

9 *Human hunting seasonality*

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Introduction

Human hunting strategies, like those of many non-human primates, vary seasonally with fluctuations in prey abundance, encounter rates, and profitability (Winterhalder 1981; Smith 1991). Temporality in resource supply has profound social effects as well, and some of the earliest studies of hunter–gatherers emphasized the impact of seasonality on settlement size, mobility, general economic organization, and even property rights, religion, family structure, and the sexual division of labor (Mauss & Beuchat 1906; Thomson 1936). For Mauss and Beuchat (1906), seasonality meant temperature: they suggested that Inuit families were organized very differently in the summer than in the winter as a result of the nature of changes in foraging opportunities. For Thomson (1936), seasonality meant rainfall, commenting that the effect of distinct wet and dry seasons in northern Australia might lead one to think that they were observing two different “tribes” of people. Anthropological interest in seasonality and its effects on human social organization has waned since then, frustrated by an inability to find correlations between seasonality and human behavior. Our goal in this chapter is to explore the utility of two approaches to understanding the relationship between seasonality and social behavior. One attempts to use comparative ecological data across groups to explain differences in aspects of social and economic behavior such as mobility and land tenure decisions; the other examines how different individuals within a group may respond differently to resource seasonality. Toward this end, we focus on a single case study: explaining why we see seasonal sex differences in hunting game among Western Desert Australian aborigines.

Hunter-gatherer responses to seasonality

One of the simplest models predicting how foragers respond to changing spatial and temporal patterns of resource availability is the contingent prey choice model (Stephens & Krebs 1986). This model predicts that if prey types are distributed in a fine-grained manner in space, then temporal reductions in encounter rates with higher-ranked prey cause foragers to become less selective and to broaden the number of prey types that they include in their diet. If resources are not distributed randomly, then patch choice models predict that a reduction in the overall foraging efficiency within a habitat (such as when a forager can no longer gain energy by foraging as it travels between food patches) would cause foragers to either remain in a patch longer or travel farther in order to reach more profitable patches (Charnov 1976). Humans often respond to predictable seasonal variability in food supply by broadening or narrowing the diet and by changing mobility patterns (Binford 1980; Smith 1991). However, they also rely on sociocultural flexibility to mediate their responses to seasonality: investing in technology to reduce handling costs, changing social structure (Bahuchet 1988), using alternative hunting methods (Bailey & Aunger 1989), and maintaining long-distance exchange relationships with other groups (Cashdan 1985).

However, mobility remains one of the most widely recognized effects of seasonality on human subsistence strategies. The relationship between spatial and temporal resource patchiness and mobility patterns in anthropology is commonly analyzed with the “forager-collector model” (Binford 1980). The forager-collector model specifies that mobility patterns vary along a continuum from “forager” (high residential mobility) to “collector” (high logistical mobility), according to the spatial and temporal patchiness of staple resources. The basic assumptions of the model are those long recognized in foraging theory: the degree to which resources are distributed randomly should have large effects on mobility, settlement, and subsistence patterns (Cashdan 1992). While not drawn explicitly from foraging theory, Binford’s model links a spatially and temporally homogeneous distribution of resources with high residential mobility, constant low levels of production, low logistical mobility, little storage, and a generalized and expedient tool technology. At this end of the continuum, “foragers” map themselves on to resources, moving people to food in response to temporal and spatial fluctuations in abundance. As resources become more patchy in space or time, people begin to pin their camps more permanently to particular locations and become “collectors.” Collectors adjust to a heterogeneous environment where resources are acquired

asynchronously by transporting goods to people (increasing logistic mobility). Ultimately, this influences the degree to which foragers rely on food storage and other complex, specialized technology to even out spatial and temporal fluctuations in supply.

The forager–collector model is commonly evaluated using broad environmental correlates of resource patchiness (such as latitude, average annual rainfall, and temperature), along with measures of residential mobility (such as average number of camp moves per year) across different study groups (Thomas 1983; Binford 2001). The availability of water, in particular, is often promoted as a key influence on seasonal patterns of foraging and mobility, especially in more arid areas. Daily water requirements for humans should make seasonal fluctuations in the effective environment of savannas and deserts, especially salient. As Taylor (1964) notes, foragers in these environments are especially “tethered” to key resources.

While we expect that seasonality in rainfall will have a profound effect on behavior in more arid areas, we should not expect a simple correlation between the two. Binford’s (2001) data show that even under highly controlled circumstances, people respond to seasonality in manifold and elaborate ways. For example, if we measure the degree of seasonal variation in rainfall as the ratio of rainfall in the driest month to that of the wettest, limit our analysis to savanna and desert Australian foragers, and attempt to predict estimates of the average number of residential moves per year, then we still find no predictable correlation: $r = 0.143$, $t = -0.578$, $P = 0.5711$ (Fig. 9.1) (data from Binford [2001]: Tables 4.01, 5.01, and 8.04).

In the case of seasonal mobility, Kelly (1995:126–30) suggests that our inability to predict mobility based on very broad environmental variables lies in the fact that foragers tethered to water respond in maddeningly complex ways to very local conditions. The factors that determine the availability of water (local substrate, subsurface geology, topography, local evapotranspiration, etc.) are extremely variable and localized in space (Mather 1962). Since all other subsistence resources that people rely on are also tethered in intricate ways to the same variability in access to water, then the layers of environmental complexity make descriptive generalizations highly problematic as heuristic models. However, if we attempt to solve the complexity issue by adding additional variables to an inductive model, then we lose explanatory power: eventually, the model becomes a specific description of local conditions. Thomas (1983) makes this point clear for different groups of western Great Basin Shoshone. While each group experienced similar broad climatic regimes, their social

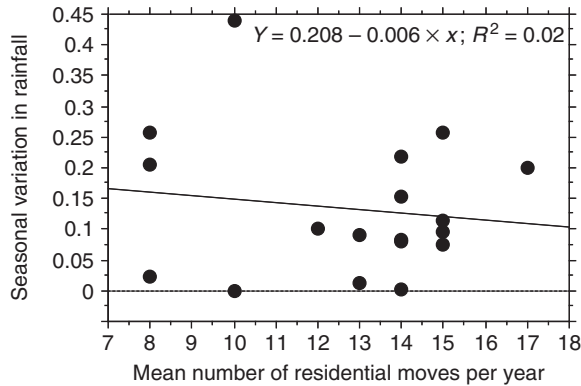


Figure 9.1 The relationship between the amount of seasonal variation in rainfall (calculated as the ratio of the amount of rainfall in the driest month to the amount of rainfall in the wettest month) (see Binford [2001]: Table 4.01) and residential mobility for 17 Australian Aboriginal societies living in regions of savannas and deserts that experience less than 1000 mm of rainfall per year (groups listed in Binford [2001]: Tables 8.01 and 5.01).

organization and mobility patterns differed considerably. All three groups responded to seasonal variability in their staple food source, piñon pine nuts, by storing them through the winter. However, those living in regions without water catchment areas, and with smaller, unpredictably producing piñon groves, were more mobile and lacked individual ownership for specific piñon groves. In each case, if we wanted to account for each group's specific land tenure and mobility pattern using the forager–collector model, then we would need to incorporate such specific climatic, geologic, and social variables that the model would fit only that single case.

Given these empirical and methodological problems, we are suspicious of inductive generalizations about hunter–gatherer seasonality that attempt to explain variability between groups using broad environmental generalizations. However, we do not argue that what Binford (2001: 11) refers to as “autocorrelated dynamics of social organization” relative to seasonality are simply arbitrary or incomprehensible relative to ecological variables. Rather, we suggest that the evidence of seasonal fluctuations in local conditions is a critical source of data to evaluate the utility of theoretically deduced hypotheses about the goals and constraints that structure variability in human behavior within groups. We may gain more insight into the complexity of human responses to seasonality by incorporating the idea that foraging strategies are constrained and facilitated by individual social and reproductive tradeoffs. Below, we provide a more detailed analysis of sex differences in hunting strategies to illustrate

this approach, beginning with some theoretical approaches to sex differences in non-human primates.

Seasonality and sex differences: within-group analyses

The primate context

As many chapters in this book have shown, primate behavior flexes responsively to accommodate dynamic environmental variability in resource supply. However, the circumstances that shape foraging flexibility are complex and not predictable, given broad generalizations about rainfall, latitude, and temperature (See Chapter 3). While primates react to changing costs and benefits of foraging for particular food items, their responses are not designed solely to maximize foraging efficiency. Primates must always trade off food intake with other fitness-related pursuits, such as finding mates, caring for offspring, and competing with others for social position. Differences in the nature of such tradeoffs are likely to lie at the root of some of the complexity we see in primate responses to seasonality. Individuals within groups may respond to temporal fluctuations in food supply differently if they face different social and reproductive tradeoffs with acquiring certain types of foods; this is often particularly apparent between males and females (Boinski 1988) and between old and young individuals (Altmann 1998).

Responses to seasonal changes in the abundance of higher-ranked resources are usually mediated by one or more of these tradeoffs. Physical tradeoffs can make some alternative seasonal resources quite costly to exploit. For example, among *Cebus* living sympatrically in the seasonal rainforests of Cocha Cashu (Terborgh 1983), species with more robust jaw and tooth morphology (*C. apella*) broaden the diet to include palm nuts, while those with more gracile masticatory apparatus (*C. albifrons*) range further to exploit increasingly rare patches of fruit. Responses to seasonality are also influenced by social tradeoffs: primates that aggregate in response to predation may find it less costly to respond to seasonal reductions in fruit productivity by traveling further, while primates living in smaller groups that respond to predation through more cryptic strategies might respond by broadening their diet. Finally, primate responses to seasonality are also mediated by reproductive tradeoffs. Where baboons are forced to guard estrous female mates, males reduce the time they spend foraging (Alberts 1996); squirrel monkey males that must invest in competitive interactions with other males forage as time-minimizers, attempting to

minimize the time it takes to reach a certain nutritional threshold, while females forage as energy-maximizers, especially when pregnant and lactating (Boinski 1988). Females often face tradeoffs with energy-maximizing when such strategies conflict with putting on fat, nursing infants, or conserving energy.

Among chimpanzees, where male reproductive strategies involve alliance formation and grouping, males find solitary foraging strategies (ant dipping and nut cracking) more costly (Boesch & Boesch 1984). Female chimps generally spend more time foraging for ants and termites, nut cracking, and hunting terrestrial prey, while males spend more time hunting arboreal prey (McGrew 1992). The difference between the male and female foraging patterns is most profound during seasons when males are hunting arboreal monkeys, fruit is abundant, and groups are larger (See Chapter 8). Since larger groups nearly always contain more females, and more estrous females, male hunting has sometimes been interpreted as a reproductive strategy involving the exchange of meat for sex (Stanford 1996). Although estrous females may be more likely than non-estrous females to get meat (Tutin 1979), sharing is directed more often toward other males (Nishida *et al.* 1992); when it is directed toward estrous females, it does not measurably impact male copulatory frequency (Mitani & Watts 2001). Stanford *et al.* (1994) further note that individual hunters actually receive less meat by joining a monkey hunt than they could by pursuing prey alone. Why, then, should male hunters prefer to acquire less meat from arboreal monkeys to use as a tool to acquire sex or allies, when they might more easily acquire more meat from solitary pursuits of terrestrial game? The data so far seem to be consistent with an explanation that males seasonally hunt arboreal monkeys as part of a mating investment strategy involving the competitive display of quality to other males via the “honest” nature of hunting as a signal of dominance. Honest signals are those that are tied intrinsically to the quality being displayed. Signals may be kept honest through a number of mechanisms, one of which is the differential cost or benefit of the display (costly signaling) (Zahavi 1975; Grafen 1990; Johnstone 1997).

The honest signaling hypothesis proposes that males hunt monkeys in order to create alliances and gain the respect of rivals (Nishida *et al.* 1992), but the primary benefits of the hunt lie not in the subsequent sharing and consumption of meat (else why not simply take terrestrial mammals?) but in the hunting display itself. Hunting arboreal monkeys by chasing them through the treetops is energetically costly, difficult to accomplish, and inherently dangerous, and observers often find that some males are better hunters than others (Stanford 1996). If monkey-hunting success allows

males to acquire or maintain dominance rank, or intimidates others into letting them gain access to females during times when they are most likely to be fertile, then it might function as a sexually selected signal of competitive ability, more akin to branch-shaking displays than dipping for termites. This hypothesis squarely places only arboreal monkey hunting as a sexually selected male display, because it satisfies the conditions of an honest signal of quality and it differs significantly from what females do. Other types of hunting that both males and females engage in, such as the capture of terrestrial prey, may be more explicable as an energy- or protein-maximizing foraging strategy. This does not mean that females might never engage in monkey hunting (they occasionally do) or that monkey hunting never provides a net nutritional benefit. The nutritional benefits gained through sharing and distribution of the prey are erratic with respect to the hunter: many times, the hunter does not eat the prey or control distributions. With the honest signaling hypothesis, the problematic focus on sharing as the avenue of benefit for hunters is replaced by a focus on the information value of the hunting display itself. The costly signaling model predicts that males may hunt monkeys only seasonally because (i) the benefits of display are higher when groups are larger; (ii) the costs of acquisition are higher because more individuals other than the hunter consume meat; and (iii) reproductive competition among males nets higher payoffs when more females are in estrous, as might occur if estrous cycles are even moderately seasonal.

Individual variation among human foragers

The possibility that reproductive strategies might influence foraging decisions among humans has not gone unexplored, but we still know very little about how foraging strategies vary within groups and less still about how different individuals respond to seasonal fluctuations in prey abundance and distribution. The data that we do have tend to suggest that sex differences in foraging (often referred to as the “sexual division of labor”) often vary seasonally and that the foraging decisions of both sexes are affected by reproductive tradeoffs. Hadza women respond to seasonal availability of roots and tubers depending upon their current reproductive and provisioning tradeoffs: nursing and pregnant women and women with children focus on berries, while postmenopausal women exploit roots intensively (Hawkes *et al.* 1989, 1995, 2001a, 2001b). In South America, Hiwi women spend more time foraging when roots are in season, except when they are pregnant or nursing, while men devote more effort to

foraging when large amounts of fruit are available (Hurtado & Hill 1990). In Australia, women often hunt small animals seasonally: in Arnhem Land, women are active hunters of birds and fish in the dry season and provide nearly 30% of all game acquired (Altman 1987).

Similar patterns are suggested for other Aboriginal groups, particularly those in the Western Desert, where women are very active hunters (Cane 1987; Tonkinson 1991). Here, seasonal fluctuations in the availability and profitability of game animals seem to correspond to changes in men's and women's hunting strategies. Men seem particularly drawn to hunting for larger animals, while women prefer smaller game. We hypothesize that these differences are a function of sex differences in social and reproductive tradeoffs, particularly in the benefits of skill display. One way to test this hypothesis is to use seasonal variability in key prey species as an independent variable predicting men's and women's foraging choices. If men's choices are biased toward acquiring costly prey or prey that honestly signal some quality of the acquirer, while women's choices are biased toward those that provide better for maximizing foraging efficiency given the tradeoffs of caring for a family, then seasonal variability in encounter rates or profitability of "signaling" prey versus "provisioning" prey may predict seasonal variability in men's and women's hunting strategies. Among Western Desert Mardu, key prey species vary seasonally in abundance and the method of capture: goanna lizard and bustard are the most important of these. While women pursue goannas year round using different methods, but never pursue bustards, men focus on bustards and pursue goannas only seasonally, when they are tracked on the surface. Is this difference a result of the influence of sex-specific reproductive strategies on prey choice? To answer this question, we turn toward a more detailed investigation of hunting seasonality among the Mardu.

Case Study: hunting seasonality in the arid grasslands of Australia's Western Desert

Methods

The term "Mardu" conventionally refers to foraging groups whose traditional estates are located in the northwest section of Australia's Western Desert (Walsh 1990; Tonkinson 1974, 1991). Our study focused on Mardu currently living in Parnngurr (23.1° S, 123.5° E), comprising a core population of about 100 individuals. All Mardu participants, including the children, spent most of their lives in the desert, and the formative years

of those aged 35 years and older were spent as full-time foragers. Foraging is defined as time spent searching, pursuing (including tracking and extracting an individual prey), collecting, and processing wild foods. Mardu participants traveled by vehicle from Parnngurr (on trips that ranged from 1 to 22 days) to field camps of their choosing, and then from those camps walked or drove to foraging locations. Data are available from 101 camp-days over three field seasons between 2000 and 2002, with observational data from all months but October and November. During foraging trips, we conducted detailed focal individual follows: each researcher accompanied a single individual and noted all time allocated to travel, search, pursuit, collecting, and processing, along with the weight of each item (if game) or parcel (if fruit, vegetable, or insects) captured at the end of foraging. A total of 763 focal individual follows (481 female, 282 male) are used in the analysis of hunting presented below (children's foraging activities are currently being analyzed; see Bird & Bliege Bird [2004]). In addition to the focal follows, we recorded the duration of all foraging episodes and the weights (by item or type) of all food captured by all camp or trip participants. A total of 2086 foraging hours were recorded by 28 different women and 15 different men. Energy values were taken from published sources analyzing the composition of aboriginal foods (Brand Miller *et al.* 1993). Edible weights for animals were calculated in the field by weighing uncooked individuals and asking foragers to discard the waste material from those same individual animals into a receptacle. On foraging trips, individuals averaged 1702 ± 210 (standard error [SE]) kcal per forager per day, not including those in camp who did no foraging (only the smallest children and the researchers). We supplied an average of 300 kcal per day per participant, primarily in the form of flour and sugar.

Temporality in resources and foraging behavior

In the northwestern region of the Western Desert, tropical moisture flows in from the north, producing widespread rainfall in the hottest part of the year (December–February). In between these occasional storms, isolated thunderstorms can produce localized heavy rainfall. Outside of the hot season, very little rain falls, except during the height of the Austral winter (June–August), when southerly storm systems occasionally stretch far enough north to produce light rainfall over wide regions of the desert (Fig. 9.2).

As detailed by Walsh (1990), before European establishment of permanent wells in the heart of their estates, Mardu mobility and group size were tethered to the availability and distribution of rainfall. Generally,

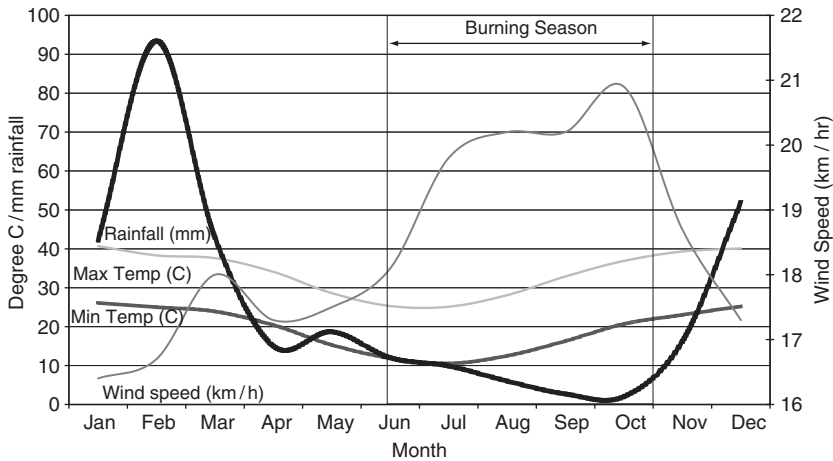


Figure 9.2 Climatic averages from 1970 to 1990 for the northern section of the Western Desert (the Great Sandy Desert), collected from the recording station at Telfer Gold Mine, located approximately 100 km north of Parnngurr.

residential mobility was highest during *Yalijarra* (January–April, the hot/wet season), when widespread rains filled dispersed ephemeral claypans and watercourse soaks. When these emptied as *Wandajarra* (May–August, the cool/dry season) progressed, people would resort to more permanent water sources (rockholes, the Rudall River system, and “native wells”). During *Wandajarra*, residential mobility decreased and group size generally increased. As temperatures began to increase through *Dulbarra* (September–December, the hot/dry season), and if there was no rain through December, then residential mobility declined dramatically and groups would retreat to core reserve areas of their estates, where they had access to large, shady rockholes in deep gorges or permanent springs.

Table 9.1 provides a general description of seasonal variability in Mardu resource use. Today, Mardu depend on animal resources for the majority of their foraged foods. While the relative importance of collecting plants, especially grass and tree seeds, has declined with an increasing reliance on flour, the Mardu insist that hunting has always occupied most of men’s, women’s, and children’s foraging time (see Bird & Bliege Bird 2004). During our study period, large and small goanna lizards (perenti *Veranus gigantius*, sand goanna *V. gouldii*, and ridge-tail goanna *V. acanthurus*), bustards (*Ardeotis australis*), feral cats, snakes (especially *Aspidites* spp.), and grubs (*Cossidae*) provided 68% of the daily calories, while bush fruits, roots, and seeds provided 13%. The remainder (19%) was supplied by store carbohydrates (mostly flour and sugar). Nearly all meat came from game under

Table 9.1 *Mardu seasonal calendar of resources*

Mardu resource	<i>Yalijarra</i>				<i>Wandajarra</i>				<i>Dulbarra</i>			
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Primary animals</i>												
Marlu and Karlaya – kangaroo and emu (spear)	I	t	t	t	t	t	t	t	t	I	I	I
Marlu and karlaya – kangaroo and emu (gun)	t	t	t	t	t	t	t	t	t	t	t	t
Kipara – bustard	T	T	t	t	T	T	T	T	T	T	T	T
Yaliburra – perenti goanna	T	T	T	T					t	t	t	t
Parnipundi – sand goanna	T	T	T	T/B	B	B	B	B	T/B	T	T	T
Longuda – skink					T	T	T	T				
Feral cat	T	T	T	T	T	T	T	T	T	T	T	T
Lunki – <i>Cossid larvae</i> spp.	X	X	X	X	X	X	X	X	X	X	X	X
<i>Primary plants</i>												
Tree seeds – <i>Acacia</i> spp.	x	x							X	X	X	X
Grass seeds – woollybutt				X	X	x	x	x				
Ganjimara – vigna yam					X	X	X	X				
Jinjiwirri – <i>Solanum centrale</i>				X	X	X						
Wamala – <i>Solanum</i> spp.	V			X	X	X	X	X			V	V

Mardu seasons as they correspond roughly with the Gregorian calendar in an average year. B, burrowed and hunted with fire; I, intercepted at waterholes; t, tracked but rarely encountered; T, tracked; T/B, transitional month, goanna active on surface only at midday; V, variably available, depending upon rainfall; x, reduced availability; X, usually available. Timing of availability of most plant resources varies according to local onset of rainfall: two growth periods may be possible for *Solanum* if winter rains fall. See also Walsh (1990).

10 kg in body size. Larger game, such as kangaroo (*Macropus rufa* and *M. robustus*) and emu (*Dromaius novaehollandiae*) was acquired only occasionally. Feral camels were encountered widely but were shot rarely. While Mardu consider approximately 150 plant and animal species edible (Walsh 1990), during our study, which took place during three very wet years, four species supplied 81% of all calories acquired: sand goanna (*V. gouldii*), bustard (*Eupodotis australis*), bush tomato (*Solanum diversiflorum*), and bush raisin (*S. centrale*).

While goanna and bustards can be acquired throughout the year, acquisition patterns vary seasonally. In both seasons, there are two primary

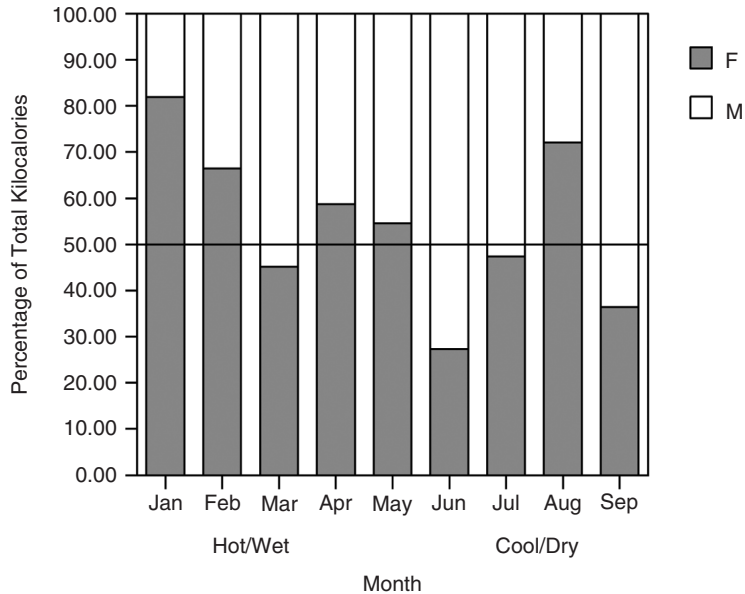


Figure 9.3 Variability in amount of foraged foods (kcal) acquired by men and women in each month sampled during 2000–02. Data are derived from a total of 763 adult foraging follows: 481 women and 282 men.

“hunt types:” *wana* (digging stick) hunting and gun hunting. *Wana* hunting involves searching primarily for goanna and other smaller prey using a digging stick. During months when the average high temperature is above 36 ° C (generally October through March), goannas are tracked on the surface during the day. When the days become too cool, the lizards begin to burrow. Mardu often describe *Wandajarra* as the burning season: hunters burn off tracts of old-growth spinifex grass in order to search for recent burrows, and then probe with a *wana* for the lie. Gun hunting uses small-gauge rifles or throwing sticks (spears are used today only for traditional punishment) and focuses on larger, mobile game, particularly bustards. Bustards are a more variable resource year round but tend to be more scarce at the end of *Yalijarra*, when they disperse to mate.

Over the sampled period (January through September), women produced 45% of the meat calories and 52% of all calories through foraging. The percentage of total foraging production attributed to women varied by month, from a high of 82% of all calories at the beginning of *Yalijarra* to 27% of all calories at the beginning of *Wandajarra* (Fig. 9.3). While women are culturally proscribed from using spears and spear-throwers, they are not prevented from hunting larger game using other methods, and

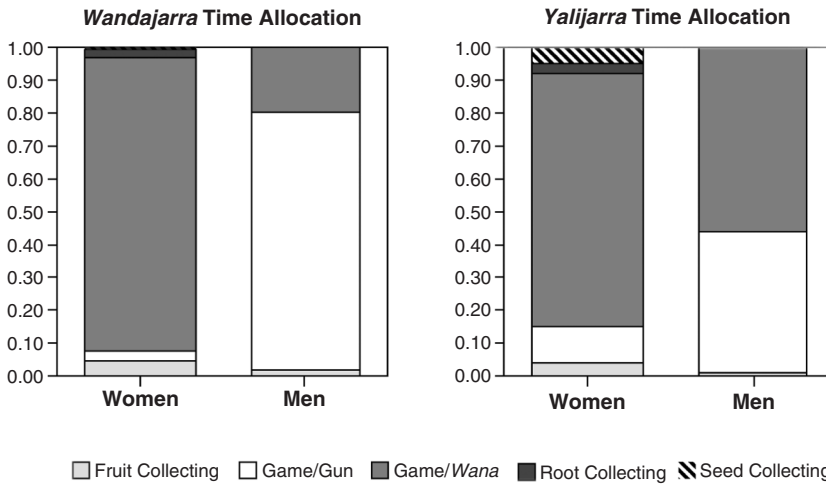


Figure 9.4 Seasonal variability in time allocation to different foraging activities by Mardu men and women in 2000–02 during *Yalijarra* (the hot/wet) and *Wandajarra* (the cool/dry). Data cover 2086 forager-hours – 1305 during *Wandajarra* and 781 during *Yalijarra* – with similar samples of men and women in both seasons.

women and children often help men to spot game on gun hunts. However, women prefer to spend their time *wana* hunting: the proportion of time that women allocate to *wana* hunting does not change seasonally (Fig. 9.4). Men spend a significantly greater proportion of foraging time *wana* hunting in *Yalijarra* and more time gun hunting for larger game in *Wandajarra* (Fig. 9.4). *Wana* hunting carries lower average return rates than gun hunting, but with less variability: non-parametric statistics that ignore the effects of outliers reveal that *wana* hunting is ranked higher than gun hunting ($U = 33429$, $P = 0.0001$). This is because 58% of gun hunts fail to acquire any calories, and 74% fail of gun hunts to acquire the targeted large prey, while only 11% of *wana* hunts fail.

Explaining contemporary variability

The question we will consider here is why men today choose to spend more time *wana* hunting for smaller game in *Yalijarra* and more time gun hunting for larger game in *Wandajarra*.

Hypothesis 1

Men switch to *wana* hunting in *Yalijarra* because it is a more predictably efficient hunting option. This hypothesis considers gun hunting and *wana*

Table 9.2 Prey ranking

Prey	Season	No. of pursuits	On-encounter return rate (kcal/h)	Rank	Overall returns (kcal/h)
Bustard	<i>Wandajarra</i> (cool dry)	88	22 392	1	Women, 733; men, 2125
Skink		26	20 131	2	
Cat		14	6295	3	
Goanna		475	5318	4	
Bush tomato		12	4217	5	
Small lizard		6	3248	6	
Bush raisin		19	3150	7	
Gum		1	1500	8	
Flowers		30	1437	9	
Snake		8	1074	10	
Grub		87	630	11	
Perenti		5	501	12	
Kangaroo		14	416	13	
Yam		8	382	14	
Bandicoot		2	0	15	
Bilby	1	0	16		
Echidna	1	0	17		
Rabbit	6	0	18		
Bustard	<i>Yalijarra</i> (hot wet)	32	24 796	1	Women, 944; men, 859
Skink		1	7098	2	
Bush tomato		9	4835	3	
Goanna		87	4647	4	
Perenti		18	3687	5	
Snake		8	1736	6	
Cat		4	1203	7	
Grub		11	745	8	
Corm		5	285	9	
Yam		1	276	10	
Kangaroo		1	0	11	

significantly different by season: 77% of *Yalijarra* and 57% of *Wandajarra* hunts experienced either search or pursuit failure ($\chi^2 = 3.092$, $P = 0.0787$).

This suggests that men may be sensitive to encounter rates with bustard and widen their diet breadth as the prey choice model predicts. However, this would explain men's seasonal prey choice only if search failure in both seasons caused men to increase the time they spend *wana* hunting.

Hypothesis 3

If men are switching to *wana* hunting only as a result of reductions in encounter rates with bustard, then they should be just as likely to *wana* hunt following a search failure in *Wandajarra* as in *Yalijarra*.

To test this hypothesis, we examined men's time allocation to gun hunting on days that they also switched to *wana* hunting, excluding those hunts where men tried to combine both activities. There were significant seasonal differences in time that men spent *wana* hunting following failure to encounter bustard (Table 9.3). In both seasons, when men were successful in capturing bustard, they spent just over 40 minutes per day also hunting goanna. However, failure to encounter prey had very different effects on men's seasonal time allocation to goanna hunting. In *Yalijarra*, men spent significantly more time *wana* hunting after failing to encounter bustard (154 minutes/day) than when they failed to encounter bustard in *Wandajarra* (50 minutes/day: $DF = 26$, $t = 3.078$, $P = 0.0049$). This was also the case for pursuit failures, although the sample size (three failed pursuits in the wet season) is too small to draw meaningful statistical inferences. Only failure in *Yalijarra* caused men to spend more time *wana* hunting. This suggests that while men may be paying attention to seasonal changes in the encounter rate with higher-ranked animals, they choose to respond to this only in *Yalijarra*, when goanna are among many animals tracked on the surface. This may mean either that the benefits to men of hunting goanna in *Yalijarra* are higher, possibly due to a preference for tracking, or that there are fewer opportunity costs to *wana* hunting, since there is no burning of large areas of grassland that frighten larger game away.

Hypothesis 4

If *wana* hunting is preferred in *Yalijarra* because prey are tracked, why would this bias men toward preferring to hunt goanna? One possibility is that men are "variance-prone" foragers, preferring prey that offer greater variance. Previous work examining variance and hunting suggests that high-variance activities can hold the potential to discriminate skill among foragers if more skilled individuals are able to demonstrate lower variance around their mean returns or a lower failure rate than other individuals (Bliege Bird *et al.* 2001). Are goanna harvests associated with higher variance and higher failure rates in *Yalijarra*?

To test this hypothesis, we examine variability in the total harvest (in kilocalories) of goanna acquired through *wana* hunting in each season (Table 9.4). Both the average size of the harvest and the variance are higher by all measures in *Yalijarra*. For comparison, we also include the mean harvest size and variance associated with hunts solely for larger game.

Table 9.3 Minutes that men spent searching and pursuing goanna on days when bustard was:

	Captured successfully			Encountered, but pursuit failed			Not encountered, search failed		
	Count	Mean	SE	Count	Mean	SE	Count	Mean	SE
Yalijarra	6	44	14	3	153	87	16	154	26
Wandajarra	25	41	13	20	53	13	12	50	18
		Mean differential	<i>t</i>		Mean differential	<i>t</i>		Mean differential	<i>t</i>
		3.48	0.124		99.65	2.262		103.708	3.078
			<i>P</i>			0.034			<i>P</i>
			0.902						0.005

SD, standard deviation; SE, standard error.

Table 9.4 *Variance and hunting strategies*

Season	Mean harvest (kcal)	<i>N</i>	Variance	CV	SE
<i>Wana</i> hunts (mostly goanna)					
<i>Wandajarra</i>	834	212	537 145	0.879	50.3
<i>Yalijarra</i>	1265	124	1 602 293	1.001	113.7
Gun Hunts (mostly bustard)					
<i>Wandajarra</i>	2864	118	58 635 525	2.674	705
<i>Yalijarra</i>	2353	28	44 216 150	2.826	1257

CV, coefficient of variation; SE, standard error.

However, *wana* hunt variance is still an order of magnitude lower than gun hunt variance in *Yalijarra*. Further complicating the issue is that pursuit success rates for goanna prey are higher in *Yalijarra*: both men and women have poorer success at capturing individual prey in *Wandajarra*. A multiple logistic regression model (Table 9.5) of sex and season shows a strong effect of season: hot/wet season goanna + perenti pursuits are more than three times more likely to be successful than cool/dry season hunts. There is little effect of sex: both men and women have poor goanna pursuit success in *Wandajarra* and do much better in *Yalijarra* (Table 9.6). While *Yalijarra wana* hunt harvests are more variable than *Wandajarra* hunts, foragers are actually more likely to have a successful pursuit. This does not suggest that men switch to *wana* hunting during *Yalijarra* because it offers higher pursuit failures than during *Wandajarra*.

Discussion and conclusions

Mardu men do not respond to seasonal resource variation in the same way that women do. Men often pass over opportunities to obtain very high return rates from seasonal fruits and roots. They spend very little time hunting goanna unless they are unsuccessful in the search for larger game, but only during *Yalijarra*, when goanna are tracked. The inability to find bustard does not influence men to hunt like women during *Wandajarra*, when goanna are hunted with fire and dug from burrows.

We suggest two possible explanations for this. First, *wana* hunting during *Yalijarra* may not be entirely exclusive with continuing to track larger game, while *Wandajarra wana* hunts may actually preclude hunting larger game. *Wandajarra* season hunts involve burning large tracts of grassland, which drives away larger game, leaving only the smaller

Table 9.5 Logistic model coefficients table for goanna pursuit outcome by sex and season

	Coefficient	SE	Coefficient/SE	χ^2	<i>P</i>	<i>R</i>	Coefficient	95% lower CL	95% upper CL
Success: constant	-0.624	0.104	-5.977	35.721	<0.0001	-0.213	0.536	0.437	0.658
Season: Yalijarra	1.139	0.241	4.72	22.283	<0.0001	0.165	3.123	1.946	5.011
Sex: male	-0.318	0.237	-1.344	1.807	0.1789	0	0.728	0.458	1.157

CL, confidence limit; SE, standard error.

Table 9.6 *Goanna pursuit outcome by season*

	<i>Wandajarra</i>		<i>Yalijarra</i>		Total	Chi-squared test	
	No. of pursuits	%	No. of pursuits	%			
Women							
Fail	251	64	29	43	280	DF	1
Success	140	36	39	57	179	χ^2	11.305
Total	391		68		459	<i>P</i>	0.0008
Men							
Fail	64	76	5	26	69	DF	1
Success	20	24	14	74	34	χ^2	17.43
Total	84		19		103	<i>P</i>	< 0.0001

DF, degrees of freedom.

burrowed animals within a radius of about five 5 km. This facilitates tracking small game but increases the time that men must spend tracking larger game and likely increases the chance of losing the animal. During *Yalijarra*, men who *wana* hunt often encounter the fresh tracks of other animals as they track goanna and perenti. When they do, they often pursue the larger game (cat, kangaroo, bustard, or emu).

Second, men may prefer mobile game in all seasons because only tracking has the potential to discriminate skill levels among hunters. While Mardu ascribe no political power to skilled trackers, they do make overt distinctions in skill for male and female hunters. A *mildilya* is a good hunter and can refer to either sex and any acquirer of any type of meat, large or small. As one Mardu woman put it, "*Mildilya* women are those who always come back with much meat. A *mildilya* man can track and hunt meat better than other men." In 1927, Spencer and Gillen noted that the Aranda men and women in the Central desert

know the track of every beast and bird . . . In [tracking] the men vary greatly . . . Whilst they can all follow tracks which would be indistinguishable to the average white man, there is a great difference in their ability to do so when they become obscure . . . a really good one will unerringly follow them up on horse- or camel-back.

If women gain status through hunting, as men do, then are they gaining status the same way? According to Mardu, they are not. Men gain *mildilya* notoriety through their ability to more consistently find animals tracked over long distances where the track often disappears; women gain status through their productive or provisioning capacity. This difference is visible

seasonality affects primate groups and allow us to design better models of the evolution of hominid behavior in seasonal environments.

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