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BRIEF REPORT

"Displacement" Sand Flipping in the Northern Elephant Seal (*Mirounga angustirostris*)

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In a pre- and posttest design an attempt was made to quantify sand flipping in the behaviorally aroused Northern elephant seal (*Mirounga angustirostris*). Following pretest a seal was approached by the experimenter in order to induce a conflict between attack and escape tendencies. Sand flipping occurred more frequently when a seal was aroused than when it was resting regardless of the amount of solar radiation, degree of wetness, wind speed, etc.

Reproductive behavior of the Northern elephant seal (*Mirounga angustirostris*) occurs from December through March on island rookeries off the coasts of California and Mexico. For the past 6 yr, Le Boeuf and his associates (e.g., Le Boeuf, Whiting and Gantt, 1972) have been studying the reproductive behavior of the elephant seal population on Año Nuevo Island, an 8-acre island, one-half mile off shore of Año Nuevo Point and 45 miles south of San Francisco. The increased population density on the island (Le Boeuf, 1974) during the breeding seasons of 1971-72, 1972-73, and 1973-74 has led to large numbers of bulls, sometimes as many as 25-30 at one time, hauling out to "rest" on the beach at Año Nuevo Point. The males on the coastal beach, where no females are present, sometimes exhibit the same pattern of agonistic behaviors which are most prominent on the breeding grounds of the island. The presence of these males at Año Nuevo Point permits observational as well as experimental study of the behavior of elephant seals.

One of the most prominent behaviors of elephant seals is "sand flipping," the tossing of sand on their backs with their foreflippers. Newborn

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pups perform this motor movement within minutes after birth (Le Boeuf, Whiting and Gantt, 1972; White and Odell, 1971) and one of us (R.J.S.) observed a 2-yr-old's sand flipping motion just moments before death.

Sand flipping has been suggested to function (a) in relief of skin irritation during molting or drying of skin due to wind and sun exposure (Laws, 1956); (b) in thermoregulation as a heat dissipation mechanism governed by solar radiation, temperature (White and Odell, 1971), and wind speed (Rasa, 1971), or even as an insulatory mechanism since both Rasa (1971) and one of the authors (M.E.H.) have observed sand flipping in animals hauling out from the sea on cold windy days; (c) as a "displacement activity" (Laws, 1956; Rasa, 1971). Examples of sand flipping as a displacement activity are cows sand flipping after giving birth, pups and nonreceptive females sand flipping when a male pins them to the ground attempting to copulate and under other conditions of stress, and sand flipping motor movements used on an inappropriate substrate such as gravel or rock. However, there have been no quantitative observations of sand flipping in elephant seals subjected to a relatively standardized mild disturbance in which solar radiation, wind speed, degree of wetness, social interactions, and other environmental variables were taken into account by the experimental design.

Data were collected during 9 days (between Jan. 2 and Feb. 27, 1974) on 22 different adult or subadult bulls and one yearling. Eight of the bulls were observed two or three times under varying environmental conditions (see Table 1). Elephant seals were chosen randomly from those lying quietly on the beach within sight of the investigators and which had not interacted socially with other individuals for at least 15 min. Observational sessions never began before 0745 and were terminated by 1300 hours. Observations were tape recorded and included sand flips, vocalizations (primarily threat vocalizations), breaths, various postures, lunges, number of undulations during locomotion, eyes open or closed, and flipper movement or position.

An observational session consisted of consecutive pretest, test, and posttest periods, each 5 min in duration. During the pretest and posttest periods (baselines) the seal's behavior was recorded from a distance of at least 12 m. During the test phase one of the experimenters served as the "arousing agent" and approached the seal to a distance in which it opened its eyes and raised its head (usually within 1 or 2 m). If the seal remained still with his eyes closed, then the experimenter touched the animal. While stationed at this critical distance, hands were raised over head at about 20-sec intervals to increase height and simulate an elephant seal threat posture for 5 sec. The spatial relations between the experimenter and the seal were maintained in order to induce in the seal a conflict between attack and escape tendencies (Zeigler, 1964). Recording during the test was not begun until the seal raised its head.

TABLE 1

Environmental Data and Selected Activities from Each Observation Session.

Subject	Temperature BB[a] °C	Temperature Air °C	Wind-speed mpm[b]	Sandflips Pre-	Sandflips Test	Sandflips Post-	Undulations Pre-	Undulations Test	Undulations Post-	Total vocalizations Pre-	Total vocalizations Test	Total vocalizations Post-
1	6.6	6.6	0	0	0	0	0	0	0	0	5	0
2	7.2	7.2	91	0	0	0	0	8	0	0	3	0
3	9.3	8.9	23	0	0	0	0	33	19	0	0	0
4	10.0	9.3	84	5	16	2	0	6	0	0	1	0
5	10.5	9.7	309	0	7	2	0	4	13	3	5	2
6	10.8	10.7	107	0	7	4	0	3	0	0	0	1
7	11.2	11.2	229	0	0	0	0	9	0	0	0	1
8	11.2	11.2	244	0	0	0	0	12	5	0	3	0
9	11.2	11.3	411	0	0	0	0	9	0	0	21	2
7	11.3	11.3	152	0	12	1	0	7	68	0	5	0
10	11.8	11.3	30	0	11	0	0	0	0	0	4	0
11	12.0	12.0	30	0	4	0	0	18	29	0	4	1
12	12.3	12.0	260	4	13	0	9	31	17	1	0	0
13	12.5	11.2	198	0	0	0	0	16	1	0	7	0
6	12.6	11.7	107	4	11	0	0	0	0	0	1	0
14	12.7	10.5	202	0	12	0	0	0	0	1	4	0
15	13.3	12.8	101	0	0	0	0	2	0	0	1	0
12	13.3	12.5	101	0	27	7	12	12	11	3	1	0
14	13.8	10.5	220	1	3	0	0	2	0	0	8	0
16	13.8	14.0	225	0	2	0	0	0	0	0	2	0
17	14.0	12.1	183	0	7	0	0	0	0	0	8	0
1	14.3	12.7	225	0	2	2	0	0	0	0	2	0
6	14.8	11.3	95	0	0	0	17	11	0	1	2	0
18	15.3	11.1	229	0	10	0	0	8	0	1	2	0
19	16.7	13.6	162	0	5	0	0	0	0	0	1	0
20	17.7	13.7	66	0	0	0	0	7	0	0	15	0
21	19.0	17.8	225	0	0	0	0	0	0	0	7	0
1	19.2	15.2	145	0	1	0	0	0	0	0	4	0
5	19.9	14.6	15	0	0	0	0	2	0	0	3	0
22	20.5	14.1	33	3	5	4	0	5	0	0	9	0
10	21.0	18.1		0	0	0	0	0	0	0	3	0
23	22.0	15.5		0	12	11	5	28	2	0	4	0

[a]Black bulb temperature.
[b]Meters per minute.

Environmental measurements of wind speed, air temperature, and black bulb temperature were made 15 cm above the ground before and after each phase of every observational session. Wind speed was measured with a hand-held windmeter. Ambient temperature was taken with a Yellow Springs Tele-thermometer and thermistor probe. The black bulb, used as an indicator of solar radiation, was a 10-cm diam hollow copper sphere painted flat black on the upper half and flat white on the lower half. A thermistor probe was positioned in the middle of the sphere.

Table 1 presents the data from each observational session. The environmental data in the table represent the means of four readings taken before and after each period of a session. Very little activity occurred during the pretest period. Generally, the animals rested with their eyes closed. There was an increase in occurrence of all activities during the test period over that occurring in the pretest period. There was also generally more activity in the posttest period than in the pretest period. Disregarding replicated observations on 7 individuals, of 19 individuals who sand flipped during an observational session all showed more sand flipping during testing than before testing ($P < .01$, sign test). Making similar statistical comparisons, there was a greater probability of sand flipping during the test period than in the posttest period ($P < .01$). If a seal sand flipped before or after the test period, it was more likely to do so during the posttest period (8 of 11) but the effect was not signficant ($P > .10$). Further statistical comparisons between pretest and test, and posttest and test periods showed that all seals who locomoted (number of undulations) or vocalized at all were more likely to do so during the test situation ($P < .01$). Although there was no significant difference in vocalization before or after the test period, there was significantly more locomotion in the posttest than in the pretest ($P < .01$).

Spearman's rank order correlation showed no relationship between sand flipping during testing and black bulb temperature ($rs = +0.01$). Moreover, although correlations were found between sand flipping and vocalizations ($rs = +0.26$) or sand flipping and locomotion ($rs = +0.34$), the correlations were not significant.

Figure 1 depicts the total sandflips for all seals during each minute of observation. Sand flipping occurred twice as often during the first minute of disturbance as compared to any previous minute of baseline measurement. During the second minute of disturbance, sand flipping occurred nearly three times more frequently as during the first minute of testing and stabilized at this high level until testing terminated. During the first minute following the test period, sand flipping declined precipitously but was still occurring considerably more frequently than during the pretest phase. Sand flipping in the posttest period finally reached its pretest baseline level after 2 min and stabilized.

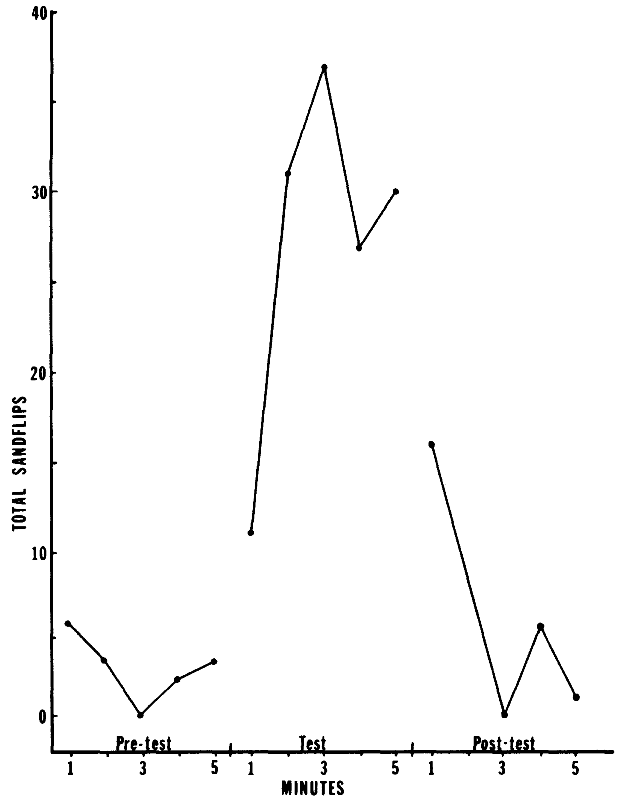

Fig. 1. Total number of sandflips per minute during pretest, test, and posttest periods for 23 individuals.

Sand flipping in elephant seal bulls at Año Nuevo Point was unlikely to occur when black bulb temperatures were below 22°C. White and Odell (1971) found that the elephant seal population on Barracks Beach, Guadalupe Island, first exposed the most reflective area of their body (the ventrum), then sand flipped and finally migrated to the surf as solar radiation increased. These were considered specific behavioral modes of heat dissipation with sand flipping an intermediate or transitional stage in a relatively stereotyped sequence eventuating in evaporative cooling with seawater. They found little sand flipping behavior when solar radiation decreased and black bulb temperature was below 22°C.

In this study sand flipping was a consistent mode of response by a majority of bull elephant seals when they were disturbed regardless of solar radiation, air temperature and wind velocity. Thus, a behavior whose primary function is to dissipate heat generated by solar radiation (McGinnis, 1975; White and Odell, 1971) also occurred interspersed between threat and flight responses indicative of high behavioral arousal.

In the brief discussion that follows, the concept of "displacement" is intended to be used descriptively and not as a statement implying a causal mechanism (see Hinde, 1970, for a discussion on the utility of the "displacement" concept).

An aroused animal in a conflict situation responds autonomically as well as somatically and a specific displacement activity may occur because of thermoregulatory, respiratory, and circulatory changes. In addition, it has been well accepted and in some cases demonstrated that posture and external cues during conflict are important determiners of the type of displacement activity which will occur (see Hinde, 1970). Sand flipping does not seem to occur during locomotion, threat postures including vocalizations, fighting, and in any position in which the seal is not prone. Fentress (1973) points out that displacement grooming in voles (Fentress, 1968) increases at an "optimal level" of disturbance whereas higher levels of disturbance decrease grooming. Similarly, sand flipping in elephant seals appears to be a "transitional" activity in that presumably higher levels of disturbance resulted in threat postures or movements which were incompatible with sand flipping. Moreover, in terms of solar radiation and peripheral heating mechanisms sand flipping occurs as a reaction to moderate thermal stress and is a transitional activity following a supine position (a reaction to low thermal stress) and precedes movement to the surf (a reaction to high thermal stress).

There has been some speculation that the evolutionary origin of sand flipping in elephant seals may be found in swimming movements. This hypothesis seems logical since sand-flipping movements occur under stressful situations and such movements may have evolved from motor patterns that would remove the animal from such situations, i.e., swimming movements. However, since elephant seals swim (as do other phocids) with their front flippers held motionless against their sides while laterally undulating the posterior part of the body (Bartholomew, 1952) the evolutionary origin of sand flipping seems unlikely to be found in swimming movements. Rather, the development of sand flipping is more likely to found in locomotor movements in which front flippers play an important role.

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