

HUNTER SELF-MONITORING AS A BASIS FOR BIOLOGICAL RESEARCH: DATA FROM THE BOLIVIAN CHACO

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ABSTRACT. Izoceño hunters from 22 communities in the Bolivian Chaco voluntarily recorded data on over 5000 captured animals between 1997 and 2000. This paper presents and assesses the quality of biological information derived from hunter self-monitoring records. The nine most commonly hunted mammals were four ungulates (*Mazama gouazoubira*, *Tayassu tajacu*, *Tayassu pecari*, and *Tapirus terrestris*) and five armadillos (*Dasyopus novemcinctus*, *Tolypeutes matacus*, *Euphractus sexcinctus*, *Chaetophractus villosus*, and *C. vellerosus*). The lack of quantitative precision restricts data analysis to qualitative assessment and relative comparisons among or within species. The data indicate seasonal reproductive activity (pregnancy rates, proportion of females and/or juveniles hunted) for all species except *T. terrestris*. The data also suggest that most species shift activity patterns during the coldest season of the year to increase day-time or mid-afternoon activity. Self-monitoring as conducted in the Izozog is not adequate for analyses of condition or habitat preferences.

RESUMEN. El auto-monitoreo de cacería como base para la investigación biológica: datos del Chaco boliviano. De forma voluntaria cazadores Izoceños de 22 comunidades del Chaco boliviano registraron más de 5000 animales cazados, junto con datos biológicos de cada animal cazado, entre 1997 y 2000. Este artículo presenta y evalúa la calidad de la información biológica proveniente de los datos que aportan los cazadores del auto-monitoreo de cacería. Los nueve mamíferos más cazados fueron cuatro ungulados (*Mazama gouazoubira*, *Tayassu tajacu*, *Tayassu pecari*, and *Tapirus terrestris*) y cinco armadillos (*Dasyopus novemcinctus*, *Tolypeutes matacus*, *Euphractus sexcinctus*, *Chaetophractus villosus* y *C. vellerosus*). La falta de precisión cuantitativa de los datos restringe el análisis a una evaluación cualitativa y a comparaciones relativas entre diferentes especies o dentro de una misma especie. Según los registros de los cazadores, todas las especies excepto *T. terrestris* presentan una reproducción estacional (tasas de reproducción, proporción de hembras y/o juveniles cazados). Los registros además sugieren que la mayoría de las especies cambian patrones de actividad durante la estación más fría del año para incrementar la actividad durante el día y la tarde. El auto-monitoreo, tal como es llevado en el Izozog, no es adecuado para realizar el análisis de condición o preferencias de hábitat de las especies en cuestión.

Key words: Bolivia, hunting, self-monitoring, ungulates, armadillos.

Palabras clave: Bolivia, cacería, auto-monitoreo, ungulados, armadillos.

INTRODUCTION

The future of wildlife in the tropics depends not only on conservation in protected areas, but on sustainable utilization outside protected areas by rural and indigenous populations (Robinson and Bennett, 2000). In order to study wildlife in tropical forests and wildlife exploitation by indigenous populations, researchers have employed a variety of methods including participant observation of hunting activities (Robinson and Redford, 1991; E. Cuéllar, 1999, 2000; Robinson and Bennett, 2000), interviews (Robinson and Redford, 1991; E. Cuéllar, 1999, 2000; Robinson and Bennett, 2000), daily household visits (Ayala, 1997; R.L. Cuéllar, 1999; Robinson and Bennett, 2000), and to a limited degree, self-monitoring (Marks, 1994, 1996; Guinart, 1997; Rúmiz and Solar, 1997; Townsend, 1997; Robinson and Bennett, 2000). Most studies have focused on a single community with less than 100 active hunters.

Among larger human population groups, and at larger geographic scales, self-monitoring may offer two important advantages: 1) to involve an important sector of the local population in wildlife research and management activities, and 2) to expand the number of data collectors far beyond the capacity of a small number of researchers and assistants. In order to address these objectives, the authors initiated a hunter self-monitoring program in 1996 with the 22 communities and 8000 inhabitants of the Izozog, with support from the Wildlife Conservation Society (WCS), the Capitanía del Alto y Bajo Izozog (the traditional Izoceño political authority, CABI), and the United States Agency for International Development (USAID) through the Kaa-Iya Project (1996-2003).

The Izoceño communities and CABI became involved in formal conservation and wildlife management early in the 1990s, in collaboration with WCS, achieving the establishment in 1995 and subsequent co-management of the 34,400 km² Kaa-Iya National Park (Taber et al., 1997). The government has charged CABI with the design of a wildlife management plan as a condition for granting the Izoceños an indigenous territory (Tierra Comunitaria de Origen or TCO) of 19,000 km² adjacent to the

Kaa-Iya National Park. Izoceño hunters actively exploit an area of approximately 4,000 km², within which human population density is approximately 2 persons/km². The authors are employed by WCS and CABI, and data from the self-monitoring program will provide the basis for this community wildlife management plan. To date, hunters have reported over 5000 mammals (31 species), 3000 birds (15 identified species), and 280 reptiles (5 identified species) (Noss, 1998, 1999; R.L. Cuéllar, 2000; Leños and Cuéllar, 2000). This article presents the biological data acquired from hunter self-monitoring on nine principal prey species which have been relatively poorly studied (grey brocket deer *Mazama gouazoubira*, three-banded armadillo *Tolypeutes matacus*, yellow armadillo *Euphractus sexcinctus*, and hairy armadillos *Chaetophractus villosus* and *C. vellerosus*) or studied principally in environments quite different from the Chaco dry forest (collared peccary *Tayassu tajacu*, white-lipped peccary *Tayassu pecari*, lowland tapir *Tapirus terrestris*, and nine-banded armadillo *Dasyus novemcinctus*).

STUDY AREA AND METHODS

The 22 Izoceño communities are located along the Parapetí river, 300 km to the south-east of the city of Santa Cruz (Fig. 1). The region is part of the boreal Chaco, with an average altitude of 300 m, and average annual temperature of 26° C (0° - 42°). It is the driest portion of the Chaco: annual rainfall averages only 550 mm, and the dry season lasts from May to November. The xeric Chaco vegetation is generally dense, low and thorny (Taber et al., 1997; Navarro and Fuentes, 1999).

Izoceños hunt principally with firearms and/or with dogs. In order to capture *M. gouazoubira*, hunters walk or ride horses along trails looking for deer active or resting to the sides of the trail. Upon sighting an animal they shoot it with a firearm (.22 rifle and 16-gauge shotgun).

In contrast, pursuit with dogs is the primary method for capturing peccaries and tapir. Unlike brocket deer, when pursued these animals stop at bay, turn to fight the dogs, or take refuge in a pond (*T. terrestris*) or hollow log (*T. tajacu*) (Arambiza and Guerrero, 2000; Ayala, 2000a, 2000b; Noss et al., 2002). When cornered by dogs, or when encountered by chance, they are killed with a firearm. Hunters in pursuit of tapir or peccaries and with

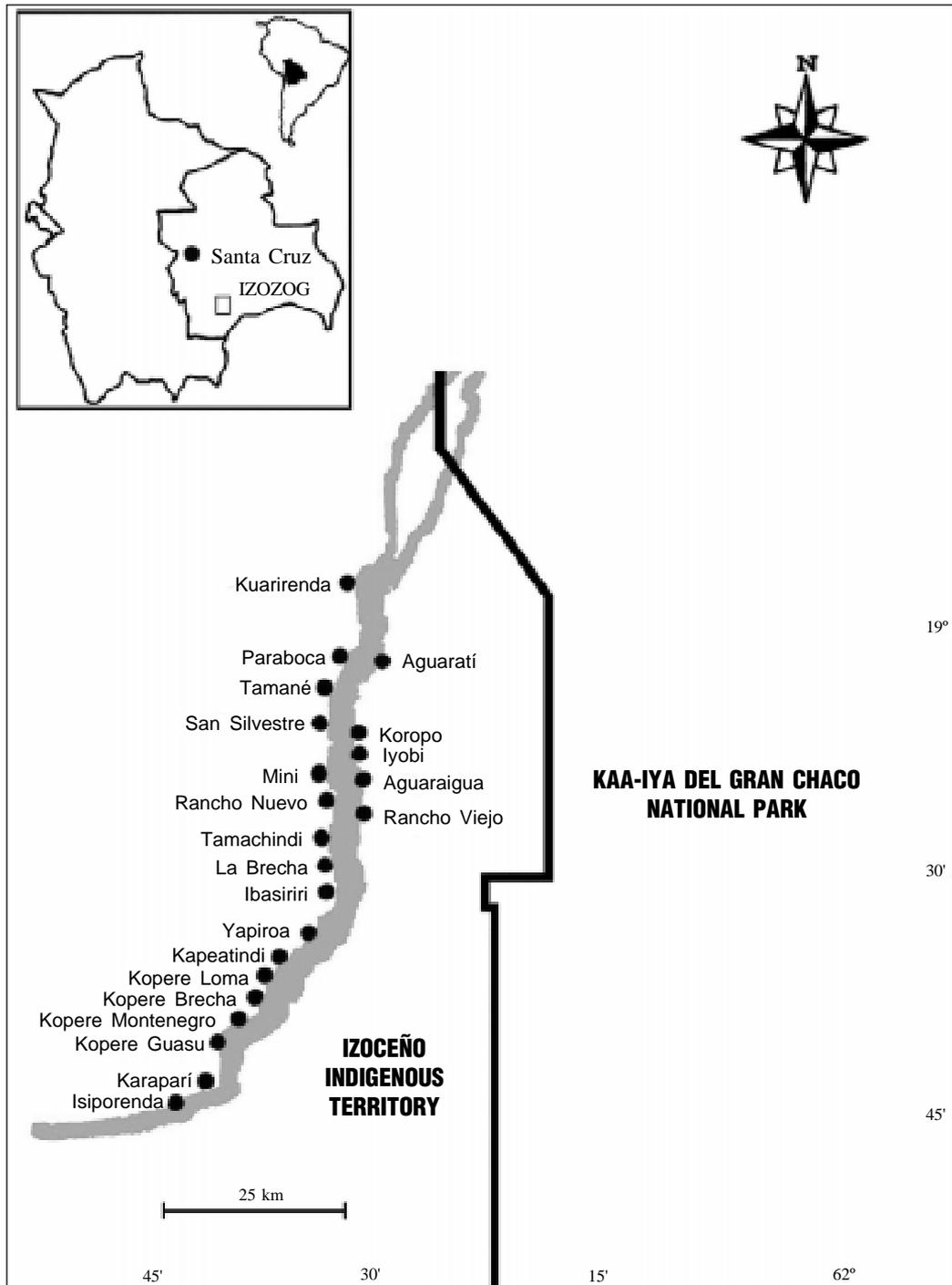


Fig. 1. Study area with Izocéño communities along Parapetí river.

trained dogs walk trails early in the morning. When they find fresh sign, the hunters track visually until the dogs can pick up the scent and give chase.

Pursuit with dogs is also the most important method for hunting armadillos, particularly in the case of nocturnal species (*D. novemcinctus*, *T. matacus*, *C. vellerosus*). The two diurnal species are also hunted with dogs, but occasionally are shot with a firearm or slingshot or seized by hand when encountered by chance in the open. As with ungulates, hunters with trained dogs walk along trails by day or night until the dogs cut a fresh armadillo trail and give chase.

The authors designed data sheets (see **Appendix I**) for self-monitoring together with Izoceño hunters, accompanied numerous hunts to see what type of information could reasonably be collected, and revised the data sheets in accordance with the hunters' observations. We provided pocket-size notebooks of data sheets to all hunters who expressed interest in participating voluntarily, together with tape measures and spring scales (12 kg and 50 kg). We provided no direct payment to hunters for data or specimens, although we did provide a trimestral donation of medicines to the hospital in the Izozog as an indirect form of compensation. We hired 11 half-time wildlife monitors, each responsible for 1-2 communities, to explain the objectives of the program, distribute data sheets and materials, and collect data once a month. Through formal courses and demonstration during accompanied hunts we trained wildlife monitors as well as hunters in data collection using the materials we provided.

Abundance and distribution

Considering ungulates and armadillos as groups, we calculate the proportion by species in the two groups reported for particular communities or groups of communities. Finally we compare these disaggregated proportions with the mean for the Izozog as a whole to determine where hunting of a particular species is relatively high or low.

Assumption 1: Izoceño hunters do not select for particular prey species

Among the entire range of potential prey species available to them, Izoceño hunters generally ignore several such as primates and foxes (Noss, 1998, 1999). However, the nine species discussed in this paper are all preferred prey species, with the possible exception of *E. sexcinctus* which several hunters profess not to consume (E. Cuéllar, 1999). With respect to these species, therefore, hunters are opportunistic and pursue what they encounter. Cap-

ture rates should then reflect relative abundance and distribution, if two additional factors are considered: hunting method and vulnerability.

The choice of hunting method itself depends to a large extent on the relative abundance of prey. For example, hunters in some communities report that they no longer hunt tapir or peccaries because they lack "good" dogs. However, dogs are trained in the field by hunting the species, and the local decline of the hunted species means that dogs no longer learn to hunt. Nevertheless, the most compelling comparisons are between species that are hunted using the same method, for example the two peccary species.

Vulnerability to hunters varies among species and may account for a slight underestimation of *E. sexcinctus* abundance. Of the five armadillos this species is the most powerful runner and digger, with 13% of encountered animals escaping, in comparison to 2-7% of the other species escaping. However these differences in vulnerability do not alter the general trends derived from the self-monitoring data.

Reproduction

Hunters recorded information on sex of hunted animals and litter size. They often recorded that an animal was both pregnant and lactating. In the case of *M. gouazoubira*, we confirmed one case of a female lactating a juvenile and simultaneously pregnant with a 20 day old fetus. In all species it may be possible to express a liquid from teats of animals approaching parturition, thus recording them as both pregnant and lactating. These two categories are therefore reported separately here.

We evaluated the proportions of captured females that are pregnant or lactating each month to determine whether reproduction is seasonal, and to estimate fecundity rates. We examined sex ratios of monthly captures by species to determine whether seasonal patterns are evident in activity of female versus male animals.

Assumption 2: Izoceño hunters do not select for males over females

Just as Izoceño hunters do not select for any of the species discussed in this paper, they do not select for males. As a potential management measure we have discussed in community meetings throughout the Izozog the possibility of hunting only males during certain periods of the year. Hunters respond that it is impossible to distinguish male and female ungulates at a distance. Only *M. gouazoubira* presents sexual dimorphism, but antler growth and loss in males is non seasonal. Although they capture

most armadillos alive, hunters cannot release females because of the household need for meat, and because rejecting a gift of the “kaa-iyá” spirit guardians of wildlife would imperil future hunting successes (Noss and Cuéllar, 2001).

Therefore sex ratios of harvested animals reflect encounter rates, though perhaps not actual sex ratios in the population. Limited data on fetal sex ratios suggests that birth rates may be skewed towards males (*D. novemcinctus*) or females (*M. gouazoubira*), and we have no information on differential survival rates by sex from birth to adulthood. Males may be more frequently encountered by both human and natural predators if they are more active and/or range further than females, as is the case with *M. gouazoubira* but not *T. terrestris* (Barrientos and Maffei, 2000; Ayala, 2002). We do not yet have data to support our impression that male armadillos may also be more active than females in defense of territory and search for mates, whereas females may restrict their activity to a small area near their burrow particularly when they are caring for young.

Age classes

Based on subjective criteria such as size, shell wear, or color, hunters in some cases indicated age of hunted animals as “juvenile”, “adult”, or “old adult”. In addition, we used weight to differentiate juvenile animals from adults, considering juveniles to be either: 1) below the minimum weight of pregnant, and therefore mature, females; or 2) less than 60% of average adult weights reported in the literature. Using the weight-based method of identifying juvenile animals, we examine monthly captures by species to determine whether seasonal patterns are evident in proportions of juvenile animals within the population.

Assumption 3: Izoceño hunters do not select for adults over juveniles

For the same reasons that Izoceño hunters do not spare female animals, they likewise do not spare juvenile animals that they encounter. However, in the case of sociable peccaries, hunters select for larger animals in a herd, while herd structure protects juvenile animals in the center with older animals on the vulnerable periphery. Harvests of juvenile peccaries are therefore lower than those of animals ages 3-4 years (Maffei, 1999, in press). The solitary *M. gouazoubira* presents an opposite scenario where juveniles lacking in experience may be more vulnerable than adults to hunters. Thus harvests of juveniles (<1 year) exceed all other age classes (Maffei, 1999, 2001).

For armadillos, capture rates probably reflect encounter rates more directly, though once again not actual population structure. Instead, harvests by age class are related to activity patterns in armadillos. If the young remain in the burrows for the first two months following birth, they are not vulnerable to Izoceño hunters who depend on dogs to follow fresh armadillo tracks to burrows. By 2-3 months of age the young have grown to 1/3 of adult size, have been weaned (Meritt, 1971; Eisenberg and Redford, 1999; McBee and Baker, 1982; Roberts et al., 1982; Redford and Wetzel, 1985), venture forth from the burrow, and comprise a greater proportion of hunter captures. Similarly, Loughry and McDonnell (1995) report that in Texas disproportionately few juvenile *D. novemcinctus* are encountered as road-kills, confirming differential activity patterns for juveniles.

Condition

We constructed an index to evaluate condition of hunted animals, dividing average weight by average total length. In the index we included only adult animals, determined by weight as described above. We then compare monthly averages with the annual average for each species to determine whether seasonal patterns are evident in body condition.

Assumption 4: Izoceño hunters do not select for fat over thin animals

For the same reasons that Izoceño hunters do not spare female or juvenile animals, they likewise do not spare animals in poor condition that they encounter. In the absence of other information, body measurements provide a rough assessment of condition in hunted animals. The variation among armadillo species in when the “thin” season occurs may result from a combination of related factors: reproductive activity, rainfall, ambient temperature, activity levels, and food availability. In the smallest ungulates the cold dry season is the thin season. Self-monitoring data as recorded provide only vague suggestions of body condition in hunted animals. This theme requires more detailed and focused studies including more precise instruments for hunters, and examination of indicators such as kidney fat.

Habitat preferences

Izoceño names for habitat types are extremely variable, including over 80 categories based on characteristics such as height of the forest or dominance of a particular plant. We convert the Izoceño categories to four habitat types of Chacoan thorn

woodland described by Navarro and Fuentes (1999) for the Izozog. The first three are vegetation series of the Chaco alluvial plain landscape system: Chaco forest on well-drained or sandy soils (W), low xeric Chaco forest on medium-drained soils (M), and low xeric Chaco forest on poorly-drained soils (P). The fourth is the Chaco riverine landscape system (R). An additional category includes all areas converted to human use such as communities, corrals, and farms (C). We then compared the proportions of animals of each species hunted in each habitat with the proportions of each type of habitat in the hunting area: 5% P, 70% M, 16% W, 5% R, and 4% C.

Assumption 5: Izoceño hunters distribute hunting effort in proportion to the availability of habitat types

Izoceño hunters did not record information that would allow us to calculate effort or encounter rates in particular habitat types. Do hunter records confound predator behavior with prey behavior? The cultivated area (C) and riverine forest (R) habitat types in the study area are confined to a narrow strip along the Parapetí river. All the Izoceño communities are located in this strip, thus opportunistic captures are more likely to occur in these habitat types. Nevertheless, the data suggest that in the Izozog wild ungulates are not attracted to cultivated areas (C), but armadillos do occasionally raid crops.

Excluding the narrow strip of along the Parapetí river, the Izozog presents a mosaic of the remaining three habitat types. The thick and thorny vegetation generally restricts hunters to existing roads, the majority of which are oil exploration roads established on a 4 x 4 km grid oriented north-south and east-west. Hunters tend to walk or ride along these roads in search of game, and therefore randomly encounter the three vegetation types in approximately the same proportion to which they exist in the Izozog. The exception is that hunters are not restricted to trails in the relatively open habitats on well-drained soils (W), and may exploit these areas disproportionately. At the same time, these soils may offer more favorable burrowing conditions and therefore support higher populations of armadillos. Finally, these habitats offer better visibility to hunters who must see *M. gouazoubira* at a distance in order to shoot it. A relatively high proportion of captures of ungulates in habitat types on poorly drained soils (P) may reflect their defensive strategy in heading for the thickest vegetation when pursued by dogs.

Activity patterns

We grouped times of day into six four-hour periods. We also compared activity patterns across three seasons: "WET" from December-April, "CD = cold dry" from May-July, and "WD = warm dry" from August-November. Data recorded from 1997-1999 by CABI personnel at Cerro Cortado field site in the Izozog indicate average monthly minimum and maximum temperatures and average monthly precipitation for each season as follows: 22.0-31.1°C and 87 mm in the wet season, 17.0-26.2°C and 14 mm in the cold dry season, and 20.3-32.2°C and 43 mm in the warm dry season (E. Cuéllar, 1999).

Assumption 6: Activity patterns. Izoceño hunters encounter animals that are active

As described above, hunters capture most armadillos by using dogs to track fresh sign to a burrow. Except for *T. matacus* which rolls into a ball to protect itself, armadillos take refuge in burrows from which hunters dig them out (E. Cuéllar, 1999, 2000). Unlike Aché hunters in Paraguay (Hill et al., 1997), the Izoceños do not search by day for occupied armadillo burrows to excavate. In attempting to census armadillos using trained dogs, E. Cuéllar (2002) found that dogs were unable to follow trails more than two hours old. Therefore capture times closely reflect activity periods for the particular species of armadillos. The daytime captures of "nocturnal" species such as *D. novemcinctus* and *T. matacus* may reflect somewhat greater hunting effort during daytime hours, although the literature also reports diurnal activity for these species in response to environmental conditions such as cold, rain, or drought (McBee and Baker, 1982; Eisenberg and Redford, 1999).

In the case of ungulates, however, hunter records do not reflect true activity patterns. Hunters frequently encounter and kill deer that are lying down or resting. Hunters also follow by sight peccary and tapir tracks of the previous night's activity to where the animals may be resting. Izoceño hunters do not track ungulates at night with dogs, do not spotlight, and only rarely sit in blinds at night. Radiotelemetry data at a study site on the eastern edge of the Izozog indicates crepuscular activity peaks (5-9:00 and 16-20:00) for *M. gouazoubira* and *T. tajacu* (Barrientos and Maffei, 2000; Miserendino, 2002), and predominantly nocturnal activity for *T. terrestris* (Ayala, 2002).

Other studies suggest that activity patterns for ungulates also depend on environmental conditions,

with greater diurnal activity in cooler environments or during cooler seasons, and greater nocturnal activity in warmer environments or during warmer seasons (Mayer and Wetzell, 1987; Padilla and Dowler, 1994; Taber et al., 1994; Ilse and Hellgren, 1995; Richard et al. 1995; Eisenberg and Redford, 1999).

RESULTS

Over 700 Izoceño hunters provided data on hunting activities during the 46 months between August 1996 and May 2000. Although some provided information on only a single recorded kill, others recorded more than 100 hunted animals during the three-year span (maximum 155, mean 12.7, SD 20.7). Numerous recorded species are hunted only infrequently, with correspondingly limited data. Hereafter we consider only the nine principal game species listed in **Table 1**, each of which represents >1% of the total biomass, or >2% of the total number, of hunted mammals.

Abundance and distribution

D. novemcinctus represents from 0% (Isiporenda to Kapeatindi) to 72% (Rancho Nuevo to Kuarienda) of armadillo captures. *Tolypeutes matacus* replaces *D. novemcinctus* in the first set of communities as the most

important armadillos species, attaining 70% of armadillo captures, while *C. villosus* and *E. sexcinctus* also increase in relative importance (**Table 2**).

Tapirus terrestris is rarely hunted except in the community of Isiporenda (17% of ungulates). *T. pecari* is more frequently encountered at the northern end of the Izozog, where it comprises 17% of ungulate captures. However, a single windfall event can skew the totals: in February, 1998 a herd of *T. pecari* appeared among the four Kopere communities, and local hunters killed 15 animals in two days.

Reproduction

Table 3 presents litter size, sex ratios, and reproductive status according to hunter records. Of 109 female brocket deer reported to be pregnant, nine were carrying twins. If sex ratios in the population are 1:1, hunting records indicate a sex bias towards male animals of all species. The bias is particularly noteworthy in *T. terrestris*, *T. matacus*, and *C. villosus* with females comprising less than one-third of captured animals.

The brocket deer and peccaries exhibit seasonality in reproduction (**Fig. 2**). Although reproduction continues throughout the year, *M. gouazoubira* shows a sharp decline in repro-

Table 1
Principal mammalian game species of Izoceño hunters
(% by number and by kilograms of total mammal captures)

Scientific name	Common names	Avg kg	N	% N	% kg
UNGULATES			2452	45.9	87.8
<i>Mazama gouazoubira</i>	Grey brocket deer (urina)	17.2	1352	25.3	38.9
<i>Tayassu tajacu</i>	Collared peccary (taitetú)	18.7	746	14.0	22.7
<i>Tayassu pecari</i>	White-lipped peccary (tropero)	27.5	284	5.3	13.1
<i>Tapirus terrestris</i>	Lowland tapir (anta)	130.0	70	1.3	13.1
ARMADILLOS			2620	49.0	9.2
<i>Dasybus novemcinctus</i>	Nine-banded armadillo (tatú mula)	2.3	1054	19.7	4.2
<i>Tolypeutes matacus</i>	Three-banded armadillo (corechi)	1.4	784	14.7	1.8
<i>Euphractus sexcinctus</i>	Yellow armadillo (peji)	3.7	242	4.5	1.5
<i>Chaetophractus villosus</i>	Large hairy armadillo (pecho amarillo)	2.3	385	7.2	1.4
<i>Chaetophractus vellerosus</i>	Screaming armadillo (tatú llorón)	1.2	155	2.9	0.3

Table 2

Prey species by communities (comparative percent by species of ungulates and armadillos respectively)

	Ungulates					Armadillos					
	N	Mg	Ttj	Tp	Tte	N	Dn	Tm	Es	Cvi	Cve
Kuarirenda Aguarati Paraboca Tamané San Silvestre	440	-	+	+	-	143	+	+	-	-	+
Koropo Iyobi Aguaraigua Rancho Viejo	220	++	=	-	-	486	++	—	-	-	-
Rancho Nuevo Tamachindi La Brecha Ibasiriri Yapiroa	341	-	+	-	-	662	-	+	=	-	+
Kapeatindi Kopere Loma Kopere Brecha Kopere Montenegro Kopere Guazu	585	++	—	+	+	1037	—	++	+	+	+
Isiporenda Karaparí	1144	+	-	-	+	498	—	++	++	++	-
Total	2783	56	30	11	3	2970	42	28	9	15	5

Notes: (+) 1-9 points greater, (++) 10 points or more greater, (-) 1-9 points lesser, (—) 10 points or more lesser than Izozog average.

Ungulates: Mg = *Mazama gouazoubira*, Ttj = *Tayassu tajacu*, Tp = *Tayassu pecari*, Tte = *Tapirus terrestris*.

Armadillos: Dn = *Dasybus novemcinctus*, Tm = *Tolypeutes matacus*, Es = *Euphractus sexcinctus*, Cvi = *Chaetophractus villosus*, Cve = *Chaetophractus vellerosus*.

ductive activity during the cold dry months of May-July. The highest monthly fecundity rate for *M. gouazoubira* is only 22%. In contrast, *T. tajacu* reproductive activity declines in the months January-May, the period of heaviest rains and the beginning of the dry season. Pregnancy rates peak in October, and lactation rates in December. With a more concentrated birth period relative to *M. gouazoubira*, monthly fecundity rates in *T. tajacu* attain 35% in De-

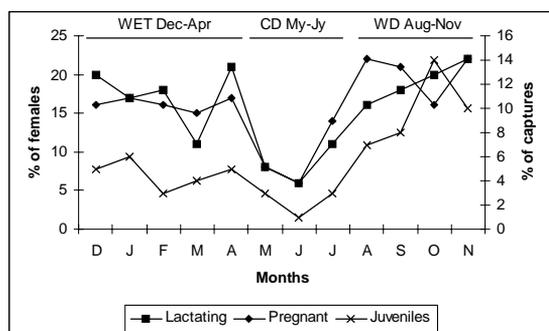
ember. Patterns are less clear with the smaller sample of *T. pecari* females. Nevertheless, no pregnant females were hunted in April-July, suggesting seasonal reproduction in this species as well.

The armadillos, in particular *D. novemcinctus*, exhibit a strongly marked seasonality in reproduction, with captures of pregnant females concentrated during the warm dry season (**Fig. 3**). Pregnancy rates for *D.*

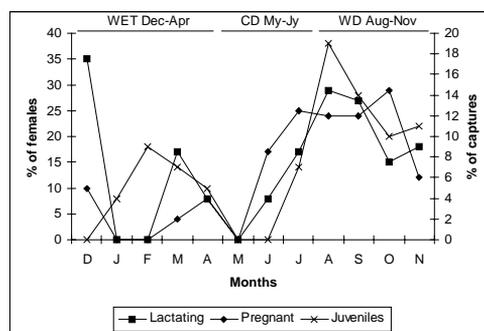
Table 3
Sex ratios and reproductive status of hunted animals

Scientific name	M	F	%F	%P	%L	Number of Young	Fetal % F (N)
UNGULATES							
<i>Mazama gouazoubira</i>	714	635	47.1	17.2	17.3	1.06	66.7 (24)
<i>Tayassu tajacu</i>	456	271	37.3	15.9	17.3	1.95	36.4 (11)
<i>Tayassu pecari</i>	136	118	46.5	11.0	22.0	1.77	66.7 (3)
<i>Tapirus terrestris</i>	43	22	27.3	22.7	27.3	1.00	—
ARMADILLOS							
<i>Dasytus novemcinctus</i>	608	452	42.6	22.4	18.6	3.88	40.9 (44 x 4 identical young)
<i>Tolypeutes matacus</i>	464	222	32.4	6.8	7.7	1.00	22.2 (9)
<i>Euphractus sexcinctus</i>	154	82	34.8	3.7	8.5	1.33	—
<i>Chaetophractus villosus</i>	285	121	29.8	1.7	5.0	1.50	—
<i>Chaetophractus vellerosus</i>	81	49	37.7	12.2	6.1	1.83	—

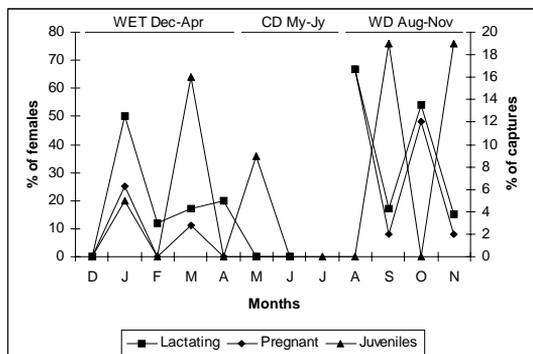
Notes: **P** = pregnant, **L** = lactating



(a)



(b)



(c)

Fig. 2. Reproductive activity in ungulates. **a)** *Mazama gouazoubira* (N = 635 females, 902 captures). **b)** *Tayassu tajacu* (N = 271 females, 469 captures). **c)** *Tayassu pecari* (N = 118 females, 164 captures)

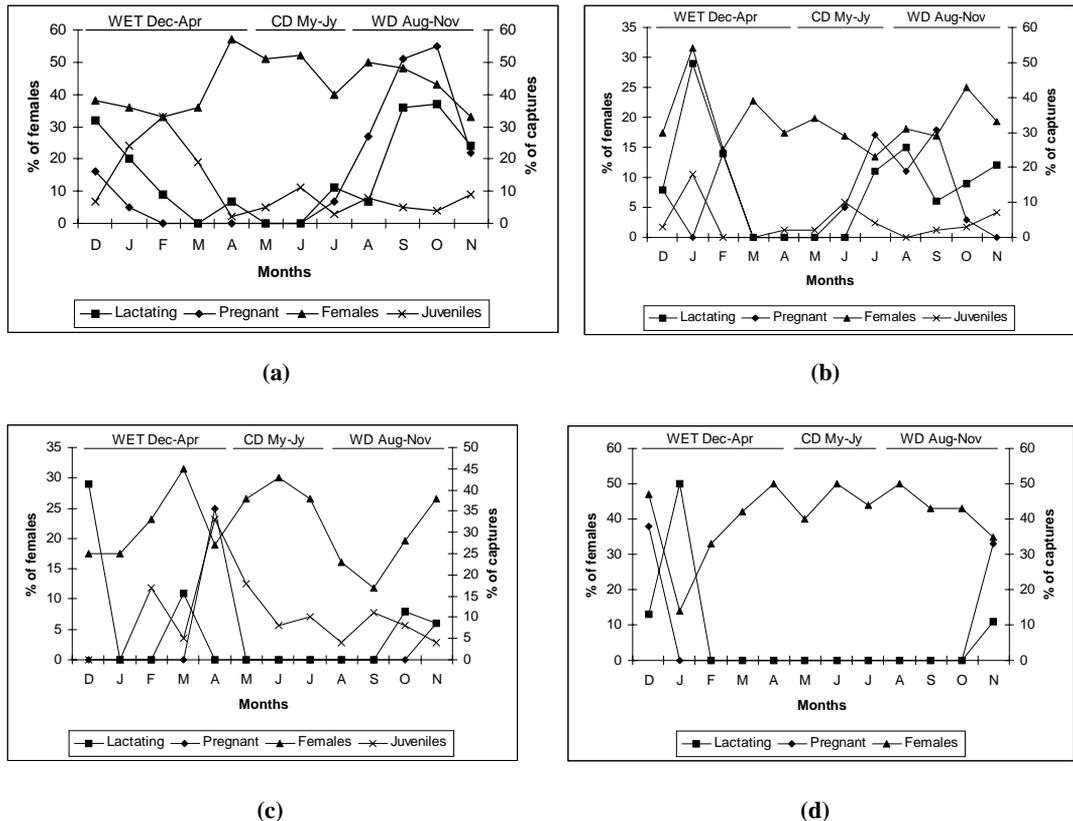


Fig. 3. Reproductive activity in armadillos. **a)** *Dasypos novemcinctus* (N = 452 females, 921 captures). **b)** *Tolypeutes matacus* (N = 222 females, 550 captures). **c)** *ChaetophRACTUS villosus* (N = 121 females, 332 captures). **d)** *ChaetophRACTUS vellerosus* (N = 49 females, 109 captures).

novemcinctus attain a peak of 55% in October. *Tolypeutes matacus* also shows a seasonal reproduction pattern, though somewhat more extended than in the case of *D. novemcinctus*, from July through February. Alternatively *T. matacus* may reproduce twice during this period, as evidenced by the two peaks in pregnancy rates: a first peak in July-September and a second in December-February. The few data on *C. villosus* also suggest the possibility of two peaks in reproduction, the first from October-December and the second from March-April. Even fewer data for *E. sexcinctus* and *C. vellerosus* indicate a short and concentrated reproductive season from October-December and November-January respectively. However, hunters also reported lactating *E. sexcinctus* in March and July. Maximum fecundity rates for the two species are 27% for *E. excinctus* in December and 50% for *C. vellerosus* in January.

Related to reproductive activity among the armadillos is the seasonal variation in the proportion of females captured by hunters (Fig. 3). The pattern is again most pronounced in the case of *D. novemcinctus*, with proportionally fewer females captured in September-March when they are pregnant and lactating. The pattern is less clear for the other armadillo species, although the data may indicate that *T. matacus*, *E. sexcinctus*, and *C. villosus* reproduce twice a year.

Age classes

The two methods for determining age classes, first the hunters' subjective categories and second the weight-based categories, coincide only in the case of *T. terrestris* (Table 4). For all other species the first method reported 3-5 times as many juveniles among captured animals as the second.

Among the ungulates, seasonality in the relative importance of juveniles among captured animals is most pronounced in the case of *M. gouazoubira* and *T. tajacu*. Juveniles as a proportion of total captures peak during the months from September-November for *M. gouazoubira*, and August-November for *T. tajacu*. These periods coincide with the reproduction peaks for both species (Fig. 2). Hunters recorded no juvenile *T. pecari* from June-August, coinciding with the period of minimum pregnancy and lactation rates.

Captures of *D. novemcinctus* present a seasonal pattern with relatively high proportions of juvenile animals concentrated in January-March (Fig. 3). The peak in juvenile captures follows three months after the peak in pregnancy rates. *T. matacus* also presents peaks in January, 4-6 months after the two peaks in pregnancy rates. The peak for *C. villosus* occurs in April, 4-6 months after the October-December peak in reproductive activity. No baby armadillos are reported by Izocoño hunters, and many fewer females are hunted, particularly in the months with the highest reproductive activity (Fig. 3).

Condition

Combining weight and body length in a single index (for adult animals only), Table 5 suggests relatively “fat” seasons for *M. gouazoubira* and *T. tajacu* from November-March/April. With respect to armadillos, more notable are relatively “thin” seasons of 3-6 months at different times of the year according to the species. These data emphasize relative comparisons within species across months.

Habitat preferences

Assuming that hunting effort is distributed in proportion to availability of habitat types throughout the Izozog, and that vulnerability does not vary with habitat type, then capture rates for each species by habitat type suggest habitat preferences. Thus Table 6 indicates that none of the ungulates but three of the armadillo species (*D. novemcinctus*, *E. sexcinctus*, *C. vellerosus*) are hunted disproportionately near communities or cultivated areas (C). All ungulates and the same three armadillos species are hunted relatively frequently in riverine forest (R). All armadillos, though *D.*

Table 4
Age classification

Scientific name	Hunter classification				Weight classification			
	N	%J	%A	%O	N	Wt	%J	%A
UNGULATES								
<i>M. gouazoubira</i>	1129	39	58	3	902	12	8	92
<i>T. tajacu</i>	603	36	58	6	469	12	9	91
<i>T. pecari</i>	223	23	69	8	164	16	7	93
<i>T. terrestris</i>	58	47	41	12	47	100	40	60
ARMADILLOS								
<i>D. novemcinctus</i>	912	29	65	7	921	1.5	10	90
<i>T. matacus</i>	538	30	65	5	550	0.7	4	96
<i>E. sexcinctus</i>	197	24	68	8	201	2.0	9	91
<i>C. villosus</i>	311	31	64	5	332	1.5	9	91
<i>C. vellerosus</i>	113	35	62	3	109	0.7	12	88

Notes: Hunters reported age of hunted animals as **J** = juvenile, **A** = adult, and **O** = old adult. **Wt** = kg delimiting adult from juvenile animals.

Table 5
Condition index by season and month: average weight/average body length
(converted to present only two relevant digits)

Species	Av	Wet					Cold Dry			Warm Dry			
		D	J	F	M	A	M	J	J	A	S	O	N
UNGULATES													
<i>M. gouazoubira</i>	71	+	+	+	+	+	-	=	-	-	+	-	+
<i>T. tajacu</i>	20	=	+	+	=	-	-	=	-	=	=	-	=
<i>T. pecari</i>	25	+	+	-	-	-	+	+	-	-	-	+	=
<i>T. terrestris</i>	8	=	+	+	+	=	+		-	=	-	-	-
ARMADILLOS													
<i>D. novemcinctus</i>	42	=	+	+	+	+	+	+	=	-	-	-	=
<i>T. matacus</i>	39	+	-	+	-	-	-	-	-	-	+	-	=
<i>E. sexcinctus</i>	62	-	-	+	-	+	+	=	+	+	+	-	-
<i>C. villosus</i>	48	-	=	+	=	+	+	+	-	+	-	-	-
<i>C. vellerosus</i>	33	+	-	+	-	+	+	-	-	-	-	+	-

Notes: (+) greater than, (-) less than, (=) equal to annual average for species.

Table 6
Captures by habitat type*

	W	M	P	R	C	W	M	P	R	C
Distribution of habitat types in Izozog (%)	16	70	5	5	4					
UNGULATES										
<i>M. gouazoubira</i>	17	72	4	6	1	+	+	-	+	-
<i>T. tajacu</i>	15	67	6	11	1	-	-	+	+	-
<i>T. pecari</i>	13	57	5	22	3	-	--	=	++	-
<i>T. terrestris</i>	14	63	7	15	2	-	-	+	++	-
ARMADILLOS										
<i>D. novemcinctus</i>	22	59	1	12	6	+	--	-	+	+
<i>T. matacus</i>	32	59	3	5	2	++	--	-	=	-
<i>E. sexcinctus</i>	28	50	4	8	9	++	--	-	+	+
<i>C. villosus</i>	45	46	2	5	2	++	--	-	=	-
<i>C. vellerosus</i>	29	35	9	19	9	++	--	+	++	+

Notes: Rows do not total 100 because of rounding.

***W** = Xeric Chaco forests on well-drained soils, **M** = Xeric Chaco forests on medium-drained soils, **P** = Xeric Chaco forests on poorly-drained soils, **R** = Chaco Riverine Forest (Navarro and Fuentes 2000), **C** = Population center.

(+) 1-9 points greater, (++) 10 points or more greater, (-) 1-9 points lesser, (--) 10 points or more lesser than distribution of habitat types in Izozog.

novemcinctus to a lesser degree than the other species, are hunted relatively frequently in habitats on well-drained soils (dominated by grasslands). *Mazama gouazoubira* is hunted relatively frequently in habitats on well-drained or medium-drained soils, whereas the other ungulates are hunted more frequently in habitats on poorly-drained soils.

Activity patterns

Assuming that hunters encounter animals that are active, then time of capture coincides with the animals' activity patterns. Accordingly, self-monitoring data suggest that all ungulates are

diurnal, with activity peaks for *M. gouazoubira*, *T. tajacu* and *T. pecari* in the 8-11:00 period, and for *T. terrestris* in the 8-15:00 periods (**Fig. 4**).

Among the armadillos, *D. novemcinctus* shows a nocturnal activity peak (20-3:00). *C. vellerosus* shows both mid-day and mid-night activity peaks. *C. villosus* and *E. sexcinctus* are strongly diurnal, with little nocturnal activity in any season. *T. matacus* presents diurnal activity peaks, though with a high level of nighttime activity as well (**Fig. 5**).

All of the armadillos as well as *T. terrestris* appear to shift their activity patterns in the cold dry season, increasing their day-time activity

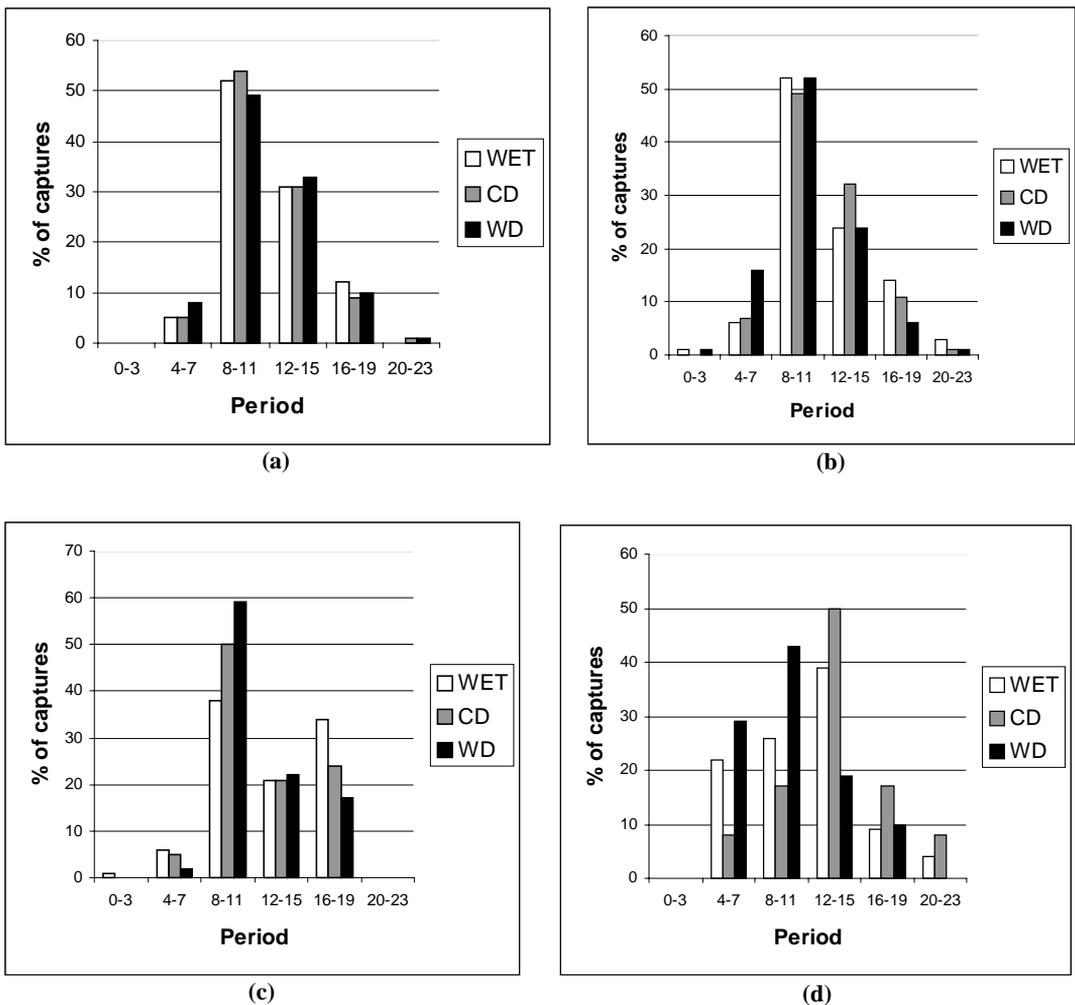


Fig. 4. Activity patterns for ungulates. WET from December-April, CD = cold dry from May-July, WD = warm dry from August-November. **a)** *Mazama gouazoubira* (N = 417 WET, 145 CD, 471 WD). **b)** *Tayassu tajacu* (N = 161 WET, 82 CD, 337 WD). **c)** *Tayassu pecari* (N = 100 WET, 42 CD, 41 WD). **d)** *Tapirus terrestris* (N = 23 WET, 12 CD, 21 WD).

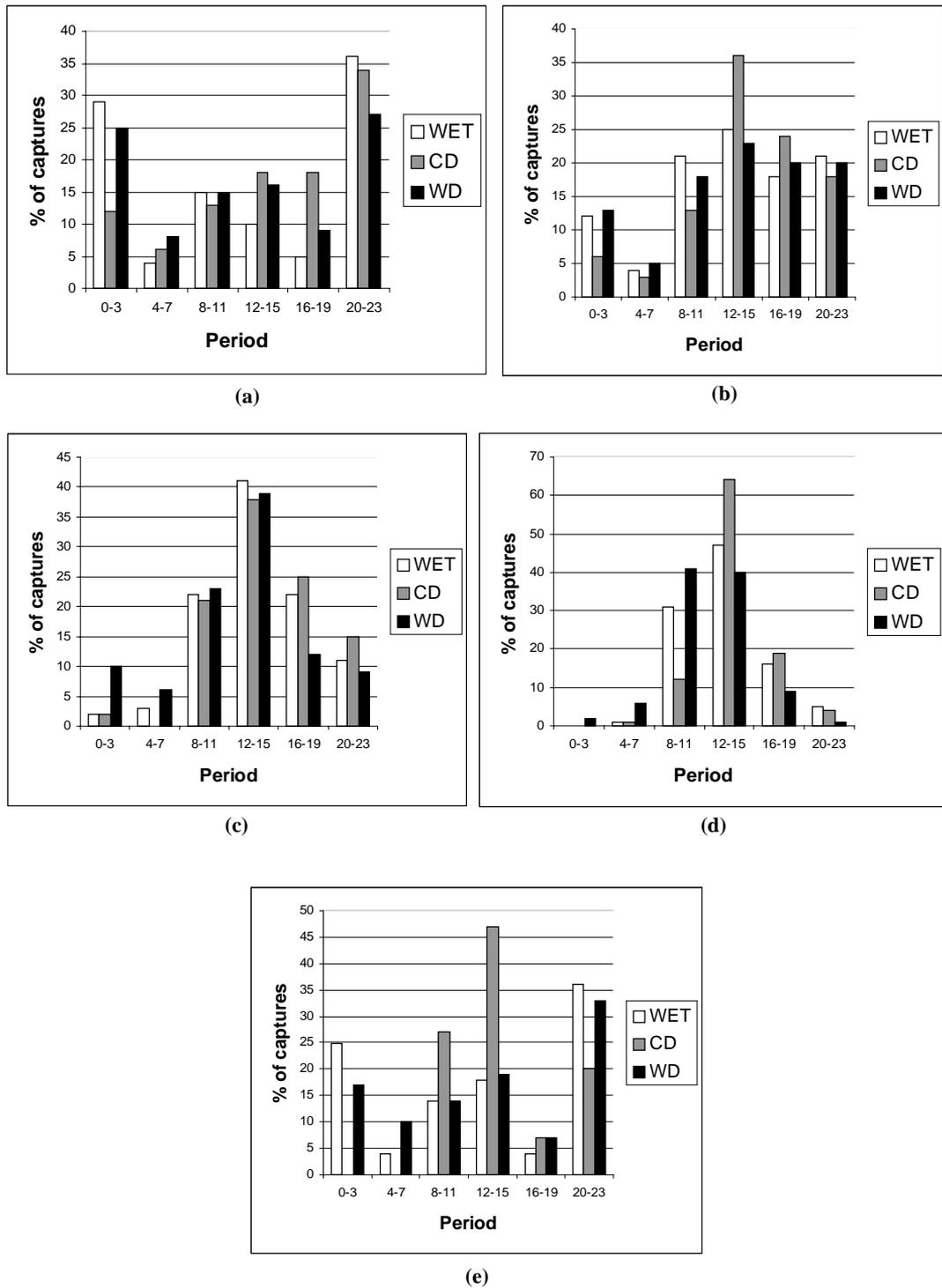


Fig. 5. Activity patterns for armadillos. WET from December-April, CD = cold dry from May-July, WD = warm dry from August-November. **a)** *Dasypus novemcinctus* (N = 282 WET, 142 CD, 444 WD). **b)** *Tolypeutes matacus* (N = 171 WET, 213 CD, 240 WD). **c)** *Euphractus sexcinctus* (N = 64 WET, 53 CD, 98 WD). **d)** *Chaetophractus villosus* (N = 85 WET, 164 CD, 141 WD). **e)** *Chaetophractus vellerosus* (N = 56 WET, 15 CD, 42 WD).

in the case of nocturnal species, or shifting to the warmest afternoon hours in the case of diurnal species. *Tayassu pecari* demonstrates a slight shift from afternoon (wet season) to morning activity (dry seasons). No shifts in activity patterns are evident for *M. gouazoubira* or *T. tajacu*.

DISCUSSION

Can hunter self-monitoring provide valid biological data on prey species? In some cases it appears that the answer is no. For example, actual lactation and pregnancy rates may be considerably higher than those recorded in **Figures 2 and 3**, given that small fetuses (first half of gestation) and lactation may not be evident to hunters. Gottdenker and Bodmer (1998), analyzing reproductive tracts, report average annual pregnancy rates of 32% in *T. pecari* and 46% in *T. tajacu* for the Peruvian Amazon. In comparison, Izoceño hunters recorded average annual pregnancy rates of only 12% and 16% respectively. Likewise, beyond suggesting general differences among similar species (the five armadillos or the two peccaries respectively), the data provided by hunters to date do not permit analyses of wildlife habitat use.

Volunteer data collectors with minimal formal quantitative training evidently commit errors in recording precise data (e.g., weights, measurements, time), and these errors invalidate the data as **absolute** measurements. However, we focus on **relative** comparisons among species, for example abundance or activity patterns, as well as on **relative** differences within species, for example comparing monthly data to the average for the species. We also emphasize qualitative data such as reproductive state and subjective criteria for age.

In some cases, therefore, we can derive useful biological information from hunter records if we interpret them using our knowledge of hunting practices and environmental conditions in the study area. For example, data from track plots—data that are independent of hunting method and vulnerability—indicate similar distributions and relative abundances of the four ungulate and five armadillo species discussed in this paper (Noss and Cuéllar, 2000). The

literature coincides with Izoceño hunter records in describing *E. sexcinctus* as principally diurnal, and *C. vellerosus* as principally nocturnal (Greegor, 1980; Redford and Wetzel, 1985; Eisenberg and Redford, 1999). Litter size according to hunter records from the Bolivian Chaco also generally coincides with what is reported elsewhere (McBee and Baker, 1982; Wetzel, 1982; Redford and Wetzel, 1985; Mayer and Wetzel, 1987; Padilla and Dowler 1994; Gottdenker and Bodmer, 1998; Eisenberg and Redford, 1999).

Izoceño hunters collected a small set (N=16) of *M. gouazoubira* fetuses. Using biometrics to predict birth dates, Chávez (2000) confirms the seasonality of reproduction, with a decline in births in May–July. Nevertheless, post-partum estrus contributes to births throughout the year, and has also been reported widely for the species (Stallings, 1986; Richard et al., 1995; Eisenberg and Redford, 1999).

The seasonal reproduction patterns we have observed for *M. gouazoubira* and *T. tajacu* coincide with studies in other sites with strong seasonal patterns in temperature and rainfall. The Izozog is located in the driest section of Chaco with rainfall around 550 mm/year, and a dry season lasting up to eight months. The strong seasonality of the Chaco apparently produces reproductive responses linked to physical condition in *M. gouazoubira* and *T. tajacu* similar to the southern United States or northern Argentina (Lochmiller et al., 1986; Bodmer and SOWLS, 1993; Hellgren et al., 1995; Eisenberg and Redford, 1999) which do not occur in the aseasonal Amazon basin or Central America (Mayer and Wetzel, 1987; Gottdenker and Bodmer, 1998). Other studies also report reproduction peaks for *M. gouazoubira*, but at different times than in the Izozog: October–February in Tucumán, Argentina (Richard et al., 1995) and January–June in the Paraguayan Chaco (Stallings, 1986).

Also using biometric examination of 176 fetuses (44 litters) of *D. novemcinctus*, Rojas (2001) reports the same strong pattern of seasonality in reproduction as described in **Figure 3**. With a 4.5 month gestation following a 3.5 month delayed implantation (Enders, 1966; Wetzel and Mondolfi, 1979; Wetzel, 1982;

Eisenberg and Redford, 1999), the Chaco's seasonality restricts *D. novemcinctus* females to one litter per year. In contrast, species with short gestations of 60-70 days, e.g. *E. sexcinctus* or *Chaetophractus* spp. (Wetzel, 1982; Redford and Wetzel, 1985), may reproduce twice each wet season. *T. matacus*' gestation of 105 days is unlikely to permit two litters per wet season, and dual peaks in reproductive activity may represent a single extended breeding season, although post-partum estrus is reported for this species (J. Gramiere, pers. comm.).

Izoceño hunters have collected skull or jawbone specimens of ungulates, and analyses of tooth wear (four categories for peccaries, three for tapir and brocket deer) are consistent with the hunters' classification (Leaños and Cuéllar, 2000; Noss, 1999). Analysis of dental annuli for brocket deer (1-14 years) and peccaries (1-17 years) are also consistent with the hunters' classification (Maffei, 1999, 2001, in press). Therefore hunters' subjective age classification provides a reliable record of population structure in general terms.

CONCLUSION

Hunter self-monitoring can provide a wealth of biological information on game species, for example on abundance and distribution, reproduction (litter size, seasonality, fecundity), age structure, and activity patterns (for armadillos though not ungulates in the Izoceño case). Hunter data on sex ratios of hunted species do not necessarily correspond to actual population structure, but nevertheless provide valuable information on activity patterns, for example of males versus females, or adults versus juveniles. Our data do not permit analyses of condition or habitat preferences beyond indicating general trends, though these and the other themes listed above could be investigated with local hunters if they were provided further quantitative training and equipment. Finally, the method promotes the active and direct participation of local hunters in research activities and community wildlife management in ways that other methods cannot.

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APPENDIX

Hunter self-monitoring data sheet with English translation

CACERIA Comunidad _____
Quienes salieron? _____

Cuántas horas o días duró la salida _____
Dónde cazó? _____ Clima _____
Qué cazó? _____
No. de etiqueta _____
Fecha _____ Hora _____ Tipo de monte _____
Cómo lo consiguió? Montados _____ Cuántos perros _____
Con qué arma _____
Sexo: Macho _____ Hembra _____ Tiene leche _____
Cuántas crías en la barriga _____
Peso: Con tripas _____ Sin tripas _____
Medidas: Total _____ Cola _____ Pata trasera _____ Oreja _____
Edad: Juvenil _____ Adulto _____
Animales heridos pero no cazados: _____

Otros animales encontrados pero no cazados _____

¿Por qué? _____
Observaciones: _____

HUNTING Community _____
Who hunted? _____

How many hours or days did the trip last? _____
Where did you hunt? _____ Weather _____
What did you hunt? _____
Specimen no. _____
Date _____ Hour _____ Habitat type _____
How did you hunt? Horseback _____ no. of dogs _____
With what weapon? _____
Sex: Male _____ Female _____ Lactating _____
Number of fetuses _____
Weight: Whole _____ Cleaned _____
Measurements: Total _____ Tail _____ Hindlimb _____ Ear _____
Age: Juvenile _____ Adult _____
Animals injured but not captured: _____

Other animals encountered but not hunted _____

Why? _____
Observations: _____
