Recipient of the 2006 International Prize for Biology

Dr. Serge Daan

Date of Birth: 11 June 1940

Citizenship: Kingdom of the Netherlands

Position: Niko Tinbergen Chair in Behavioral Biology
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Career:

1973	Ph.D. in biology, University of Amsterdam
1973-1975	Postdoctoral Fellow, Stanford University
1975-1985	Senior scientist, Zoological Laboratory, University of Groningen
1985-1990	Associate professor of Animal Ecology and Ethology, University of Groningen
1990-1996	Associate professor of Chronobiology, University of Groningen
1996-2004	Full professor of Ethology, University of Groningen
2003-today	Niko Tinbergen Chair in Behavioral Biology, University of Groningen

Awards and Distinctions:

1982	Annual Award, Victor & Erna Hasselblad Foundation, Sweden
1990	8th Laurence Irving-Per Scholander Memorial Lecturer, Institute of Arctic Biology, University of Alaska
1992	Prize from the Dutch Society for Light Therapy
1992	Alexander von Humboldt Forschungspreis (Research Prize), Germany
1999	Hollandse Maatschappij der Wetenschappen (Dutch Society of Sciences)
2000	Royal Society of Canada, elected Foreign Fellow
2005	Ridder in de Orde van de Nederlandse Leeuw (Knight in the Order of the Dutch Lion)

RESEARCH ACHIEVEMENTS

Dr. Daan has pursued comparative ethological studies of circadian rhythms in a wide variety of animal species, from mice and birds to humans, focusing on rhythms of behavior, sleep and waking. His perspective encompasses not only the mechanism of circadian rhythms but also a deep understanding of their ecological significance, that is, the role of cyclic activity patterns in relation to fitness and survival value. In keeping with the breadth of his interests, Dr. Daan's methodology has not been limited to the laboratory but has extended also to field studies and experiments.

1. Research on circadian rhythms in rodents

With Dr. Colin Pittendrigh, Dr. Daan conducted detailed observations and investigations of circadian rhythms in rodents, using behavior as an indicator. Their work determined the basic properties and fundamental role of circadian rhythms in behavior and physiology; further, they established a research methodology in this field by using their results to formulate a model capable of explaining the underlying mechanism.

This work led Dr. Daan to propose the concept of the circadian system and to arrive at an empirical and theoretical analysis of almost all the important properties of the circadian system in rodents, together with their adaptive significance. Among the questions he investigated were the mechanism by which the circadian rhythm is synchronized to the light-dark cycle (entrainment) and its ecological significance, the after-effects of entrainment, seasonal adaptation, and a regulatory mechanism for bimodal rhythms (those with dawn and dusk activity peaks) which involves separate Morning and Evening (M-E) oscillators.

These findings were published in 1976 as five papers, co-authored with Dr. Colin Pittendrigh, in the *Journal of Comparative Physiology*. Today these are regarded as classic papers in chronobiology, and they are required reading for every scientist who studies biological clocks. The M-E two-oscillator model was particularly innovative; it provides an elegant explanation for the diurnal cycle of circadian rhythms, their seasonal adaptation, and photoperiodic response, and to this day it remains an influential paradigm in circadian system research, not only in mammals but also in insects such as the fruit fly *Drosophila melanogaster*. The dual oscillator model has led to the recent discoveries of a region in the suprachiasmatic nucleus in mammals which responds to the M-E oscillators, and of neurons which have a similar response in the brain of *Drosophila*. Dr. Daan himself has examined this question in various species. He recently proposed that the M-E oscillators may be driven by separate clock genes, and he is currently studying this hypothesis using animals in which the relevant genes have been knocked out.

2. Research on sleep regulation

Dr. Daan proposed a "two-process model" of human sleep regulation, in which sleep is regulated both by a circadian rhythm and by sleep-regulating variables. According to this model, the sleep-regulating variables increase with accumulating fatigue or decreasing bodily functions during wakefulness, until an upper threshold is reached and sleep is induced; during sleep the variables decrease until they reach a lower threshold and waking results. Further, the level of the range between these sleep-wake thresholds oscillates with a cycle of approximately 24 hours, regulated by a circadian pacemaker; thus, the timing and duration of sleep are regulated by this pacemaker. This is the most powerful model yet obtained for explaining human sleep rhythms, and its predictions have been extensively validated by experiments. The model has also contributed to the treatment of seasonal depression and to light therapy for jet lag.

In ecological studies of annual cycles in hibernating animals, Dr. Daan discovered that the need for sleep increases during hibernation, and that hibernators must wake periodically from torpor in order to sleep. Thus Dr. Daan changed the prevailing idea of these winter states as being similar to sleep, demonstrating instead that hibernation actually has a sleep-deprivation effect.

3. Ecological research on circadian rhythms

Dr. Daan was one of the first to focus on the ecological significance of circadian rhythms. Analyzing the temporal structure of a predator-prey system, the kestrel and the common vole, he showed that the temporal organization of flight-hunting in the kestrel is separate from that of the need to feed, with the peak flight-hunting frequency depending on the daily peak hunting success rate and the activity peak of the prey; he also showed that the voles vary their hours of activity in response to predation. These findings demonstrated that, for both predator and prey, daily habits have survival value. In an analysis of the timing and success rate of reproduction in the kestrel, he showed that reproductive timing is tuned to the storage of energy resources in the female. Through these studies, Dr. Daan contributed greatly to the understanding of the adaptive significance of circadian rhythms and seasonality.

Through these multifaceted approaches, both experimental and theoretical, Dr. Daan has continued to make major contributions to the field of chronobiology from its genesis to the present day.