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Neotropical dry forest wildlife water hole use and management

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Abstract: Selected wildlife species diurnal use of a natural water hole (QD) and an artificial water hole (AW) were studied during 1990 dry season at Guanacaste Conservation Area, Costa Rica. In total, 919 individuals (six mammal and one game bird species) consumed water from QD, while 713 individuals (four mammal species) consumed water from AW. Estimated daily water consumption by selected wildlife species was 29.7 l at QD and 27.3 l at AW. Estimated 24-h water consumed by all wildlife species or evaporated was 44.6 l at QD and 41.1 l at AW. This resulted from summing: a) water consumed by studied species, b) estimated 24-hour water consumed by other wildlife (QD = 14.85 l, AW = 13.65 l) and c) daily water evaporation (QD = 0.04 l, AW = 0.10 l). During a 120-day dry season, AW required about 4 932 l of water from the park administration. Management implications for neotropical dry forest water holes are discussed.

Key words: Costa Rica, dry season, management, neotropical dry forest, water holes, wildlife

Use and management of water sources for wildlife has been studied in semiarid and seasonally dry environments on several continents. In Africa, water holes are critical for wildlife existence (Ayeni 1975, Hitchcock 1996, Knight 1989, Knight *et al.* 1988). In central Mexico, white-tailed deer (*Odocoileus virginianus*) depend on water holes and preformed water sources in dry season (Mandujano and Gallina 1995). Wildlife use (see Krausman and Etchberger 1996) and management of natural and man-made water developments (see Kie *et al.* 1994, Tsukamoto and Stiver 1990, and Yoakum *et al.* 1980) has been well studied in the western United States. In neotropical dry forests, McCoy *et al.* (1990), Vaughan and Rodriguez (1991) and Shaw (1996 unpublished manuscript) documented wildlife water hole use, while Cornelius (1974) and Vaughan *et al.* (1982) recommended management practices for water holes. The objectives of this study were: a) to estimate selected species diurnal use of water at a natural and an artificial water hole in the neotropical dry forest, b) to estimate 24 h and seasonal water consumption by all wildlife species at both water holes and c) to recommend water hole management practices for wildlife.

MATERIALS AND METHODS

Study site: The study was carried out in Guanacaste Conservation Area (GCA), Costa Rica, located 30 km north of Liberia, the Guanacaste Province capital. GCA consists of 70 000 ha, and was created to preserve the largest area of primary dry forest (several hundred hectares) and restore the rest to tropical dry forest, considered the most endangered tropical ecosystem (Janzen 1986). Located between Matzalan, Mexico and northwest Costa Rica, the Pacific Mesoamerican tropical dry forest receives 900-2400 mm of rainfall annually between May and December. During the January to May dry season, surface water becomes scarce. Moisture-containing vegetation, fruit, prey and dry season water holes (tree hollows, springs and pools in stream and riverbeds and artificial sources) may provide water, which maintains wildlife in the region.

The two water holes monitored were located in forested areas within 800 m of the Casona (85°37"N, 10°50"W) on a plateau between 220-350 m elevation. No other water holes were found within 500 m . The natural water hole (QD) was located in a secondary dry forest in Quebrada Duende, approximately 10 m SE of the stream intersection with the Indio Desnudo Nature Trail. Many tourists walk the nature trail and visit QD, hoping to observe wildlife there. QD was enlarged from about four to a 12 l capacity in 1987 using cement and rock. The artificial water hole (AW) was located about 1.5 km NE of QD in a 20-year old forest with occasional *Pithecellobium saman* trees. Unknown to tourists, AW was originally installed in 1988 for use by white-faced monkeys (*Cebus capucinus*). It consisted of half a tractor tire with an 11 l water capacity fed by a 500 m long 1.0 cm plastic hose from a nearby camping area.

Wildlife species observation: Between March 8-April 28, 1990, all mammalian species and one game bird species which visited QD and AW. between 0600-1800 h were counted. For each individual observed, data on species, date and time of visit was taken. Species and numbers of small birds and reptiles were not documented. Observations at QD were made from a large rock located approximately 10 m N of the water hole and partially hidden by large rocks and trees. The observation blind for AW was behind a stone corral fence, approximately 30 m N of the water source. One observer, using binoculars when necessary, recorded data on alternate days at each water hole.

Analysis: For analysis, average number of individuals/species were calculated by dividing total observations for each species visiting each water hole by 18 days of observation. Estimated daily consumption (liters) by an individual of each species was calculated multiplying average species body weight (kg)(Robinson and Redford 1986) by the formula proposed by Calder (1984).

Daily total water turnover or intake was calculated by adding metabolic water intake, preformed water intake and drinking water intake (Calder 1984 page 136). Preformed water intake was not calculated, thus we may have overestimated drinking water.

total water turnover - metabolic water intake = drinking water + preformed water:

mammals $0.123\,M^{0.90} - 0.0126M^{0.75}$ = *drinking water*
birds $0.115M^{0.75} - 0.0141M^{0.72}$ = *drinking water*

For each water hole, average number of individuals visiting per day of each species multiplied by the estimated daily water consumption by each species resulted in daily total water consumption by each species. For each species, summing total water consumption per species gives total water consumed by selected species. For a given water hole, Clarkson and Sturla (1990) calculated total daily water consumption by all wildlife species and evaporation summing: a) total water consumed daily by selected species (A);

b) average 24-hour water use by unstudied individuals, such as insects, birds, reptiles and nocturnal animals(B); and c) average daily evaporation (E).

Average 24-hour water consumption by other species was estimated at 50% total daily water used by selected wildlife species (B = .5A) because: a) Clarkson and Sturla (1990) used 50%; b) Shaw (1996 unpublished manuscript) found 133 of 476 (28%) mammals visiting a GCA water hole were nocturnal during 24-hour observation periods, and c) many insects, including honeybees, were observed at both water holes and probably consumed significant amounts of water. For instance, a honeybee hive (*Apis mellifera*), used up to 15 600 l of water yearly (Taber 1979). Daily evaporation (E) was estimated as half the average temperature multiplied by the surface area (SA), divided by 30 days (Clarkson and Sturla 1990) or E = (T/2 * SA)/30). Temperature was calculated at 25°C and surface area (SA) for QD was 100 cm^2 and for AW was 250 cm^2 .

RESULTS

No rainfall occurred during the study period. At each water hole during the 18-day study period, 919 observations of six mammal species and a large game bird were made at QD, while 713 observations of four mammal species were made at AW (Table 1). Four wildlife species used both QD and AW: white-nosed coatimundi (*Nasua narica*), collared peccary (*Tayassu tajacu*), *O. virginianus*, and *C. capucinus*. The agouti (*Dasyprocta punctata*), spider monkey (*Ateles geoffroyi*) and great currasow (*Crax rubra*) used only AW. Many birds, especially the inca dove (*Columbina inca*), were observed drinking at both waterholes. The collared peccary visited AW (179) more then QD (116)(Table 1). Estimated daily water co sumed per individual varied from 0.29 l for *C. capucinus* and 0.31 l for *D. punctata* to 2.25 l for *O. virginianus* and 1.11 l for *T. tajacu* (Table 1). *D. punctata* consumed the least amount of water per day (0.2 l and 0.5 visits) at QD while *O. virginianus* consumed the most (7.7 l in 3.6 visits) at AW.

Total water consumed daily by selected species (A) at QD and AW was 29.7 l/day and 27.3 l/day, respectively. Water consumption by all other wildlife species (B) would be 50% of the total above or 14.85 l (QD) and 13.65 l (AW). Evaporation (E) was estimated at 0.04 l/day (QD) and 0.10 l/day (AW). Therefore, total water consumed daily by all wildlife and evaporation (A + B + E) was approximately 44.6 l at QD and 41.1 l at AW. Estimated total water consumed and evaporated during a 120-day dry season was 5 352 l at QD and 4 932 l at AW.

TABLE 1

Selected wildlife species observed and their estimated water needs at two water holes, Guanacaste Conservation Area, Costa Rica (March-April, 1990).

			Quebrada Duende(QD)			Artificial Water hole (AF)		
Species	wieght (kg)	water consumed/ individual/ day (I)	total individuals in study period	average individuals/ day	total water consumption/ day (I)	total individuals in study period	average individuals/ day	total water consumption/ day (I)
Dasyprocta punctata	3.6	0.31	9	0.5	0.2	0	0	0
Nasua narica	3.9	0.33	221	12.3	4.1	191	10.6	3.5
Odocoileus virginianus	40	2.25	65	3.6	8.1	66	3.7	8.3
Tayassu tajacu	17.5	1.11	116	6.4	7.2	179	9.9	11
Cebus capucinus	3.3	0.29	271	15.1	4.4	277	15.4	4.5
Ateles geoffroyi	7.5	0.56	122	6.8	3.8	0	0	0
Crax rubra	4	0.29	115	6.4	1.9	0	0	0
Total individuals/study area			919			713		
Total liters/waterconsumed/day/water hole					29.7			27.3

DISCUSSION

Wildlife species/individuals at water holes: Free water sources can determine wildlife species presence/absence, movements and carrying capacity in seasonally dry, semi-arid and desert environments (Bradford 1975, Rautenstrauch and Krausman 1989). We wondered why many GCA mammal species were not observed during our study. Shaw (1996 unpublished manuscript) observed wildlife drinking at a GCA water hole for 24-hour periods: *D. punctata*, *N. narica*, *O. virginianus*, and *C. capucinus* were diurnal visitors common to both studies. Shaw (1996 unpublished manuscript) also observed the coyote (*Canis latrans*) and variegated squirrel (*Sciurus variegatoides*) during the day and howler monkey (*Allouata palliata*), margay (*Felis wiedii*), *O. virginianus* and four-eyed opossum (*Philander opossum*) at night. A female Baird's tapir (*Tapirus bairdii*) drank seven times during the day and 8 times at night. Likewise, we probably recounted individuals as they drank once or more times daily. Wildlife species not observed probably either drank from other water holes or used preformed water.

Preformed water: Water intake as animal tissue, succulent leaves and fruit is called preformed water and may meet part or all of daily water needs for some species (Calder 1984). Mandujano and Gallina (1995) found *O. virginianus* dependent on *Spondias purpurea* fruit for preformed water in Mexico during the late dry season when vegetation and water holes contributed little water. However, succulent leaves were uncommon during the late dry season at our study site. We analyzed dry season diets in dry forest for *N. narica*, *O. virginianus*, *C. capucinus*, *T. tajacu* (Espach and Saenz 1995, McCoy *et al.* 1990, Morera 1997, Moscow and Vaughan 1987, Saenz 1995). *C. capucinus* fed infrequently on animal tissue in the form of insects, reptiles, mammals or birds. Probably fruits of only two species of the 14 reported, *Manikara chicle* (*N. narica*) and *Solanum americana* (*O. virginianus*), provided sufficient quantities of preformed water. Based on an apparent lack of preformed water sources for selected wildlife species in GCA, we consider water holes very important for wildlife species in GCA during late dry season.

Body size vs water usage, evaporation: Although 28% more individuals visited QD then AW (919 vs 713), only about 10% more water was consumed at QD (29.7 l vs 27.3 l). This was because heavier species, such as *T. tajacu*, were proportionally more abundant at AW then QD and consumed more water then lighter species. Although *C. rubra* and *T. tajacu* visited QD equally (115 vs 116), *C. rubra* consumed only 25% of the water *T. tajacu* did because it was lighter and had a different water balance formula. Over a 120-day dry season, at QD, *C. rubra* would consume 228 l of water, while *T. tajacu* would consume 864 l of water. *O. virginianus* consumed as much water as six *N. narica*, six *C. capucinus* or four *A. geoffroyi*. *T. bairdii* weighs 300 kg (Robinson and Redford 1986) and requires 14.5 l of water daily, equivalent to seven *O. virginianus*, 44 *N. narica* or 50 *C. capucinus*. Including nocturnal species, insects, and/or birds, would more accurately calculate total water hole water consumption. Evaporation accounted for only 1-2% of water loss, because of the small surface area.

Water hole management: Natural and artificial water holes can be managed: a) to increase species and carrying capacity of wildlife using them, b) to stimulate regeneration by attracting wildlife which defecate seeds near the water, c) to expand habitats for wildlife during dry periods, and d) to stimulate ecotourism and biological education use by human users.

The manager can use plastic and/or masonry work to reduce water wastage at water holes. Shade, reducing surface area and other methods can reduce evaporation (see Kie *et al.* 1994 and Tsukamoto and Stiver 1990). Where applicable, domestic livestock should be excluded from wildlife water developments, because they consume at least four to five times the water deer and other large neotropical game species do and contaminate water holes with trampling, wallowing, etc (Rice 1990). If water is limited, controlling *O. virginianus* numbers by hunting and/or fencing could favor smaller species such as primates or coatimundis, important for wildlife viewing and as seed dispersers (Brigham 1990, Ernst and Tolsma 1990).

Placing artificial water holes strategically on public and private lands could increase wildlife species carrying capacity if sufficient food and shelter exists (see Kie *et al.* 1994, Tsukamoto and Stiver 1990, and Yoakum *et al.* 1980. Water hole management could also favor wildlife protection and visitor observation. AW and QD received comparable number of wildlife visitors throughout the 1990 dry season, indicating relative importance of artificial water holes. AW would require almost 5 000 l of water during a normal 120-day dry season to satisfy wildlife species needs. This could be in the form of a storage tank, well or other water source.

In GCA, Vaughan *et al.* (1997) found 14 of 20 natural water holes monitored during the 1995 dry season dried up, some early in the dry season. QD has dried up at least a month early since 1990. Natural phenomena (*ie* El Nino?), overuse of aquifers by park officials and other factors might be responsible. However, without free or preformed water sources, wildlife might be forced to migrate or perish. Should artificial water sources replace natural water holes in seasonally dry environments to better control the water resource? Managers should calculate water availability, local aquifer capacity, administrative and wildlife water needs on their ranches and wildlands. The present "laissez faire" approach to wildlife water management in neotropical dry forest regions is a cause for concern.

RESUMEN

Se estudió el uso diurno por especies faunísticas p 1 3de un ojo de agua natural (QD) y otro artificial (AW) a finales de la época seca de 1990 en el Area de Conservacion de Guanacaste, Costa Rica. En total 919 individuos (seis especies de mamíferos y una de ave cinegética) consumieron agua de QD y 713 individuos (cuatro especies de mamíferos) de AQ. Se estimó que en un dia, las especies de vida silvestre estudiados tomaron 29.7 l y 27.3 l de agua de QD y AW, respectivamente. El total de agua consumido o evaporado de cada ojo de agua durante 24-horas fue estimado en 44.6 l en QD y 41.1 l en AW, con base en: a) agua bebida durante 12 h por las especies seleccionadas, b) agua bebida por todos los otros individuos durante 24 h (QD = 14.85 l, AW = 13.65 l) y c) evaporación diaria (QD = 0.04 l, AW = 0.01 l). Para abastecer AW durante una epoca seca de 120 días, la administración del parque debe proveer 4 932 l de agua. Se discute las implicaciones de manejo en las regiones de bosque seco neotropical.

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