

Table 2. Details of flight activity observed relative to ambient air temperatures. *Specimens in this sample were not sexed.

Date	Site	Period	Temperature Range (°C)	Catch Success Males/Females
19 Mar 86	Pinta	1800-2200	23-30	<i>T. erwini</i> , 0/1
21 Mar 86	Pinta	2030-2215	24.5-27	none
28 Feb 86	Darwin Station	2200-2400	24	<i>T. vittiger</i> , 11/12
16 Mar 86	Darwin Station	1900-2230	27-28.5	none
29 Mar 86	Darwin Station	2000-0200	21-25	<i>T. vittiger</i> , 53*; <i>T. sp.</i> , 0/1
14 Mar 86	Bahía Tortuga	2030-2130	24.5-26	<i>T. vittiger</i> , 10/19
14 Mar 86	Bahía Tortuga	2130-2230	24.5-25.5	<i>T. vittiger</i> , 8/8

REVIEW: FUR SEALS, MATERNAL STRATEGIES ON LAND AND AT SEA

Edited By: Roger L. Gentry and
Gerald L. Kooyman

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Reviewed By: Hendrick N. Hoeck

In 1986 two outstanding books on Galápagos species were published by Princeton University Press. One is Peter Grant's *Ecology and Evolution of Darwin's Finches* (reviewed elsewhere in this issue) and the other, which is reviewed here, is *Fur Seals, Maternal Strategies on Land and at Sea* in which Fritz Trillmich and his associates present in five chapters the results of their 10 years of research on the behavioral ecology of Galápagos fur seals and sea lions.

In mammals, the females bear almost all the cost of rearing the young. The long gestation and postnatal period up to weaning is energetically very costly. The mother/offspring group is therefore the key unit for understanding the social organization in mammals.

The overall allocation of maternal energy resources can be divided into several categories such as foraging and travel costs, energy spent for avoiding predators, energy loss due to parasites and diseases,

and finally milk production and maintenance metabolism. The pattern of energy allocation to these categories has evolved in response to environmental pressures balanced against physiological limitations.

The book tells the fascinating story of how females of six different species of Otariids, living in Galápagos under tropical conditions and in the Arctic and Antarctic under subpolar conditions, manage to raise a maximum number of offspring. Fourteen scientists (all experts and some with years of field experience) give a detailed account of the behavioral ecology of Northern, Antarctic, South African, South American, and Galápagos fur seals and Galápagos sea lions.

Of the 15 chapters, the first gives an overview of the evolutionary history of the species studied and a brief description of their systematics, distribution, and biology. The second chapter deals with methods. Chapters 3, 6, 8, 10, 11, and 13 describe the attendance behavior of each species, while Chapters 4, 5, 7, 9, 10, 12, and 14 describe the feeding and diving behavior of the six species and the free ranging energetics of the Northern fur seals. In the last and most important chapter, nine authors integrate the results and draw conclusions.

The Northern fur seal and the Antarctic fur seal occur in the subpolar regions where there are extreme cold temperatures but predictable seasonal changes. In contrast, the Galápagos fur seal and sea lion live on the Equator, where the seasonal changes are less profound but are highly unpredictable. Between these environmental extremes a fur seal mother has to adapt in order to produce a maximum number of young. The different options and strategies that fur seal females use are presented.

The authors not only applied conventional methods of data acquisition but successfully used new technologies as well. Isotopic tracers, for example, were used to measure the amount of energy flow from the lactating mother to the pup. Milk was analyzed during different lactation periods for protein, fat, and water content. A Time-Depth-Recorder (TDR) that was specifically developed to record parameters of diving physiology and feeding ecology of fur seals was effectively placed on individual females.

The results for the two subpolar and the two tropical species show the different strategies for raising pups. Northern and Antarctic fur seals have highly synchronous pupping seasons and short weaning periods of about 4 months. During lactation the mothers undertake relatively few feeding trips, each of medium to long duration and alternating with attendance periods of 2 days with the pups. In contrast, the Galápagos fur seal and sea lion show a long synchronization in pupping, and the rearing period is prolonged to such an extent that consecutive offspring are simultaneously nursed by the mother. The females' feeding trips and the periods spent attending pups are seldom longer than 1 day.

Despite these differences in the attendance patterns, the pup growth rates of all six species are similar. The median doubling time for birth weight is about 66 days, and the initial growth rates are similar too. Therefore, the major differences lie not in the pup growth but rather in the weaning time and in varying milk composition. The fat content in the Northern and the Antarctic fur seals is rich (47% and 40%, respectively) whereas in the Galápagos fur seal and sea lion it is lower (25% and 18%, respectively).

The pups of the subpolar species have a well-developed fat layer: they molt into their adult pelage at an age of 3 months, and a month later they are prepared for nutritional independence. In contrast, pups of the Galápagos fur seals have few fat reserves, start molting at 4 months, and begin independent feeding at an age of 10-12 months.

The fasting abilities of both Galápagos species are only 1.5-3 days between mothers' visits, whereas the pups of both subpolar species must fast for 4-7 days between feedings. At the weaning age of 18 months, they are as advanced in their development as a Northern fur seal pup at 4 months. At weaning, the pups of the subpolar species have additional fat reserves for the postweaning period, which help them while gaining feeding experience. In contrast, the Galápagos fur seal at weaning has a considerable amount of open-water feeding experience with few additional fat reserves.

The data obtained with the TDR were very interesting for behavioral and physiological conclusions. The diving behavior of all fur seal species

is similar; diving occurs mainly during nighttime hours. Most diving is done to about 30 m; however, the animals can reach a depth of over 100 m. Calculations indicate that 200 m would be near the physiological limit for fur seals and sea lions because oxygen consumption would reduce arterial oxygen to a critical level.

Across species there is also a clear difference in the foraging ranges. The subpolar seals range over 200 km from shore whereas the tropical species forage within 75 km of shore. Unfortunately, it is difficult to interpret most diving patterns because the authors have very few data on the behavioral patterns of the prey exploited by fur seals and sea lions. Only for the Antarctic fur seal, a feeding specialist, is the behavior of the prey species known.

Another interesting comparison is developed in Chapter 14 which deals with the question of the ecological separation between the sympatrically occurring Galápagos fur seal and the sea lion. The Galápagos fur seal is the smallest fur seal and one of the smallest marine mammals. Adult males weigh 70 kg and females weigh about 35 kg. They feed during the night and most dives are in depths shallower than 30 m. This diving habit probably reflects the most common depths of squids, the fur seals' main food resource. The Galápagos sea lion primarily dives during the day, thus avoiding many thermoregulatory problems on land. The data show that the sea lion reaches greater depths than the fur seal, but both species are equally successful in capturing prey.

The most complete and substantiated information is available for the two tropical and subpolar species. The data on the attendance behavior and diving behavior of the South African (Chapters 8 and 9) and the South American (Chapter 10) fur seals are limited. The South African species, the largest of the fur seals, is very shy and only two females could be fitted with the TDR. The South American fur seal was studied during the strongest "El Niño/Southern Oscillation" (meteorological and oceanographic phenomena) in over 100 years and only one female was observed.

This book is one of the best and most complete comparative studies on the maternal behavior of species living under different environmental conditions. Because of its clarity, the application of new technologies in field studies, and the well-organized format, with each chapter having its own introduction and summary, this book is a must not only for biologists interested in mammals but also as an exemplary study for biology students and laymen interested in behavioral ecology, marine biology, and physiology.

This book and Peter Grant's book on finches show the importance of long-term field research. Such

research not only has academic value in understanding the evolution of the organisms' differing environments but, in addition, clearly presents the responses of individual species to environmental changes from year to year. The latter aspect is important for conservation. It is hoped that these and other long-term projects will continue in Galápagos.

**Hendrick N. Hoek, Universität Konstanz,
Postfach 5560, D-770 Konstanz 1, Germany.**

REVIEW: ECOLOGY AND EVOLUTION OF DARWIN'S FINCHES

Authored By: Peter R. Grant

Published 1986, xiv + 458 pages, 101 figures, 24 tables, 63 plates including 8 in color, US - \$55.00 cloth, \$22.50 paper; UK - £36.70 cloth, £15.10 paper. Princeton University Press, 3175 Princeton Pike, Lawrenceville, New Jersey 08648, USA

Reviewed By: Peter T. Boag

John Wiens (1984, *Auk* 101:202-203) commented recently on the importance of long-term studies of avian populations, concluding that for many purposes "a long-term approach that spans the periodicity of the normal dynamics of the system is essential." Peter Grant's sweeping synthesis of more than 12 years of fieldwork on Darwin's finches in the Galápagos provides us with an excellent illustration of the merits of extended field studies. This volume is a state-of-the-art synthesis of past and present research on a group of birds that has become a paradigm of the evolutionary process.

In 16 chapters, Grant not only summarizes his group's research on the ground finches (Genus *Geospiza*), but also provides up-to-date detail on the other, lesser known finches. Aspects of the Galápagos environment ranging from geology, climate, and vegetation to the history of scientific research in the islands are included. Complementing the text are plates, which include 117 black-and-white and 24 color photographs. The photographs not only illustrate inter- and intraspecific morphological variation in the finches, but also vividly describe study techniques, the effects of El Niño rains on vegetation, unusual feeding behaviors, and some of the important food plants for the birds.

The book begins with a description of how the project began and with a brief history of the study of Darwin's finches. Grant sets himself the task of explaining "why so many different types of species

have arisen, and why they vary so much in form, function, and behavior." Two chapters then set the stage by summarizing first the general characteristics of the islands, and next, the general characteristics and distributions of the finches.

The meat of the book follows in six chapters which detail the data collected by Grant and his colleagues since 1973. The results of over 60 scientific papers produced by the group in this time are described and integrated, with many of the original figures and tables reproduced or elaborated upon. Two technical chapters provide an overview of morphological variation in the finches, as well as statistical methods for dealing with both adult morphological patterns and the ontogeny of morphology. Chapter 6 examines the relations between beak morphology and diet, as well as dietary differences within and between species. Chapter 7 follows with a detailed look at the links between food supplies and finch population dynamics, arguing that food is often a limiting resource, and hence a driving force behind the evolution of specific feeding structures and behaviors.

Chapter 8 presents the genetic data now available for Darwin's finches, with an emphasis on the quantitative genetics of morphological characters, and the relationship between heritabilities and the response to natural selection in times of food stress. A major theme is the search for reasons why many *Geospiza* populations are so variable. This chapter also attempts to unravel the mechanisms of natural and sexual selection which are responsible for the observed population means and levels of sexual dimorphism.

The final data chapter looks at mating behavior. There is good evidence that reproductive isolating mechanisms are based on both morphology and song. However, considerable flexibility in species-recognition behavior seems to exist, with some cases of hybridization known, and several instances of misimprinting during song development.

In the following four chapters, Grant turns his attention to interpretation of this wealth of data. He first examines various models for the evolution of finch species, and then compares the relative importance of allopatric divergence on ecologically diverse islands with competition in sympatric situations in the evolution of finch communities. The patterns are complex, and the paucity of fossils or other historical data complicates their interpretation. However, the main conclusion is that during speciation, the finches appear to have adapted both to direct changes in their physical environment and to indirect changes caused by competitors. The effects of competition are most evident in the large scale patterns seen at the community level. The evolution of reproductive isolating mechanisms is dealt with briefly. Two interesting findings emerge; first, the

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Gerald L Kooyman. Filter your search. Showing 1 to 14 of 14 results.Â Weddell Seal. Gerald L. Kooyman. 04 Jun 2009. Paperback.Â
Fur Seals. Roger L. Gentry. 19 Apr 2016. Hardback. US\$173.83. Add to basket. Fur Seals. Roger L. Gentry. 14 Jul 2014. Paperback.
US\$71.54. Add to basket. Weddell Seal, Consummate Diver. Gerald L Kooyman. 01 Jan 1981. By Roger L. Gentry. Ratings: Rating: 4
out of 5 stars4/5 (1 rating).Â Here Roger Gentry draws on nearly two decades of research on three different islands to show how
behavior among these seals changes with population size, sex ratio, and environment, to explain the behavior of the population
beginning with individuals, and to generalize the results to other members of the eared seal family.Â His book analyzes behavior on
scales of hours to lifetimes, investigates the mating system, considers processes that underlie the mating system (site fidelity, behavioral
estrus, and the development of territoriality), and addresses specific aspects of maternal strategy (female attendance behavior, pup
growth, seasonal influences, and the effects of continental shelf width). Kooyman, Gerald L. Subjects. Biology.; Northern fur seal -
Behavior.; Female fur seals - Parental behaviour. Summary. The contributors to this volume have accomplished a breakthrough in our
ability to collect data on ocean-dwelling mammals. In the first large-scale comparison of fur seals, they have employed quantitative
methods and a special instrument called a Time-Depth-Recorder to study the strategies used by females in six species of eared seals to
rear and wean their young in different environments. Originally published in 1986. The Princeton Legacy Library uses the latest print-on-
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