Report on Physiological Results of the Japanese Antarctic Research Expedition I, 1956–57.

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第1次日本南極地域観測隊人体生理研究報告

緒　方　道　彦*

要　旨

I. G. Y. に際し，各国観測隊の医学関係者により，健康管理のみならず，更に生理学上の問題を採り上げ，協同研究を行うことになり，第1次観測においても，次の如き項目により，予備的な調査を行つた．

調査項目　1) 医学気候　例えば体感温度の如く，生物学的な立場からの気象条件の測定．カタ冷却力，凍力，紫外線量等．

2) 気候馴化　極地での寒冷馴化と，航海中温帯——熱帯——寒帯での馴応現象を主として，体温調節機能の面から調査する．基礎代謝，皮膚温等．

3) 生理機能の日周差（24時間リズム）　生理機能の日周差には，内因のみならず，外部環境の影響も考えられる．昼夜比の大きく変動する極地は格好の研究対象となり得るが，第1次観測では口腔体温の日間変動につき調査する．

結　果　上記3項目につき出来得る限り広範囲の調査を計画したが，第1次観測隊の性格上，接岸・設営が主であり，かつ予想外に宗谷のローリングが烈しく，船上での測定に技術的な困難が多く，実施項目は限定されざるを得なかつた．

1) 医学気候　全航海中経験した気候の概要はFig. 1 の気候図に示す．結局，隊員は6カ月中に冬を一回夏を二回経験したことになるが，寄港及び接岸中を除くと，自然気候ではなく，航海気候というべきであろう．Fig. 2 c は気温変化を，Fig. 3 はカタ冷却力（宗谷ボートデッキ，停船時）を示し，Fig. 4 は氷海域での白夜の頃の日間紫外線量を示す．

船内居住性は，暖房は有効であつたが，熱帯航海中は蒸暑く（カタ値．Fig. 3），中央船室は軽度の空気汚染（CO_2 0.2%）を示していた．

2) 気候馴化　基礎代謝（B.M.）の変動に重点をおいたが，これも少数例に止った．

B. M. はインド洋で低く極地で高く，日本本土の季節変化に似た変動を示す（Fig. 2 a）．気温と B. M. の相関も日本本土と類似している（Fig. 5）．

呼吸商（R. Q.）は，熱帯で高く極地で低い（Fig. 2 b）．

3) 生理機能の日周差　全航海中同じ生活条件（B. M. 測定日）で，地方時（Local Ship Time）により口腔体温の日間変動を測定したが（Fig. 6），一般に体温は地方時に一致して変動する．

白夜圏に侵入（1月7日）直後の 8, 12 日頃は，日間変動は尚以前の型が残つているが，23, 24 日頃になると平坦化し，基礎体温は上昇している（Fig. 2 e）．これは白夜が終り，夜が長くなり始めると，再び回復して来る．

附　記

第1次観測航海中の生理学的調査に際し，終始御尽力を蒙つた中野征紀，伊藤洋平両隊員（医療班），懇切に御指導頂いた吉村教授（京都府立医大），緒方教授（熊大体研）並びに南極特別委員会医学部門の諸先生，国立栄養研究所の鈴木生理部長，大島技官の方々に深甚の謝意を表すると共に，被験者の労を快く引受けた小口・北村・中村各隊員に感謝します．

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Introduction

In cooperation with scientific research in the International Geophysical Year Program in the stern polar climate, the Medical Branch of the Japanese National Antarctic Committee had made preparations for the medical care of the expedition and also planned to undertake research into some physiological problems in the Antarctic region. As the numbers of medical experts were, however, so limited and logistic work was too much, only a few problems from the plan were actually investigated. The following are outlines of the plan and of the results of physiological research.

Plan of Research and Items of Measurement

In accordance with the American memorandum[1], the main project is to investigate physiological adaptations to the polar climate. The investigations are divided into three series. One is to observe physiological adaptations, through the voyage from Tokyo to Syowa Base which passes through northern temperate, tropical, southern temperate and frigid (Antarctic) zones. Two is to investigate physiological adaptation to cold in the Antarctic region. Three is to study 24 hours rhythms of physiological functions which may differ considerably from those in the temperate zone.

Along these plans, the items of measurement and the equipment are arranged as follows;

1. Measurements of meteorological factors From the biological point of view, some ecological instruments were prepared in addition to the ordinary meteorological research.

A. Cooling power as a simplified index to the effective temperature:
   1. Dry- and wet- kata-thermometer (L. Hill)
   2. Freezing power meter (KANAE)[2], a kind of kata-thermometer specially prepared for low temperature (+2°C~0°C~ −2°C)

B. Ultra-violet dosis: Ultra-violet dosimeter (Crystal violet photometry manufactured by Japan Meteorological Agency)

C. Radiation: Globe thermometer (H. M. VERNON)

2. Acclimatization

A. Variation of basal metabolism: The Douglas bag method with modified Haldane apparatus of portable "ROKEN" type.

B. Skin temperature: Thermocouples

C. Properties of blood and urine: Related instruments prepared for wintering party

3. Diurnal fluctuation in the physiological functions

Influence of day-night on the 24 hour bodily rhythms

A. Diurnal fluctuation in the human body temperature (mouth): Body temperature thermometer

B. Properties of blood and urine: Related instruments

Results

The SOYA, the ship of the Japanese Antarctic Research Expedition I, left Tokyo on the 8th November 1956. She called at Singapore at the end of November and at Cape Town at the end of December on the way to the Antarctic. At the beginning of Jan. 1957 m/s SOYA anchored at the fast ice of Lützow-Holm Bay in the Antarctic continent. After the establishment of the scientific station, named Syowa Base, the SOYA left there on the 15th Feb. and returned to Tokyo on the 24th Apr., 1957.

During 6 months of the full voyage the expedition members spent about two

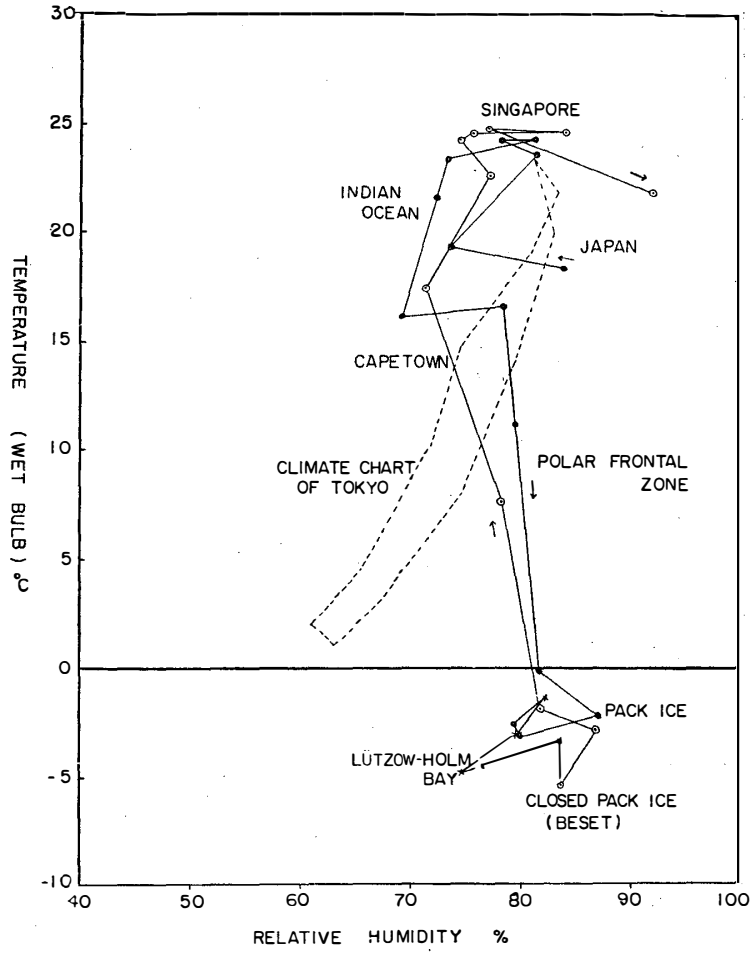


Fig. 1. Showing the climate chart of the SOYA. Plotted along mean values of every five days. ● outward voyage, ○ homeward voyage, × during anchoring at Lützow-Holm Bay.

months in each climate zone, i. e. temperate, tropical, and frigid zone.

All of the members were in a good state of health through the voyage. As the index to the condition of health, body weights of the members were measured periodically. The mean value of 26 members, measured all of five times, increased in the frigid (Antarctic) zone and decreased after sailing across the Indian Ocean (Fig. 2 d).

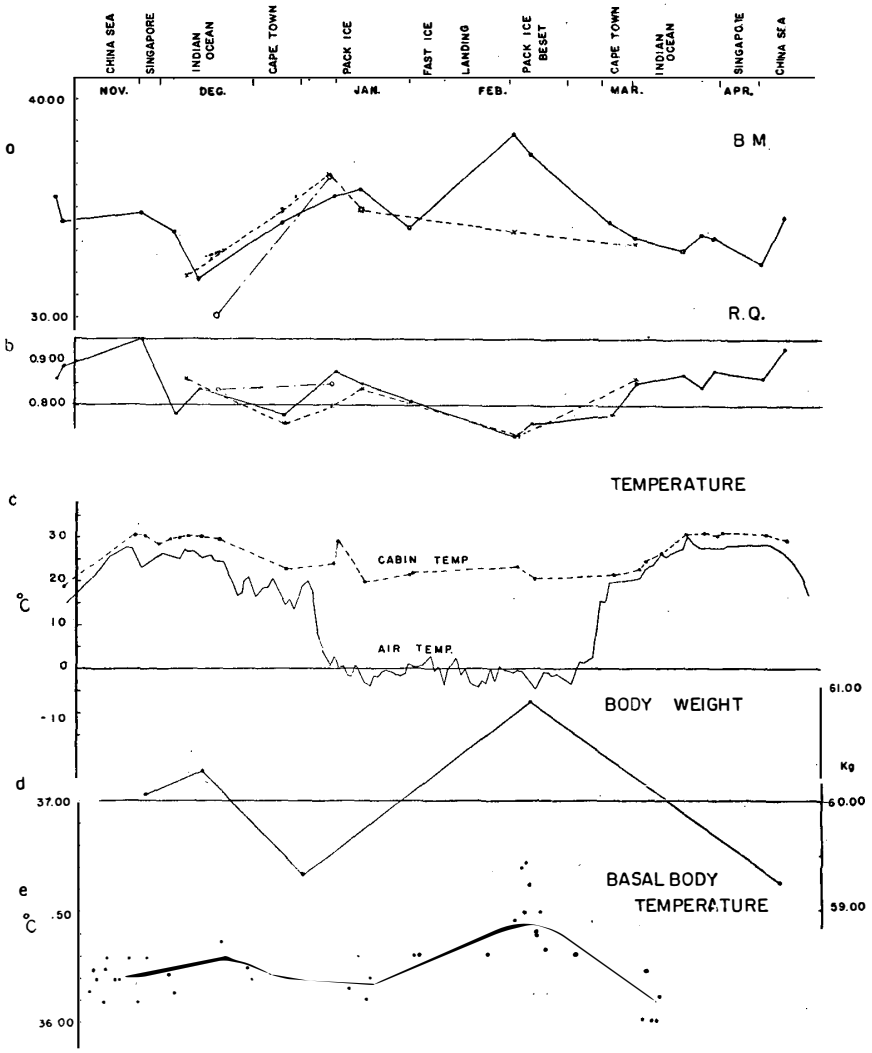


Fig. 2. Showing results of some observation throughout the full voyage.

a) variation of basal metabolism (B. M.). b) variation of respiratory quotient (R. Q.). c) changes of air and cabin temperature. d) changes of mean body weights of 26 members. e) variation of basal body temperature (mouth).

1. Changes of climate in the voyage To observe the influence of environment on the human body through the voyage, the air temperature, a cooling power of the atmosphere as an indication of the effective temperature, and ultra-violet dosis on the boat deck as well as in the cabin were measured. Carbon dioxide content of the cabin air was also determined.

The climate chart of the full voyage is plotted in Fig. 1 which gives an outline of the climate experienced on board in comparison with that of Tokyo[3]. During a period of staying at Syowa Base, from Jan. 24 to Feb. 15, it was rather milder than the stern Antarctic climate expected.

Exactly speaking, the expedition members experienced a kind of "voyage climate" except the period of calls at Singapore and Cape Town, and the period of anchoring at the fast ice of Lützow-Holm Bay. In other words, kata values observed on the boat deck during the voyage did not show natural sultriness in the Equator zone (Fig. 3). Cabins of the SOYA were inevitably hot and stuffy in the tropical zone and carbone dioxide content of the cabin air was raised to 0.2% throughout the voyage, which indicates an air contamination. Fig. 2 c shows the variation of air temperature and cabin temperature.

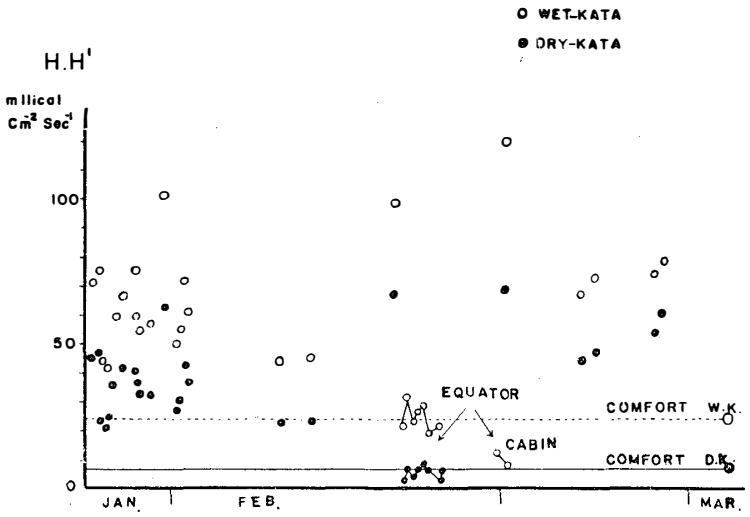


Fig. 3. Showing cooling power in the Antarctic, wet-kata (open circles), dry-kata (filled circles). For reference values in the Equator zone are entered.

Various logistic works prevented us from continuing a serial observation, therefore only the fluctuations of kata values, cooling power, are shown in Fig. 3. Fig. 4 shows ultra-violet dosis in the Antarctic summer. Among the closed pack ice and the fast ice U-V dosis was rather high as expected. Pigmentation caused by U-V radiation was more obvious in the polar and tropical zone than in the temperate zone. As shown in Fig. 1, the climate of the Lützow-Holm Bay was rather milder in summer than expected and even in winter the meteorological observation at Syowa Base

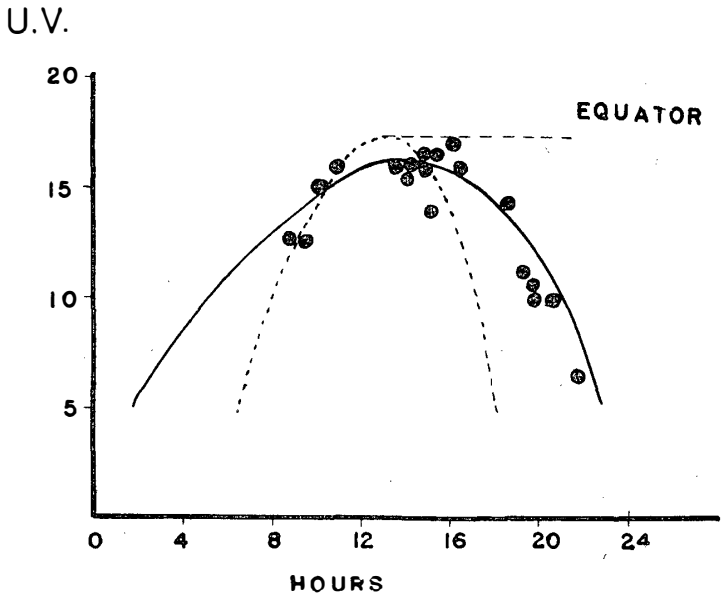


Fig. 4. Diurnal fluctuation of ultra-violet dosis in the pack ice zone compared with the Equator zone.

proved that it is not such a stern climate. Thus the climate in Syowa Base is favorable for scientific research work in the Antarctic, especially in summer.

2. Variation of basal metabolism Many Japanese authors (SIRAI 1940, FUKUHARA 1950, FUKUDA 1953, SASAKI 1954, SUZUKI 1956, OSIBA 1957) investigate the presence of seasonal variation of basal metabolism in Japan, i. e. increase in winter, decrease in summer. Range of the variation in Japan was 14% (OSIBA 1957[4]) or 8–13% (SUZUKI 1956[5]) in a year. E. MASON observed that her own B. M. decreased 8.3% in 10 days on the way from Honolulu to the tropical zone[6].

The hard rolling peculiar to the ice-breaker (without bildge keel) caused unexpected difficulties in measuring B. M., and limited the number of subjects. The only subject measured throughout the entire voyage was the author's own, out of three cases.

The interrelation between B. M. and outdoor air temperature shows a similar regression line in comparison with that studied in Japan (Fig. 5.) (OSIBA[4]), and the regression coefficient is a little lower than that in Japan. The difference of these two regression coefficients may be explained by the difference of duration for acclimatization between the two. In a case of the voyage climate, the ship passed rapidly various climatic zones, and thus the adaptation could not follow fully the changes of the air temperature.

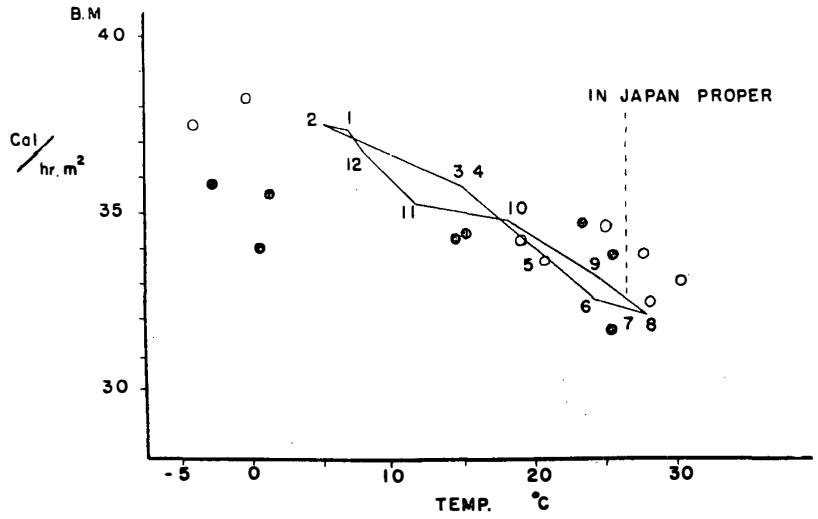
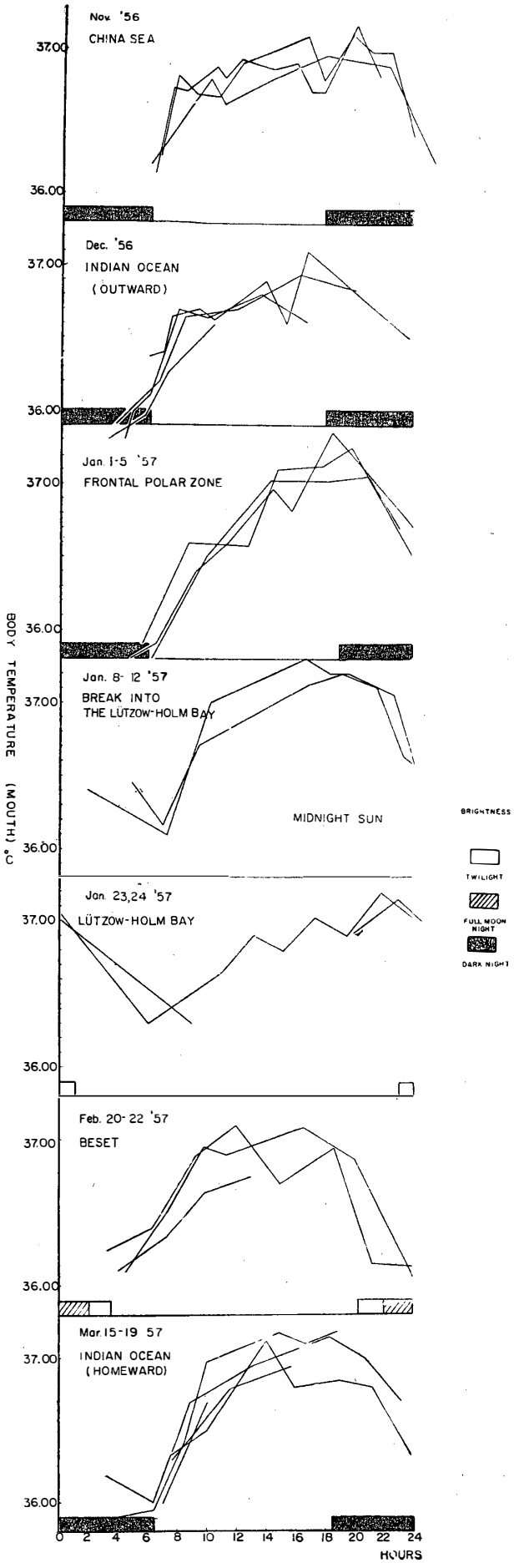


Fig. 5. Correlation between basal metabolism and environmental temperature in comparison with the seasonal change of B. M. in Japan proper.
● outward voyage ○ homeward voyage

Respiratory quotient (R. Q.) varied with air temperature, decreased in the frigid zone and approximated to 0.90 in the tropical zone. Similar results were observed by UCHIDA on the voyage from Japan to Australia[7]. In the next expedition, it should be very interesting to measure the skin temperature in connection with adaptative changes of basal metabolism.

3. Diurnal variation in the physiological functions (24 hour rhythms) It is



generally believed that the bodily rhythm (diurnal fluctuations in body temperature, urinary excretion, etc.) is maintained by intrinsic factors but may be influenced by many extrinsic factors. Some investigators concluded that daily periodicity is a function only of the mode of life; on the other hand, another observed that day-night has no influence on the 24 hour bodily rhythms. The Antarctic expedition offers a unique opportunity for carrying on research work along these lines.

The program previously planned included various items, but in the first expedition only the diurnal fluctuation of body temperature (mouth) could be observed serially. The body temperature was always measured under the same life condition, usually when the basal metabolism was measured. The standard time used was the Local Ship Time. Patterns of the diurnal fluctuation of body temperature are shown in Fig. 6. It seems to change synchronously with the Local Ship Time.

In the Antarctic summer, fluctuation pattern had a tendency to become flat and the basal body temperature tended to be higher than in another climate zone (Fig. 2 e). These tendency was found about a week after the SOYA arrived at the Antarctic zone. While the activity of the subject was kept the same as in another climate, the midnight sun at that zone presumably influenced directly or indirectly the 24 hour rhythm of physio-

Fig. 6. Showing patterns of diurnal fluctuation of body temperature (mouth).

logical functions.

SEA SICKNESS AND BODY TEMPERATURE: The interrelation between the fluctuation of body temperature and the Labyrinth was observed on the trans-Pacific voyage[8]. When the SOYA encountered a typhoon on the outward voyage, irregular fluctuation of the body temperature and hypothermia were noticed in the severe cases of sea sickness. A hard stimulus to the Labyrinth seems to affect particularly the mechanism of the thermoregulation of the body temperature. Insufficient nutrition caused by severe sea sickness might cause hypothermia.

Summary

During 6 months of the entire voyage of the expedition to the Antarctic region, 1956–57, the expedition members experienced summer season (tropical zone) twice and winter season (polar zone) once. The basal metabolism varies with changes of air temperature, and has a resemblance to the seasonal variation of the basal metabolism in Japan proper, increasing in winter season and decreasing in summer season.

On the contrary, the respiratory quotient increased in summer season (tropical zone), and decreased in winter season (polar zone).

During the voyage, the diurnal fluctuation of body temperature changed synchronously with the Local Ship Time. During the midnight sun in the Antarctic, however, the basal body temperature (mouth) tended to be raised, and the diurnal fluctuation of body temperature seemed to be flattened. The temperature of sufferers from severe sea sickness fluctuated irregularily and presented a slight hypothermia.

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