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# Home range and seasonal movements of *Giraffa camelopardalis angolensis* in the northern Namib Desert

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## Abstract

Estimates of home range size of giraffe in the northern Namib Desert were on average larger than those in other populations. In particular, the largest individual home range of any giraffe bull (1950 km<sup>2</sup>) was recorded – correlated with low population density, reduced forage density and increased searching for receptive cows. The predominant pattern of movement was linear, along the riparian environments, however, large-scale irregular movements into tributaries and other areas were also recorded. Small-scale movements by bulls into the mountains above the Hoarusib River as well as by cows into the northern tributaries of the Hoanib River were observed. Seasonal movements of giraffe were not as distinctive as those in other giraffe populations. Small-scale habitat segregation was observed in the Hoarusib River study area with giraffe cows foraging only in the Gomatum River during the hot-dry season. The first ever study of GPS satellite collared giraffe provided some of the highest resolution data on giraffe movements to date, including strong biphasic movement behaviour of giraffe over 24-h periods.

*Key words:* giraffe, GPS satellite collaring, home range, Namib Desert, spatial movements

## Résumé

Les estimations de la taille du domaine vital des girafes du nord du désert du Namib furent en général plus grandes que celles des autres populations. En particulier, on a enregistré le plus grand domaine vital individuel pour une girafe mâle (1950 km<sup>2</sup>) – lié avec une faible densité de population, une densité de nourriture réduite et une recherche accrue de femelles réceptives. Le schéma de

déplacement dominant était linéaire, le long des environnements riverains, bien que l'on ait aussi enregistré d'importants déplacements irréguliers vers des affluents et vers d'autres régions. Des déplacements de faible ampleur furent aussi observés, de mâles dans les montagnes au-dessus de la rivière Hoarusib et de femelles vers les affluents plus au nord de la rivière Hoanib. Les déplacements saisonniers des girafes n'étaient pas aussi typiques que ceux d'autres populations de girafes. Une ségrégation de l'habitat à petite échelle fut observée dans la zone d'étude de la rivière Hoarusib, avec des femelles qui ne mangeaient que dans le bassin de la rivière Gomatum pendant la saison chaude et sèche. La première étude jamais réalisée d'une girafe équipée d'un collier à émetteur GPS a fourni certaines des données les plus précises sur les déplacements de girafes à ce jour, y compris un comportement en deux phases de déplacement très nettes par période de 24 heures.

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## Introduction

Dispersal and home range sizes of arid-adapted mammals are larger in comparison to that of the same or similar species in higher rainfall environments (e.g. Du Toit, 1990; Dickman *et al.*, 1999). Local rainfall, availability of food and free water are dominant factors driving mammal movements in arid environments, with individuals moving to obtain patchy and ephemeral resources compared to mesic environments where resources are often richer and more stable.

The giraffe *Giraffa camelopardalis* Linnaeus 1758, with large body mass and high bioenergetic requirements, has more expansive home ranges than smaller ungulates in the same environment (e.g. Cloete & Kok, 1986; Du Toit, 1990). However, large differences in giraffe home range sizes have been reported across their range (e.g. Berry, 1978; Dagg &

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Foster, 1982). Abiotic (e.g. climate, topography), biotic (e.g. forage availability and quality, herbivore and predator densities) and human influences (e.g. poaching, population growth) are contributing factors that affect giraffe range and distribution (e.g. Dagg & Foster, 1982; Ciofalo, 1995).

The use of varying sampling techniques and limited research have previously resulted in underestimation of giraffe home range (e.g. Langman, 1973; Dagg & Foster, 1982; Van Der Jeugd & Prins, 2000). Home range analyses have historically been limited to direct field observation (e.g. Foster & Dagg, 1972; Berry, 1978; Van Der Jeugd & Prins, 2000), although the use of telemetry has provided considerably more data (e.g. Langman, 1973; Dagg & Foster, 1982). Advanced methods of animal movement and core home range analysis used for other species e.g. African elephants (e.g. Douglas-Hamilton, Krink & Vollrath, 2005) have more recently provided a more accurate estimate of animal ranges and movements. However, so far few studies have attempted to gain a better understanding of giraffe home range and movements. This is the first study using GPS satellite collaring of giraffe.

## Materials and methods

### Study area

The study region extends across a large portion (c. 7500 km<sup>2</sup>) of the northern Namib Desert. It comprised the

lower catchments of the Hoanib (c. 3750 km<sup>2</sup>), Hoarusib (c. 2750 km<sup>2</sup>) and Khumib Rivers (c. 1000 km<sup>2</sup>) (Fig. 1). These river catchments are the three northernmost of the twelve major westerly flowing ephemeral river systems that occupy the hyper- to semi-arid areas of western Namibia. All three ephemeral rivers end in the Namib Desert Sand Sea within the Skeleton Coast Park (SCP).

Located between a latitude of c. 18.5°S and 19.5°S and a longitude of c. 12.5°E and 13.5°E, the study region ranges in altitude from near sea level in the west to c. 1200 m in the mountains. The three river systems in the study region are ecologically linked as wildlife migrates between the catchments (Viljoen, 1988; Jacobson, Jacobson & Seely, 1995). The riparian woodlands of the three catchment areas are the main source of life for all larger mammals of the region, from wildlife to domestic stock and humans. The region predominantly comprises communal farmland, although it extends into the protected SCP in the extreme west of the Hoanib and Khumib River study areas. No fences restrict the free movement of wildlife between communal farmland and the protected SCP.

The density of wildlife throughout the study region is substantial for such an arid environment (Jacobson *et al.*, 1995), although the species richness of large mammals is far less than in more densely vegetated, mesic environments (Holmes, 1992; Berger, 1997).

The Namib Desert's climate is characterized by low average temperatures, high humidity and the presence of

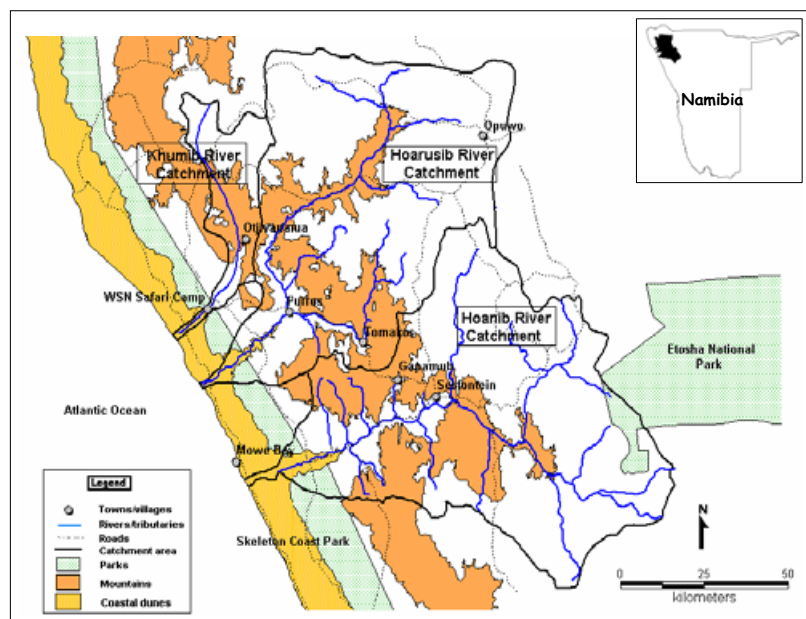


Fig 1 Study Area (Hoanib, Hoarusib and Khumib River catchments) in the Kunene Region, northwestern Namibia

fog, with a marked increase in temperature and a decrease in humidity eastwards from the coast (Seely, 1978; Tarr & Tarr, 1989). Precipitation, in the form of rain, is regarded as the single most important factor in the Namib Desert and semi-desert ecosystem and a direct correlation between rainfall and vegetation cover has been recorded (Seely, 1978; Viljoen, 1980; Tarr & Tarr, 1989). Rainfall is highly localized and spatially and temporally irregular (Seely, 1978; Sharon, 1981), with <100 mm per annum and a mean of 13.2 mm per annum with 90% variability at the coast (Jacobson *et al.*, 1995; MWTC, unpublished data, 2000).

The climate of Namibia's northwest can be classified into two distinct seasons; a wet (March–May) and a dry season. The dry season further divides into a cold-dry (June–August) and hot-dry (September–February) season based on ecological considerations, mean monthly rainfall and temperature (Viljoen, 1988).

Temperatures correlate with latitude and prevailing seasonal winds, ranging from moderate to extreme, with temperatures in the hot-dry season often reaching 50°C. In the cold-dry season, temperatures are lower and range from 5°C to 27°C, while the temperature fluctuations during the wet season are the greatest as a lag period from the hot-dry season persists before the rains arrive and the temperature is lowered (MWTC, unpublished data, 2000).

The distinct geographical separation of the ephemeral rivers and the differences in human use associated with them provide a clear methodological separation for assessing subpopulations in the greater study region. However, as climate, animals and vegetation types are similar between each of the study areas, it also allows for the compilation of data sets for analysis where sample sizes were not large enough.

### Methods

Over more than 2 years (2001–2003), individual giraffe co-ordinates were recorded during monthly field trips. Additional data were collected from GPS satellite collars (developed by African Wildlife Tracking) fitted to four giraffe (three bulls and one cow); two bulls in the Hoarusib River study area, one bull and one cow in the Hoanib River study area (see Fennessy, 2004 for details).

Numerous authors have developed and/or adapted identification methods for individual giraffe (e.g. Foster, 1966; Leuthold, 1979). This study further adapted these methods using a combination of individual identification

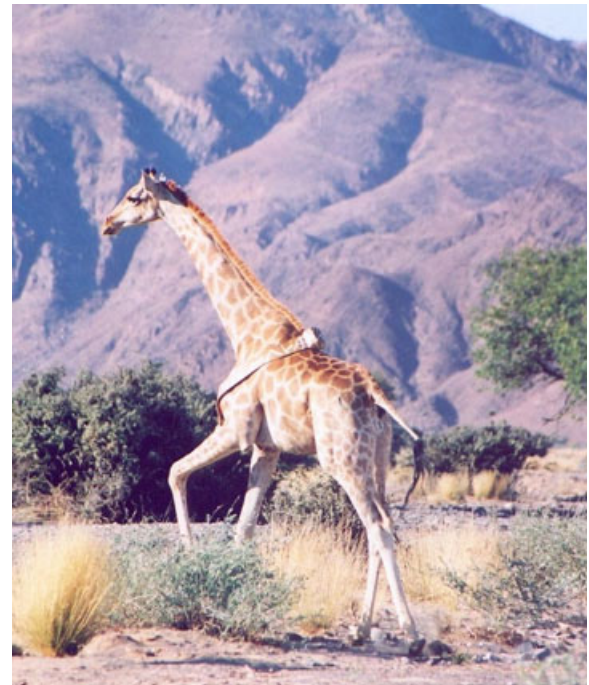


Fig 2 Example of GPS satellite collared giraffe in the study region: collared cow giraffe in the Hoanib River study area, September 2003 (photo courtesy of R. Caudle)

methods including sex, size, right and left hand-side pelage patterns, ossicones, colour and tail length.

The GPS unit (MT2000 terminal) used was a light-weight (<900 g) mobile transceiver, with the battery pack acting as a counter balance for the collar with an in-built VHF telemetry transmitter (Fig. 2). The GPS satellite system used was an Inmarsat 3. All collars were programmed to transmit coordinates and ambient temperature at 8-h intervals, while three collars also transmitted hourly GPS readings for four to five consecutive days per month.

Estimates of home range size were calculated using data from individually identified giraffe and the GPS satellite collar data. Individual home ranges were estimated for giraffe with at least ten observations collected over a minimum period of 1 year. Published estimates for giraffe have used fewer observations to obtain home ranges (e.g. Foster & Dagg, 1972; Berry, 1978), however, no asymptotic home range size has been reached for any population, as the numbers of fixes obtained per individual were considered too low.

Home range sizes were estimated using both the 100% minimum convex polygon (MCP) and 95% or peeled MCP

methods (Jenrich & Turner, 1969), analysed in the Map-Info extension program Range Manager v.1 (Data Solutions, 1998). Mean monthly and weekly ranges were estimated using 100% MCP, while mean hourly and daily movements were calculated by tallying total distance travelled. Differences in home range estimates between sexes and study areas were tested using Kruskal–Wallis and two-tailed Mann–Whitney *U*-tests. The results obtained during this study provide the first home range estimates for giraffe in Namibia.

## Results

### Home range

The largest recorded home range estimates for any giraffe in Africa were observed for a giraffe bull (1950 km<sup>2</sup>) and the second largest for a cow (1098 km<sup>2</sup>) (Table 1). Home range estimates varied markedly both between and within the sexes (Table 1). Data on home range sizes of juvenile giraffe were limited (*n* = 2), but essentially they occupied smaller areas than bulls and cows.

The MCP 95% home ranges of giraffe were markedly reduced and provided a more accurate estimate of home range sizes and core resident areas, e.g. eliminating gravel plains, when compared to the MCP 100% estimates (Table 1): approximately 50% for cows and 70% for bulls and juveniles.

Differences in home range estimates between sexes and study areas as well as between sexes within the study areas were tested using Kruskal–Wallis and two-tailed Mann–

Whitney *U*-tests. These nonparametric techniques were preferred to analysis of variance because of non-normality in the distribution of data, which could not be correlated by transformation.

The mean home range sizes of giraffe bulls in the total study area were greater than those of cows (two-tailed Mann–Whitney *U*-test, *U* = 208; *P* = 0.016 respectively). In the Hoanib River study area, where sample sizes were sufficient for comparisons, home ranges of bulls were also greater than those of cows (two-tailed Mann–Whitney *U*-test, *U* = 74; *P* = 0.039 respectively).

The mean home range estimates were not significantly different between the three areas (Kruskal–Wallis: MCP 100%; *H* = 1.829; d.f. = 2; *P* = 0.401; and MCP 95%; *H* = 1.437; d.f. = 2; *P* = 0.487 respectively) because of the large variation in individual range estimates within each. Small population numbers and limited access to the Khumib River study area may have contributed to an underestimate of home range size and comparative analyses.

The mean home range estimate for cows in the Hoanib River study area (219.7 km<sup>2</sup>) was almost twice that for cows in the Khumib River study area (117.3 km<sup>2</sup>). However, comparisons using MCP 100% and 95% were not significantly different (Kruskal–Wallis: Hoanib–Khumib; *H* = 0.222; d.f. = 1; *P* = 0.637 and *H* = 0.041; d.f. = 1; *P* = 0.84 respectively) because of the large variance in range estimates within the two study areas. Limited observations of individual cows in the Hoarusib River study area restricted any analysis of home ranges.

**Table 1** Mean annual home range size estimates (km<sup>2</sup>) and ranges (km<sup>2</sup>) of giraffe in the study region using the 100% and 95% MCP method (*n* = number of individuals)

Study region	<i>n</i>	Estimates of home range size (km <sup>2</sup> )			
		MCP 100%		MCP 95%	
		Mean (km <sup>2</sup> )	Range (km <sup>2</sup> )	Mean (km <sup>2</sup> )	Range (km <sup>2</sup> )
<b>Bull</b>					
Hoanib River	20	494.1	26.7–1950	330.4	11.5–1773
Hoarusib River	22	572.6	33.9–1627	408.5	10.1–14.9
Khumib River	2	67.1	66.1–68.1	22.7	21.8–23.7
Study region	44	513.9	26.7–1950	355.5	11.5–1773
<b>Cow</b>					
Hoanib River	13	219.7	12.9–1098	119.1	8.3–702.1
Khumib River	3	117.3	34.6–158.6	23.6	23.5–23.9
Study region	16	199.5	12.9–1098	100.0	8.33–702.1
<b>Juvenile</b>					
Study region	2	20.8	10.7–30.9	14.5	10.3–18.7

### Movements

Giraffe predominantly used the main riverbeds in the study region (Fig. 3), foraging up the tributaries and sometimes into adjacent study areas. No seasonal movements or seasonal home range partitioning was observed.

### Movements – long distance

Long distance movements (>50 km) were most commonly undertaken by giraffe bulls. The majority of the long distance movements, along distinct tributary corridors

(Fig. 3) was observed between the Hoanib and Hoarusib River study areas, 70 km in a straight line. Thirty individual giraffe bulls representing *c.* 42% of the bull population moved between these two study areas. One bull moved between the Hoanib and Hoarusib River study areas three times. Only one giraffe bull was observed to have moved between the Hoarusib and Khumib River study areas, a movement of *c.* 35 km in a straight line. Seven cows were recorded undertaking long distance movements predominantly between the Hoanib and Hoarusib Rivers southern tributaries, *c.* 55 km. These movements were the first recorded movements by giraffe

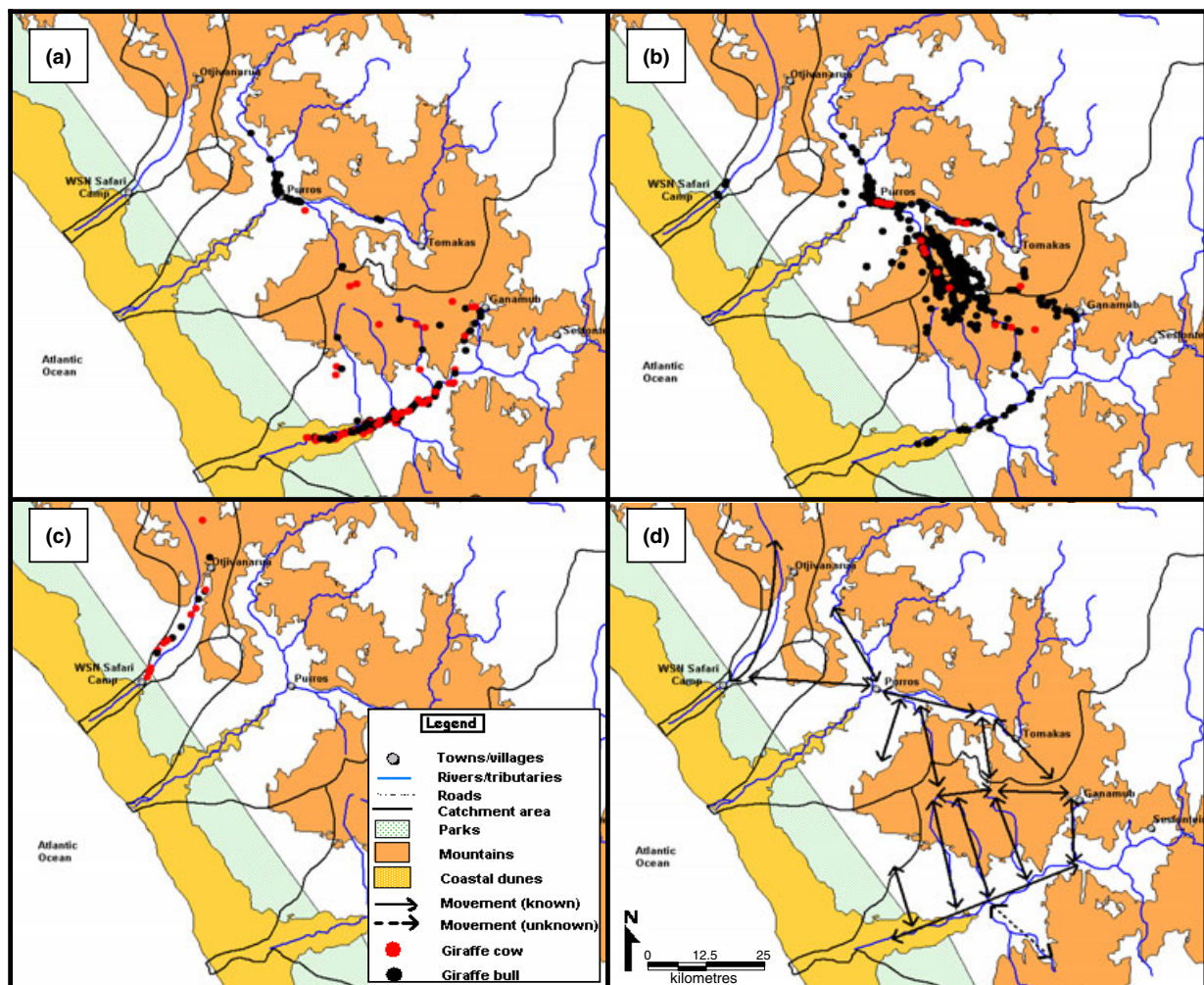


Fig 3 GPS locations of all giraffe sightings during the study. All giraffe were assigned to the study area of their first observation: (a) Hoanib River; (b) Hoarusib River; and (c) Khumib River. All giraffe sightings (d) – known and assumed movement corridors

**Table 2** Daily linear movements (mean  $\pm$  SD, km) and ranges ( $\text{km}^2$ ) of two GPS satellite collared giraffe bulls (HSBM3 & HSBM12) and one cow (HNBF18), October 2002–January 2003

Month (hot-dry season)	Mean daily movement (km $\pm$ SD)	Range ( $\text{km}^2$ )
HSBM12 (n = 83)		
October	7.51 $\pm$ 7.02	0.90–20.86
November	6.12 $\pm$ 6.25	0.29–28.81
December	4.31 $\pm$ 2.15	0.09–8.95
January	5.29 $\pm$ 2.83	2.08–9.58
HSBM3 (n = 82)		
October	4.99 $\pm$ 4.36	1.16–21.39
November	6.12 $\pm$ 6.52	0.40–32.24
December	5.16 $\pm$ 2.97	0.42–10.08
HNBF18 (n = 15)		
October	1.87 $\pm$ 2.05	0.06–7.41

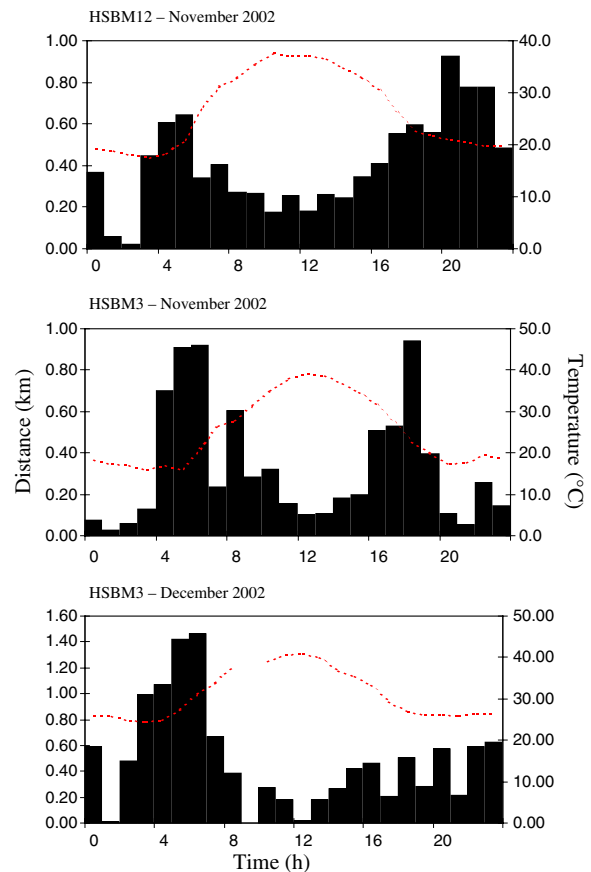
Although expressed as mean values  $\pm$  SD, the movement data are derived from repeated measurements on the same individuals and hence cannot be considered independently. In this context, mean values  $\pm$  SD are presented simply as convenient summary statistics.

between the three river systems. No correlation between long range movements and seasons was apparent for either sex.

#### Movements – daily and hourly

Hourly fixes from GPS satellite collared giraffe (two bulls and one cow) during the hot-dry season were obtained over a combined total of 180 days (Table 2). The average daily movements of the bulls were 5.64 km compared to 1.87 km for the cow. The difference in the daily movements of the two bulls was not in proportion to the difference in their estimated weekly, monthly and annual home ranges. This variance is a reflection of the nonlinear foraging pattern of giraffe.

No correlation was found between daily distance travelled and mean ambient temperature ( $r = 0.129$ ,  $P > 0.05$ : linear regression), nor between hourly movements and hourly ambient temperatures ( $r = -0.345$ ,  $P > 0.05$ ) (Fig. 4). However, hourly linear movements were shorter predawn but increased at dawn and post-dawn in correspondence with an increase in ambient temperature. During the hottest periods of the day, giraffe travelled only short distances. Mean hourly movements increased again pre- and postdusk, corresponding to reduced ambient temperatures.



**Fig 4** Hourly linear movements (km) (black blocks) and hourly temperature ( $^{\circ}\text{C}$ ) (dashed red line) of two satellite collared giraffe bulls in the hot-dry season 2002. Note different distance scales on graphs

## Discussion

### Home range

Giraffe bulls in the northern Namib Desert had substantially larger home ranges than cows ( $>2.5$  times). The two largest bull home ranges were 1950 and 1627  $\text{km}^2$ , and represent the largest ever recorded. Previously, the largest bull home range was reported from Niger (1559  $\text{km}^2$ ; Le Pendu & Ciofolo, 1999). The two largest bull home ranges in this study incorporated two main riparian woodlands – Hoanib and Hoarusib Rivers and their tributaries. These large home ranges presumably reflect the reduced probability of giraffe encountering potential mates, maintaining their dominance and/or seeking forage to maintain their energetic and nutritional requirements in this sparsely vegetated arid environment.

Giraffe cow home ranges were substantially smaller than bulls, with only one cow occupying a range >1000 km<sup>2</sup>. The largest cow home range reported was also in Niger (1379 km<sup>2</sup>; Le Pendu & Ciofolo, 1999), where they seasonally migrate between communal farmland. The arid environmental conditions experienced by giraffe in Niger and Namibia account for their similarly large ranges.

Home range sizes of juvenile giraffe were small (20.81 km<sup>2</sup>) compared to those of both cows and bulls; however, they did correspond with their mothers' home ranges for the same period. Although juvenile home ranges were greater than those observed elsewhere (e.g. 12.8 km<sup>2</sup> in South Africa, Langman, 1973), they were likely to be grossly underestimated. Limited observations of juveniles restricted true home range estimates, however in the Hoarusib River study area they ranged a minimum of 200 km<sup>2</sup> (J. Fennessy, personal observation). Increased research would help provide a better indication of their home ranges.

Although giraffe in arid environments have larger home ranges, the larger comparative ranges of bulls versus cows are less pronounced (e.g. Berry, 1978; Leuthold & Leuthold, 1978; Le Pendu & Ciofolo, 1999; Van Der Jeugd & Prins, 2000). Undoubtedly, giraffe range sizes vary between areas of different population structures and densities as well as between environments differing in size, forage availability, seasonal rainfall and predator density. A negative correlation ( $r = -0.45$ ) was observed between published estimates of home range size against population density in giraffe indicating that giraffe in sparse populations generally occupy larger mean home ranges. Decreased availability of forage and high variability in seasonal and spatial rainfall generally limit giraffe densities and increase their range in arid environments (e.g. Scheepers, 1992; Le Pendu & Ciofolo, 1999).

Along forage rich riparian environments, home ranges are often linear and elongated (e.g. Berry, 1978; Scheepers, 1992) but can be irregular in shape (e.g. Leuthold & Leuthold, 1978; Dagg & Foster, 1982; Pellew, 1984a). In the northern Namib Desert, giraffe were observed to be considerably more mobile than previously assumed, even though most home ranges were linear because of the main riparian environments and their tributaries being the life-lines of the region. Giraffe seldom used all their areas in their home range, as much of it was devoid of forage and encompassed inhospitable terrain.

With one exception, no apparent spatial or seasonal segregation in habitat use was observed for either sex in

the northern Namib Desert, with giraffe bull and cow home ranges overlapping both within and between study areas. No giraffe cows were ever observed in the Hoarusib River and only infrequently foraged in one tributary (Gomatum River) preferring the other southern tributaries. As a consequence, the Hoarusib River population was strongly bull-biased in an area of considerable forage availability compared to elsewhere. It has been reported that bulls need more food than cows to maintain their larger body mass (Du Toit, 1990), hence bioenergetic advantages would presumably accrue to bulls enabling them to exploit the Hoarusib River.

However, if such rich food resources were available in this arid environment, why should bulls, but not cows, exploit them? It has been hypothesized that, in various ungulate species, cows forgo foraging benefits for environments that are more suitable for raising young (e.g. Main & Coblentz, 1990). Giraffe cows in the Hoarusib River study area foraged only in the hot-dry season in the Gomatum River when food availability was reduced elsewhere. The avoidance of the Hoarusib and, to a lesser extent, Gomatum Rivers may be an attempt to reduce conflict with both bulls and communal farmers and thus protect offspring by limiting unwanted interactions. Similar hypotheses have been postulated for the distribution of giraffe cows and juveniles elsewhere (e.g. Pratt & Anderson, 1982; Pellew, 1984b; Young & Isbell, 1991). This resource-shelter trade-off may be feasible when population numbers are low, however, if giraffe numbers increase it may begin to deplete food resources in areas away from the main riverbeds.

#### *Movements and corridors*

Giraffe in the northern Namib Desert showed the highest preference for the riparian environments almost to the exclusion of other habitat types, although sighted in all habitat types. Their strong preference for riparian environments is similar to that reported for desert-dwelling elephants in the northern Namib Desert (Viljoen, 1988, 1989; Leggett, 2006).

During the cold-dry and occasionally the early hot-dry season, giraffe foraged into the mountains. Precipitation in the form of evening fog blankets the mountains and raises the average moisture content in selected species such as *Commiphora* Jacq. (Viljoen, 1988; Scheepers, 1992). Giraffe foraged on these species seasonally, as desert-dwelling elephants do (Viljoen, 1988, 1989; J. Fennessy, personal observation). Although distinct seasonal movements of



giraffe between areas were limited in this study, giraffe seasonally move between distinct forage areas elsewhere e.g. Niger (e.g. Ciofolo & Le Pendu, 2002; Caister, Shields & Gosser, 2003).

In general, giraffe movements and home range sizes are linked strongly to seasonal browsing and/or water availability (e.g. Hall-Martin, 1974; Berry, 1978; Pellew, 1984b). Specifically, seasonal movements have been associated with phenological changes in preferred plant species (e.g. Hall-Martin & Basson, 1975; Leuthold & Leuthold, 1978), with shifts in forage preferences leading to seasonal expansion or contraction of ranges (e.g. Hall-Martin & Basson, 1975; Leuthold & Leuthold, 1978; Ciofolo & Le Pendu, 2002). The few observations of giraffe drinking water in the northern Namib Desert (less than ten sightings in 70 years: Viljoen, 1981; Scheepers, 1992; Fennessy, Leggett & Schneider, 2003) indicate that surface water is not a factor influencing either seasonal or annual giraffe movements.

Seasonal east–west movements of giraffe along the riparian environments in the northern Namib Desert have been previously reported (Fennessy *et al.*, 2003). During the hot-dry season, giraffe aggregate in the eastern and central sections of the study areas in response to the increased availability of *Faidherbia albida* (Delil) A.Chev. pods, an essential dry-season food and an early flush in *Colophospermum mopane* (J.Kirk ex Benth.) J. Léonard leaves. *Acacia Robinia acacia* L. species, *Salvadora persica* Wall. and *Euclea pseudebenus* E. Mey. were also relatively abundant, but little other forage was available. This behaviour directly corresponded with giraffe's ability to obtain greater forage with high nutrient and moisture composition (Fennessy, 2004).

#### *Long distance movements*

This study recorded the first long distance movements of giraffe in the northern Namib Desert, previously assumed to be restricted to catchments because of the large distances between them (Viljoen, 1982; Scheepers, 1992). Forty-two per cent of giraffe bulls made long distance movements probably as a result of searching for receptive cows, new forage sources and moving from newly occupied communal settlements. Cow movements most likely were the result of the latter two. Similar giraffe movements have been reported elsewhere, e.g. giraffe synchronizing with communal farmer activities in Niger (e.g. Le Pendu & Ciofolo, 1999) and searching for forage in Zambia (Berry, 1978).

Research on elephants in the northern Namib Desert correlated long-range movements with forage quality, proximity of forage to water, seasonal rainfall and flood events (e.g. Viljoen, 1980; Viljoen, Bothma & Du, 1990) with elephants observed moving up to 70 km in a 24-h period between forage and water resources (Viljoen *et al.*, 1990; Leggett, Fennessy & Schneider, 2003) and in excess of 600 km in one season (Leggett, 2006). However, giraffe survival is not dependent on water and thus not correlated with proximity of forage to water, but rather forage quality and availability (Fennessy, 2004).

#### *GPS satellite collar movements*

Daily movements varied markedly between all collared giraffe. The giraffe cow's average daily movement (1.87 km) was lower than for cows elsewhere: 2.9 km in South Africa (Langman, 1973) and  $\leq 2.3$  km in Zambia (Berry, 1978). However, the cow's home range (199.51 km<sup>2</sup>) was substantially larger than reported elsewhere: South Africa (24.6 km<sup>2</sup>: Langman, 1973) and Zambia (68 km<sup>2</sup>: Berry, 1978). The two collared bulls' daily movements averaged 5.64 km similar to or greater than observed elsewhere in Africa: 2.6 and 5.9 km in South Africa (Innis, 1958; and Langman, 1973; respectively) and 3 km in Zambia (Berry, 1978). As the daily movement data were collected during the hot-dry season, coinciding with the highest ambient temperatures, smaller movements were expected. Additionally, Giraffe in more densely vegetated habitats appear to use a greater portion of their seasonal range each day compared to those in open, arid environments. Similar patterns have been reported for other species in the Artiodactyla family (Clutton-Brock, Albion & Guinness, 1989; Fischer & Linsenmair, 1999).

The mean hourly movements of the collared giraffe (for the hot-dry season) were strongly biphasic throughout 24 h. Increased movements occurred postdawn/early morning and in the period following as well as pre-dusk/early evening. Distance travelled was the least during the hottest period of the day (midday), thus reducing excess heat loads, as postulated in the 'heat-load' concept (e.g. Leuthold & Leuthold, 1978; Pellew, 1984b). Although no direct correlation was recorded between ambient temperature and distance travelled, the results suggested that giraffe rest predominantly during the middle of the day and increased activity again in the late evening/early morning. Evaluation of giraffe activity

budgets provides further insight into the biphasic movement patterns of giraffe and their engagement in energy consuming activities at different ambient temperatures (Fennessy, 2004).

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