinate daily activities, and a clan as individuals who occupy the same seasonal range. While the Hoanib River catchment constitutes a small section of the total range of these elephants, it represents an important core area for elephants in the Kunene Region (Leggett 2006).

There are approximately 54 elephants in seven family units (between 3 and 9 individuals) plus 7 adult males at any one time in the western section of the research area. Only two family units and 4 free-ranging adult males moved between the Hoanib and Hoarusib Rivers. One of the family units (Western Kunene Female, WKF-18) and one free-ranging adult male (Western Kunene Male, WKM-10) were GPS collared in September 2002. Douglas-Hamilton (1998), Blake et al. (2001) and Leggett (2006) have previously described the use of GPS collars for tracking elephants. Two other elephants were also GPS collared; their home ranges are presented in figure 2. The other family unit (Western Kunene Female, WKF-14) was closely observed and its locations recorded during the study period.

Elephant drinking behaviour was recorded for individual males and for family units over each study period (February 2002; February, May and September 2003). Elephants were located daily and followed during diurnal hours, and their behaviour was recorded. AWPs were checked morning and evening for spoor to determine whether elephants had drunk

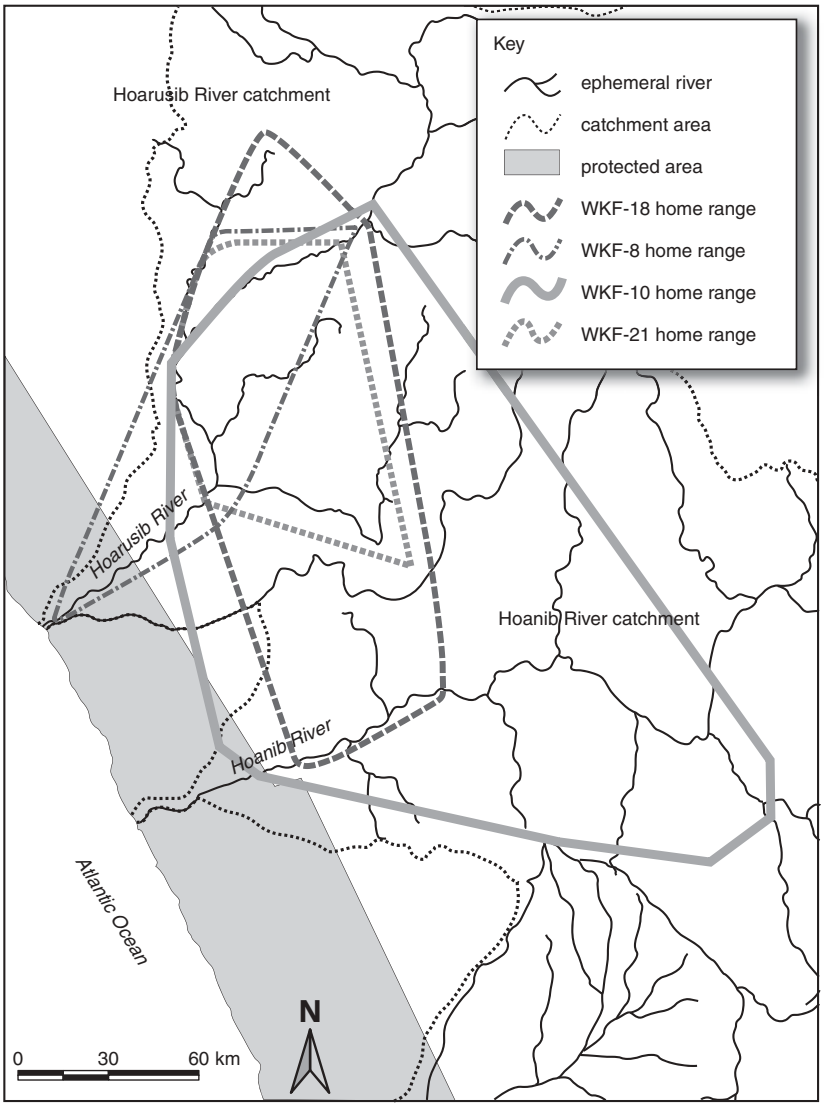

Figure 2. Home ranges of four GPS-collared elephants, north-west Namibia, 2003 and 2004.

there during my absence. Only data for elephants whose locations were known during the study period are presented.

Data analysis

All GPS readings were converted to a Schwarzek projection using MAPINFO, a geographical information system (GIS) (MapInfo Corporation 1998). Using overlays of GPS readings of the elephant locations and water-source information (both artificial and naturally occurring), the number and position of elephants within a 1-, 5- or 10-km radius of either the AWPs or the wetlands was determined. The non-parametric Mann-Whitney *U*-test was used for all statistical analyses.

Results

Observational data on the density of elephants in the lower Hoanib River over the period 1998–2004 are presented schematically in figure 3. The densities of family units before AWPs were provided (January 1998–November 2002) are presented in figure 3a, while figure 3b shows the density after AWP (December 2002–April 2003). Similarly, figures 3c and 3d show the density of male elephants before and after AWPs were provided.

Average distance of elephants away from permanent natural water sources and AWPs is presented in table 1. Additionally, this table contains the percentage of elephant observations within radii of 1, 5 and 10-km and a radius greater than 10 km of natural and artificial water sources.

Before AWPs were provided, family units were observed 22% of the time within a 1-km radius of wetlands, 61% within a 5-km radius and 13% within a 10-km radius, with only 4% observed more than 10 km away from a wetland. The average distance of family units away from a wetland was 3.65 ± 3.54 km (n = 23). After AWPs were added, however, only 2% of family unit observations occurred within a 10-km radius of a permanent natural water source, while 98% of observations located elephants at distances greater than 10 km away. The average distance of elephants away from permanent natural water sources was 17.90 ± 5.43 km *(n = 41)*, which is significantly different from the pre-AWP situation *(U* = 39, $p < 0.001$).

Free-ranging adult males showed distribution different from the family units. Before AWPs 40% of free-ranging adult male elephants were observed within a 10-km radius of the natural permanent water sources, while 60% of observations were greater than 10 km away. The average distance males were observed from the wetlands and ghorras was 10.77 ± 8.66 km (n = 52). However, after the AWPs were provided, observed free-ranging adult males showed a distribution (U = 1187, p = 0.779) similar to family units with 98% of observations being greater than 10 km away from the natural permanent water sources. Their average distance was 17.95 ± 6.45 km (n = 60), which was significantly different (U = 839, $p < 0.001$) from the pre-AWP distance.

Family units and free-ranging adult males showed similar distributions around the AWPs with average observation distances of 3.97 ± 3.53 and 4.20 ± 2.92 respectively. There was no significant difference (U = 791, p = 0.395) between the distribution of family units and free-ranging adult males after AWPs were provided.

Collared elephant movement

WKF-18 returned to her seasonal range in the Hoanib River on 3 October 2002 (fig. 4a). From October to November, she and her family unit occupied their traditional range around the wetlands, with occasional excursions down past the Obias and Mudurib Rivers. After the construction of AWPs in November 2002, the female and her family unit gradually shifted their range until by the end of January, they occupied the area to the west of the Mudurib River almost exclusively (fig. 4b). The herd moved out of the Hoanib River on 29 January 2002. WKF-18 did not return to the Hoanib River during the 2003 hot dry season, remaining at the Hoarusib River instead.

WKM-10 returned to the Hoanib River on 29 October 2002 (figs. 4c and 4d). From October until December 2002 he occupied a range approximately 10 km to the west of permanent natural water sources. He then occupied a similar range for January, but in February and March 2003 he moved farther west and remained there until he moved out of the Hoanib River on 28 March 2003. He returned to the Hoanib River on 28 October 2003 and again occupied the western range area around the Mudurib AWP before leaving the river on 12 February 2004.

Seasonal movement

The seasonal movement of WKF-14 and her family unit, pre- and post- AWPs, is presented in figure 5.

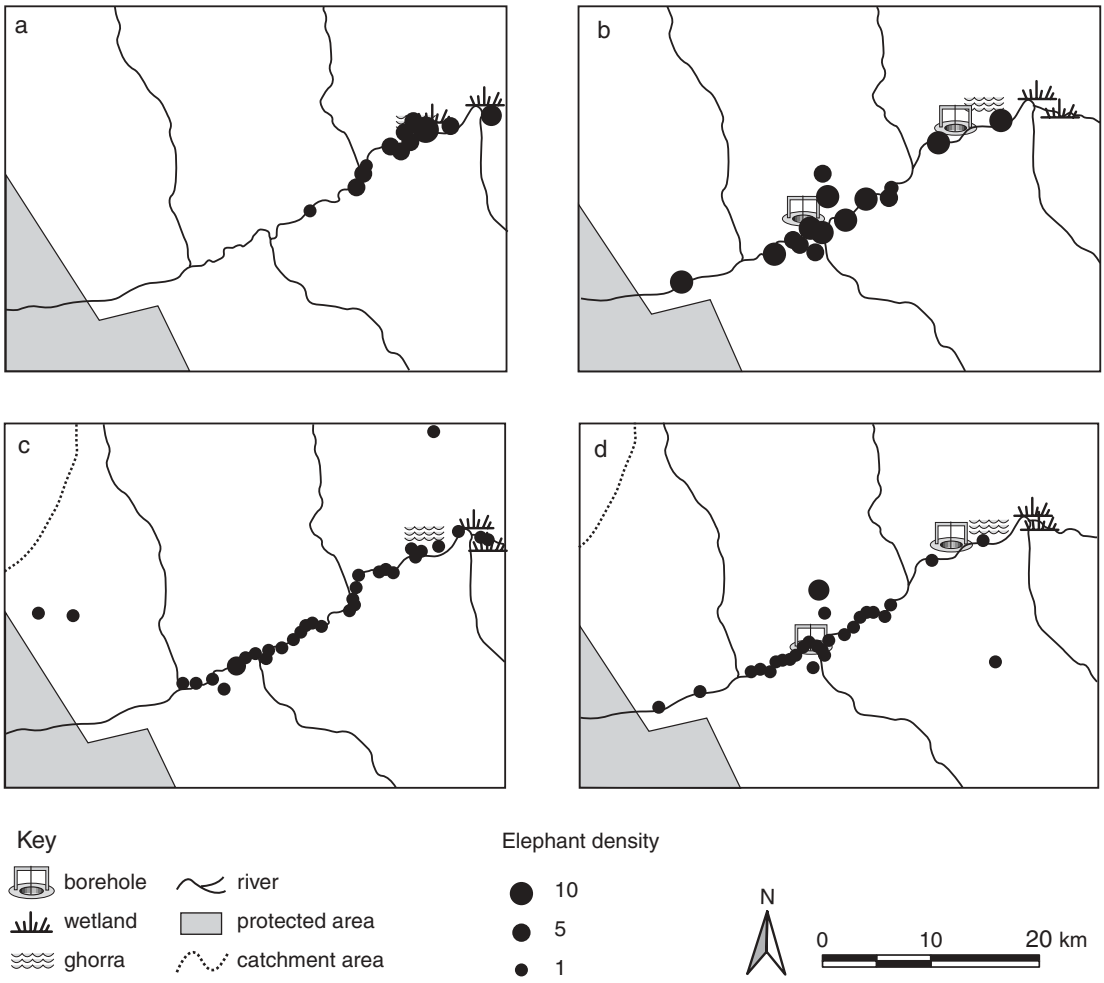

Figure 3. Elephant locations in the lower Hoanib River: female family units a) January 1998–November 2002, b) December 2002–June 2004; adult male elephants c) January1998–November 2002, d) December 2002–June 2004.

Table 1. Average distance from, and the percentage of elephant sightings within 1-, 5-, 10- and > 10-km radii of water sources in the lower Hoanib River, north-west Namibia

	No.	Average distance (km)	Elephants within 1-km radius (%)	Elephants within 5-km radius (%)	Elephants within 10-km radius (%)	Elephants > 10-km radius (%)
Pre-artificial water points, in wetlands and ghorras						
Females	23	3.65 ± 3.55	22	61	13	4
Males	52	10.77 ± 8.66	16	24	12	48
Post-artificial water points, in wetlands and ghorras						
Females	41	17.90 ± 5.43	1	0	1	98
Males	60	17.95 ± 6.45	1	1	1	97
Artificial water points						
Females	35	3.97 ± 3.53	27	52	20	1
Males	57	4.20 ± 2.92	15	55	34	1

Before AWPs were constructed, WKF-14 and her family unit moved (over the study period) at the end of the hot dry season from the Hoanib to the Hoarusib River, returning during the cold dry season. However, once AWPs were built in the river, WKF-14 and her family unit did not move back to the Hoarusib River but stayed at the Hoanib River for all of 2003 until June 2004. There was also a spatial displacement of the location of this family unit toward the western section of the river, centring on the AWP at the Mudurib River.

Neither WKF-18 and her family unit nor WKM-10 disrupted their seasonal movement patterns after AWPs were added.

Drinking frequency

During drinking studies carried out on two males and one family unit during February 2002, it was established that males drank every 3–5 days (n = 3) and female units every 2–3 days (n = 3). A similar study was undertaken in February, May and September 2003, when drinking frequencies for two males were observed to be 2–3 days (n = 9) and 2–3 days for one family unit (n = 12).

Flood events and ghorra use

Leggett et al. (2001a,b) and Leggett et al. (2005) described rainfall, flood events, water chemistry and sediment levels during flood events. The Hoanib River flooded twice during the 2003 wet season, with flood durations of four days and one day. During the 2004 wet season the Hoanib River flooded three times with flood durations of seven, three and four days (pers. obs.). Although elephants have been observed drinking from ghorras during all seasons, it was most common to observe them drinking during the cold dry and hot dry season (n = 12). After AWPs were constructed elephants were no longer observed to drink from ghorras during the cold dry and hot dry seasons; however, they were observed to do so during the wet season (n = 3). The reason for the low number of observations is because the area becomes inaccessible when rivers flood or rains occur.

Discussion

Providing AWPs in most areas of Namibia as elsewhere in Africa has led to permanent occupation by people and domestic stock, resulting in environmental degradation (Du Toit and Cumming 1999). This has not occurred in the western areas of the Hoanib River as local pastoralists have never used them extensively because they were too remote, access routes were poor and grazing erratic (Leggett et al. 2004). Large wildlife populations around AWPs can have a similar effect on the environment as domestic stock (Leggett et al. 2003b); however, this effect is partially mitigated by the nature of the arid areas. Rainfall is not a certainty and neither is grazing. Grazers thus periodically migrate into and out of the area, effectively reducing pressure on the vegetation around AWPs, allowing it to recover.

Historically, large herds of elephants were seasonally observed in the western section of the Hoanib River, particularly in the floodplains at the base of the dune field where seasonal water was available (Viljoen 1987). These aggregations were observed during the study period, with few elephants being observed in the western section of the research area. Before AWPs, family units were restricted to areas close to natural permanent water sources around Dubis. However, AWPs allowed elephant family units to shift their foraging range spatially approximately 22 km to the west, into areas they had previously visited only seasonally. They then maintained similar ranges around the AWPs, with approximately 80% of sightings made within 10 km of the AWP. The main cause restricting range of the family units was the need for juvenile elephants to drink more often than adults (Moss 1982; Viljoen 1988). This concentrates the family units into areas within a distance from permanent water sources to which juvenile elephants can walk in one-and-half to two days. Elephant populations tend to stay more permanently in riverine areas, where their potential impact on the vegetation (particularly *Faidherbia albida* trees) is far greater. However, it is believed that these herds will again start their regular seasonal movements once the readily accessible vegetation has been removed.

Adult male elephants have been reported to have greater foraging range than family units in the western section of the Hoanib River (Viljoen 1988). Viljoen (1988) proposed that this greater foraging range resulted from the ability of free-ranging adult males to go for relatively long periods (3–5 days) without water. Both these observations were supported by this study. With AWPs the free-ranging adult male's average foraging range decreased to a size similar to that of family units. In addition, the drinking frequency

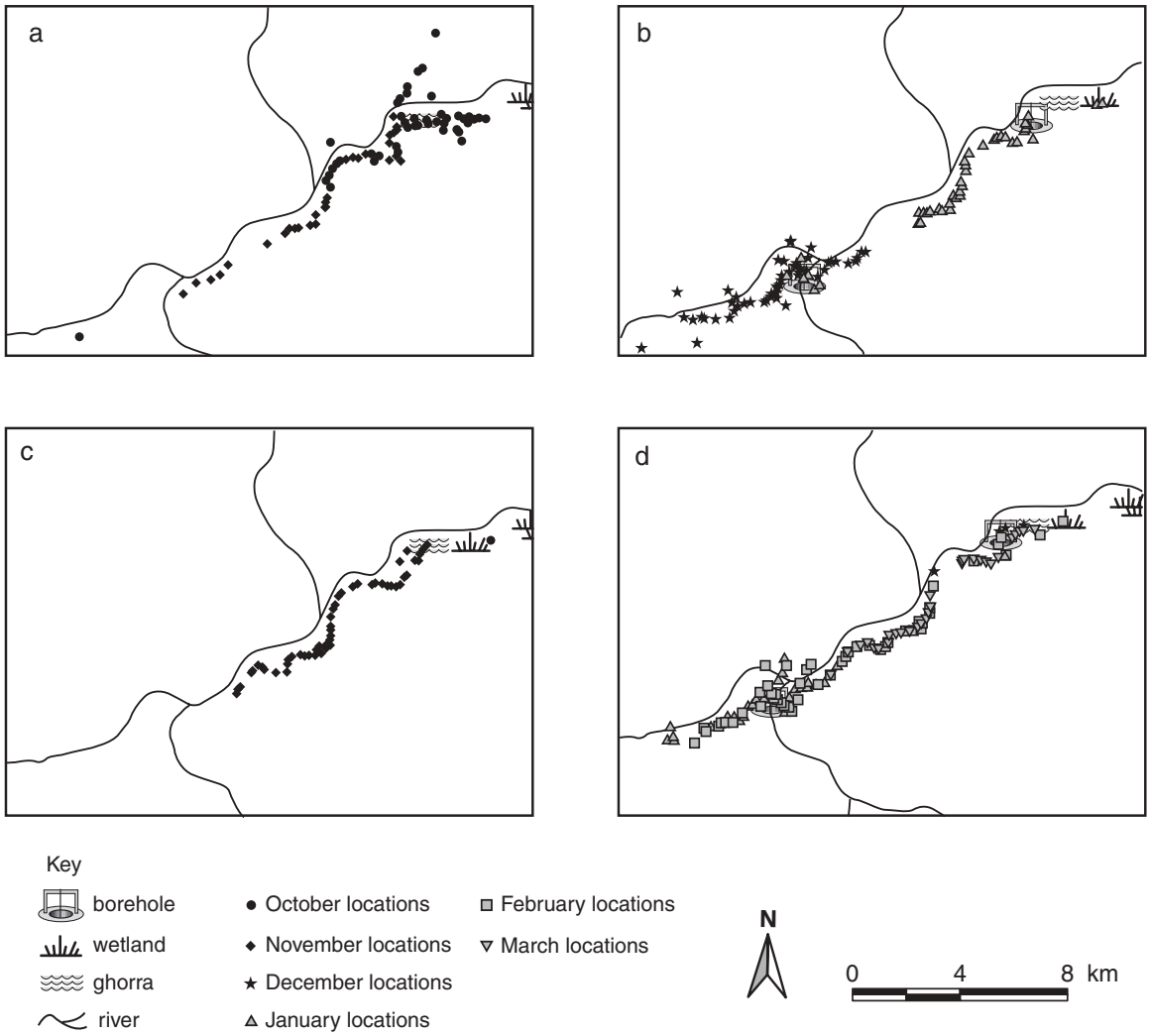

Figure 4. Movement of adult GPS-collared elephants in the Hoanib River: female WKF-18 a) October–November 2002, b) December 2002–January 2003; male WKM-10 c) October–November 2002, d) December 2002–March 2003.

increased to every second or third day. The spatial movement of elephants toward the western section of the Hoanib River was confirmed by GPS collar data from WKF-18 and WKM-10. Both elephants were observed to shift their foraging ranges once they discovered the western AWP. Verlinden et al. (1998) described similar spatial movements of domestic stock and wildlife in response to AWPs in the Kalahari Desert.

Providing AWPs has disrupted the seasonal movement of at least one family unit (WKF-14). Before AWPs, WKF-14 and her family unit would move seasonally from Hoanib to Hoarusib Rivers. Throughout 2003 and until June 2004, however, WKF-14 and her family unit did not move away from the Hoanib River. The reason the family unit remained there most probably was linked to the easily accessible foraging areas close to the AWPs. There was simply no need to move if forage and water both were readily available.

In other areas of Africa, providing AWPs has resulted in a rise in reproductive rates of elephants (Weir 1971; Dudley et al. 2001). This would be unlikely in this elephant population as the elephant density is relatively small and their intercalving period is relatively large (Viljoen 1988).

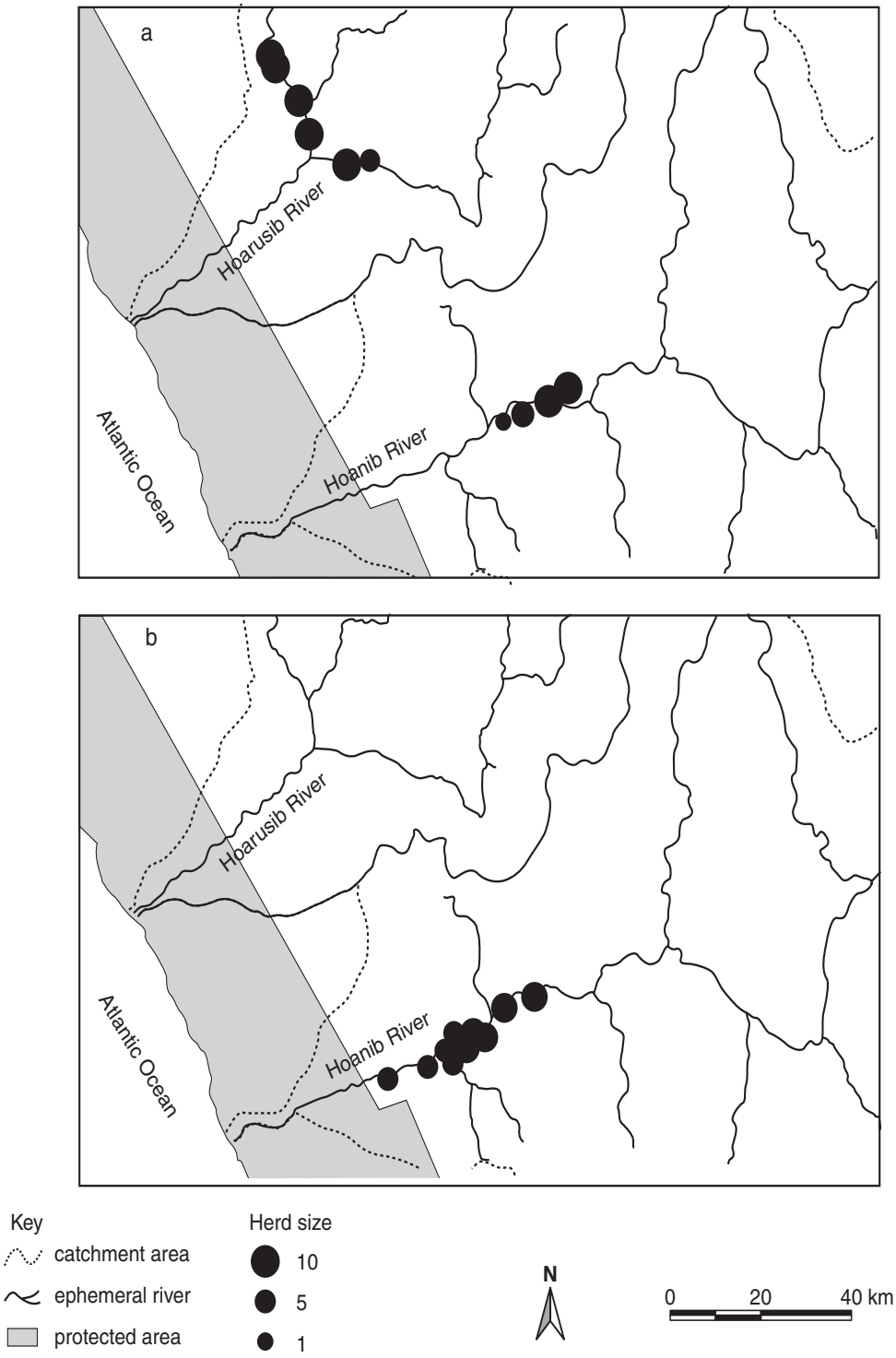

Figure 5. Observed locations of WKF-14 and her family unit in north-west Namibia, a) January 1998–November 2002, b) December 2002–June 2004.

In addition to changes in drinking behaviour and foraging ranges, other changes in water-foraging strategies have been observed. Before November 2002, the elephants routinely dug ghorras in the riverbed during all seasons, from which they obtained relatively clean water. During the cold dry and hot dry seasons, elephants would continue to dig ghorras to ensure good water quality. Digging and drinking of water from ghorras was a time-consuming process for elephants, taking up to one hour for an elephant to be sated (pers. obs.). With the addition of clean, readily available fresh water from AWPs, elephants abandoned the practice of digging and drinking from ghorras during the cold dry and hot dry seasons. However, this practice continued during the wet season and with the arrival of the first floods. Floodwater quality is generally low, as it contains large amounts of suspended sediment (Leggett et al. 2005). As the ghorras filter most of the suspended sediment from the water, the quality of ghorra water was probably better than that of AWPs during the wet season, due to a high water table in the rivers. During the cold dry and hot dry seasons as the water table falls in the rivers, ghorra water becomes more saline (Leggett et al. 2001b) and probably less palatable to elephants than the AWP water.

Conclusion

The addition of AWPs to the western section of the Hoanib River has allowed spatial movement of elephants from their traditional drinking and foraging areas to areas that previously were visited only periodically. Family units in particular have benefited from AWPs with a spatial shift in foraging range from 3.65 ± 3.55 km up to 17.90 ± 5.43 km from natural permanent water sources. Free-ranging adult males have also benefited by travelling shorter distances to drink. Both free-ranging adult males and family units were observed foraging within similar ranges around AWPs, 3.97 ± 3.53 km and 4.20 ± 2.92 km respectively**.** Potential does exist for elephants to damage the riverine vegetation (particularly *Faidherbia albida* trees) in these extended foraging areas; however, it is believed that they will renew their seasonal movement patterns once the readily available vegetation has been removed.

AWPs affected the seasonal movement of at least one family unit that remained in the Hoanib River, in preference to undertaking its normal seasonal move to the Hoarusib River. The seasonal movements of other family units and free-ranging adult males appeared to be little affected. Free-ranging adult males also appeared to increase their drinking frequencies, preferring to drink every 2 to 3 days instead of every 3 to 5 days as they had before AWPs were constructed. Drinking frequencies of family units remained unchanged. The practice of digging ghorras for water during the cold dry and hot dry seasons also appeared to cease, although elephants still dug ghorras during the wet season to obtain relatively clean drinking water.

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