Ascending call, chirps, accelerating chirps.—These three calls are basically the same, differing in duration and interval between calls. The ascending call starts at 2,000 Hz and quickly ascends to 3,200 Hz (Fig. 1C). Duration of the call is about 0.25 sec. Chirps have a duration of approximately 0.1 sec and an interval between chirps of about 1.3 sec. The chirp has a strong percussive beat at its initiation as a burst of air escapes from the vocal chords. Three recorded accelerating chirp calls had durations of 1.0, 1.1, and 2.0 sec, respectively. The call consists of an initial ascending chirp followed by a pause, then a sequence of from five to seven accelerating chirps. The chirps are of progressively decreasing duration and with decreasing intervals between chirps (Fig. 1D).

Low frequency call.—The low frequency call is a waiving note of about 0.3 sec duration between 1,000 and 3,000 Hz (Fig. 1E). It ascends to an early peak, then gradually descends in pitch.

Growl.—The growl varies in intensity but takes two distinct forms. The steady growl is an utterance performed while exhaling and continued while inhaling so that no break is heard (Fig. 1F). The barking growl (Fig. 1G) has a strong impulse that ranges from a short burst to a loud screaming noise that lasts for a second or two.

Whining.—One marmot was recorded whining in its burrow in response to growls from another. The whining varied from about 300 Hz to about 900 Hz (Fig. 1H).

Tooth chattering.—Tooth chattering was heard only in captive marmots which gnashed their teeth as they sat in a trap facing their captor.

Discussion.—General observations suggested that the long call was given in response to the sighting of a potentially dangerous intruder. Humans, bears, raptors (Falconiformes), coyotes, and deer elicited long calls. Other colony members became alert and stopped what they were doing upon hearing a long call. Normally the first individual to detect a disturbance uttered long calls. However, on one occasion six marmots within a 200 m radius gave long calls together as a coyote passed by within 50 m of the nearest marmot.

Hawks which appeared suddenly over a ridge and swooped low over the colony elicited descending calls. Marmots showed alarm upon hearing the descending call and reacted by running for the cover of a burrow where they either dashed in or stopped at the opening to look around.

All other vocalizations with the exception of tooth chattering appeared to represent communication elicited by and directed to another marmot. Definitive statements about the communicative function of these calls are beyond the scope of this study.

LITERATURE CITED


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COMPOSITION OF ELEPHANT SEAL MILK

The milk of most marine mammals contains more fat and less water than that of terrestrial mammals (Silvertsen, 1941; Amoroso and Matthews, 1950; Kooymen, 1963; Ling et al., 1961; Harrison and Kooymen, 1968). This highly concentrated milk may facilitate water conservation in both mother and pup (Krogh, 1939; Kooymen, 1963) and promote rapid weight gain in pups.
The administration analyzed weeks to the average of entire milk. The study indicated that fat content was lower compared to other milk species. The mean fat content for elephant seal milk was 55.4% during the brief nursing period characteristic of some pinnipeds. In several pinnipeds, the duration of the nursing period and milk concentration are inversely related (Harrison and Kooymans, 1968).

We report the results of milk analysis in northern elephant seals, Mirounga angustirostris, a species in which the nursing period lasts only 4 weeks, mothers do not eat or drink during the entire nursing period, and pups gain weight rapidly on a diet of mother’s milk alone (Le Boeuf et al., 1972). Typically, a female gives birth 6 days after arriving on the rookery, nurses her pup two to four times daily for 28 days, copulates during the last 4 days of nursing, and then weans her pup abruptly and with finality by returning to sea. All females fast completely during the 34-day stay on land. During the short nursing period, their pups undergo a fourfold to sevenfold increase in body weight. Pups weigh approximately 34 kilograms (kg) at birth (Le Boeuf et al., 1972) and average 136 kg (range 113–238 kg) at weaning (Ortiz et al., 1977; Le Boeuf, unpublished data).

Nine nursing females on Ano Nuevo Island, California, were immobilized with intramuscular administration of Sernylan and Sparine (Shaughnessy, 1969) or Ketamine hydrochloride (Briggs et al., 1975) during breeding seasons ranging from 1971 to 1976. Milk was collected in glass jars placed under the teats following intramuscular injection of oxytocin. The stage of development of the suckling pups indicated that all females sampled were in the third or fourth week of nursing. The milk was frozen in tightly capped containers at −20°C for periods ranging from several weeks to 6 months. Fat, protein, water, and ash analyses were performed on all samples, except Sample No. 6 (Table 1), by Stoner Laboratories, Santa Clara, California. Sample No. 6 was analyzed at Letterman Army Medical Center, Fort Baker, California. Sodium and potassium determinations were performed in our laboratory using conventional flame photometry.

The results, shown in Table 1, reveal that northern elephant seal milk has a higher mean fat content (54.5% per cent) and a lower mean water content (32.8 percent) than any mammal investigated previously (Silvertsen, 1941; Kooymman and Drabek, 1968; Pilson and Kelley, 1962; Pilson and Waller, 1970; Ridgway, 1972). Protein content values resemble those observed in other marine mammals (Ridgway, 1972) and are two to three times higher than the values reported for most terrestrial species (Ling et al., 1961). Sodium and potassium levels are similar to those reported for terrestrial species (Ling et al., 1961; Konar et al., 1972). The estimated caloric content of milk is much higher than that of other mammals previously investigated.

Elephant seal females are exceptional mammals in that they fast while nursing. Therefore, water is not available for milk production and all water and nutrients must be rigorously conserved. The unusual composition of northern elephant seal milk, with its low moisture and high fat content, is clearly an adaptation which permits the female to transfer a large amount of energy and essential compounds to her pup from body stores alone in a short time and with minimum water expenditure.

**Acknowledgments.**—We are grateful to numerous colleagues who assisted in collecting the milk samples. This research was supported in part by National Science Foundation grants GB 16321 and BNS 74-01363 A02, and authorized by Marine Mammal Permit No. 60, U.S. National Marine Fisheries Service, and the California Division of Beaches and Parks.

### Table 1.—Composition of elephant seal milk expressed as grams per 100 g whole milk.

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Year collected</th>
<th>Fat</th>
<th>Protein</th>
<th>Water</th>
<th>Ash</th>
<th>Potassium (K+)</th>
<th>Sodium (Na+)</th>
<th>Kilocalories* (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1971</td>
<td>55.4</td>
<td>8.5</td>
<td>33.8</td>
<td>0.6</td>
<td>—</td>
<td>—</td>
<td>560.8</td>
</tr>
<tr>
<td>2</td>
<td>1974</td>
<td>53.2</td>
<td>8.6</td>
<td>36.5</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
<td>542.4</td>
</tr>
<tr>
<td>3</td>
<td>1974</td>
<td>53.5</td>
<td>9.1</td>
<td>35.1</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
<td>545.4</td>
</tr>
<tr>
<td>4**</td>
<td>1974</td>
<td>62.7</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>1974</td>
<td>58.9</td>
<td>7.1</td>
<td>30.8</td>
<td>0.7</td>
<td>0.096</td>
<td>0.065</td>
<td>588.2</td>
</tr>
<tr>
<td>6</td>
<td>1975</td>
<td>58.2</td>
<td>8.7</td>
<td>30.3</td>
<td>0.7</td>
<td>0.106</td>
<td>0.085</td>
<td>478.7</td>
</tr>
<tr>
<td>7</td>
<td>1976</td>
<td>45.8</td>
<td>10.5</td>
<td>32.0</td>
<td>0.6</td>
<td>0.093</td>
<td>0.048</td>
<td>542.0</td>
</tr>
<tr>
<td>8</td>
<td>1976</td>
<td>53.0</td>
<td>9.4</td>
<td>32.0</td>
<td>0.6</td>
<td>0.105</td>
<td>0.072</td>
<td>505.2</td>
</tr>
<tr>
<td>9</td>
<td>1976</td>
<td>48.8</td>
<td>10.1</td>
<td>31.8</td>
<td>0.6</td>
<td>0.100</td>
<td>0.067</td>
<td>543.8</td>
</tr>
</tbody>
</table>

Mean ± one standard deviation = 54.4 ± 5.2 ± 1.0 ± 2.2 ± 0.1 ± 0.006 ± 0.015 ± 37.7

* Caloric content estimated as fat × 9.46 Kcal/gm + protein × 4.32 Kcal/gm (Schmidt-Nielsen and Schmidt-Nielsen, 1952).

** Insufficient data for complete analysis.
LITERATURE CITED


SCENT-MARKING BEHAVIOR IN THREE SPECIES OF WOODRATS (NEOTOMA) IN CAPTIVITY

Indirect evidence suggests that olfaction is an important mediator of social behavior and organization in woodrats. Woodrats concentrate their fecal pellets at den sites and along runways (Linsdale and Tevis, 1951). Males of several species have mid-ventral sebaceous glands (Howell, 1926; Linsdale and Tevis, 1951; Thompson, 1972) which apparently impart a musky odor to dens. Other authors have observed woodrats scent marking in captivity (Kinsey, 1976; Escherich, personal communication) but have not studied the behavior extensively.

This paper investigates the functions of scent marking in three species of woodrats (Neotoma mexicana pinetorum, N. albígula albígula and N. stephensi stephensi) which have mid-ventral glands and which are sympatric in northern Arizona. Most experimental animals were live-trapped in Padre Canyon, about 40 kilometers ESE of Flagstaff. A few animals were not used because they may have been hybrids (Birney, 1976). Species identity was determined by comparing differences in hair color, tail form, and behavior (Freeman, personal communication).

Scent-marking data were collected as part of a study on the social behavior of paired woodrats in two types of arenas (Howe, 1976). A two-chambered, rectangular plexiglass arena measuring 1.2 by .6 by .3 meters (m) was used in 75 interspecific male-male and 30 intraspecific male-male, 15-minute pairings. A three-chambered rectangular arena (1.8 by 3.7 by .3 m), covered with hardware cloth, was used in 15 interspecific male-male, 14 interspecific male-male, and 10 in-