Importance of borehole water to doves and sandgrouse in the semi-arid southern Kalahari

M. H. Knight
Kalahari Gemsbok National Park, Private Bag X 5890, Upington, 8800 Republic of South Africa

Received 22 March 1988; accepted 29 September 1988

The use of borehole water of different mineral quality by doves and sandgrouse in the semi-arid southern Kalahari was investigated. All species selected the least saline water available. Their use of the water supplies appeared to be affected by each species' tolerence of heat and different combinations of ambient temperature and rainfall variables. The provision of artificial water supplies has encouraged permanent residence by these otherwise nomadic species.

Die benutting van boorgatwater met wisselende minerale-inhoud deur duiwe en sandpatryse in die halfwoestyn van die suidelike Kalahari, is ondersoek. Al die spesies het die water met die laagste soutkonsentrasie benut. Benutting van die beskikbare water deur duiwe en sandpatryse is beïnvloed deur wisselende maandelikse omgewingstemperature en reënval, en die spesies se vermoë om hitte te kan weerstaan. Die kunsmatige voorsiening van water het permanente verblyf aangemoedig vir die andersins nomadiese voëlsoorte.

Keywords: Doves, Kalahari, sandgrouse, water provisioning, water quality

Introduction

The southern Kalahari is a vast semi-arid region which comprises predominantly red sands overlying a calcareous sandstone layer. The region experiences high daily and seasonal ambient temperature fluctuations with an erratic annual rainfall of 150–200 mm, restricted mainly to the late summer months (Leistner 1967).

No natural surface water exists, except for that held in the pans and dry riverbeds for short periods after heavy rainstorms. Artificial waterholes supplied with borehole water of variable quality have been erected within the Kalahari Gemsbok National Park, South Africa since the 1930s. The value and influence of this practice has been the subject of much speculation (Child, Parris & Le Riche 1971; Mills & Retief 1984; Knight, Knight-Eloff & Bornman 1988), as most of the indigenous fauna are considered to possess physiological and behavioural adaptations which reduce their dependence on drinking water (Maclean 1968; Taylor 1968; Lewis 1977; Dawson 1984; Louw 1984; Thomas 1984a).

It has been suggested that for some of the indigenous bird species, and particularly the nomadic granivores such as the doves and sandgrouse, the provision of drinking water enables them to remain as permanent residents (Maclean 1968; Fisher, Lindgren & Dawson 1972; Rowan 1983). However, the degree to which they use the available water is dependent upon its quality (Maclean 1968; Williams & Main 1977), the proximity to adequate and suitable food supplies (Fisher *et al.* 1972) and the species' ability to cope with problems of heat and water scarcity (Dawson 1984). Thus, to evaluate the importance of rainfall, ambient temperature, and water quality to doves and sandgrouse, their seasonal use of two closely located waterholes of different quality was monitored.

Study area

The study was undertaken in the Kalahari Gemsbok National Park (KGNP) of South Africa which adjoins the Gemsbok National Park (GNP) of Botswana. Ninety-six windmill-driven boreholes with variable water quality are present within the KGNP but none exist within the GNP.

The fresh Cubitje Quap (CQ) and saline Kousaunt (KN) waterholes, directly 27 km apart on the dry Nossob River were chosen for the study. Fresh drinking water is considered to have less than 0,6% total dissolved solids (TDS) (Winter 1985). At KN, water was pumped into an open-topped fibre-glass storage tank (from which the birds could drink) which fed a ball-valve-controlled trough. CQ water was pumped directly into a low concrete storage tank. Overflow from the storage tanks formed pools at the base of the tank. Water was available from the storage tank, trough and overflow pools throughout the study.

Methods

Single water samples were taken from the storage tank, trough and overflow at Kousaunt (KN) and from the storage tank and overflow at Cubitje Quap (CQ) waterholes in the early summer (October 1984). The samples were collected in glass bottles without the addition of preservatives, and analysed within two weeks of collection. The standard analytical methods employed by the National Institute for Water Research (NIWR) were used (Smith 1983; Siebert 1985).

Observations of doves (Cape turtle-dove *Streptopelia capicola* and Namaqua-dove *Oena capensis*) and sandgrouse (Namaqua sandgrouse *Pterocles namaqua* and Burchell's (spotted) sandgrouse *P. burchelli*) drinking at each waterhole were made once a month from an hour before sunrise until an hour after sunset from March 1984 to April 1985. The instantaneous-scan sampling method (Lehner 1979), with a 10 min interval was used. As this study formed part of a larger project monitoring the importance of waterholes to wildlife, observations were made from a vehicle situated at least 200 m from the waterholes. Hence, the two sandgrouse species were lumped into a single group. The numbers of birds drinking from the storage tank, trough and overflow water were recorded.

Rainfall was monitored monthly from rain gauges at Nossob camp and Grootbrak waterhole that were within 10 km of CQ and KN waterholes respectively. Ambient temperatures were recorded at Nossob.

Data are presented as means with standard deviations (*SD*). Data were initially tested for normality using univariate analysis (SAS 1986). One-way ANOVA was used to compare differences between means for normally distributed data (Runyon & Haber 1980). Siegel (1956) was followed for the Mann-Whitney U (U) and chi-square (χ^2) tests on non-parametric data. Percentile data were analysed using arcsine transformations (Sokal & Rohlf 1981). The standard multivariate statistical package (Statgraphics 1986) was used for linear correlation and partial correlation analyses.

Results

Rainfall

No significant differences were found in the summer rainfall at Nossob and Grootbrak within or between years (Table 1).

Table 1 Total summer and mean monthly rainfall (mm) at Nossob (NS) and Groot Brak (GB) waterholes in the Kalahari Gemsbok National Park

Variable	Summer season	Sites NS (mm)	GB (mm)	Test
Total	1983/84	182,0	115,4	
Mean±*SD*		26,0±28,1[a]	16,5±14,8[b]	U=27,5; $n_{1\&2}$=7 *P*>0,549
Total	1984/85	128,9	191,1	
Mean±*SD*		18,4±14,0[a]	27,3±25,6[b]	U=23; $n_{1\&2}$=7; *P*=0,451

Statistical tests for values in columns with like superscripts are: [a] U = 21,5; $n_{1\&2}$ = 7; *P* = 0,355, [b] U = 17; $n_{1\&2}$ = 7; *P* = 0,159.

Water analyses

Drinking water at KN was found to be approximately six times more saline than that from CQ (Table 2). Mineral concentrations at KN increased from 1,2% total dissolved solids (TDS) in the storage tank to 1,5 and 3,5% TDS in the overflow and trough respectively, while CQ water was fresher (0,2% TDS) with little difference between the storage tank and overflow water concentrations.

Sodium was the most concentrated ion in both waterholes, followed closely by Cl^- and SO_4^{2-} (Table 2). Only the NO_3^- and NO_2^{2-} nitrogen, and PO_4^{3-} levels of CQ water were higher than those at KN.

Bird numbers

Significantly more doves and sandgrouse drank at CQ than KN waterhole (Table 3). Turtle-doves were the most numerous drinkers at both waterholes. No seasonal differences were found in the numbers of each species drinking at the waterholes (Table 4).

At KN, sandgrouse (χ^2 = 45; *df* = 1; *P* < 0,001), turtle-doves (χ^2 = 77,9; *df* = 1; *P* < 0,001) and Namaqua-doves (χ^2 = 45; *df* = 1; *P* < 0,001) avoided drinking from the trough (Table 5). Sandgrouse preferably drank from the overflow (χ^2 = 5,4; *df* = 1; *P* < 0,05), while turtle-doves (χ^2 = 5,4; *df* = 1; *P* < 0,05) and Namaqua-doves (χ^2 = 29,1; *df* = 1; *P* < 0,001) drank from the storage tank. Only the Namaqua-doves showed a preference (χ^2 = 24,2; *df* = 1; *P* < 0,001) for drinking from the storage tank at CQ.

Correlation matrices were generated to assess the relative importance of rainfall and temperature variables on mean monthly bird numbers visiting the waterholes (Table 6). Turtle-dove numbers showed a significant negative correlation with rainfall of a given month. The relationship became stronger through removal of the influence (by partial correlation analyses) of the mean monthly temperature. Removal of monthly rainfall positively increased the relationship between turtle-dove numbers and mean monthly temperature.

Namaqua-dove numbers positively correlated with the mean maximum and monthly temperatures (Table 6). However, the rainfall of a given month and of the previous month had a relatively strong negative

Table 2 Concentrations [parts per million (ppm)] of ions and total dissolved solids (TDS) in filtered water samples collected at Cubitje Quap (CQ) and Kousaunt (KN) waterholes in the Kalahari Gemsbok National Park

Waterhole	Collection site	pH	Electrical conductivity (mS/m)	Ions (ppm) Na	Ca	NO_3 + NO_2	NO_2	SO_4	PO_4	PO_4^{3-}	Cl	F	TDS
KN	Storage tank	8,81	2460	4465	35	9,6	0,4	3493	<0,2	<0,2	4295	4,0	12300
	overflow	9,25	3340	5677	11	0,4	0,4	4505	<0,2	<0,2	5732	5,0	15930
	trough	9,14	7880	10830	18	0,3	0,3	10228	1,4	1,0	13370	6,8	34460
CQ	Storage tank	8,96	405	755	5	20,3	3,1	414	1,7	0,2	429	0,8	1630
	overflow	9,17	444	824	6	19,8	<0,1	519	1,6	0,3	471	1,0	1840

Table 3 Mean daily numbers (± *SD*) of sandgrouse and doves visiting the fresh Cubitje Quap (CQ) and saline Kousaunt (KS) waterholes

Species	Water-holes CQ (n = 13)	KS (n = 12)	Test
Sandgrouse	73,2± 67,0^{ac}	17,3±18,5^{df}	U=4,1; P<0,001
Turtle-doves	250,7±126,7^{ab}	66,9±61,6^{de}	F=20,7; df=1&23; P<0,001
Namaqua-doves	136,9± 68,9^{bc}	8,4±11,8^{ef}	U=4; P<0,001

Statistical tests for values in columns with like superscripts are: ^{a} U = 32,5; P < 0,05 ^{b} F = 19,9; df = 1&23; P < 0,001 ^{c} F = 3,61; df = 1&23; P > 0,05 ^{d} U = 13; P < 0,001 ^{e} U = 28,5; P < 0,05 ^{f} U = 52,5; P > 0,05.

Table 4 Mean (± *SD*) monthly numbers of sandgrouse and doves visiting two waterholes in the summer (October–March) and winter (May–September)

Species	Summer	Winter	Test
Sandgrouse	91,4 ± 85,1	69,6 ± 16,6	U = 20; n = 8&5; P = 0,528
Turtle-doves	134,3 ± 50,0	199,8 ± 80,8	F=3,33; df=1&11; P > 0,05
Namaqua-doves	45,3 ± 32,2	45,4 ± 40,6	F=0,0001; df=1&11; P > 0,05

Table 5 The proportion of sandgrouse and doves drinking from the storage tank, overflow and trough at the fresh Cubitje Quap (CQ) and saline Kousaunt (KN) waterholes in the Kalahari Gemsbok National Park. TD = turtle-doves, ND = Namaqua-doves and SG = Namaqua and Burchell's sandgrouse

	Waterhole						
	CQ (fresh)			KN (saline)			
Species	Tank	Overflow	n	Tank	Overflow	Trough	n
TD	56,3	43,7	3259	68,2	31,1	0,7	803
ND	75,4	24,6	1779	77,2	22,8	0,0	101
SG	42,8	57,2	951	0,0	67,9	32,1	208

influence on the above correlation.

Sandgrouse numbers showed a significant positive correlation with rainfall of the previous two months (Table 6). None of the other variables influenced this relationship.

Drinking patterns

Three drinking-time patterns were evident (Figure 1). Turtle-doves had two relatively short drinking periods, one in the early morning and one in the late afternoon, with the latter peak considerably smaller (except in winter) than the former.

Sandgrouse restricted their drinking to a short period in the early morning (Figure 1). This coincided with that of the turtle-dove peak at 08h00 in summer (2 h after sunrise) but shifted to 10h00 in winter, about 2 h after the turtle-doves' winter peak.

Namaqua-doves drank more or less throughout the day, with a tendency towards a midday peak (Figure 1).

Table 6 Correlation (*r*) and partial correlation coefficients of mean monthly sandgrouse and dove numbers with various ambient temperature and rainfall variables. Superscripts indicate which variable was removed to calculate the partial correlation coefficient. TD = turtle-doves; ND = Namaqua-doves; SG = Namaqua and Burchell's sandgrouse. Significant correlations (P) are in parentheses

Species		Mean monthly temp.	Prev. monthly mean temp.	Mean monthly max. temp.	Monthly rain	Previous month's rain	Rain of two months ago
TD	r	–0,09	–0,36	–0,02	–0,66	0,06	–0,06
	P				(0,0001)		
	partial	0,45^{d}			-0,74^{a}		
ND	r	0,43	0,02	0,48	–0,11	–0,36	–0,22
	P	(0,04)		(0,01)			
	partial	0,59^{d}		0,62^{d}	–0,47^{a}	–0,48^{a}	
		0,52^{e}		0,57^{e}	–0,45^{c}	–0,49^{c}	
		–0,22^{c}		0,32^{a}			
SG	r	–0,06	0,10	0,03	0,04	0,51	0,53
	P					(0,006)	(0,004)
	partial	–0,16^{e}	–0,19^{e}			0,52^{a}	0,53^{a}
		0,08^{f}	0,09^{f}			0,53^{b}	0,53^{b}
						0,43^{f}	0,46^{e}

^{a} = with mean temperature of a given month
^{b} = with previous month's mean temperature
^{c} = with mean maximum temperature of a given month
^{d} = with rainfall of a given month
^{e} = with rainfall of the previous month
^{f} = with rainfall of two months ago.

Discussion

Both sandgrouse and doves selected for the freshest drinking water available. Greater numbers of each species drank from the fresh CQ waterhole than at the saline KN waterhole, and all three species selected for the least saline water available to them at the saline waterhole. The close proximity (27 km) of the two waterholes to each other, well within flying range of doves and sandgrouse (Maclean 1968; Rowan 1983; Thomas 1984a), and the similar rainfall patterns and presumably similar productivity (Seely 1978) and food availability at both sites suggests that the comparison of drinking patterns between the two waterholes is valid.

Concentrations of 248 mmol/l Na^+ and 162 mmol/l Cl^- in the overflow water at KN were similar to that

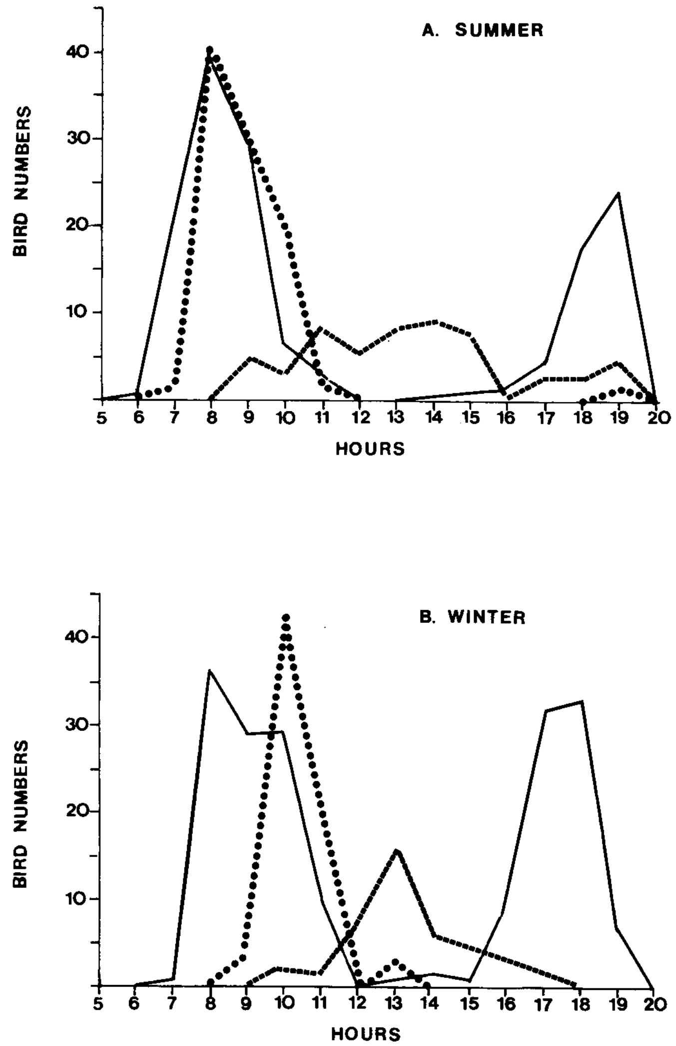

Figure 1 The daily drinking patterns of sandgrouse and doves at waterholes in the Kalahari Gemsbok National Park. Turtle-doves = solid line; Namaqua-doves = dashes; Sandgrouse = dots.

considered maximally tolerable and infrequently used by sandgrouse (Maclean 1968) and other xerophilic birds (Dawson, Shoemaker, Tordoff & Borut 1965; Willoughby 1971; Williams & Main 1977). Consumption of water from the KN storage tank, overflow or trough where osmotic concentrations of 340, 428 and 971 mOsm/l respectively were found, may be physiologically stressful to birds as these concentrations approximate and exceed the plasma osmotic concentration of 370 mOsm/l found for North American mourning doves (Smyth & Bartholomew 1966).

Besides the high mineral concentrations, the ionic composition could also have influenced the drinking site selection (Willoughby 1971). The high concentrations of SO_4^{2-} (0,3 to 1,0%) at KN, were well in excess of the 0,2% found to be hazardous to livestock (Church 1979). Although no data were available it is likely that these levels may also be stressful to birds and prevented doves and sandgrouse from drinking it. However, intermittent drinking of saline water by granivorous birds may supplement their NaCl intake, because seeds along with most other plant material are generally low in salts (Thomas 1984b).

The borehole water analyses presented here (Table 2) were collected at the time of year when the boreholes are noted to produce their freshest water because of delayed recharge of the previous summer's rain water (Mazor 1982; Dreyer 1987). Thus, the drinking water would be even less favourable at other times of the year.

Adult sandgrouse are able to reduce their dependence on drinking water through a combination of reduced metabolism and water turnover, behavioural adaptations, and the occasional intake of succulent foods (Dixon & Louw 1978; Thomas & Maclean 1981; Thomas 1984a). However, they do require drinking water during summer and for breeding in winter (Thomas 1984b). The positive correlation between sandgrouse numbers drinking at waterholes and the previous two months' rainfall suggests either a response to a decline in the availability of other natural rain water pools or a local movement influenced by food availability. Monthly temperature appeared to play an insignificant role in influencing the number of sandgrouse drinking at the waterholes.

Doves, on the other hand, appeared to be even more dependent on drinking water because of their predominantly granivorous diet (Rowan 1983) and high rates of cutaneous water loss (Marder & Ben-Asher 1983; Marder 1983), characteristic of the family (Dawson 1984). The small size of the Namaqua-dove and concomitantly larger surface area and higher rates of cutaneous water loss probably accounts for the positive correlation between monthy ambient temperature and their numbers drinking at the waterholes, and their tendency to drink during the hotter periods of the day. Drinking during midday has the added advantage of less interference from the other bird species, plus a possibly lower presence of predatory birds at the waterhole.

The negative correlation between turtle-dove numbers at waterholes and mean monthly rainfall probably reflects a decline in other sources of drinking water, or declining food quality and a greater need for water. Removal of the influence of rainfall, also revealed that mean monthly temperature has a relatively strong positive effect on turtle-dove numbers using the waterholes, which may again be related to their high rates of cutaneous water loss.

As natural drinking water is virtually non-existent in the winter in the southern Kalahari (Leistner 1967), both doves and sandgrouse would normally move to more favourable areas. However, the overall lack of any seasonal variation in numbers visiting the waterholes strongly suggests that the presence of suitable borehole water encouraged continuous residence throughout the year, and that sufficient food existed. The ecological implications of this permanent residence on the vegetation and other granivores, such as the rodents, is not known.

The temporal separation between the morning drinking times of sandgrouse and turtle-doves in winter, is probably indicative of the sandgrouse foraging further afield during this time of year. Sandgrouse are known to travel up to 60 km to water (Maclean 1968) while turtle-doves have been observed to be no further than 35 km from water (personal observation).

It can be concluded that the use of waterholes by doves and sandgrouse in arid environments is dependent upon their physiological adaptations, the environmental conditions, and quality of drinking water.

Acknowledgements

The Directors of the National Parks Board of Trustees, South Africa, and the Department of Wildlife and National Parks of Botswana are thanked for making this study possible. The National Institute for Water Research, CSIR is thanked for the water analyses, as are Drs A. Hall-Martin and M. Mills and Mr C. Sapsford for their criticisms of an earlier draft. Anette Knight-Eloff is thanked for her assistance throughout the study.

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