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Body temperature of parids in the arctic winter.[1])

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Measurements of body temperature in birds by means of thermocouples (BALDWIN & KENDEIGH 1932, UDVARDY 1953) indicate a considerably lower standard temperature in Passerines than was suggested by earlier temperature measurements. From this and from the recent discovery of low body temperature or even temporary poikilothery in the closely related orders *Caprimulgiformes* and *Apodiformes*, it seems extremely interesting that PALMGREN (1944) recorded extremely low body temperatures in the Siberian Tit, *Parus cinctus* L., of the Arctic. His three measurements range from 34.6° to 39.8° C. PALMGREN explained these extraordinary values as a possible adaptation to the arctic winter.

In what follows I give an account of my own measurements of the body temperature of Siberian Tits, and some closely related species from Arctic and Subarctic localities of Northern Europe.

Environment. The experiments were carried out 3 km SE of the village of Jukkasjärvi (67° 51′ N. Lat., 20° 34′ E. Long.) on Torneälv river in Sweden, between February 21 and March 2, 1951. This area lies in the taiga forest zone, and the locality where the birds were trapped was a secondary growth of Scotch pine, *Pinus silvestris*, with a few scattered summer cottages alongside the riverbed. The

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winter fauna at this time was extremely sparse. During a daily ski trip of 2 1/2 km each way, from the highway to the summer cottage where the experiments were performed, I saw the following 8 species.

Raven *Corvus c. corax*
Siberian Jay, *Cractes i. infaustus*
Great Tit, *parus m. major*
Willow Tit, *P. a. atricapillus*
Siberian Tit, *P. c. cintus*
Pine Grosbeak, *Pinicola e. enucleator*
Bullfinch, *Pyrrhula p. pyrrhula*
Redpoll, *Carduelis linaria*

Most of the tits were found around two feeding stations about 3 km from one another alongside the river, and some days no birds other than these tits were observed.

Prior to my arrival a feeding tray was established at one of the cottages, and it attracted at least five Siberian Tits, two Great Tits and three or four Willow Tits. Colour banding of the Tits showed that some of them used a feeding tray about 300—400 metres away on the opposite side of the river; the birds must have crossed at least 300 metres over the treeless expanse of the frozen riverbed. Since at this tray the birds were less shy some of the trappings were done there.

The weather during the period of experimentation was moderate, sometimes quite mild. Long sunny periods alternated with some snow, but no storm occurred. The temperature fluctuated between —9° C and + 2° C during the daytime and thus was relatively warm.

Experimental. I measured the proventricular temperature of the birds by means of copper-constantan thermocouples in the manner described earlier (UDVARDY op.c.). The captured birds were covered with a dark cloth for about 10—15 minutes in order to level off high temperatures caused by excitement. The thermocouple was then inserted through the beak, and the bird was rolled in a cheesecloth bag, and while it lay on its back, the body temperature was read at five-minute intervals.

Part of the experiments were carried out at 0° to + 6° C room temperature, while in other cases the room temperature rose as high as + 14° C. The explanation is that at first I used an uninhabited cottage where only by lighting a fire in the hearth did I get the room temperature somewhat above freezing. This, however, caused great delay in the investigations, since the flashlight batteries operating the lamp of the galvanometer would not work at such low temperatures.

and had to be warmed and alternated periodically. The use of an inhabited cottage during the second half of my stay eased the situation. However, measurements taken in the warmer room do not differ in range from those taken at the lower temperatures. Moreover, the temperature outdoors also fluctuated; thus the difference between the temperature of the natural environment, and the experimental surroundings varied between 9° and 18° C.

Table I gives the initial temperature values for the individuals investigated. These were read not more than 20 seconds after the insertion of the thermocouple into the proventriculus.

Table II summarizes initial temperatures, and standard temperatures (these latter were read 15 minutes after the beginning of the experiment) of the parids measured at Jukkasjärvi; and also those of 11 parids investigated during the winters of 1948 and 1949 in Hel-

Table I. Body temperature of parids measured at Jukkasjärvi Feb.—March 1951. Central European Time. Temperatures in ° C.

Parus sp.	No.	Date 1951	Time	Temperature 0800 hours	Room temp.	Out door temp.	Initial temp.	Standard temp.	Weather
cinctus	1	22/2	14.00	—12°	+ 6°	—8°	41.38°	40.30°	cloudy
»	2	22/2	14.25	—12°	+ 6°	—8°	42.13°	41.98°	»
»	3	23/2	09.30	— 8°	+ 3°	—7°	41.12°	40.09°	»
»	4	26/2	13.39	—12°	0°	—9°	41.20°	40.22°	sunny
»	5	26/2	14.36	—12°	+ 2°	—9°	41.36°	40.30°	»
»	5*)	2/3	09.42	— 2°	+14°	+1°	41.97°	40.77°	»
»	6	2/3	08.56	— 2°	+14°	+1°	41.54°	40.85°	»
Mean values of 6 *P. cinctus*							41.46°	40.62°	»
atricapillus	1	26/2	15.11	—12°	0°	—9°	41.19°	40.89°	»
»	2	1/3	10.46	—15°	+14°	—4°	42.25°	41.55°	»
»	3	1/3	11.54	—15°	+14°	—4°	41.33°	41.40°	»
major	1	2/3	14.29	— 2°	+14°	+2°	41.09°	40.09°	»
»	2	2/3	14.45	— 2°	+14°	+2°	42.85°	42.48°	»
»	3	2/3	14.57	— 2°	+14°	+2°	42.87°	42.60°	»
Mean values of 6 other parids							41.93°	41.50°	»
Mean values of all 12 parid individuals							41.69°	41.06°	

*) P. *cinctus* No. 5 was recaptured and its temperature retaken March 2.

sinki, Finland (60° 10′ N. Lat.). The birds were captured in the vicinity of Helsinki, and were kept several days prior to the experiment at + 18° C room temperature; therefore they were for the most part »warm-adapted» birds. For completeness data on three parids from Ottenby, Sweden (56° 10′ N. Lat., 16° 25′ E. Long.), are also included (from UDVARDY, op. c.).

Discussion. The data show no striking differences between the body temperature of the different parid species. Both standard and initial temperatures are within the range which is usual for Passerines. The mean standard temperature of 311 passerine individuals

Table II. Body temperature measurements of parids.

Parus sp.	Locality	Date	Initial Temp. °C	Standard Temp. °C
major	Helsinki	15/ 2 1949	42.20	39.85
»	»	24/11 1949	41.20	40.50
»	»	26/ 2 1949	42.20	39.90
»	Jukkasjärvi	2/ 3 1951	41.09	40.09
»	»	2/ 3 1951	42.85	42.48
»	»	2/ 3 1951	42.87	42.60
caeruleus	Helsinki	14/10 1949	41.60	38.40
»	Ottenby	8/10 1950	42.07	41.37
»	»	9/10 1950	40.24	39.92
»	»	9/10 1950	38.45	38.89
ater	Helsinki	12/ 2 1949	39.60	39.00
cristatus	»	8/ 2 1949	41.55	40.85
»	»	10/ 2 1949	41.25	39.92
»	»	11/ 2 1949	41.20	39.90
cinctus	Jukkasjärvi	22/ 2 1951	41.38	40.30
»	»	22/ 2 1951	42.13	41.98
»	»	23/ 2 1951	41.12	40.09
»	»	26/ 2 1951	41.20	40.22
»	»	26/ 2 1951	41.36	40.30
»	»	2/ 3 1951	41.54	40.85
atricapillus	Helsinki	7/ 2 1949	41.65	40.05
»	»	8/ 2 1949	40.50	39.20
»	»	17/2 1949	38.60	37.95
»	Jukkasjärvi	26/ 2 1951	41.19	40.89
»	»	1/ 3 1951	42.25	41.55
»	»	1/ 3 1951	41.33	41.40
Mean of 26 parids			41.25	40.33

were previously determined to be 40.6° C. (UDVARDY, op. c.), while that of the 26 parids investigated above is 40.33° C. (Tab. II).

The samples are mostly too small for comparison of the separate species. Nevertheless, since the Siberian Tit is the arctic species which is most likely to be cold-tolerant, we might attempt to compare the six Siberian Tit temperatures with all 20 individuals of the 5 other species. The difference is not significant ($t = 0.725$). Neither can a significant difference be shown if we compare these Siberian Tits with the six arctic records of Great and Willow Tit temperatures (Tab. I) using here as in the previous calculation the standard temperature values ($t = 1.7973$).

The discrepancy between the earlier mentioned findings of PALMGREN (1944), and those reported here may be due to two circumstances.

First, we may consider the accuracy of the method used by him, as a possible source of bias. The birds were obtained by shooting them, and the temperature was secured immediately after death by means of a mercury thermometer inserted through the throat deep into the body.

In a cool environment the dead body starts to cool down immediately. Results of experiments shown in Table III illustrate this cooling. The birds died from extreme heat, and cooling took place either in the hot chamber, or at room temperature. However, the cooling was quite rapid even in these moderate to warm environments: five passerine individuals at 20° C to 40° C environmental temperature averaged 0.32° C reduction of body temperature per minute, following death. The size of these birds is close to that of the parids considered.

Table III. Body temperature of birds after death.

From experiments carried out at Ottenby, Sweden, autumn 1950. The original notes and graphs are deposited in the archives of the Bird Station.

Species	No.	Temp. of environment	Body temp. at death	Decrease in one minute
Anthus spinoletta	350	40° C	46.16° C	0.35° C
» »	361	20°	44.17°	0.27°
Erithacus rubecula	523	35°	45.86°	0.35°
» »	525	34°	41.20°	0.27°

Earlier, BERNARD, CAYOUETTE and BRASSARD (1944) obtained similar results in experiments on the Bronzed Grackle (*Quiscalus quiscula aeneis*), a much bigger bird. According to them mean cooling at room temperature was 0.4° C in the first minute after death.

We may assume that the rate of cooling is faster when the difference between body and environmental temperature is greater, as was presumably the case in PALMGREN's experiments, which were carried out mostly in the middle of the winter. It would be very difficult to take into consideration the insulating effect of the plumage in preventing fast post mortem cooling, since this factor may vary considerably according to the state of the plumage at death: it may be erected, slightly raised, smoothed, etc.

Further, the temperature of the thermometer surface might have had a cooling effect on the surrounding tissues of the small dead bird, depending on the size relations.

Finally, an adjustment is usually necessary in such measurements, in respect to the relative lengths of the inserted and non-inserted portion of the thermometer. Failing this correction error increases with increasing difference between body and environmental temperature.

Some of these factors might have caused or influenced the strikingly low body temperature records of the Sibirian Tits of PALMGREN.

This argument has one weak point, i.e. that all the other parid temperatures of PALMGREN are in good agreement with my own findings about these birds. His other parids, however, were all taken around the 60° Latitude, and only the three Siberian Tits were measured in the arctic winter; thus we still might suspect the biasing effect of extremely low environmental temperature and difficulties in reaching the bird quickly after death.

We can even rule out the possibility that the low body temperatures reflect a low stage of the customary diurnal variation of body temperature, since the birds were evidently shot during the hours of daylight, and my conflicting observations were also made between 8.56 a.m. and 14.36 p.m.

A statistical comparison of all 12 parid temperatures taken by PALMGREN and all 26 initial temperatures tabulated above shows no significant difference of the mean values ($t = 1.1476$). Thus, it is possible that his low temperatures for Siberian Tits are merely chance variations. In a similar manner, two of my Blue Tits had extremely low standard temperatures (Table II).

In the light of the above, it does not seem proved that the Siberian Tit has specially adapted its body temperature to the arctic winter. Under indentical circumstances it did not differ from that of other parids of the arctic, neither from that of parids of subarctic habitats.

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S u m m a r y: Winter body temperatures of Siberian Tits, taken during daylight hours, were compared with those of other tits, in arctic and subarctic habitats. All these temperatures are similar. Thus thermal adaption of the Siberian Tit to the arctic winter was not indicated, at least in daytime.

Previous data which seemed to indicate such adaption were obtained by a method that is open to several sources of error, and involved only three birds.

R e f e r e n c e s. BALDWIN, S. P. & S. C. KENDEIGH, 1932, Sci. Publ. Cleveland Mus. Nat. Hist. 111. pp. 196. — BERNARD, R., CAYOUETTE, R., and BRASSARD, J.-A., 1944 Rev. Canad. Biol. 3 (2): 251—277. — PALMGREN, P., 1944, Ornis Fenn. XXI: 99—104. — UDVARDY, M. D. F., 1953, Zool. Bidrag 30: 25—42.

S e l o s t u s: **Tiaisten talvinen ruumiinlämpö.** Kirjoittaja vertasi lapintiaisen ruumiinlämmöstä saamiaan mittaustuloksia muiden tiaislajien ruumiinlämpöön arktisilla ja subarktisilla olinpaikoilla ja totesi, että kaikki nämä lämpöarvot olivat yhtäläisiä. Tulokset on saatu päiväsaikaan tehdyillä mittauksilla. Nämä viittaavat siihen, ettei lapintiaisella esiinny ainakaan päiväsaikaista ruumiinlämmön sopeutumaluontoista määräytymistä arktisten talviolosuhteiden mukaan.

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