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Szilárd Donhoffer

Mastermind of the study demonstrating how cold prevented death of protein deficiency

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Dear Editorial Board members,

This is our reply to the letter by Maloney,[1] which answers our riddle published in the recent editorial.[2] The riddle described a paradox, in which one unfavorable condition nullified the effect of another. This is how the riddle was phrased: "A group of rats was fed a low-protein chow and kept at room temperature; all animals died. Another group of rats was fed the same chow but kept in the cold; all survived. How would you explain the phenomenon observed?"

Professor Shane Maloney correctly explains that the rats kept at room temperature became protein-deficient, whereas the rats kept in the cold were driven by an appetite for energy, ate more of the low-protein chow, and thus increased their protein consumption and avoided the lethal protein deficiency. Not only does Professor Maloney give a nearly perfect answer and examine the underlying relationships thoroughly, but he also illustrates the relevance of the phenomenon discussed to diverse problems faced today in various areas of human activity—from feeding military personnel to raising animals for meat. How ambient temperature affects protein metabolism and various characteristics of muscle tissue remains an important question for meat growers, and the article by Montilla

Reply to: Maloney SK. Low protein feeding and energy transduction in rats. temperature 2014; 1:97-8; http://dx.doi.org/10.4161/temp.28661

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Figure 1. Professor Szilárd Donhoffer (ca. 1961). The photo was taken at the time when he and his colleagues were performing the experiments discussed in this Reply. Reproduced from ref. 7, with permission.

et al.[3] in the previous issue of *Temperature* confirms this.

Maloney's letter,[1] possibly for brevity, repeatedly refers to the value of ambient temperature (e.g., 21 °C) in such a way that it creates the impression that ambient temperature by itself unequivocally determines whether conditions are thermoneutral. Ambient temperature is only 1 of several physical factors determining heat exchange with the environment. Other factors include air humidity, air velocity, barometric pressure, contact area with materials in the environment, thermal conductivity of these materials, and radiant field.[4] Depending on these factors, the same ambient temperature can be subneutral, neutral, or supraneutral for the same animal.[4,5] If rats are housed several per cage, with a sufficient amount of bedding, and with a filter top, the room temperature of 21 °C can easily be neutral (discussed in ref. 5). It can even be supraneutral, e.g., if the cages are kept near a heated wall.

Professor Maloney correctly determines that our riddle was based on the study by Andik et al.,[6] conducted at what is known today as the Pécs University Medical School. As it was typical in those days (early 1960s), rats were kept in a room without a proper temperature control. The room was heated in winter with a large stove, but it was not cooled in the summer. Rats were housed in cages made of thick metal wire, with metal plates for droppings underneath. For the study by Andik et al.,[6] rats were housed one per cage (to monitor food intake), and the cages were stuck densely on wooden shelves. Many cages with many animals were maintained in a relatively small room. Whereas in the figures Andik et al.[6] marked the control group as "21 °C," they explained in the text that ambient temperature actually varied between 20 and 25 °C. The lower portion of this range was probably close to the lower critical temperature, as suggested by Maloney; the upper portion was likely thermoneutral or near-neutral.

A historically interesting twist is that the mastermind behind the study reported in the Andik et al.[6] paper was neither the first nor last author. Instead, it was the second author—Professor Szilárd Donhoffer (1902–1999; **Fig. 1**; also see ref. 7). At that time, many British journals required that authors on a paper were listed alphabetically, irrespective of their role in the study. The Andik et al.[6] study completed the line of investigation started by Donhoffer in the 1940s.[8] We feel we are obliged to acknowledge Professor Donhoffer's role both in this work and in founding the Hungarian school of thought in the areas of energy balance and thermoregulation. One of us (M.S.) joined the Donhoffer laboratory as a volunteer within a year after publication of the Andik et al.[6] study and became the last Ph.D. student of Professor Donhoffer.

Disclosure of potential conflicts of interest

M.S. reports no conflicts of interest. A.A.R. is the Editor-in-Chief of *Temperature*.

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